# ALTERNATIF PENERAPAN TEKNOLOGI INFORMASI DALAM PENENTUAN SUPPLIER INDUSTRI MANUFAKTUR BERBASIS *BILL of MATERIAL DAN GROUP TECHNOLOGY*

## DISERTASI

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**MINAT TEKNIK INDUSTRI MANUFAKTUR**

**Ditujukan untuk memenuhi persyaratan**
**memperoleh gelar Doktor Teknik**

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**UNIVERSITAS BRAWIJAYA**
**FAKULTAS TEKNIK**
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**DISERTASI**

**ALTERNATIF PENERAPAN TEKNOLOGI INFORMASI DALAM PENENTUAN SUPPLIER INDUSTRI MANUFAKTUR BERBASIS *BILL of MATERIAL DAN GROUP TECHNOLOGY***

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**pada tanggal 14 Januari 2021**
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**PERNYATAAN**
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# RIWAYAT HIDUP

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Malang, 14 Januari 2021

Penulis

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Malang, 1 Juli 2021

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# RINGKASAN

**Denny Trias Utomo**, NIM : 137060200111002, Program Doktor Teknik Mesin, Fakultas Teknik Universitas Brawijaya, Juli 2021, *Alternatif Penerapan Teknologi Informasi Dalam Penentuan Supplier Industri Manufaktur Berbasis BoM dan GT*
Dosen Pembimbing : Pratikto, Purnomo Budi Santoso, Sugiono

Pemilihan supplier merupakan permasalahan yang komplek pada era Industri 4.0 sekarang ini. Banyaknya jumlah supplier dengan kualitas performansi yang berbeda-beda menyebabkan sulitnya pihak internal perusahaan untuk memilih supplier yang sesuai. Di sisi lain macam-macam bahan baku yang dibutuhkan untuk membuat produk jadi, sangat beragam. Kesesuaian supplier berkualitas yang diperlukan untuk memasok bahan baku yang dibutuhkan oleh industri menjadi hal yang penting untuk diselesaikan. Begitupun halnya dengan industri perakitan traktor tangan, industri kecil menengah ini juga sangat tergantung pada ketersediaan bahan pasokan, dan sudah pasti tergantung pula dengan pemilihan supplier itu sendiri.

Penelitian disertasi ini bertujuan untuk memperoleh metode terbaru untuk memilih supplier pada industri manufaktur dengan studi kasus pada perakitan industri kecil traktor tangan. Penelitian disertasi ini diawali dengan kegiatan studi literatur melalui FGD, dan studi pustaka, kemudian diikuti dengan pembuatan desain prototipe aplikasi. Dimana untuk menyusun database bahan baku disusun menggunakan struktur produk pada *Bill of Material*, penentuan bobot kriteria optimal menggunakan *Genetic Algorythms* dan pemilihan supplier menggunakan metode *multi criteria decision making.* Studi kasus penelitian ini di sentra Industri Logam Ceper Klaten Solo, yaitu di Politeknik Manufaktur Ceper. Sedangkan pelaksanaan penelitiannya di Lab Komputasional dan Sistem Informasi serta Laboratorium Rekayasa Sistem Informasi Politeknik Negeri Jember. Uji coba aplikasi diimplementasikan pada studi kasus sesungguhnya, dengan data supplier 153, data bahan baku 70 bahan baku dengan variabel kriteria pemilihan supplier sebanyak 10 variabel. Pada tahap akhir diverifikasi menggunakan kuesioner online Google Form, dengan data responden sebanyak 101, banyaknya responden yg memilih "Sangat mudah" dan "Mudah" atau "Sangat lengkap" dan "Lengkap" atau "Sangat tepat" dan "Tepat" $\geq$ **80 %**, ini menunjukkan bahwa aplikasi / web yang dihasilkan dalam penelitian ini sesuai dengan harapan IKM pengguna (*Verified*).

Kata kunci : Pemilihan pemasok, *Computational intelegence, Bill of Material, Group Technology, Multi Criteria Decision Making dan Genetic Algorythms.*

# SUMMARY

**Denny Trias Utomo**, NIM : 137060200111002, *Doctoral Program of Mechanical Engineering, Faculty of Engineering, Brawijaya University, July 2021, Alternative Application of Information Technology in Determining Suppliers for Manufacturing Industry Based on BoM and GT.*
*Academic Supervisor* : Pratikto, Purnomo Budi Santoso, Sugiono

*Supplier selection is a complex problem in the current Industry 4.0 era. The large number of suppliers with different performance qualities makes it difficult for the company's internal parties to choose the appropriate supplier. On the other hand, the kinds of raw materials needed to make finished products are very diverse. The suitability of quality suppliers needed to supply raw materials needed by the industry is an important matter to be resolved. Likewise with the hand tractor assembly industry, this small and medium industry is also very dependent on the availability of supply materials, and of course it also depends on the selection of the supplier itself.*

*This dissertation research aims to obtain the latest method for selecting suppliers in the manufacturing industry with a case study on the assembly of a small hand tractor industry. This dissertation research begins with literature study activities through FGDs, and literature studies, then followed by making an application prototype design. Where to compile a database of raw materials compiled using the product structure in the Bill of Materials, determining the optimal weight criteria using genetic algorithms and selecting suppliers using the multi criteria decision making method. The case study of this research is in the center of the Ceper Metal Industry, Klaten Solo, at the Ceper Manufacturing Polytechnic. Meanwhile, the research is carried out at the Computational and Information Systems Lab and the Jember State Polytechnic Information System Engineering Laboratory. The application trial was implemented in a real case study, with 153 supplier data, 70 raw material data with 10 supplier selection criteria variables. In the final stage it was verified using an online Google Form questionnaire, with 101 respondent data, the number of respondents who chose "Very easy" and "Easy" or "Very complete" and "Complete" or "Very precise" and "Exact" > 80%, This shows that the application / web generated in this study is in accordance with the expectations of the users' IKM (Verified).*

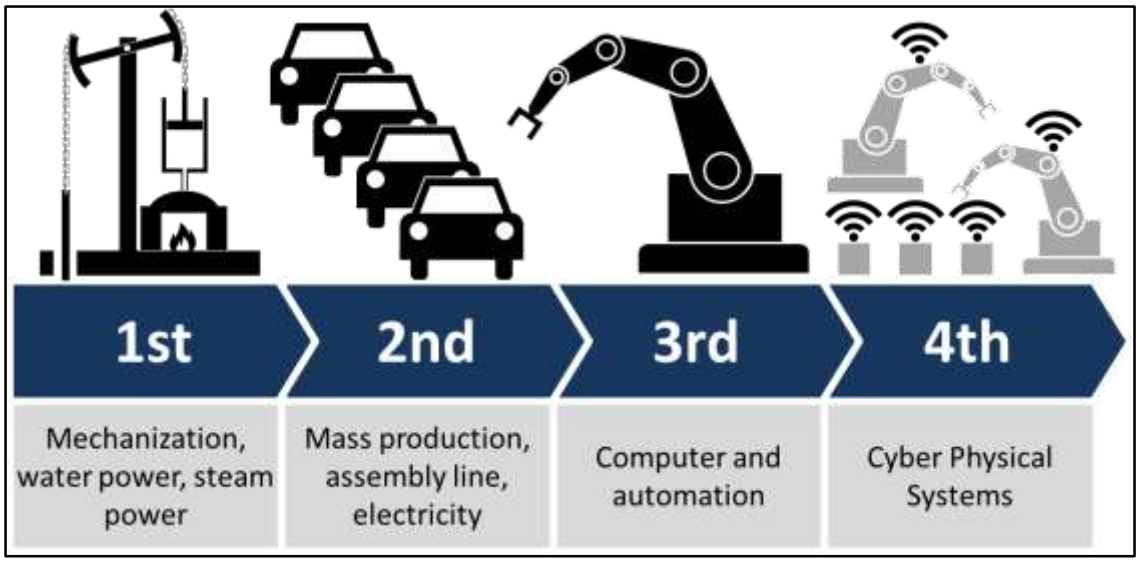
*Keywords* : *Supplier Selection, Computational intelegence, Bill of Material, Group Technology, Multi Criteria Decision Making dan Genetic Algorythms.*

# BAB 1

# PENDAHULUAN

Pada Industri 4.0 pelaku industri mengintegrasikan jaringan komputer dan berkomunikasi satu sama lain melalui jaringan internet yang akhirnya, dengan metode kecerdasan tertentu yang ditanamkan dalam aplikasi dalam bentuk basis pengetahuan cerdas akhirnya dapat membuat keputusan tanpa keterlibatan manusia. Kombinasi dari sistem fisik-cyber, *Internet of Things (IoT),* dan *Internet of Systems* membuat Industry 4.0 menjadi mungkin, serta membuat pabrik pintar *(smart factory)* menjadi kenyataan. (Vavra, 2016)

Di Indonesia, perkembangan Industry 4.0 sangat didorong oleh Kementerian Perindustrian. Menteri Perindustrian Airlangga Hartarto mengatakan, agar Indonesia dapat bersaing dengan negara lain di bidang industri, Indonesia juga harus mengikuti tren. (ManufacturingIndonesia.com, 2018)




Gambar 1. 1 Timeline Teknologi Industri (Vavra, 2016)

Transformasi Revolusi Industri 4.0 bidang logistik industri manufaktur, dimulai dengan integrasi proses produksi dan logistik dengan sistem teknologi informasi yang sesuai. Ini termasuk pertukaran data produk dan produksi di dalam perusahaan serta dengan pelanggan dan pemasok. Menurut kamus Cambridge definisi supplier adalah perusahaan, orang, dan lain lain yang menyediakan hal-hal yang orang inginkan atau butuhkan, terutama selama proses produksi dalam periode waktu yang panjang (Dictionary, 2016)

Supplier dalam Indsutri 4.0 khususnya, mendapat manfaat dari pertukaran desain dan data rantai pasokan. Komunikasi di seluruh proses produksi mendekati waktu nyata di antara manusia, mesin, suku cadang, dan produk. Sistem yang saat ini merupakan milik berkembang menjadi jaringan berjenjang dan hierarkis dengan antarmuka terbuka dan standar. Data disimpan di *cloud* untuk meningkatkan ketersediaan dengan akurat. Ini akan memungkinkan lebih banyak fleksibilitas ketika bereaksi terhadap perubahan (baik yang diharapkan maupun tidak terduga) dalam proses produksi (Rü\s smann et al., 2015)

Dengan adanya Revolusi industri 4.0, manajemen persediaan dituntut untuk lebih global karena Industri 4.0 sifatnya adalah integrasi ekonomi dengan teknologi informasi maka akan tercipta proses arus barang, jasa, investasi dan modal, masuk dari satu daerah ke daerah lainnya dengan tingkat kompetitif yang sangat tinggi. Dengan demikian maka memerlukan suatu kebijakan produk lokal yang benar-benar kompetitif yang bernilai dan berdaya saing tinggi agar mampu bersaing dengan produk sejenis dari negara lain. (Anindhitya, n.d.) Dalam kaitannya dengan manajemen persediaan dunia industri di era Industri 4.0, hal-hal yang paling berpengaruh adalah pemasok.

Dalam industri 4.0, memilih supplier yang bisa memenuhi pesanan bahan baku yang sesuai dengan standar industri perusahaan dalam durasi jangka panjang mutlak dibutuhkan. Aktifitas ini dikategorikan dalam aktifitas strategis, dikarenakan peran supplier menjadi penentu dalam keberhasilan perusahaan. Apabila bahan baku yang dipasok oleh supplier berkualitas buruk, sehingga hal ini juga akan mempengaruhi kualitas produk yang dihasilkan, sehingga produktivitas menurun (Dolgui et al., 2015; Iacob et al., 2014; K. Lien et al., 2014; Laborda et al., 2014; Mihăescu et al., 2015; Pannek et al., 2016; Seliger et al., 2015; Shi et al., 2014). Ketepatan pemilihan supplier sangat mempengaruhi efisiensi biaya. (Dolgui et al., 2015; Mihăescu et al., 2015). Pasokan bahan baku yang tepat menjamin suatu produk yang dihasilkan berkualitas bagus. Dengan pasokan bahan baku yang bagus, mengakibatkan adanya peningkatan efisiensi proses sehingga biaya operasi perusahaan bisa ditekan. Serta mempengaruhi peningkatan pemasaran, yang berakibat meningkatkan keuntungan perusahaan. Apabila supplier tidak bisa memasok, bahan baku sesuai dengan kebutuhan perusahaan, maka dipastikan jadwal produksi terganggu. (Kotula et al., 2015)

Pemilihan supplier secara umum adalah permasalahan multi kriteria dimana setiap kriteria yang digunakan mempunyai kepentingan yang berbeda dan informasi mengenai hal tersebut tidak diketahui secara tepat. Dalam hal ini pemilihan supplier yang berdasarkan penawaran harga yang rendah sudah tidak efisien lagi. Untuk mendapatkan kinerja rantai pasok

yang maksimal harus menggabungkan kriteria lain yang relevan dengan tujuan perusahaan.(Scott et al., 2015a)

Pemilihan supplier baru yang belum pernah menjadi rekanan perusahaan, merupakan masalah yang lebih komplek, karena data belum tersedia, dan kinerja supplier belum diketahui. Untuk memilih supplier baru tidak boleh menggunakan asumsi-asumsi tetapi harus berdasarkan data empiris yang bisa dipertanggungjawabkan, karena sangat mempengaruhi kinerja produksi. (Pujawan et al., 2015). Berbeda halnya dengan pemilihan supplier lama yang selama ini sudah berkerjasama dengan perusahaan. Data-data kemampuan bisnis, rekam jejak dan kinerja lainnya sudah ada dalam database perusahaan, sehingga lebih mudah dalam memilih dan mengavaluasi supplier yang akan menjadi rekanan perusahaan. Dimana untuk supplier lama rekam jejak, kapabilitas manajemen, harga, kinerja pengiriman, kesadaran lingkungan, service atau layanan, Fleksibilitas, kemampuan teknis, inovatif, pendekatan manajemen,letak geografis telah diketahui, sementara untuk supplier baru belum diketahui(Qian, 2014)

Pemilihan supplier tergolong permasalahan yang semi terstruktur, dimana sebagian dari permasalahan ini cukup terstruktur untuk dipecahkan oleh komputer (perhitungan kriteria, perhitungan efisiensi, dan lain sebagainya) dan sebagian lagi membutuhkan keputusan dari manajer (pemilihan metode evaluasi, pemilihan kriteria, pemasukan nilai). (Ávila et al., 2012). Proses pemilihan supplier dengan berbagai kriteria dapat diselesaikan oleh sebuah sistem komputer yang mampu berinteraksi dengan pengambil keputusan. Sistem tersebut merupakan sistem pendukung keputusan (SPK) untuk pemilihan supplier (Turban, 2006), (Kar, 2015). Metode yang pernah digunakan untuk pemilihan supplier ini adalah *Fuzzy Analytical Hierarchy Process FAHP* (Deng et al., 2014; Galankashi et al., 2016; Heidarzade et al., 2016) dan *Fuzzy Logic* (Karsak and Dursun, 2015; Kilic, 2013).

Berdasarkan hasil kajian dan studi literatur diperoleh keterangan bahwa untuk mendukung pengambilan keputusan telah digunakan beberapa metode diantaranya yaitu *Multi Criteria Decision Making*, *Fuzzy TODIM* dan *TOPSIS*, namun dari paper tersebut belum ada yang mengintegrasikan Sistem Pendukung Keputusan tersebut menggunakan media online berbasis web yang disebut SPK Online.

SPK Online adalah Sistem Pendukung Keputusan yang merupakan aplikasi program perangkat lunak komputer menggunakan media internet berbasis web. Pengguna mengakses halaman tertentu pada situs di internet kemudian memasukkan data-data perusahaannya untuk dianalisa oleh perusahaan menggunakan aplikasi online tersebut. Hasil evaluasi segera di-

*update* secara interaktif menggunakan media web tersebut. Pada tabel 1.2 diilustrasikan perbandingan SPK Konvensional dengan SPK Online.

Berdasarkan uraian diatas, maka pada penelitian disertasi ini dirancang suatu metode baru untuk menyeleksi dan mengevaluasi supplier baru secara online berbasis web yang bertujuan untuk meningkatkan kinerja pengambilan keputusan yang selama ini sudah ada.

Target luaran hasil penelitian disertasi ini adalah diperolehnya metode pemilihan supplier baru dan membangun perangkat lunak sistem pemilihan supplier online sebagai alat ukur baru untuk mengambil keputusan yang cepat dan akurat. Disamping itu juga mempublikasikan hasil penelitian desertasi ini melalui publikasi jurnal internasional.

## 1.1. Rumusan Masalah

Pada penelitian disertasi ini, rumusan masalah yang ada adalah

1. Bagaimanakah mengidentifikasi faktor utama dalam memilih pemasok spare parts pada industri traktor tangan serta merancang metode baru berbasis database relasional untuk menyimpan data spare parts traktor dan data supplier yang baik untuk memilih supplier
2. Bagaimana cara mengintegrasikan database spare parts dan supplier dengan metode optimasi pemilihan supplier
3. Bagaimana membangun prototipe aplikasi yang berbasis web untuk menguji temuan diatas

## 1.2. Batasan Masalah

Untuk mencapai maksud dan tujuan yang diharapkan dari peneltian ini, permasalahan yang ada dibatasi pada studi kasus rakitan traktor tangani produksi Polman Ceper yang merupakan teaching factory hand tractor.

## 1.3. Tujuan Penelitian

Tujuan penelitian disertasi ini adalah :

1. Mengidentifikasi faktor utama dalam memilih pemasok spare parts pada industri traktor tangan serta merancang metode baru berbasis database relasional untuk menyimpan data spare parts traktor dan data supplier yang baik untuk memilih supplier
2. Mengintegrasikan database spare parts dan supplier dengan metode optimasi pemilihan supplier
3. Membangun prototipe aplikasi yang berbasis web untuk menguji temuan diatas

## 1.4. Manfaat Penelitian

Manfaat penelitian ini adalah :

1. Dari sisi industri traktor membangun prototipe aplikasi untuk pemilihan supplier spare parts yang handal bagi perusahaan industri manufaktur traktor.
2. Dari sisi akademis membangun metode baru untuk menyimpan dan mengelola pada DBMS yang meliputi data supplier, data spare parts, dan data kriteria.

# BAB 2

# TINJAUAN PUSTAKA

## 2.1. Penelitian-penelitian Sebelumnya

Dalam kerangka manajemen operasi dan produksi, pemilihan supplier sangat mempengaruhi ketersediaan bahan baku (Choudhary and Shankar, 2014; Iacob et al., 2014; Mazdeh et al., 2015; Mohammaditabar et al., n.d.; Shi et al., 2014). Penelitian tentang pemilihan supplier yang tepat telah banyak dilakukan. Pemilihan supplier melibatkan multikriteria yang sangat rumit (Scott et al., 2015a) oleh sebab itu perlu direkam terlebih dahulu seluruh data yang ada dalam sebuah database supplier sesuai persyaratan yang diperlukan oleh perusahaan.

Sementara itu Kusiak tahun 2013 telah menuliskan bahwa pemilihan supplier didasarkan pada 1) rating kualitas performansi pelanggan 2) rating kualitas performansi pengiriman, 3) *total lead time* 4) harga penjualan terakhir 5) dukungan rekayasa/desain kemampuan layanan. (Kusiak, 2000a)

Sistem Pendukung Keputusan sudah digunakan oleh dunia bisnis selama bertahun tahun dalam kaitannya untuk pengambilan keputusan strategis perusahaan. Sistem Pendukung Keputusan mampu memberikan bantuan bagi pengambil keputusan untuk memberikan alternatif pemecahan permasalahan yang tidak terstruktur dan semi terstruktur (Bokovec et al., 2015; Chiang et al., 2016; Dweiri et al., n.d.; Horváth & Harazin, 2016; Saha et al., 2016; Scott et al., 2015b), yang dalam penelitian disertasi ini akan diaplikasikan dalam memilih supplier yang tepat. Sistem Pendukung Keputusan bisa “diisi” dengan algoritma Kecerdasan Buatan untuk meningkatkan kecanggihan sistem itu sendiri. Kecerdasan buatan adalah sebuah studi tentang penyelesaian masalah (An et al., 2011).

Pemilihan supplier adalah keputusan strategis dalam rantai pasokan yang meningkatkan keunggulan kompetitif. Setiap industri manufaktur perlu memiliki pilihan supplier standar yang yang sesuai dengan kebutuhan perusahaan. Dalam kaitannya dengan pemilihan supplier tersebut, banyak penelitian yang telah dilakukan diantaranya yaitu : Sistem Pendukung Keputusan untuk pemilihan supplier dengan *multi stakeholder* dan *multi-criteria environment* (Scott et al., 2015a), Model untuk mengkuantifikasi strategi pemilihan supplier pada rantai pasok farmasi (Enyinda et al., 2010).

*Supply chain management* merupakan sistem dalam proses bisnis yang digunakan untuk mengatur sebuah rencana yang matang mulai dari bahan baku diperoleh hingga barang jadi yang dihasilkan sampai pada konsumen terakhir. (Koster and Delfmann, 2005).

*Supplier* merupakan salah satu bagian *supply chain* yang sangat penting dan berpengaruh terhadap kelangsungan hidup suatu proses produksi. Pemilihan *supplier* yang tidak tepat dapat mengganggu kegiatan operational perusahaan, sedangkan pemilihan *supplier* yang tepat akan meminimalkan biaya pembelian, meningkatkan daya saing pasar dan kepuasan pengguna akhir.

Komponen-komponen utama dalam soft computing seperti sistem fuzzy, *neural network, probabilistic reasoning, dan evolutionary algorithm* memiliki keunggulan dalam penyelesaian masalah yang mengandung ketidakpastian, ketidaktepatan, dan kebenaran parsial. Komponen-komponen tersebut bukan merupakan pesaing satu dengan yang lain karena masing-masing mempunyai kelebihan dan kekurangan masing-masing. Bahkan komponen tersebut justru saling melengkapi. Integrasi dalam soft computing sering disebut dengan system hybrid. Integrasi ini bisa diaplikasikan dalam pengambilan keputusan dan optimalisasi.

Seluruh metode dalam penelitian yang telah ditulis tersebut saat ini belum diaplikasikan secara online melalui web untuk memilih pemasok. Sistem lelang elektronis yang disebut *e-procurement* yang saat ini mulai berkembang belum mengintegrasikan antara pengambilan keputusan pemilihan supplier menggunakan metode-metode pada *soft computing* dengan aplikasi online yang bisa diakses oleh publik selama 24 jam sehari. Oleh karena itu penelitian disertasi ini bertujuan membuat prototipe sistem pendukung keputusan pemilihan supplier yang diakses online.

## 2.2. Dasar Teori

### 2.2.1. Pemilihan Supplier Bahan Baku Industri Manufaktur

Pemilihan Supplier bahan baku pada industri manufaktur memiliki kriteria-kriteria teknis yang sudah umum, seperti yang sudah dikemukakan para ahli terdiri dari 10 faktor yang umum. (Kusiak, 2000a)

1. **Kemampuan manajemen**

a. **Sistem mutu;** yaitu merupakan sekumpulan prosedur terdokumentasi dan praktek-praktek standar untuk manajemen sistem yang bertujuan menjamin kesesuaian dari suatu proses dan produk (barang atau jasa) terhadap kebutuhan persyaratan tertentu yang ditentukan oleh pelanggan dan organisasi. Kualitas ini menitikberatkan pada data statistik, yaitu sertifikasi ISO 9000 dan kepuasan pelanggan

b. **Manajemen informasi** merupakan segala kegiatan yang berkaitan dengan pemerolehan informasi, penggunaan informasi seefektif mungkin, dan juga pembuangan terhadap informasi (yang tidak berguna) pada waktu yang tepat Definisi sistem informasi manajemen, istilah yang umum dikenal orang adalah sebuah sistem manusia/mesin yang terpadu *(integrated)* untuk menyajikan informasi guna mendukung fungsi operasi, manajemen, dan pengambilan keputusan dalam sebuah organisasi. Sistem ini menggunakan perangkat keras (hardware) dan perangkat lunak (software) komputer, prosedur pedoman, model manajemen dan keputusan, dan sebuah "database". Kecanggihan sistem informasi manajemen seharusnya merupakan sarana untuk mengembangkan respon cepat terhadap perusahaan secara berkelanjutan. (Mc Leod, Jr and P. Schell, n.d.).
c. **Manajemen kualitas total** : suatu pendekatan manajemen untuk suatu organisasi yang terpusat pada kualitas, berdasarkan partisipasi semua anggotanya dan bertujuan untuk kesuksesan jangka panjang melalui kepuasan pelanggan serta memberi keuntungan untuk semua anggota dalam organisasi serta masyarakat.(Hambali, 2021) Pendekatan TQM harusnya bertitik berat pada konsep peningkatan nilai tambah, memverifikasi eliminasi aktifitas tidak bernilai tambah, menguji proses kritis, dan memanfaatkan praktek terbaik

2. **Harga** : adalah suatu nilai tukar yang bisa disamakan dengan uang atau barang lain untuk manfaat yang diperoleh dari suatu barang atau jasa bagi seseorang atau kelompok pada waktu tertentu dan tempat tertentu. Istilah harga digunakan untuk memberikan nilai finansial pada suatu produk barang atau jasa. Biasanya penggunaan kata harga berupa digit nominal besaran angka terhadap nilai tukar mata uang yang menunjukkan tinggi rendahnya nilai suatu kualitas barang atau jasa. Dalam ilmu ekonomi harga dapat dikaitkan dengan nilai jual atau beli suatu produk barang atau jasa sekaligus sebagai variabel yang menentukan komparasi produk atau barang sejenis. Dalam memilih supplier harga harus bersaing dan memberikan diskon
3. **Kesadaran Lingkungan :** Supplier harus sadar bahwa pelanggan (perusahaan industri) mempunyai tanggung jawab terhadap lingkungan, yaitu mengungkapkan bahan rahasia, membuang kemasan dari pelanggan dan membuang produk usang dan / atau gagal
4. **Kinerja Pengiriman** : Kepastian produk yang tepat disampaikan pada waktu yang tepat dalam jumlah yang tepat.
5. **Service atau layanan.** Layanan adalah kegiatan atau serangkaian kegiatan yang berlangsung dalam interaksi dengan orang atau mesin fisik dan yang memberikan kepuasan

konsumen. Layanan supplier harus mengikuti petunjuk penanganan keluhan, kemudahan berbisnis dan respon cepat (quick respon)

6. **Fleksibilitas** adalah kemampuan untuk menyesuaikan volume dan waktu pengiriman.
7. **Kemampuan teknis.** Peralatan modern, kemampuan untuk mengikuti perkembangan.
8. **Inovatif**, Kemampuan seseorang dalam mendayagunakan kemampuan dan keahlian untuk menghasilkan karya baru yang belum ada sebelumnya serta bisa sangat berharga bagi setiap orang yang memilikinya. Inovasi yang dilakukan dalam rangka meningkatkan produk dan mengurangi biaya.
9. **Pendekatan Manajemen.** Hubungan yang baik dan komitmen terhadap manajemen perusahaan.
10. **Lokasi geografis.** Lokasi adalah letak atau tempat dimana fenomena geografi terjadi dalam hal ini di mana supplier berada.

### 2.2.2. Sistem Pendukung Keputusan

Sistem Pendukung Keputusan (DSS) atau Decision Support System (DSS) adalah suatu sistem yang dapat memberikan keterampilan pemecahan masalah dan keterampilan komunikasi untuk masalah dengan kondisi semi terstruktur dan tidak terstruktur. Sistem ini digunakan untuk membantu pengambilan keputusan dalam situasi semi-terstruktur dan tidak terstruktur, di mana tidak ada yang tahu persis bagaimana keputusan harus dibuat (Turban et al., 2005). DSS bertujuan untuk memberikan informasi, panduan, prakiraan, dan memandu pengguna yang terinformasi untuk membuat keputusan yang lebih baik. DSS adalah implementasi dari teori keputusan dan telah diperkenalkan ke bidang ilmiah seperti riset operasi dan manajemen. Bedanya hanya di masa lalu, untuk mencari solusi dari problema yang dihadapi, Anda melakukan perhitungan iteratif secara *manual (biasanya mencari nilai minimum, maksimum, atau maksimum yang optimal), sekarang komputer PC telah memberikan kemampuan untuk menyelesaikan masalah yang sama dalam waktu yang relatif singkat.

a. Database Management

Merupakan subsistem data yang terorganisasi dalam suatu basis data. Data yang merupakan suatu sistem pendukung keputusan dapat berasal dari luar maupun dalam lingkungan. Untuk keperluan SPK, diperlukan data yang relevan dengan permasalahan yang hendak dipecahkan melalui simulasi.

b. Model Base

Merupakan suatu model yang merepresentasikan permasalahan kedalam format kuantitatif (model matematika sebagai contohnya) sebagai dasar simulasi atau pengambilan keputusan, termasuk didalamnya tujuan dari permaslahan (objektif), komponen-komponen terkait, batasan-batasan yang ada (*constraints*), dan hal-hal terkait lainnya. Model Base memungkinkan pengambil keputusan menganalisa secara utuh dengan mengembangkan dan membandingkan solusi alternatif.

c. User Interface / Pengelolaan Dialog

Terkadang disebut sebagai subsistem dialog, merupakan penggabungan antara dua komponen sebelumnya yaitu Database Management dan Model Base yang disatukan dalam komponen ketiga (user interface), setelah sebelumnya dipresentasikan dalam bentuk model yang dimengerti computer. User Interface menampilkan keluaran sistem bagi pemakai dan menerima masukan dari pemakai kedalam Sistem Pendukung Keputusan.

Manfaat Sistem Pendukung Keputusan

SPK dapat memberikan berbagai manfaat dan keuntungan. Manfaat yang dapat diambil dari SPK adalah :

1. SPK memperluas kemampuan pengambil keputusan dalam memproses data / informasi bagi pemakainya.
2. SPK membantu pengambil keputusan untuk memecahkan masalah terutama barbagai masalah yang sangat kompleks dan tidak terstruktur.
3. SPK dapat menghasilkan solusi dengan lebih cepat serta hasilnya dapat diandalkan.

Walaupun suatu SPK mungkin saja tidak mampu memecahkan masalah yang dihadapi oleh pengambil keputusan, namun dia dapat menjadi stimulan bagi pengambil keputusan dalam memahami persoalannya, karena mampu menyajikan berbagai alternatif pemecahan.

### 2.2.3. *Bill of Material*

*Bill of Material* atau struktur produk (kadang-kadang disebut BOM atau daftar struktur produk) adalah daftar bahan baku, sub-rakitan, rakitan menengah, sub-komponen, bagian, dan jumlah masing-masing yang diperlukan untuk memproduksi produk akhir. BOM dapat digunakan untuk komunikasi antara mitra manufaktur atau terbatas pada pabrik tunggal. *Bill of Material* sering dikaitkan dengan pesanan produksi yang penerbitannya

dapat menghasilkan pemesanan untuk komponen-komponen dalam *Bill of Material* yang ada dalam stok dan permintaan untuk komponen-komponen yang tidak ada dalam persediaan.(Chung and Fischer, 1994)

Penelitian tentang penerapan *Bill of Material* telah banyak dilaksanakan oleh para peneliti diantaranya adalah CBOM *(collaboration Bill of Materials)* yang mengkolaborasi BOM (Ramankutty et al., 2003).

### 2.2.4. *Group Technology*

*Group Technology* atau GT adalah teknik produksi di mana bagian yang memiliki kesamaan dalam geometri, proses pembuatan dan / atau fungsi diproduksi di satu lokasi menggunakan sejumlah kecil mesin atau proses. *Group Technology* didasarkan pada prinsip umum bahwa banyak masalah yang sama dan dengan mengelompokkan masalah yang sama, satu solusi dapat ditemukan untuk satu set masalah, sehingga menghemat waktu dan usaha. ("*Group Technology*," 2019)

*Group Technology* adalah pendekatan di mana bagian-bagian yang serupa diidentifikasi dan dikelompokkan bersama untuk mengambil keuntungan dari kesamaan dalam desain dan produksi. Kesamaan di antara bagian memungkinkan mereka untuk diklasifikasikan. Daftar Penelitian dan Publikasi ilmiah tentang *Group Technology* tersaji pada Lampiran A Daftar Publikasi 2 *Group Technology*

#### 2.2.4.1. Pengertian *Group Technology*

*Group Technology* (GT) merupakan sebuah prinsip sederhana yang sebenarnya secara tidak sadar telah kita gunakan. Sebagai contoh kita menyimpan kemeja berbeda tempat dengan celana panjang atau dengan kaos kaki. Kita mengelompokkannya berdasarkan ciri-ciri khusus yang dimiliki atau kegunaan dari barang tersebut. Cara pengaturan pakaian seperti di atas merupakan aplikasi dari GT. Dengan pengelompokkan akan memudahkan kita pada waktu pengambilan atau *retrieval.*

GT dalam manufaktur juga demikian. Dengan mengelompokkan, sebenarnya kita memanfaatkan kesamaan antara proses produksi dan desain komponen. Kesamaan-kesamaan yang ada pada komponen-komponen tersebut disusun ke dalam kelompok-kelompok komponen. Prinsip ini juga dipakai dalam disiplin ilmu yang lain yaitu pengelompokkan tumbuhan dan hewan dalam Ilmu Biologi.

Dengan demikian GT adalah sebuah filosofi yang merepresentasikan kesamaan dengan tiga cara (Soegianto, 1998) yaitu :

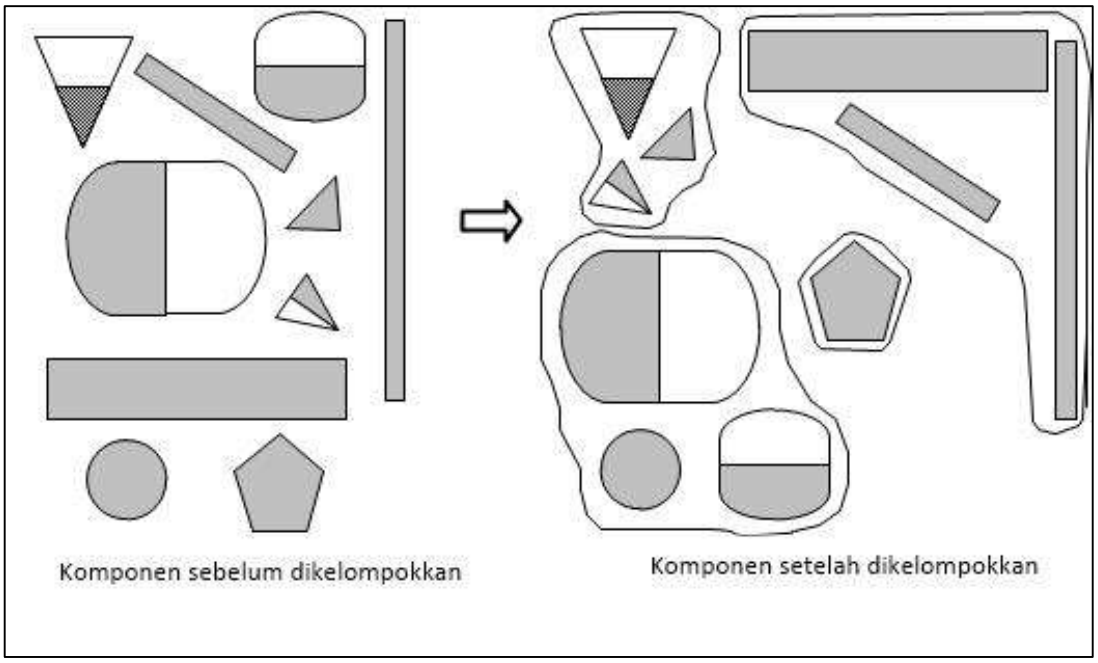
1. Mengumpulkan aktifitas yang sama, sehingga menghindari waktu yang terbuang secara sia-sia dalam berpindah dari satu aktivitas ke aktivitas lain yang tidak berhubungan.
2. Membuat standarisasi aktivitas-aktivitas atau item-item yang berkorelasi erat, sehingga hanya memfokuskan pada perbedaan-perbedaan khusus dan menghindari duplikasi yang tidak perlu.
3. Dengan menyimpan informasi yang berhubungan dengan hal-hal yang berulang akan mengurangi waktu pencarian informasi karena kita hanya memanggilnya kembali

2.2.4.2. Metode Pembentukan Kelompok Komponen

GT terlebih dahulu mengelompokkan komponen ke dalam kelompok (famili) menurut atributnya (atribut). Biasanya, atribut ini didasarkan pada geometri dan/atau proses produksi. Pengelompokan menggunakan bentuk geometris biasanya didasarkan pada ukuran dan bentuk komponen, sedangkan pengelompokan menggunakan proses produksi biasanya didasarkan pada jenis, urutan, dan jumlah komponen kerja. Kesuksesan dalam pengelompokkan merupakan kunci utama untuk pengaplikasian filosofi GT. Oleh karena itu hambatan dalam proses pengelompokkan suatu komponen menjadi masalah utama. Untuk mengatasi masalah ini sedikitnya ada tiga metode yang dapat digunakan dalam membentuk kelompok-kelompok komponen :

1. *Visual inspection*
2. *Production Flow Analysis* (PFA)
3. *Classification and coding*

Metode *Visual Inspection* adalah metode yang paling sederhana dan termurah. Pengelompokan komponen (keluarga) hanya dapat dilakukan dengan melihat komponen fisik atau foto dan menyusunnya dalam satu kelompok. Metode ini memiliki akurasi paling rendah di antara ketiga metode di atas dan sangat tidak konsisten. Jika ada lebih dari satu orang yang mengelompokkan komponen, jarang sekali hasil pengelompokan komponen dalam satu kelompok sama.




Gambar 2. 1 Contoh Pengelompokan dengan Visual Inspection

Analisis proses produksi dikembangkan oleh J.L. Burbich. PFA adalah metode untuk membangun struktur kelompok komponen dengan menganalisis urutan kerja komponen yang akan diproduksi. Komponen dengan urutan operasi dan mesin perutean yang sama dikelompokkan bersama. Kekurangan metode ini yaitu menerima semua keputusan yang terkandung dalam tabel routing, terlepas dari keputusan ini secara logis serta konsisten ataukah tidak.

2.2.4.3. Klasifikasi dan Kodefikasi

Klasifikasi komponen adalah proses pengelompokan atau pengelompokan komponen menurut prinsip-prinsip tertentu yang biasa disebut famili. Pengkodean komponen adalah proses pemberian simbol ke komponen. Simbol ini harus memiliki makna yang mencerminkan sifat-sifat komponen. Pekerjaan ini tidak sulit, tetapi klasifikasi dan kompilasi adalah masalah yang kompleks.

Beberapa sistem kompilasi klasifikasi telah dikembangkan, dan banyak orang mencoba untuk memperbaikinya. Tidak ada satu sistem pun yang dapat digunakan secara komprehensif dalam berbagai situasi karena tergantung pada masing-masing use case, misalnya keadaan pabrik berbeda dengan keadaan pabrik. negara bagian lain. pabrik. Oleh karena itu, kita harus memilih sistem klasifikasi dan kompilasi yang paling sesuai dengan situasi kita sendiri.

Saat melakukan pengkodean, komponen diklasifikasikan menurut karakteristik khusus berikut:

1. Bentuk geometri dan kompleksitas

2. Dimensi
3. Jenis Bahan
4. Bentuk bahan baku
5. Ketelitian dalam proses *finishing.*

Pengklasifikasian dan pengkodean ini untuk memudahkan pengambilan informasi yang sudah ada dalam file komputer. Hal ini juga memudahkan kita untuk menambahkan informasi tentang proses pembuatan ke file komputer. Secara umum, sistem kompilasi klasifikasi dapat dibagi menjadi tiga kategori:

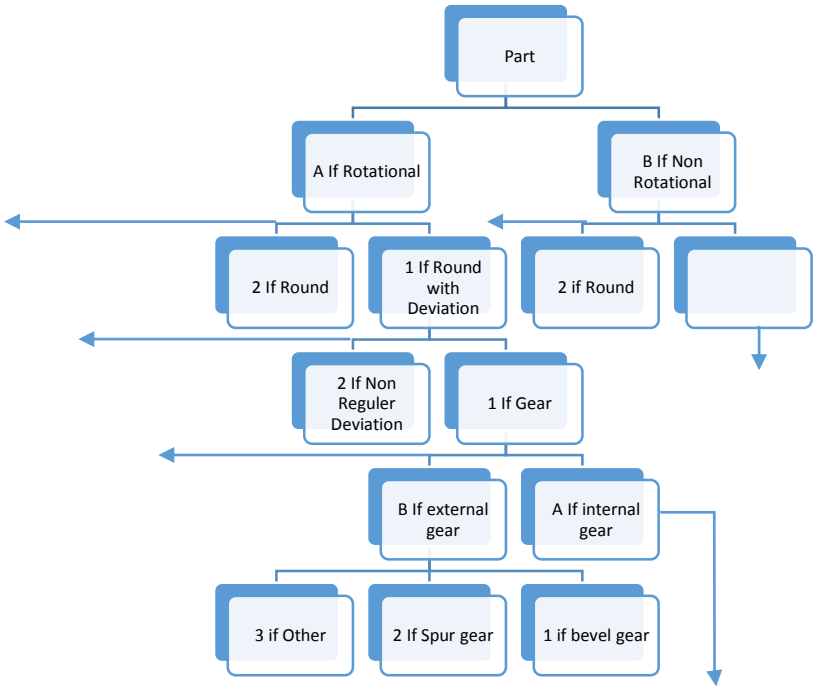
1. *Hierarchical Code* atau *monocode*
2. *Attribute Code* atau *polycode*
3. *Hybrid Code* atau *mixed*

2.2.4.4. *Hierarchical Code* atau *Monocode*

Di dalam suatu *hierarchical code*, tiap nomor kode ditentukan oleh karakter yang mendahuluinya. Dengan kata lain setiap karakter akan memperjelas informasi yang terkandung pada karakter sebelumnya. Sistem ini dapat digambarkan menggunakan struktur pohon seperti yang tampak pada gambar 2.5. Gambar tersebur merupakan contoh struktur pohon *hierarchical code*. Dari contoh tersebut kita dapat mengetahui bahwa kode untuk roda gigi lurus adalah A11B2.

*Hierarchical code* menyediakan sejumlah informasi yang banyak dengan menggunakan sedikit kararter. Keuntungan ini menjadi lebih jelas ketika kita menentukan *atribute* dalam sistem kodefikasi. Menentukan makna dari setiap digit dalam sistem *hierarchical* dapat menjadi suatu kendala, meskipun penerapan sistem ini relatif mudah.

Kita mulai dari "batang pohon" pada struktur *hierarchical* dengan menjawab pertanyaan-pertanyaan dari item-item yang menunjukkan pemberian kode pada komponen. Begitulah seterusnya sampai pada "ranting pohon" yang paling ujung, bagian akhir. Dengan merekam setiap pilihan yang kita jawab, kita dapat membentuk kode komponen. Dengan demikian arti setiap digit dalam kode telah terbentuk secara lengkap karena setiap digit harus mewakili suatu arti tertentu.




Gambar 2. 2 Hierarchical code untuk roda gigi lurus

Dalam departemen disain seringkali menggunakan sistem ini untuk komponen yang dipanggil karena type sistem ini sangat efektif untuk menentukan bentuk, bahan dan informasi ukuran. Di sisi lain, departemen manufaktur mempunyai kebutuhan berbeda yang sering didasarkan syarat-syarat dalam proses produksi. Hal ini menyulitkan untuk memanggil (*retrieve*) dan menganalisa proses yang sesuai ketika sistem ini digunakan dalam dua departemen.

### 2.2.4.5. *Attribute Code* atau *Polycode*

*Attribute Code* sering disebut juga dengan *polycode, chain code, discrete code* atau *fixed-digit code*. Dalam sistem *Attribute Code* setiap karakter tidak tergantung dengan karakter yang lain. Karena itu dapat diberikan posisi yang khusus untuk setiap atribut komponen. Gambar 2.6 memberikan contoh *attribute code* misalnya untuk sebuah roda gigi lurus mempunyai kode 22213. Kita dapat melihat bahwa "3" berada pada posisi 5 yang berarti komponen ini merupakan roda gigi lurus tidak peduli dengan karakter pada digit yang lain.

| Digit | Class of feature | Posible value of digit | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| 1 | External shape | Cylindrical without deviations | Cylindrical with deviations | Boxlike | . . . |

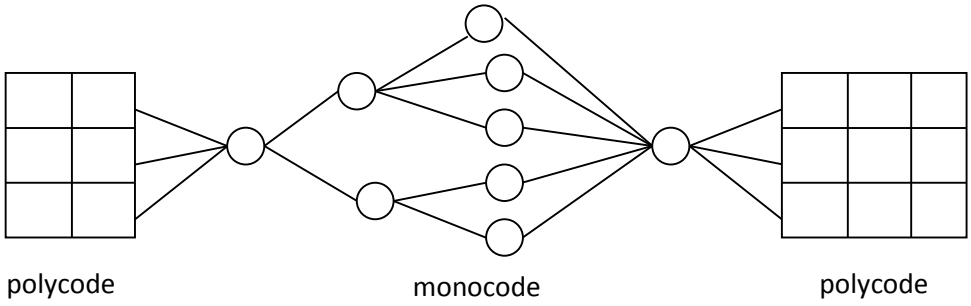
| | | | | | |
|---|---|---|---|---|---|
| 2 | Internal shape | None | Center hole | Brind center hole | . . . |
| 3 | Number of holes | 0 | 1 – 2 | 3 – 5 | . . . |
| 4 | Type of holes | Axial | Cross | Axial cross | . . . |
| 5 | Gear teeth | Worm | Internar Spur | External spur | . . . |
| . . . | . . . | . . . | . . . | . . . | . . . |

Gambar 2. 3. Contoh Attribute Code

Jika kita menggunakan *attribute code* untuk kode beberapa komponen dan ingin mencari atau memanggil semua jenis roda gigi lurus , maka kita hanya butuh mengidentifikasi dengan "3" pada posisi 5 dari kode yang dimaksud.. Pekerjaan ini menjadi mudah jika menggunakan komputer. Dengan demikian sistem *attribute code* sangat cocok diterapkan dalam departemen manufaktur karena sistem ini memudahkan untuk mengidentifikasi komponen berdasarkan kesamaan *features* yang menentukan kesamaan proses. Kekurangan dari *attribute code* adalah posisi dalam kode tidak boleh sama untuk komponen yang berbeda, akibatnya kode dapat menjadi sangat panjang.

2.2.4.6. *Hybrid Code* atau *Mixed*

Dalam penggunaan di dalam perusahaan sistem kodefikasi ini paling banyak dipakai karena sistem ini mengambil setiap kelebihan dari sistem kodefikasi yang lain. Sebagai contoh, digit pertama digunakan untuk menentukan jenis komponen, misalnya roda gigi. Lima posisi berikutnya digunakan untuk menggambarkan atribut dari roda gigi. Digit berikutnya, posisi 7,




Gambar 2. 4. Contoh Model Hybrid

digunakan untuk menentukan atribut yang lain, misalnya jenis material, diikuti dengan beberapa digit lagi yang menggambarkan atribut komponen lainnnya.

Dengan cara ini *hybrid code* dapat membuat kode yang relatif lebih padat informasi jika dibandingkan dengan *attribute code*. Selain itu *hybrid code* akan membantu untuk mengidentifikasi suatu komponen dengan karakteristik yang khusus.

### 2.2.5. *Genetic Algorythms*

Pada bukunya, Denny Hermawanto menuliskan bahwa Algoritma genetika yang dikembangkan oleh Goldberg adalah algoritma komputasi yang terinspirasi oleh teori evolusi Darwin (Hermawanto, 2021), yang menyatakan bahwa kelangsungan hidup makhluk hidup dipengaruhi oleh aturan "yang kuat menang". Darwin juga mengemukakan bahwa kelangsungan hidup organisme dapat dipertahankan melalui proses reproduksi, persilangan, dan mutasi. Kemudian terapkan konsep dalam teori evolusi Darwin ke algoritma komputasi untuk menemukan solusi masalah dengan cara yang lebih "alami". Solusi yang dihasilkan dalam algoritma genetika disebut kromosom, dan kumpulan kromosom disebut populasi. Kromosom dibentuk oleh komponen yang disebut gen, yang nilainya dapat berupa angka, biner, simbol, atau karakter, tergantung pada masalah yang akan dipecahkan. Kromosom ini akan terus berkembang dan disebut generasi. Dalam setiap generasi kromosom, tingkat keberhasilan nilai solusi dari masalah yang akan dipecahkan (fungsi_tujuan) dievaluasi menggunakan metrik yang disebut fitness. Untuk memilih kromosom yang dicadangkan untuk generasi berikutnya, proses yang disebut seleksi dilakukan. Proses seleksi kromosom menggunakan konsep aturan evolusi Darwin yang telah disebutkan sebelumnya, yaitu kromosom dengan nilai fitness tinggi memiliki peluang lebih besar untuk terpilih kembali pada generasi berikutnya. Kromosom baru, yang disebut keturunan, dibentuk oleh persilangan antara satu generasi kromosom, yang disebut proses crossover. Jumlah kromosom dalam populasi crossover ditentukan oleh parameter yang disebut crossover_rate. Mekanisme di mana faktor alam yang disebut mutasi mengubah komposisi unsur-unsur yang membentuk organisme dimanifestasikan sebagai proses perubahan nilai satu atau lebih gen dalam kromosom dengan nilai acak. Jumlah gen yang bermutasi dalam populasi ditentukan oleh parameter yang disebut mutasi_rate. Setelah beberapa generasi, kromosom yang nilai gennya konvergen ke nilai tertentu akan dihasilkan.Ini adalah solusi terbaik yang dihasilkan oleh algoritma genetika untuk masalah yang akan dipecahkan.

Algoritma Genetika sebagai cabang dari Algoritma Evolusi merupakan metode adaptive yang biasa digunakan untuk memecahkan suatu pencarian nilai dalam sebuah masalah optimasi. (Arifin, 2007) Algoritma ini didasarkan pada proses genetik yang ada dalam makhluk hidup; yaitu perkembangan generasi dalam sebuah populasi yang alami, secara lambat laun mengikuti prinsip seleksi alam atau "siapa yang kuat, dia yang bertahan (survive)". Dengan meniru teori evolusi ini, Algoritma Genetika dapat digunakan untuk mencari solusi permasalahan-permasalahan dalam dunia nyata.(Purnomo et al., 2019)

2.2.6. *Fuzzy Analytical Hierarchy Proses*

F-AHP merupakan kombinasi metode AHP dengan pendekatan konsep fuzzy. F-AHP memperbaiki kelemahan pada AHP, yaitu permasalahan mengenai kriteria yang memiliki sifat subjektif lebih banyak. Ketidakpastian bilangan nilai kuantitatif dipresentasikan menggunakan urutan skala (Prasetyo dkk., t.t.). Langkah untuk penyelesaian Fuzzy Analytical Hierarcy Process (F-AHP) menurut Chang adalah sebagai berikut (Nurcahyani dkk., 2015) :

2.2.6.1. Menentukan Nilai Sintesis Fuzzy

Menentukan nilai sintesis fuzzy *(Si)* prioritas dengan rumu

$$Si = \sum_{j=1}^{m} M_{gi}^{j} \text{ X } \frac{1}{[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}]} \qquad (1)$$

Dimana:

$S_i$ : nilai sintesis *fuzzy*

M : jumlah kriteria

$i$ : baris

$j$ : kolom

$g$ : parameter $(l, m, u)$

Untuk memperoleh $\sum_{j=1}^{m} M_{gi}^{j}$, yaitu dengan menggunakan penjumlahan *fuzzy* dari nilai $m$ pada sebuah matrik seperti pada rumus 2

$$\sum_{j=1}^{m} M_{gi}^{j} = (\sum_{j=1}^{m} l_j , \sum_{j=1}^{m} m_j , \sum_{j=1}^{m} u_j \qquad (2)$$

Sedangkan untuk memperoleh $\frac{1}{[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}]}$, dilakukan operasi penjumlahan *fuzzy* dari $M_{gi}^{j}(j = 1,2, \dots, m)$ dalam matriks keputusan $(n \times m)$, sebagai berikut:

$$\frac{1}{\sum_{j=1}^{n} \sum_{j=1}^{m} M_{ij}} = \frac{1}{\sum_{j=1}^{n} u_i . \sum_{i=1}^{n} m_i . \sum_{i=1}^{n} l_i} \qquad (3)$$

2.2.6.2. Menentukan Nilai Vektor *(V)* dan Nilai Ordinat *(d')*

Jika hasil yang diperoleh pada setiap matrik *fuzzy* $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ dapat didefinisikan sebagai nilai vektor.

$V(M_2 \geq M_1) = \sup[\min(\mu M_1(x)), \min(\mu M_2(y))]$ (4)

$$V(M_2 \geq M_1) = \begin{cases} 1, & \text{if } m_2 \geq m_1, \\ 0, & \text{if } l_1 \geq u_2, \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & \text{lainnya} \end{cases} \quad (5)$$

Jika hasil nilai fuzzy lebih besar dari k, $Mi$ (i=1,2,..,k) maka nilai vektor dapat didefenisikan sebagai berikut:

$V(M \geq M_1, M_2, \ldots\ldots M_k) = V(M \geq M_1)\ dan$

$V(M \geq M_2)\ dan\ V(M \geq M_k) = \min V(M \geq M_i)$(6)

dengan:

V : nilai vektor

M : Matriks nilai sintesis fuzzy

i : 1,2,3,…k

Sehingga diperoleh nilai ordinat (d')

$d'(A_i) = \min V(S_i \geq S_k)$ (7)

dengan:

$S_i$ : nilai sintesis *fuzzy* satu

$S_k$ : nilai sintesis *fuzzy yang lainnya*

Untuk k= 1,2,...n; k ≠ i, maka diperoleh nilai bobot vektor

$$W' = (d'(A_1),\ d'(A_2), \ldots d'(A_n))^T \quad (8)$$

dengan $A_i$ $(i = 1,2, \ldots, n$ adalah n elemen keputusan dan $d'(A_i)$ adalah nilai yang menggambarkan pilihan relatif masing-masing atribut keputusan.

2.2.6.3. Normalisasi nilai bobot vektor nilai fuzzy *(W)*

Normalisasi nilai bobot vektor diperoleh dengan persamaan:

$$d(A_n) = \frac{d'(A_n)}{\sum_{j=1}^{n} d'(A_n)} \quad (9)$$

$$W = \left(d(A_1), \quad d(A_2), \ldots d(A_n)\right)^T \quad (10)$$

dimana W adalah bilangan non fuzzy.

# BAB 3

# KERANGKA KONSEP

## 3.1. Analisa Masalah

Sebagian besar industri manufaktur di Indonesia yang berskala menengah keatas masih bersifat industri perakitan. Dalam industri perakitan mesin yang komplek, biasanya digunakan alat untuk menggambarkan hirarki produk yang disebut *BoM* atau *Bill of Material* . *BoM* adalah produk akhir yang terdiri dari daftar item, bahan, atau material yang dibutuhkan untuk merakit, mencampur atau memproduksi produk akhir. Secara spesifik struktur *Bill of Material* tidak saja berisi komposisi komponen, tetapi juga memuat langkah penyelesaian produk jadi

*BoM* terdiri dari berbagai bentuk dan dapat digunakan untuk berbagai keperluan. *BoM* dibuat sebagai bagian dari proses desain dan digunakan oleh *manufacturing engineer* untuk menentukan item yang harus dibeli atau diproduksi

Mengingat Indonesia adalah negara agraris, maka dalam kerangka konsep ini akan ditinjau industri perakitan traktor tangan. Gambar 3.1 adalah sebuah traktor tangan.

Traktor roda dua atau traktor tangan *(power tiller/hand tractor)* adalah mesin pertanian yang dapat dipergunakan untuk mengolah tanah dan lain-lain pekerjaan pertanian dengan alat pengolah tanahnya digandengkan/dipasang di bagian belakang mesin. Mesin ini mempunyai efesiensi tinggi, karena pembalikan dan pemotongan tanah dapat dikerjakan dalam waktu yang bersamaan. Traktor roda dua merupakan mesin serbaguna karena dapat juga berfungsi sebagai tenaga penggerak untuk alat-alat lain seperti pompa air, alat prosesing, gandengan (trailer). Traktor tangan atau *hand tractor* adalah produk rakitan, yang memerlukan bagian-bagian untuk merakitnya. (Niagakita.id, 2019). Gambar traktor tangan diperlihatkan pada gambar 3.1. berikut ini.

Gambar 3.1. Traktor Tangan

Sumber : (Traktor, 2019)

Permasalahan umum industri perakitan adalah sebagai berikut:

1) Permasalahan data dan informasi suku cadang. Pekerjaan perakitan traktor tangan pada industri manufaktur adalah pekerjaan yang rumit, karena membutuhkan suku cadang yang bermacam-macam jenis dengan spesifikasi yang beragam dimana bisa terdiri dari puluhan bahkan ratusan jenis.
2) Permasalahan data dan informasi supplier. Disisi lain, untuk memenuhi ketersediaan suku cadang tersebut memerlukan adanya supplier yang handal sehingga bisa memenuhi kebutuhan ketersediaan bahan suku cadang tersebut. Memilih supplier yang tepat dan sesuai dengan kriteria perusahaan tidaklah mudah. Seperti yang telah disebutkan pada bab sebelumnya, berdasarkan literatur yang diperoleh ada 10 kriteria yang digunakan untuk memilih supplier yang baik yaitu : Kemampuan manajemen, Harga, Kesadaran lingkungan, Kinerja pengiriman, Service (Layanan), Fleksibilitas, Kemampuan teknis, Inovatif, Pendekatan manajemen, Lokasi geografis (Wang and Kusiak, 2000), (Kusiak, 2000b), (Hanne and Dornberger, 2016). Pada umumnya data supplier yang meliputi hal kriteria tersebut sudah dimiliki perusahaan, namun belum dikelola dengan baik.

3) Permasalahan optimasi pemilihan supplier. Memilih supplier suku cadang adalah hal yang tidak mudah, karena jumlah suku cadang yang banyak, jumlah supplier yang banyak dan kriteria pemilihan supplier yang baik. Untuk membantu hal ini digunakan metode optimasi pemilihan supplier. Berbagai metode telah dibahas di bab 2, misalnya algoritma genetika dan *multicriteria decision making*. Pada umumnya pemilihan supplier berbasis optimasi dikemas dalam sebuah aplikasi yang disebut Sistem Pendukung Keputusan atau *Decision Support System (DSS).* DSS adalah Suatu sistem yang dapat memberikan keterampilan pemecahan masalah dan keterampilan komunikasi untuk masalah dengan kondisi semi terstruktur dan tidak terstruktur. Sistem digunakan untuk membantu pengambilan keputusan dalam situasi semi terstruktur dan tidak terstruktur, dalam hal ini tidak ada yang tahu persis bagaimana keputusan harus dibuat.(Turban et al., 2005).

Oleh karena ketiga hal itulah menurut Mc Leod dan P. Schell diperlukan adanya pengolahan database yang tepat (McLeod and Schell, 2007) untuk mencatat kebutuhan macam-macam suku cadang dengan suppliernya.

## 3.2. Kerangka Teoritis

Untuk mengatasi masalah di atas, perlu dilakukan langkah deduktif, yaitu mempelajari teori-teori umum untuk membentuk teori atau metode yang baru dan lebih baik. Teori-teori umum yang dipergunakan untuk menyusun metode ilmiah dalam rangka menyelesaikan permasalahan pada penelitian ini adalah, penyusunan *Bill of Material*, Struktur Produk, design database system, optimalisasi bobot pada kriteria menggunakan algoritma genetika, dan penyeleksian supplier menggunakan metode multicriteria decision making.

Secara teoiritis penyeleksian tersebut diuraikan dibawah ini.

### 3.2.1 *Bill of Material*

*Bill of Material (BOM)* adalah definisi produk akhir, yang berisi daftar item, bahan, atau bahan yang diperlukan untuk merakit, mencampur, atau membuat produk akhir. Secara khusus, struktur *Bill of Material* tidak hanya mencakup komponen, tetapi juga langkah-langkah untuk menyelesaikan produk jadi BOM memiliki banyak bentuk dan dapat digunakan untuk berbagai keperluan. BOM adalah bagian dari proses desain, dan insinyur manufaktur dapat menggunakannya untuk menentukan bahan yang akan dibeli atau diproduksi. Produksi dan rencana pengendalian persediaan menggunakan BOM yang terkait dengan rencana produksi induk untuk menentukan pelepasan bahan yang dibeli atau diproduksi.

Bila ditinjau dari komponen-komponen penyusun produknya, BOM dibedakan menjadi dua macam: Single Level *Bill of Material* dan Multilevel *Bill of Material*.

a. **Single Level *Bill of Material***

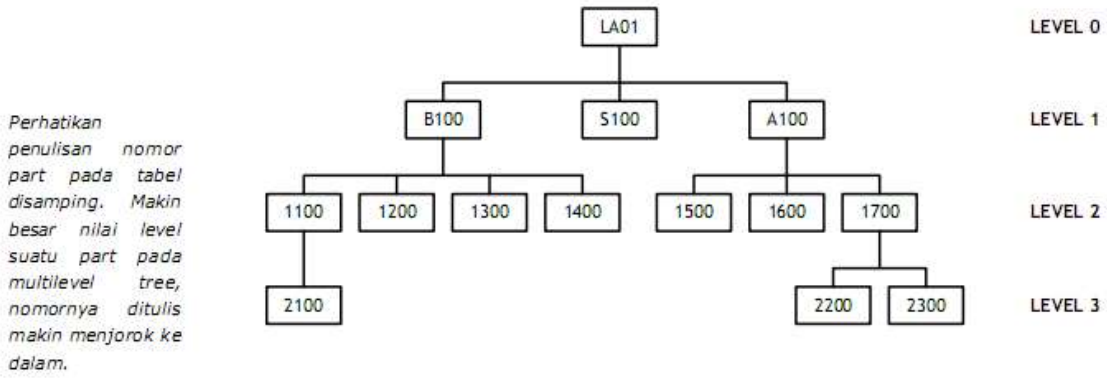
Format sederhana dari BOM disebut sebagai Single Level *Bill of Material*. Contoh Single Level BOM dapat dilihat pada Tabel 1.

Tabel 3. 1 Contoh Single Level *Bill of Material*

| ABC Lamp Company<br>Bill of Material, Part LA01 | | | | |
|---|---|---|---|---|
| Part Number | Description | Quantity for Each Assembly | Unit of Measure | Decision |
| B100 | Base assembly | 1 | Each | Make |
| S100 | 14" Black shade | 1 | Each | Make |
| A100 | Socket assembly | 1 | Each | Buy |

b. **Multilevel *Bill of Material***

Single Level Bill of Material Tagihan bahan satu tingkat tidak cukup untuk menggambarkan produk dengan sub-komponen. Untuk produk dengan komponen, gunakan Tredan multi-layer *Bill of Material*. Pohon multi-level adalah "pohon" dengan beberapa level yang menjelaskan struktur produk. Tingkat produk akhir adalah 0 (nol), dan jumlah tingkat meningkat pada tingkat berikut. Gambar 4 menunjukkan contoh pohon multi-level, dan Tabel 4 menunjukkan contoh *Bill of Material* multi-level.




Gambar 3. 2. Contoh Struktur Multivelel Tree

Pada Multilevel *Bill of Material*, penulisan setiap level ditandai dengan format penulisan Part.

Tabel 3. 2 Contoh Multilevel *Bill of Material*

| ABC Lamp Company<br>Bill of Material, Part LA01 | | | | |
|---|---|---|---|---|
| Part Number | Description | Quantity for Each Assembly | Unit of Measure | Decision |
| B100 | Base assembly | 1 | Each | Make |
| 1100 | Finished shaft | 1 | Each | Make |
| 2100 | 3/8" Steel tubing | 26 | Inches | Buy |
| 1200 | 7"-Diameter steel plate | 1 | Each | Make |
| 1300 | Hub | 1 | Each | Make |
| 1400 | ¼-20 Screws | 4 | Each | Buy |
| S100 | 14" Black shade | 1 | Each | Make |
| A100 | Socket assembly | 1 | Each | Make |
| 1500 | Steel holder | 1 | Each | Make |
| 1600 | One-way socket | 1 | Each | Buy |
| 1700 | Wiring assembly | 1 | Each | Make |
| 2200 | 16-Gauge lamp cord | 12 | Feet | Make |
| 2300 | Standard plug terminal | 1 | Each | Buy |

### 3.2.2 *Group Technology*

#### 3.2.2.1 Sejarah *Group Technology*

Penerapan *Group Technology* (GT) mulai muncul pada awal abad 20. Hal tersebut diusulkan oleh Frederick Taylor pada tahun 1919 untuk meningkatkan produktivitas. Awalnya, GT dirancang untuk mengurangi waktu setup pada sebuah mesin. Kemudian, konsep tersebut berkembang menjadi sekelompok bagian yang memiliki beberapa kesamaan, kemudian menggunakan sekelompok mesin atau unit untuk mengolahnya.(Shah and Bhatnagar, 1989)

#### 3.2.2.2 Pengertian *Group Technology*

Teknologi pengelompokan adalah filosofi manufaktur, yang dapat mengidentifikasi kesamaan komponen, dan menggunakan kesamaan dalam desain dan manufaktur untuk mengelompokkannya. Konsep dasar dari teknologi grup adalah untuk menyederhanakan dan membakukan proses (Kamrani and Parsaei, 1993)

3.2.2.3 Metode Klasifikasi GT

3.2.2.4 Klasifikasi Berdasar Pada Bentuk Part

Menurut contoh berikut, dalam klasifikasi berbasis bentuk, bagian dikelompokkan berdasarkan kemiripan dengan bentuk geometris.

3.2.2.5 Klasifikasi Berdasar Pada Proses

Dalam klasifikasi berbasis proses, menurut contoh berikut, bagian-bagian dikelompokkan menurut kesamaan proses yang dialami:

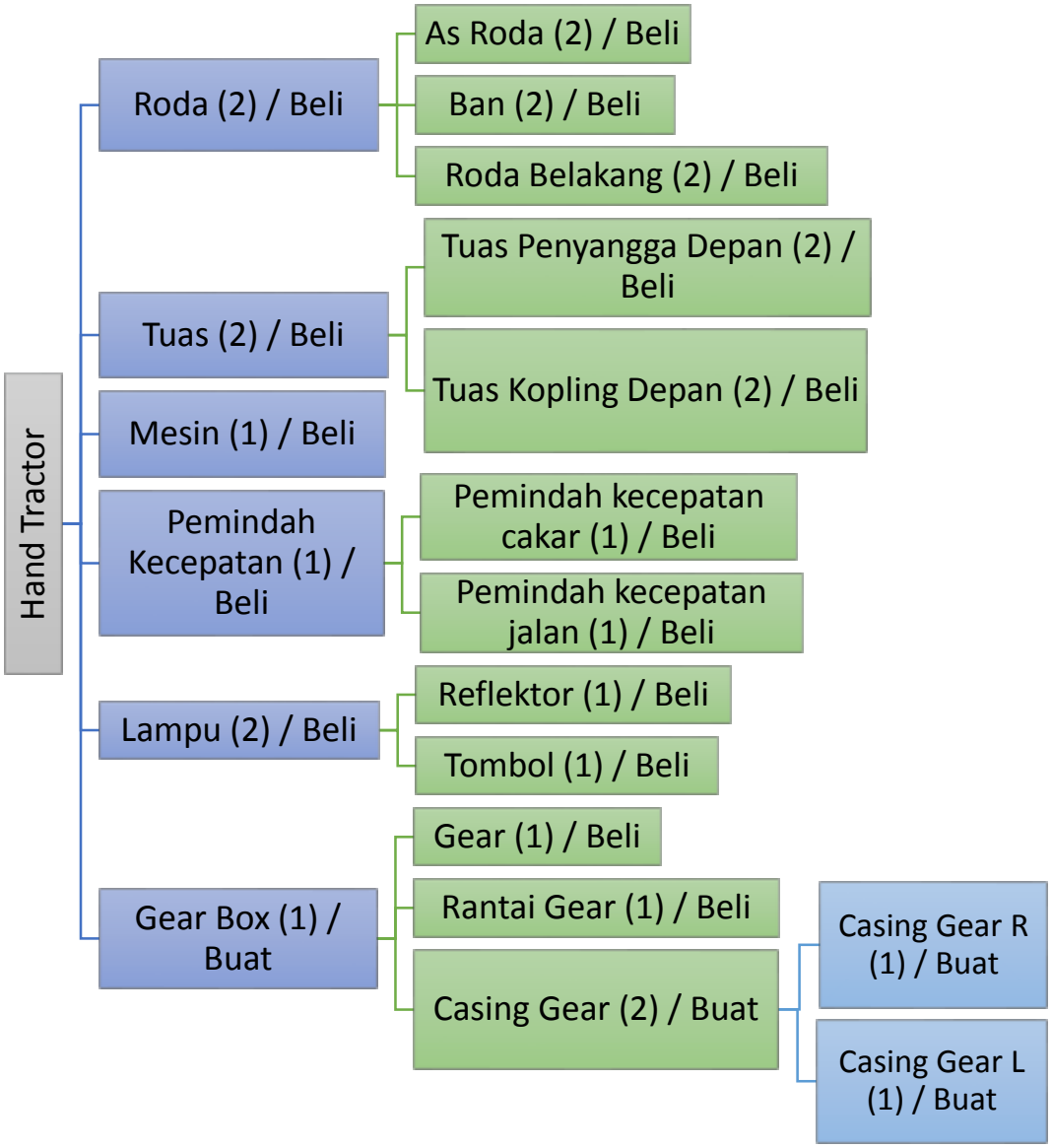
3.2.2.6 Klasifikasi Dengan Pengkodean

Menurut apa yang dikatakan Shah dan Bhatnagar pada tahun 1989, sistem klasifikasi dan pengkodean didasarkan pada atribut yang ada di bagian-bagian dan kemudian kode. Kode-kode ini berisi informasi yang terdapat di bagian yang relevan. Kode dapat berupa huruf, angka atau kombinasi keduanya. Namun, kode bagian berbeda dari nomor bagian yang biasanya ditemukan di bagian tersebut.

Proses pengkodean dimulai dengan klasifikasi bagian, yang merupakan atribut utama dari bagian yang dimaksud. Contohnya adalah proses pengkodean rak buku. Pengkodean rak buku dapat dilakukan dengan memilah jumlah rak, ukuran rak dan warna rak. Dapat juga diberi kode dengan cara mengelompokkan cara memotong kayu dari bahan rak, cara merakit rak, dan cara mewarnai rak. Anda dapat menggunakan sistem pakar (expert system) dengan fungsi terkomputerisasi interaktif untuk menyelesaikan proses pengkodean. (Shah and Bhatnagar, 1989)

3.2.3 Design System Database

Salah satu syarat database yang baik dan handal harus mempunyai *Primary code* yang bisa diakses untuk pengolahan data sehingga data yang dikelola menjadi sangat mudahUntuk membuat desain database yang handal digunakan metode *Bill of Material* untuk menyusun struktur produk barang yang akan dirakit, kemudian menentukan code part number sebagai *primary key code database* (Data, 2021)




Gambar 3. 3 Struktur Produk Traktor Tangan

Berdasarkan struktur produk, maka disusun tabel 3.1. *Bill of Material* sebagai berikut :

Tabel 3. 3. *Bill of Material*

| No | Deksripsi | Qty | Satuan | Order | bahan | proses |
|---|---|---|---|---|---|---|
| 1 | Roda | 2 | pcs | Beli | | |
| 2 | As Roda | 1 | pcs | Beli | | |
| 3 | Ban | 2 | pcs | Beli | karet | dicetak |
| 4 | Roda belakang | 2 | pcs | Beli | | |
| 5 | Tuas | 1 | pcs | Beli | | |
| 6 | Tuas Penyangga | 1 | pcs | Beli | | |
| 7 | Tuas Kopling Utama | 1 | pcs | Beli | | |
| 8 | Mesin | 1 | pcs | Beli | | |
| 9 | Pemindah kecepatan | 1 | pcs | Beli | | |
| 10 | Pemindah kecepatan cakar | 1 | pcs | Beli | | |
| 11 | Pemindah kecepatan jalan | 1 | pcs | Beli | | |
| 12 | Lampu | 1 | pcs | Beli | | |
| 13 | Tombol lampu | 1 | pcs | Beli | | |
| 14 | Reflektor | 1 | pcs | Beli | | |
| 15 | Gear Box | 1 | pcs | Buat | | |
| 16 | Rantai Gear | 1 | pcs | Beli | besi | dicetak |
| 17 | Casing gear | 1 | pcs | Beli | baja | dicetak |
| 18 | Gear | 3 | pcs | Beli | besi | dicetak |

Berdasarkan tabel diatas sebagian besar bahan baku diperoleh dengan cara membeli, hanya 1 bahan baku yang dibuat sendiri yaitu gear box, oleh karena itu dalam studi kasus perakitan traktor tangan pada industri perakitan traktor tangan di Ceper ini kebutuhan untuk memperoleh bahan baku dibeli dari pemasok.

3.3. Kerangka Pemikiran

Pada Bab III ini disajikan secara lengkap kerangka konsep untuk menyelesaikan masalah pada penelitian ini melalui beberapa langkah metodologis yang bisa dituangkan dalam beberapa algoritma. Gambar kerangka konsep penyelesaian tersebut disajikan pada gambar

3.1, sedangkan penjelasan kerangka konsep tersebut kami sajikan pada sub bab 3.1 sampai dengan 3.9, yang berisi analisa masalah, identifikasi masalah, mendefinisikan variabel operasional, menjelaskan konsep solusi permasalahan menjelaskan metode yang digunakan dalam menyelesaikan permasalahan disertasi, Diagram Input Proses Output, novelty dan hipotesa pada riset disertasi ini. Dengan adanya kerangka konsep penelitian ini diharapkan dapat memperjelas posisi penelitian yang akan dilakukan.

Ada 3 masalah mendasar yang harus dipecahkan pada penelitian ini, yaitu masalah informasi harga komponen spare part dan biaya, kebutuhan informasi supplier dan variabel kriterianya, dan optimasi pemilihan supplier. Berikut ini dijelaskan gambaran secara garis besar untuk mengatasi 3 permasalahan tersebut, yang nanti akan dijelaskan secara lengkap konsepnya pada sub bab 3.4. Konsep Solusi Permasalahan

1. Mengatasi informasi komponen, biaya dan harga

Berikut ini konsep untuk mengatasi informasi harga komponen spare part dan biaya dengan menggunakan suatu kerangka sistem database berbasis *BoM* dan GT. Desain database tersebut digambarkan pada Lampiran D - Data Dictionary, yang berisi database diagram, dan desain tabel yang akan diimplementasikan menggunakan database MySQL.

Pada tahap awal rangkaian desain database ini, dibuat struktur produk traktor tangan. Untuk menyusun database bahan baku struktur produk ini disusun dari gambar teknik traktor tangan yang diperoleh di lapangan. Gambar Struktur Produk ditunjukkan pada Gambar 3.2, dimana gambar tersebut menunjukkan struktur produk yang terdiri dari 3 tingkat. Pada gambar tersebut juga dijelaskan cara memperoleh masng-masing suku cadang, ada yang diperoleh dengan cara membeli, dan ada juga yang diperoleh dengan membuat sendiri.

Berdasarkan Struktur Produk yang telah dibuat pada langkah sebelumnya, disusun tabel *Bill of Material* seperti yang ditunjukkan pada Table 3.1.

Berdasarkan *Bill of Material* tersebut sebagian besar suku cadang diperoleh dengan cara membeli, sedangkan yang membuat sendiri adalah komponen gear box. Gear box tersebut diproduksi oleh UKM di Ceper Klaten Solo Jawa Tengah.

2. Mengatasi masalah informasi Supplier dan Variabel .

Pada penelitian dan publikasi terdahulu seperti yang sudah ditulis oleh Kusiak, Kurniawati, dan Laura pemilihan supplier ditentukan dengan beberapa kriteria (Kusiak, 2000a), (Kurniawati et al., 2013) :

1. Kemampuan manajemen

2. Harga
3. Kesadaran lingkungan
4. Kinerja pengiriman
5. Service (Layanan)
6. Fleksibilitas
7. Kemampuan teknis
8. Inovatif
9. Pendekatan manajemen
10. Lokasi geografis

Kriteria tersebut merupakan indikator seleksi pemasok, berdasarkan kriteria itu dilakukan penilaian untuk memperoleh skor pemasok.

Karena komponen dan harganya sudah dikonsepkan dalam bentuk sistem database, maka supplier beserta faktornya dapat disimpan dalam suatu tabel yg kemudian dapat dihitung menggunakan metode *multi criteria decision making* antara faktor pemilihan supp dan tabel komponen.

3. Mengatasi kesulitan optimasi.

Berbagai metode optimasi telah dibahas di bab 2, berikut ini akan dipilih metode Algoritma Genetika karena beberapa alasan seperti yang dimuat dalam website Stack Exchange (https://stats.stackexchange.com/, 2020), sebagai berikut :

1. Konsep mudah dipahami
2. Modular, terpisah dari aplikasi
3. Mendukung multi-tujuan pengoptimalan
4. Jawaban menjadi lebih baik seiring waktu
5. Mudah didistribusikan

## 3.4. Konsep Solusi Permasalahan

Sistem Pendukung Keputusan yang dibangun, adalah merupakan alat bantu untuk untuk memilih supplier berdasarkan kriteria teknis yang dibutuhkan industri manufaktur. Sistem ini bekerja dengan cara memasukkan data skor berdasarkan kriteria teknis dan budaya. Data skor tersebut dikelola menggunakan metoda Genetic Algoritma dan Multi Criteria Decision Making.

Untuk menyelesaikan permasalahan pemilihan supplier baru tersebut bisa dijelaskan langkah-langkahnya sebagai berikut ini :

1. Mendesain *Bill of Material* untuk menyusun Struktur Produk traktor tangan, Gambar desain tersebut bisa dilihat pada gambar 3.2 Struktur Produk
2. Pemanfaatan *Group Technology* untuk menyusun pengkodean bahan baku berdasarkan struktur produk
3. Desain database berdasarkan Struktur Produk dan GT
4. Berdasarkan *BoM* dan GT yang disusun pada langkah sebelumnya, maka disusun database diagram seperti pada Gambar Database di bawah ini. Struktur dan tipe data pada Database tersebut akan dijelaskan pada Lampiran
5. Membangun Sistem Informasi Supplier berbasis GT dalam lingkungan Relasional Database
6. Sistem Informasi Supplier merupakan tulang punggung dalam model penyeleksian ini.
7. Dalam mengembangkan Sistem Informasi ini, penulis menggunakan metode Prototyping karena aplikasi web yang dikembangkan masih baru belum ada sebelumnya. Bbagian ini akan dijelaskan lebih lengkap pada Bab 5 Hasil dan Pembahasan
8. Memilih Supplier menggunakan *computasional intelegence* dengan metode *Multi criteria decision making* dan *Genetic Algorithms*
9. Penyusunan daftar supplier terangking yang sesuai kriteria

### 3.4.1. Dari sisi pemilihan supplier Industri Manufaktur

Memilih supplier adalah kegiatan strategis, utamanya apabila supplier tersebut memasok item yang penting demi keberlanjutan rantai produksi. Kriteria pemilihan merupakan salah satu hal penting dalam memilih supplier. Kriteria yang digunakan pasti harus meenggambarkan strategi rantai pasok maupun karasteristik dari item yang harus dipasok. Berdasarkan studi literatur, diperoleh pemilihan supplier ditentukan dengan beberapa kriteria (Kusiak, 2000a), (Kurniawati et al., 2013), yaitu :

1. Kemampuan manajemen
2. Harga
3. Kesadaran lingkungan
4. Kinerja pengiriman
5. Service (Layanan)
6. Fleksibilitas

7. Kemampuan teknis
8. Inovatif
9. Pendekatan manajemen
10. Lokasi geografis

Oleh karena banyaknya kriteria yang diperlukan untuk menyeleksi pemasok, maka diperlukan metode kuantifikasi dan metoda optimasi dalam menyeleksi supplier tersebut yang akan dijelaskan kemudian.

### 3.4.2. Metode Kuantifikasi dan Optimasi untuk Pemilihan Supplier

Setelah menganalisa dan mempelajari literatur yang ada, diantara sekian banyak metode kecerdasan komputasional, maka yang sesuai digunakan untuk menyelesaikan permasalahan penyeleksian supplier ini adalah *Genetic Algorythms* dan *Multi criteria Decision Making*. Dengan penjelasan sebagai berikut :

*a. Genetic Algorythms*

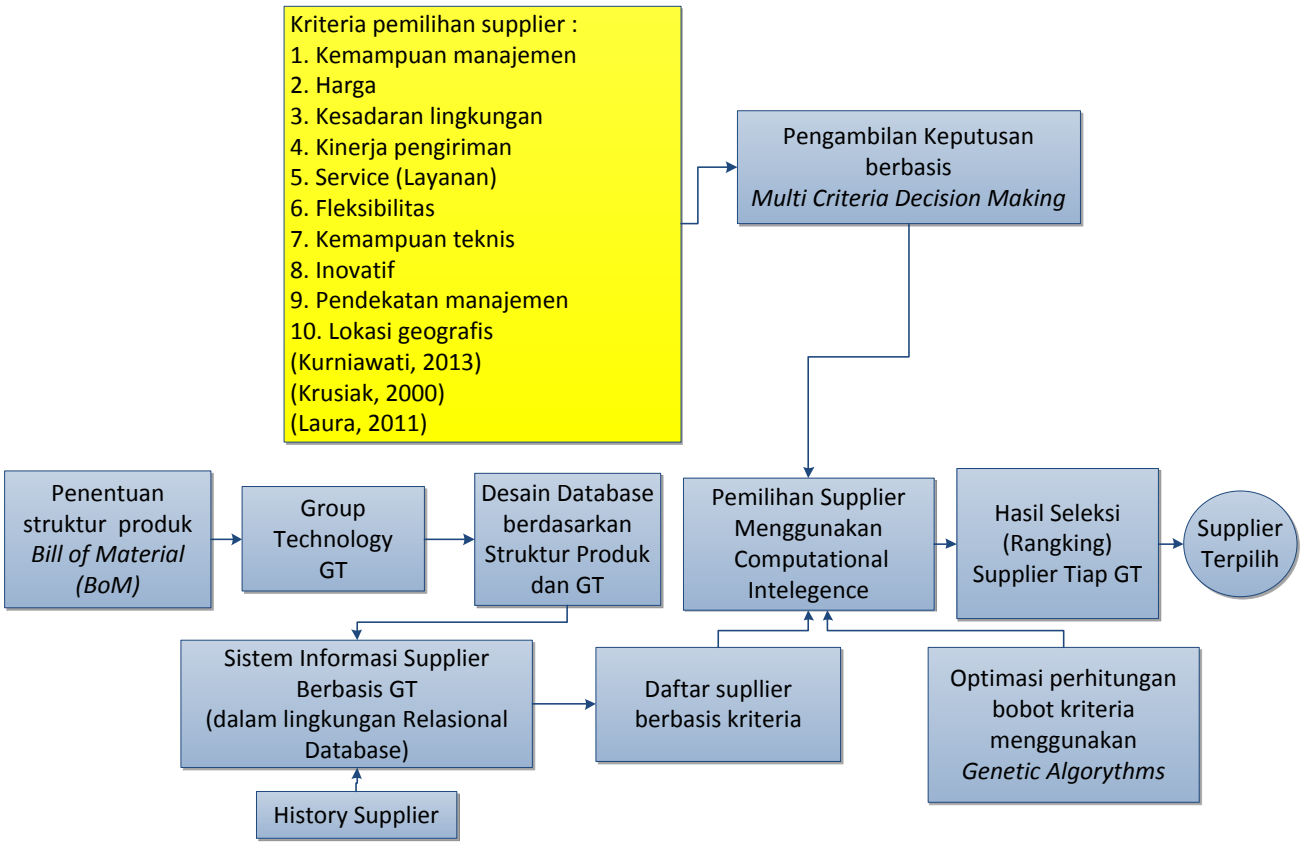
Algoritma Genetika merupakan metode optimasi yang sangat handal untuk menentukan bobot kriteria optimal bagi penilaian pemasok. Pada awalnya bobot supplier didefinisikan dengan nilai acak, kemudian dioptimasi untuk untuk mendapatkan nilai bobot optimal sesuai target yang akan menjadi bobot seleksi supplier pada *Multi criteria decision making.* (Hassanvand et al., 2015). Proses ini selanjutnya dijelaskan pada Bab 5.

*b. Multi Criteria Decision Making*

Seperti yang telah dijelaskan pada sub bab 3.1, terdapat 10 Variabel kriteria utama untuk memilih supplier. Berdasarkan bobot yang diperoleh dari perhitungan optimasi pada proses *Genetic Algorythms* sebelumnya, kesepuluh variabel tersebut kemudian diolah dan dihitung untuk menentukan rangking pemasok (Bc, n.d.)

## 3.5. Konsep Terintegrasi Sistem Informasi untuk Memilih Supplier Industri Manufaktur

Konsep ini merupakan integrasi antara berbagai metode yang sudah dibahas diatas. Secara lengkap digambarkan pada Gambar 3.4. Kerangka Konsep Disertasi

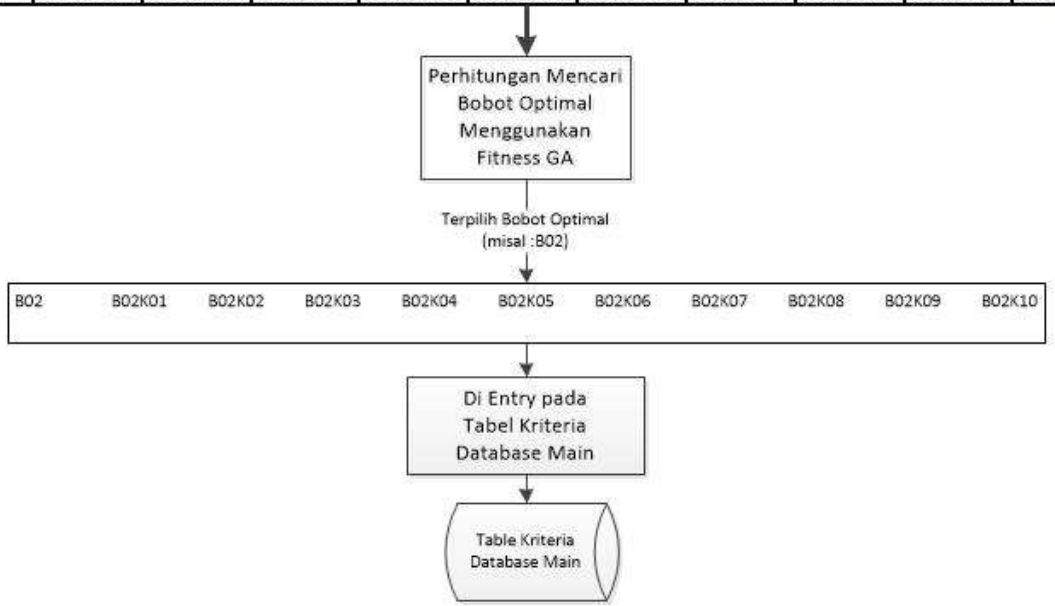



Gambar 3. 4. Kerangka Konsep Disertasi

Berikut ini penjelasan konsep solusi terintegrasi pada gambar 3.4 diatas:

1. Membangun basis pengetahuan dengan cara membuat desain *Bill of Material* untuk menyusun Struktur Produk traktor tangan,
2. Memanfaatkan konsep *Group Technology* untuk menyusun tabel bahan baku berdasarkan struktur produk serta untuk mendesain *Primary Key* yang digunakan sebagai *Code Part Number*
3. Membuat Desain database berdasarkan Struktur Produk dan GT. Desain database ini meliputi *Logical Database Design* berupa database diagram dan *Physycal Database* menggunakan MySQL.
4. Membangun Sistem Informasi Supplier berbasis web dalam lingkungan database terintegrasi menggunakan bahasa pemrograman PHP.
5. Menentukan bobot optimal tiap kriteria, untuk digunakan pada pemilihan supplier dengan menerapkan metode Algoritma Genetika. Hasil perhitungan optimal ini disimpan dalam tabel database Kriteria yang ditunjukkan pada gambar 5.2 Database Main.

| Bobot | K01 | K02 | K03 | K04 | K05 | K06 | K07 | K08 | K09 | K10 |
|---|---|---|---|---|---|---|---|---|---|---|
| B01 | B01K01 | B01K02 | B01K03 | B01K04 | B01K05 | B01K06 | B01K07 | B01K08 | B01K09 | B01K10 |
| B02 | B02K01 | B02K02 | B02K03 | B02K04 | B02K05 | B02K06 | B02K07 | B02K08 | B02K09 | B02K10 |
| B03 | B03K01 | B03K02 | B03K03 | B03K04 | B03K05 | B03K06 | B03K07 | B03K08 | B03K09 | B03K10 |




Gambar 3. 5 Alur Entry Bobot Optimal Menggunakan Fungsi Fitness GA ke Database Main pada Tabel Kriteria

Gambar 3.5 diatas menjelaskan bagaimana langkah-langkah algoritma genetika dalam menentukan bobot optimal menggunakan fungsi fitness GA pada tiap kriteria K01-K10 dan memasukkan hasil teserbut pada database. Gambar diatas juga menjelaskan alur perhitungan bobot optimal tersebut hingga diinput ke *Database MySQL*. Pada perhitungan optimasi bobot ini, data input untuk perhitungan Bobot (populasi awal) ini diperoleh melalui 2 cara, yaitu random atau diinput dari keyboard. Kemudian data input ini dihitung menggunakan fungsi fitness GA. Perhitungan fungsi fitness GA diperoleh berdasarkan referensi yang didapatkan dari studi literatur pada website *Stackoverflow*, (Stackoverflow, 2014). Berdasarkan literatur tersebut, untuk mencari bobot optimal pada tiap kriteria digunakan *script coding PHP*. Pada website tersebut juga mencontohkan studi kasus perhitungan bobot menggunakan fungsi fitness GA. Setelah perhitungan fitness GA memperoleh hasil terbaik, maka konfigurasi bobot terbaik tersebut disimpan dalam tabel bobot kriteria. Contoh keluaran dari *coding script PHP* tersebut ditampilkan pada Tabel 5.3 Bobot Kriteria, Detail penjelasan ini kemudian diuraikan pada Bab 5.4.2.

6. Menampilkan hasil pemilihan daftar supplier terangking yang sesuai kriteria menggunakan metode Fuzzy AHP

## 3.6. Identifikasi Variabel

Atas dasar analisa masalah diatas maka dapat diidentifikasi variabel atau faktor penting dalam penelitian. Variabel operasional yang digunakan pada penelitian disertasi ini disajikan pada tabel 3.2.

Tabel 3. 4. Variabel Operasional

| No | Kriteria Teknis | Sub Kriteria | Sat | Tipe | Domain | Klas | Cara pengambilan data | Var Kriteria |
|---|---|---|---|---|---|---|---|---|
| 1 | Kapabilitas Manajemen | - | - | - | - | - | - | K00 |
| | | Sistem mutu | | Numerik | Skor 1-5 | Primer | Survey dan Penilaian langsung | K1 |
| | | Manajemen informasi | | Numerik | Skor 1-5 | Primer | Survey dan Penilaian langsung | K12 |
| | | Kemampuan komunikasi | | Numerik | Skor 1-5 | Primer | Survey dan Penilaian langsung | K13 |
| | | Manajemen kualitas total | | Numerik | Skor 1-5 | Primer | Survey dan Penilaian langsung | K14 |
| 2 | Harga | - | - | - | - | - | - | K20 |
| | | Harga bersaing | | Numerik | Skor 1-5 | Primer | Survey dan Penilaian langsung | K21 |
| | | Memberikan diskon | | Numerik | Skor 1-5 | Primer | Survey dan Penilaian langsung | K22 |
| 3 | Kinerja Pengiriman | - | - | - | - | - | - | K30 |
| | | Penjadwalan | | Numerik | Skor 1-5 | Primer | Survey dan Penilaian langsung | K31 |
| | | Jangka Waktu Pengiriman | | Numerik | Skor 1-5 | Primer | Survey dan Penilaian langsung | K32 |
| 4 | Kesadaran Lingkungan | - | | Numerik | Skor 1-5 | Primer | Survey dan Penilaian langsung | K40 |
| 5 | Service atau layanan | - | | Numerik | Skor 1-5 | Primer | Survey dan Penilaian langsung | K50 |
| 6 | Fleksibilitas | - | | Numerik | Skor 1-5 | Primer | Survey dan Penilaian langsung | K60 |
| 7 | Kemampuan Teknis | - | | Numerik | Skor 1-5 | Primer | Survey dan Penilaian langsung | K70 |
| 8 | Inovatif | - | | Numerik | Skor 1-5 | Primer | Survey dan Penilaian langsung | K80 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9 | Pendekatan Manajemen | - | | Numerik | Skor 1-5 | Primer | Survey dan Penilaian langsung | K90 |
| 10 | Letak Geografis | - | | Numerik | Skor 1-5 | Primer | Survey dan Penilaian langsung | K10 |

## 3.7. Keterbaruan

Setiap disertasi dituntut adanya keterbaruan (novelty), berikut ini adalah keterbaruan dari penelitian ini:

1. Sebuah konsep sistem database dirancang menggunakan integrasi *BoM* dan GT. Sistem ini dapat menyimpan data spare part, dan data supplier
2. Sebuah konsep untuk menentukan bobot optimal pada tiap kriteria pemilihan supplier menggunakan *Genetic Algorythms*

## 3.8. Hipothesa

Atas dasar kerangka pikir diatas dapat diturunkan hipothesa sbb:

1. Data tentang supplier, kebutuhan spare part, dan kriteria pemilihan berikut bobotnya akan lebih mudah disimpan dengan menggunakan database aplikasi berbasis web
2. Pemilihan Supplier dipermudah dan dipercepat dengan cara menambahkan algoritma *multi criteria decision making* yang merupakan perhitungan optimasi dari variable-variabel kriteria pada pemilihan supplier.

# BAB 4

# METODE PENELITIAN

## 4.1. Desain Riset

### 4.1.1. Waktu

Penelitian disertasi ini dilaksanakan pada bulan Januari tahun 2020 hingga bulan Desember tahun 2020, jadwal selengkapnya dijelaskan pada Gambar 4.1.

| ID | Task Name | Start | Finish | Duration | Q1 20 | | | Q2 20 | | | Q3 20 | | | Q4 20 | | | % Complete |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Jan | Feb | Mar | Apr | Mei | Jun | Jul | Agu | Sep | Okt | Nov | Des | |
| 1 | Desain Model Database | 02/01/2020 | 31/03/2020 | 64d | | | | | | | | | | | | | 100% |
| 2 | Desain Optimasi menggunakan GA | 31/03/2020 | 30/06/2020 | 66d | | | | | | | | | | | | | 100% |
| 3 | Pembuatan Prototipe berbasis Web | 02/07/2020 | 25/09/2020 | 62d | | | | | | | | | | | | | 100% |
| 4 | Pengembangan sistem basis data MySQL pada web menggunakan bahasa pemrograman PHP | 01/07/2020 | 29/07/2020 | 21d | | | | | | | | | | | | | 100% |
| 5 | Pengembangan metode optimasi GA dan Pemilihan Supplier MCDM | 30/07/2020 | 03/09/2020 | 26d | | | | | | | | | | | | | 100% |
| 6 | Pengintegrasian database spare parts dan supplier dengan metode optimasi pemilihan supplier | 04/09/2020 | 02/10/2020 | 21d | | | | | | | | | | | | | 100% |
| 7 | Pengujian prototipe secara online pada jaringan internet | 05/10/2020 | 30/12/2020 | 63d | | | | | | | | | | | | | 75% |

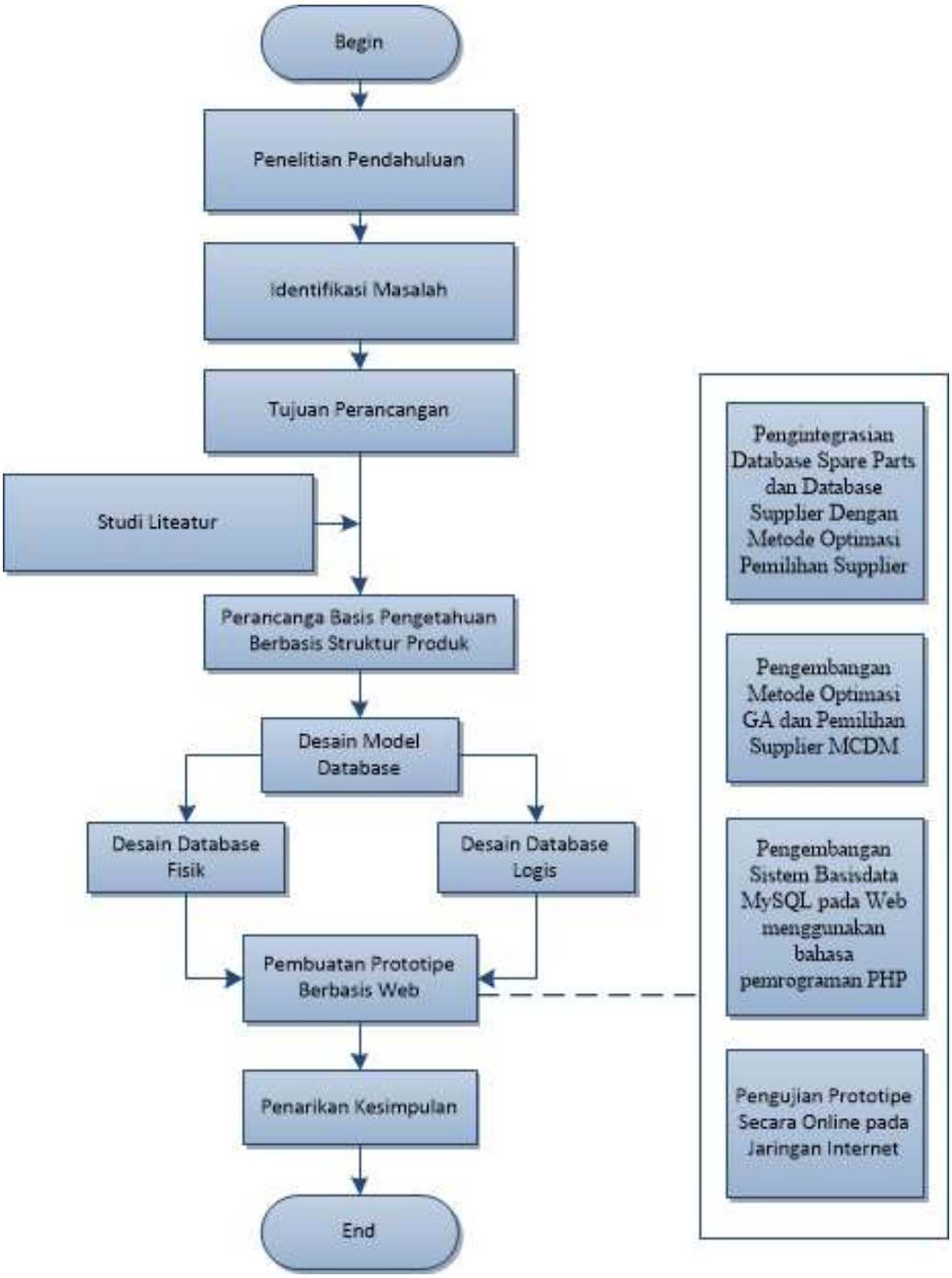
Gambar 4. 1 Jadwal Pelaksanaan Penelitian

### 4.1.2. Tempat Penelitian

Tempat pengambilan data dilaksanakan di kawasan industri logam Ceper Kab. Klaten, Jawa Tengah sedangkan pembuatan database, pembuatan aplikasi prototipe dan ujicoba online, dikerjakan di Laboratorium Komputasi dan Sistem Informasi Politeknik Negeri Jember.

## 4.2. Tahapan Riset

Pada bab ini akan dijelaskan langkah-langkah metode penelitian untuk menyelesaikan permasalahan pada disertasi ini. Langkah-langkah penelitian tersebut ditunjukkan pada gambar 4.2




Gambar 4. 2 Tahap Penelitian

Sumber : Perancangan

### 4.2.1. Penelitian Pendahuluan

Penelitian pendahuluan dimaksudkan untuk mencari dan menentukan obyek yang akan diangkat sebagai judul disertasi. Penelitian pendahuluan ini dapat dilaksanakan

dengan survei literatur di internet dan perpustakaan, dan diskusi dengan dosen atau orang-orang yang memiliki banyak ide, pengetahuan, dan pengalaman.

Dari penelitian pendahuluan ini, didapatkan Sistem Database terintegrasi sebagai obyek yang akan diangkat menjadi topik disertasi.

### 4.2.2. Identifikasi Masalah

Setelah obyek disertasi didapatkan, maka tahap selanjutnya adalah mengidentifikasi permasalahan untuk diselesaikan pada penelitian ini. Pengidentifikasian masalah ini dilaksanakan dengan survei di lapangan dengan wawancara di Sentra Industri Kecil Logam Kec. Ceper Kab. Klaten Jawa Tengah.

Dari tahap ini, didapatkan permasalahannya adalah belum terintegrasinya database spare part dengan supplier, dan belum ada sistem pemilihan supplier yang sesuai berdasarkan bobot kriteria yang optimal. Karena itu perlu dicari solusinya, yaitu dengan merancang sistem database terintegrasi untuk mengelola database supplier dan suku cadang serta sistem pemilihan supplier yang sesuai dengan bobot kriteria sehingga bisa diakses online.

### 4.2.3. Tujuan Perancangan

Berdasarkan permasalahan yang sudah diidentifikasi, maka dapat ditentukan tujuan perancangan, yaitu hasil akhir yang diharapkan pada perancangan. Tujuan perancangan perlu ditentukan agar penyusunan disertasi ini tidak menyimpang dari tujuan awal dan mendapatkan hasil yang optimal. Tujuan seringkali dipecah menjadi sub-sub tujuan. Tujuan sangat berguna untuk mengarahkan dan mengukur keberhasilan Disertasi ini. Tujuan akan menentukan landasan teori apa saja yang diperlukan. Selain itu, tujuan dan kesimpulan yang ditarik di akhir penyusunan disertasi harus sesuai.

### 4.2.4. Studi Literatur

Tahap selanjutnya adalah melakukan studi literatur, yaitu dengan mengumpulkan dan mempelajari literatur, buku, artikel, publikasi jurnal, video, dan sebagainya yang diperoleh dari perpustakaan, internet, dan sumber lainnya mengenai sistem database dan penyeleksian supplier serta materi-materi lain yang dibutuhkan dalam penyusunan laporan disertasi. Jadi, studi literatur diperlukan untuk mendapatkan dasar teori, dalam hal ini adalah dasar teori yang berkaitan tentang pengembangan sistem database dan

penyeleksian supplier dengan menggunakan Bahasa Pemrograman Web PHP yang diintegrasikan dengan Sistem Basis Data MySQL.

4.2.5. Perancangan Basis Pengetahuan

Basis pengetahuan merupakan elemen utama dari Sistem Basisdata dan pemilihan supplier. Langkah-langkah pengembangan basis pengetahuan tersebut sebagai berikut :

1. Membuat struktur produk menurut gambar teknik
2. Membuat *Bill of Material* (BoM)
3. Mendesain *Code Part Number* berdasarkan *Group Technology*
4. Membuat kode barang sebagai *primary key* pada database suku cadang
5. Memasukkan data spare part pada database *MySQL*
6. Memasukkan data kriteria, dan data supplier pada database *MySQL*

4.2.6. Desain Model Database

Tahap selanjutnya yaitu merancang basis data sebagai inti sistem informasi yang dibangun, hal ini meliputi dua pekerjaan pokok yaitu membuat *Logical Database Design (Conceptual Model Database)* dan membuat *Physical Database Design*. Kedua tahap ini bisa dijelaskan sebagai berikut :

1. *Logical Database Design* : Tahap ini dilaksanakan dengan menggunakan tools software Power Designer Data Architect, dengan membuat Database Diagram
2. *Physical Database Design* : Tahap ini dilaksanakan dengan menggunakan database engine MySQL dengan tools PHPMyAdmin yaitu dengan merancang tabel-tabel yang diperlukan, menentukan kunci-kunci dalam setiap tabel, menentukan relasi antar tabel, dan sebagainya.

4.2.7. Pembuatan Prototipe Berbasis Web

Bentuk integrasi yang digunakan adalah aplikasi sistem informasi berbasis Web Sistem Pengambilan Keputusan sebagai front-end bagi basis data. Pada tahap ini, kesimpulan akhir atau rekomendasi dari Sistem Pengambilan Keputusan
mencari rekomendasi alternatif memilih supplier sesuai kriteria. Rekomendasi ini merupakan hasil akhir yang akan diberikan kepada user.

4.2.8. Penarikan Kesimpulan dan Saran

Tahap kesimpulan dan saran merupakan tahap akhir dari langkah penelitian ini. Pada tahap ini, ditarik kesimpulan mengenai apa yang sudah dilakukan dan dicapai dalam pelaksanaan disertasi ini. Kesimpulan haruslah sesuai dengan tujuan yang telah ditetapkan di Bab Pendahuluan. Tahap ini juga memberikan saran-saran yang mungkin dapat dijadikan sebagai masukan bagi yang ingin menindaklanjuti lebih jauh atau mengembangkan *software* aplikasi ini.

4.3. Sarana Prasarana Pendukung

Alat dan bahan merupakan komponen penting yang harus diperhatikan dalam melakukan suatu penelitian. Berikut rincian alat dan bahan yang digunakan dalam penelitian disertasi.

4.3.1. Alat

Alat yang dipakai dalam penelitian ini meliputi *hardware* dan *software*. Spesifikasi *hardware* atau perangkat keras yang digunakan meliputi :

a. 1 unit komputer *Intel Core i5*
b. 1 Unit Laptop *Intel Core i5*
c. Printer Epson L210, Canon MP 145
d. *Flash Disk* 512 GB, 32 GB, 64 GB
e. *External Hardisk 1 TB*
f. Server :

| 1 | ID FAME | ID HITS | ID SUPERSTAR |
|---|---|---|---|
| Monthly Bandwidth | Unlimited | Unlimited | Unlimited |
| Max FTP Account | Unlimited | Unlimited | Unlimited |
| Max Email Account | Unlimited | Unlimited | Unlimited |
| Max quota per email address | 1024 | 1024 | 1024 |
| Max Email List | - | - | - |
| Max Databases | 1 | 10 | 20 |
| Max Sub Domain | Unlimited | Unlimited | Unlimited |
| Max Parked Domain | Unlimited | Unlimited | Unlimited |
| Max Addon Domain | Unlimited | Unlimited | Unlimited |
| Max Hourly Email | 10 | 25 | 50 |
| Max Percentage Failure sending email | 100 | 100 | 100 |
| Dedicated IP | - | - | - |
| Shell Acess / SSH | - | Yes | Yes |
| CGI access | Yes | Yes | Yes |
| Digest Authentication at account creation | - | - | - |
| cpanel theme | papern latern | papern latern | papern latern |
| Feature List | fullJH | fullJH | fullJH |
| Locale | english | english | english |

| 1 | ID FAME | ID HITS | ID SUPERSTAR |
|---|---|---|---|
| RESOURCE LVE | | | |
| Percentage CPU | 60% | 100% | 100% |
| Percentage CPU Turbo Mode | - | - | - |
| Phisycal Memory (PMEM) | 768MB | 1024MB | 1024MB |
| Phisycal Memory (PMEM) Turbo Mode | - | - | - |
| I/O | 100MB | 100MB | 100MB |
| I/O Turbo Mode | - | - | - |
| IOPS | 1024 | 1024 | 1024 |
| Entry Processes (EP) | 50 | 110 | 110 |
| NPROC | 100 | 150 | 150 |
| Inodes Soft | unlimited | unlimited | 75000 |
| Inodes Hard | - | - | 75000 |

g.

Sedangkan s*oftware* atau perangkat lunak yang digunakan sebagai berikut :

a. Sistem Operasi *Microsoft Windows 8.1 Professional*.

*b. Database MySQL*

*c.* Bahasa pemgrograman *Web PHP*

*d. Web Server Apache*

e. *Microsoft Visio* digunakan dalam pembuatan *Sistem Flow Chart* dan Kerangka Konsep Sistem

f. *Power Designer Data Architect* untuk membuat desain database

4.3.2. Bahan

Bahan yang dibutuhkan dalam penelitian ini adalah data sekunder berupa data :

a. Data Supplier : Data ini berisi Nama IKM, Alamat IKM, dan Nama Pendiri IKM seperti pada tabel 4.1. Data yang terkumpul berjumlah 152 IKM disajikan pada Lampiran C. Daftar Supplier

Tabel 4. 1 Tabel Contoh Data Supplier

| NO | NO AGT | NAMA ANGGOTA | NAMA PERUSAHAAN | ALAMAT |
|---|---|---|---|---|
| 1 | 5 | H. Margono | COKRO | BATUR, TEGAL, CEPER |
| 2 | 16 | Ali Afandi | RAJA TERANG | BATUR, TEGAL, CEPER |
| 3 | 23 | Padyo Hartono | SUMBER HIDUP | BANGKALAN, CEPER, KLATEN |
| 4 | 24 | H. Agus Salim | CV. INDRA DATA SAKTI | BANGKALAN, CEPER, KLATEN |
| 5 | 30 | H. Dawan Ashari | KARYA MAKMUR | BANGKALAN BARU, CEPER |
| 6 | 32 | H. Wachid Hasyim | BAJA JAYA | NGAWONGGO |
| 7 | 47 | H. Suarto | SINAR INDUSTRI | TAMPIRAN |
| 8 | 52 | Ishar Abadi | SINAR ABADI | BANGKALAN, CEPER, KLATEN |
| 9 | 55 | H. Asmawi | SINAR SUPER JAYA | BATUR, TEGAL, CEPER |
| 10 | 56 | H. Sholikah | JAYA MAKMUR | JEMBLOGAN |

b. Data gambar teknis traktor tangan yg digunakan untuk menyusun struktur produk diperoleh dari *teaching factory* Ceper. Ditampilkan pada Lampiran B. Gambar Teknik
c. Data-data sekunder yaitu : Data Kriteria untuk memilih supplier, data spare part, dan data supplier

# BAB 5

# HASIL DAN PEMBAHASAN

Pada bab ini dijelaskan langkah-langkah penyelesaian dan pelaksanaan penelitian disertasi secara detil sesuai kerangka konsep yang telah dijelaskan secara ringkas pada Bab 3, dan digambarkan pada Gambar 3.1, kemudian dijelaskan lebih detil pada Bab 5.

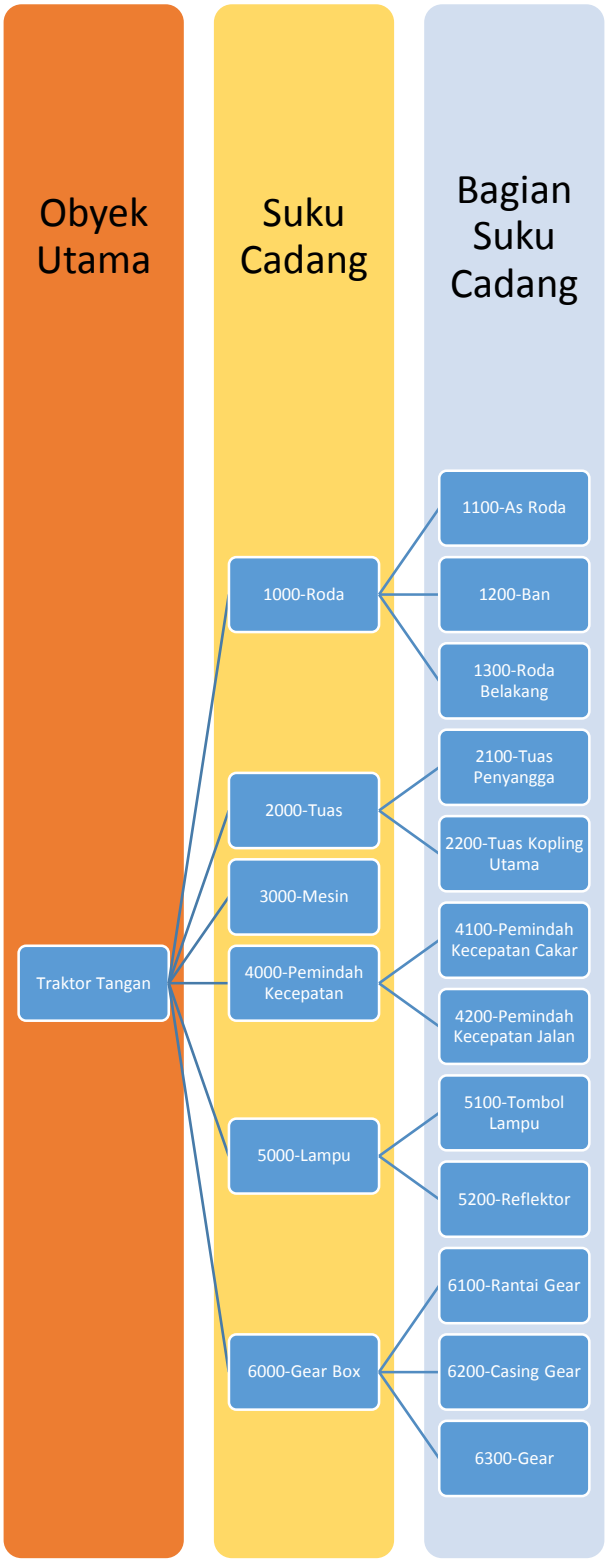
Seperti yang digambarkan pada Gambar 3.1 diatas, maka setiap langkahnya bisa dijelaskan secara detil mulai dari sub bab 5.1 sampai dengan 5.9 berikut ini.

5.1. Penentuan Struktur Produk menggunakan *Bill of Material* (BoM)

Langkah awal pada pemilihan supplier industri manufaktur ini diawali dengan proses penyusunan struktur produk berdasarkan BoM. Berdasarkan gambar teknik seperti ditunjukkan Lampiran B Gambar Teknik Hand Tractor, disusun *Bill of Material* sesuai hirarki struktur produk. Struktur Produk yang sudah tersusun bisa digambarkan pada Sub bab 3.2 Struktur Produk

*5.2.* Penyusunan *Group Technology (GT)*

Berdasarkan Struktur Produk yang telah dibuat pada langkah sebelumnya yaitu pada Gambar 3.2, disusun tabel *Bill of Material* seperti yang ditunjukkan pada Table 5.1 di bawah ini.




Gambar 5. 1. Konsep Struktur Produk untuk Menyusun *Code Part Number Spare Part*

Sumber : Perancangan

*Grup Technology* atau GT pada tahap ini diperlukan untuk menyusun Code Part Number yang akan digunakan pada penyusunan database. Code Part Number ini merupakan pengelompokan suku cadang sesuai dengan fungsinya. Code tersebut terdiri dari 4 digit,

**Digit ke-1** menunjukkan Suku Cadang

1 artinya suku cadang Roda

2 artinya suku cadang Tuas

Dst

**Digit ke-2** menunjukkan Sub Bagian Suku Cadang

11 artinya As Roda

12 artinya Ban

dst

**Digit 3 dan 4** menunjukkan Varian Sub Bagian Suku Cadang

Tabel 5. 1 *Bill of Material* berdasarkan *Group Technology*

| Code | Description | Qty | Metrics | Order |
|---|---|---|---|---|
| 1000 | Roda | 2 | pcs | Beli |
| 1100 | As Roda | 1 | pcs | Beli |
| 1200 | Ban | 2 | pcs | Beli |
| 1300 | Roda belakang | 2 | pcs | Beli |
| 2000 | Tuas | 1 | pcs | Beli |
| 2100 | Tuas Penyangga | 1 | pcs | Beli |
| 2200 | Tuas Kopling Utama | 1 | pcs | Beli |
| 3000 | Mesin | 1 | pcs | Beli |
| 4000 | Pemindah kecepatan | 1 | pcs | Beli |
| 4100 | Pemindah kecepatan cakar | 1 | pcs | Beli |
| 4200 | Pemindah kecepatan jalan | 1 | pcs | Beli |
| 5000 | Lampu | 1 | pcs | Beli |
| 5100 | Tombol lampu | 1 | pcs | Beli |
| 5200 | Reflektor | 1 | pcs | Beli |

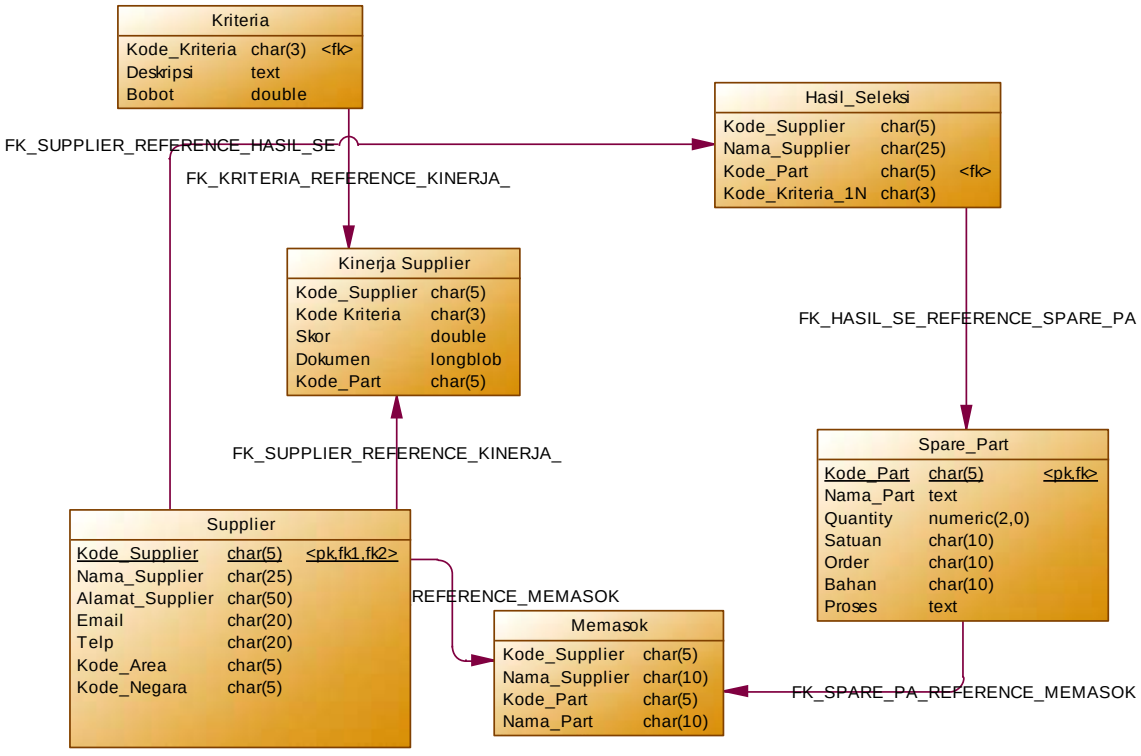
| | | | | |
|---|---|---|---|---|
| 6000 | Gear Box | 1 | pcs | Buat |
| 6100 | Rantai Gear | 1 | pcs | Beli |
| 6200 | Casing gear | 1 | pcs | Beli |
| 6300 | Gear | 3 | pcs | Beli |

5.3.Desain Database berdasarkan GT dan BoM

Berdasarkan *Group Technology* dan *Bill of Material* yang disusun pada langkah sebelumnya, maka disusunlah database spare part yang digunakan untuk pembuatan sistem informasi manajemen supplier pada langkah berikutnya.

5.3.1. Desain Database Logik berdasarkan GT dan BoM

Berikut ini akan disajikan ER-D sistem aplikasi yang dikembangkan. Desain database diagram untuk Database Main bisa diakses pada http://disertasi.project-ai.my.id/Report-Disertasi/Main.html




Gambar 5. 2. Database Main

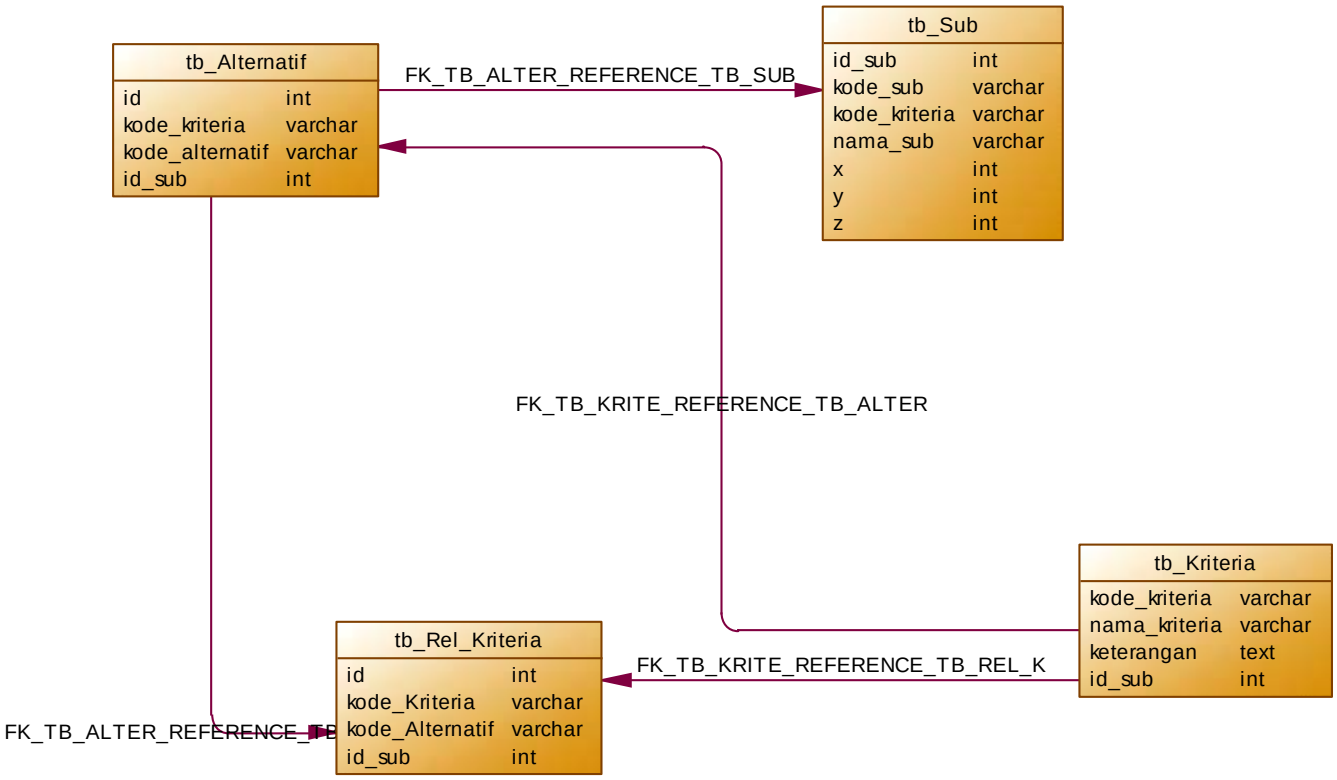
Berdasarkan gambar 5.2 diatas, dapat dijelaskan bahwa prototipe aplikasi Main yang dikembangkan tersebut memiliki 6 Tabel. Seperti dijelaskan pada tabel 5.1 dibawah ini

Tabel 5.1. Daftar Tabel pada Database Main

| No | Name | Code | Kegunaan |
|---|---|---|---|
| 1 | Hasil_Seleksi | HASIL_SELEKSI | Tabel untuk menyimpan hasil penyeleksian supplier menggunakan metode MCDM |
| 2 | Kinerja Supplier | KINERJA_SUPPLIER | Tabel kinerja supplier untuk mencatat kinerja supplier, sebagai bahan perhitungan untuk menyeleksi supplier |
| 3 | Kriteria | KRITERIA | Tabel Kriteria adalah Tabel yang menyimpan variabel kriteria |
| 4 | Memasok | MEMASOK | Tabel Memasok, adalah tabel yang digunakan untuk mencatat relasi supplier dan spare part |
| 5 | Spare_Part | SPARE_PART | Tabel Spare_Part digunakan untuk mendata spare part yang diperlukan pada pembuatan traktor tangan |

| | | | |
|---|---|---|---|
| 6 | Supplier | SUPPLIER | Table Supplier berisi data supplier yang digunakan p |

Desain database diagram untuk Database MCDM bisa diakses pada [http://disertasi.project-ai.my.id/Report-Disertasi/MCDM.html](http://disertasi.project-ai.my.id/Report-Disertasi/MCDM.html)




Gambar 5. 3 Database Diagram MCDM

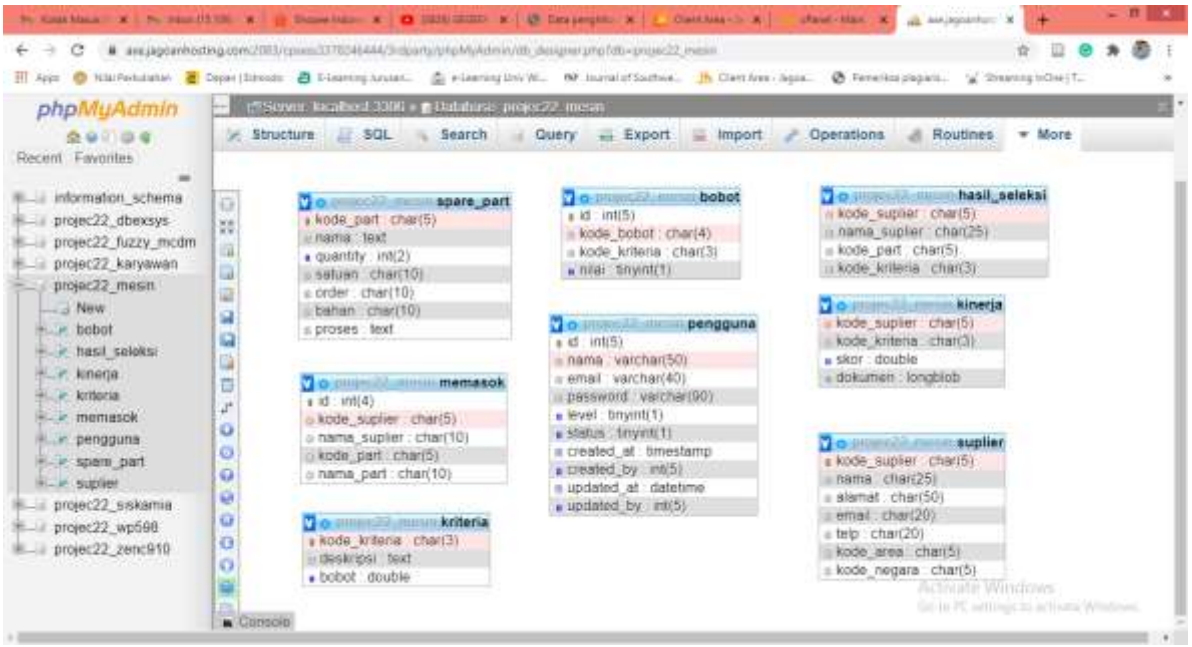
Berdasarkan gambar 5.2 diatas, dapat dijelaskan bahwa prototipe aplikasi Main yang dikembangkan tersebut memiliki 6 Tabel. Seperti dijelaskan pada tabel 5.2 dibawah ini

Tabel 5. 2 Daftar Tabel pada Database MCDM

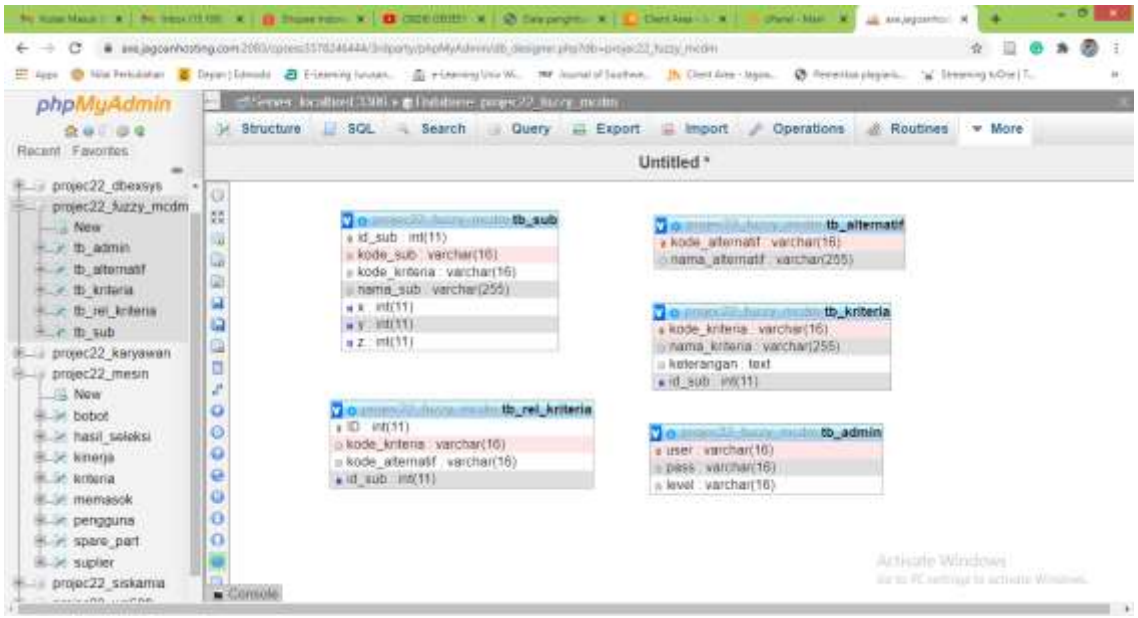
| No | Name | Code | Keterangan |
|---|---|---|---|
| 1 | tb_Alternatif | TB_ALTERNATIF | Tabel yang berisi daftar alternatif supplier |

| | | | |
|---|---|---|---|
| 2 | tb_Kriteria | TB_KRITERIA | Tabel yang berisi kriteria pemilihan supplier |
| 3 | tb_Rel_Kriteria | TB_REL_KRITERIA | Tabel Relasi antara Tabel Kriteria dan Tabel Alternatif |
| 4 | tb_Sub | TB_SUB | |

5.3.2. Desain Database Phisik



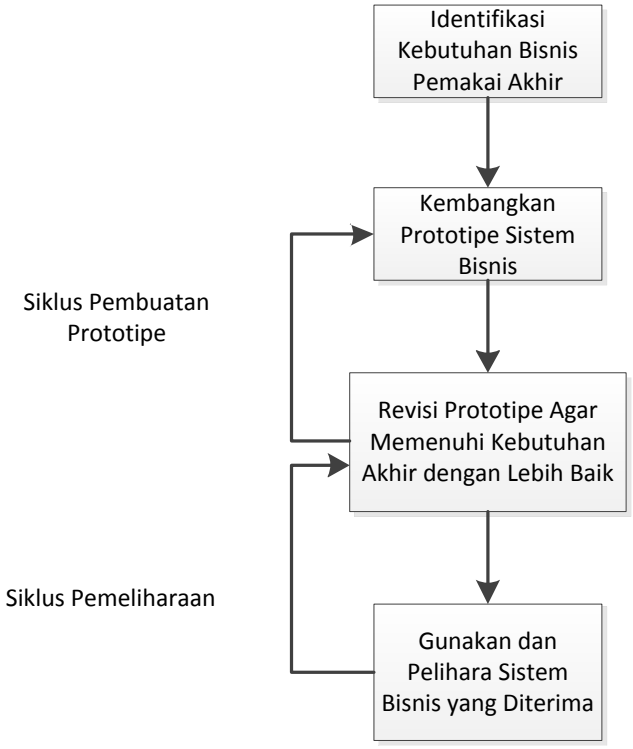

Gambar 5. 4 Fisik Database Main




Gambar 5. 5 Fisik Database MCDM

5.4. Pengembangan Sistem Informasi Supplier berbasis GT (dalam lingkungan relasional database)

Tahapan ini merupakan perancangan komponen dari SPK menggunakan metode protoyping. Detail dari metode prototyping tersebut sebagai berikut ini :




Gambar 5. 6. Siklus Prototyping

1. Identifikasi kebutuhan akhir / Identifikasi kandidat *prototyping*. Kandidat dalam kasus ini meliputi *user interface* (menu, dialog, input dan output), file-file transaksi utama, dan fungsi-fungsi pemrosesan sederhana.

Pembangunan sistem informasi memerlukan penyelidikan dan analisis mengenai alasan timbulnya ide atau gagasan untuk membangun dan mengembangkan sistem informasi. Analisis dilakukan untuk melihat berbagai komponen yang dipakai sistem yang sedang berjalan meliputi hardware, software, jaringan dan sumber daya manusia. Analisis juga mendokumentasikan aktivitas sistem informasi meliputi input, pemrosesan, output, penyimpanan dan pengendalian.

Selanjutnya melakukan studi kelayakan (feasibility study) untuk merumuskan informasi yang dibutuhkan pemakai akhir, kebutuhan sumber daya, biaya, manfaat dan kelayakan proyek yang diusulkan.

Analisis kebutuhan sistem sebagai bagian dari studi awal bertujuan mengidentifikasi masalah dan kebutuhan spesifik sistem. Kebutuhan spesifik sistem adalah spesifikasi mengenai hal-hal yang akan dilakukan sistem ketika diimplementasikan.

Analisis kebutuhan sistem harus mendefinisikan kebutuhan sistem yang spesifik antara lain :

1) Masukan yang diperlukan sistem (input)
2) Keluaran yang dihasilkan (output)
3) Operasi-operasi yang dilakukan (proses)
4) Sumber data yang ditangani
5) Pengendalian (kontrol)

Tahap analisis kebutuhan sistem memerlukan evaluasi untuk mengetahui kemampuan sistem dengan mendefinisikan apa yang seharusnya dapat dilakukan oleh sistem tersebut kemudian menentukan kriteria yang harus dipenuhi sistem. Beberapa kriteria yang harus dipenuhi adalah pencapaian tujuan, kecepatan, biaya, kualitas informasi yang dihasilkan, efisiensi dan produktivitas, ketelitian dan validitas dan kehandalan atau reliabilitas.

2. Rancang bangun prototype dengan bantuan software seperti word processor, spreadsheet, database, pengolah grafik, dan software CASE (Computer-Aided System Engineering).

Analisis sistem (system analysis) mendeskripsikan apa yang harus dilakukan sistem untuk memenuhi kebutuhan informasi pemakai. Desain sistem (system design) menentukan.

bagaimana sistem akan memenuhi tujuan tersebut. Desain sistem terdiri dari aktivitas desain yang menghasilkan spesifikasi fungsional. Desain sistem dapat dipandang sebagai desain interface, data dan proses dengan tujuan menghasilkan spesifikasi yang sesuai dengan produk dan metode interface pemakai, struktur database serta pemrosesan dan prosedur pengendalian. Desain sistem akan menghasilkan paket software prototipe, produk yang baik sebaiknya mencakup tujuh bagian :

1) Fitur menu yang cepat dan mudah.
2) Tampilan input dan output.
3) Laporan yang mudah dicetak.
4) Data dictionary yang menyimpan informasi pada setiap field termasuk panjang field, pengeditan dalam setiap laporan dan format field yang digunakan.
5) Database dengan format dan kunci record yang optimal.
6) Menampilkan query online secara tepat ke data yang tersimpan padadatabase.

Struktur yang sederhana dengan bahasa pemrograman yang mengizinkan pemakai melakukan pemrosesan khusus, waktu kejadian, prosedur otomatis dan lain-lain.

3. Uji *prototype* untuk memastikan *prototype* dapat dengan mudah dijalankan untuk tujuan demonstrasi.

Paket perangkat lunak prototipe diuji, diimplementasikan, dievaluasi, dan dimodifikasi berulang kali hingga dapat diterima oleh pengguna. Pengujian sistem bertujuan untuk menemukan kesalahan yang terjadi pada sistem dan merevisi sistem. Tahap ini penting untuk memastikan bahwa sistem bebas dari kesalahan. Menurut Sommerville (2001) pengujian sistem terdiri dari:

1) Pengujian unit untuk menguji komponen individu secara independen tanpa komponen sistem lain untuk memastikan sistem operasi yang benar.
2) Modul pengujian yang terdiri dari komponen-komponen yang saling berhubungan.
3) Pengujian sub sistem yang terdiri dari beberapa modul yang telah terintegrasi.
4) Pengujian sistem untuk menemukan kesalahan yang dihasilkan dari interaksi antara subsistem dan antarmuka mereka dan untuk memvalidasi persyaratan fungsional dan non-fungsional.
5) Uji penerimaan dengan data yang dimasukkan oleh pengguna dan bukan uji data simulasi.
6) Dokumentasi berupa rekaman setiap langkah kerja dari awal hingga akhir program.

Pengujian sistem informasi berbasis web dapat menggunakan teknik dan metode pengujian perangkat lunak tradisional. Pengujian aplikasi web meliputi pengujian tautan, pengujian browser, pengujian kegunaan, pengujian beban, pengujian tegangan, dan pengujian malar.

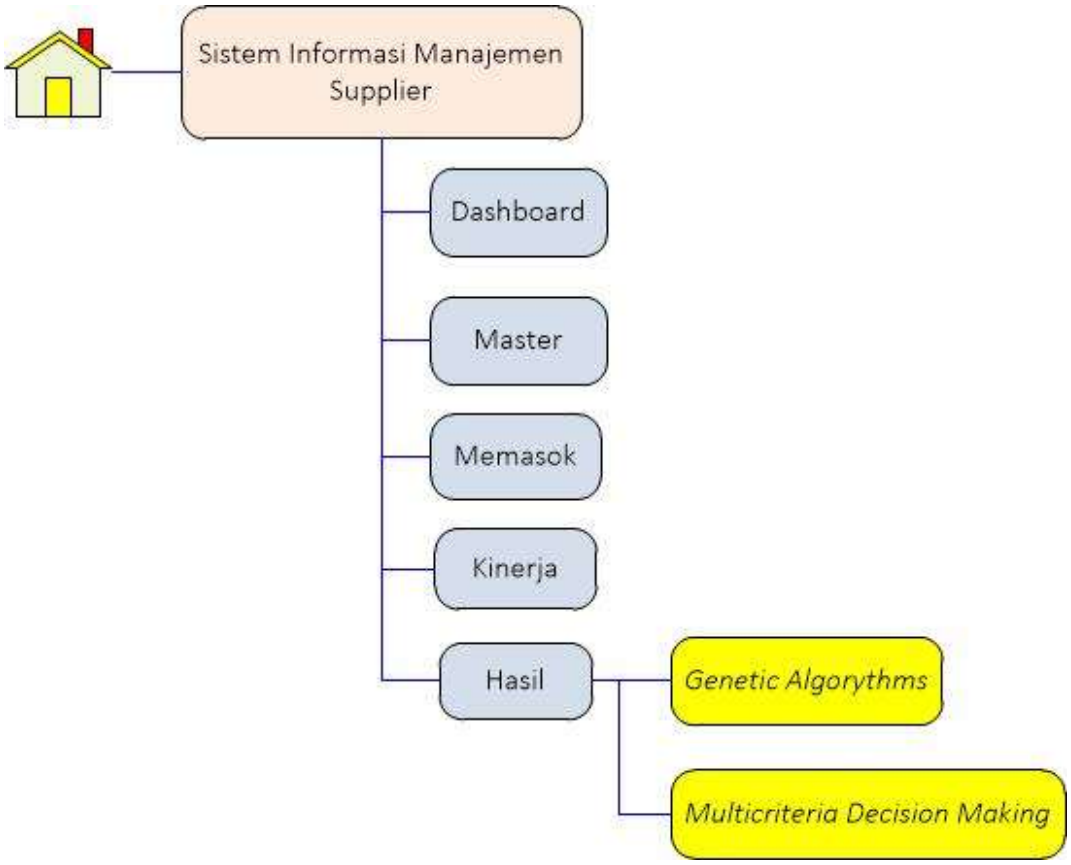
Salah satu model pengukuran yang telah diterjemahkan ke dalam beberapa bahasa yang berbeda dan tidak menunjukkan perbedaan hasil pengukuran yang signifikan adalah End User Computing (EUC) Satisfaction. Model ini menekankan pada kepuasan pengguna terhadap aspek teknologi yang meliputi aspek isi, akurasi, format, waktu dan kemudahan penggunaan sistem.

4. Evaluasi dengan pengguna untuk mengevaluasi *prototype* dan melakukan perubahan jika diperlukan.

Setelah prototype diterima, pada tahap ini adalah implementasi sistem yang siap dioperasikan kemudian ada proses pembelajaran untuk sistem baru dan membandingkannya dengan sistem lama, evaluasi teknis dan operasional serta interaksi pengguna, sistem dan teknologi informasi.

### 5.4.1. Data Penting untuk Pemilihan Supplier

Pengembangan integrasi sistem informasi manajemen dengan memanfaatkan co*mputational intelegence* dalam satu aplikasi berbasis web bisa dilihat pada gambar 5.6 Sitemap aplikasi di bawah ini.




Gambar 5. 7. Site Map dan Integrasi Modul Seleksi Supplier

Pada gambar tersebut bisa dijelaskan secara rinci, tahap demi tahap dalam pemilihan supplier menggunakan prototipe aplikasi ini terbagi menjadi 3 tahap utama, yaitu :

Tahap ke-1 Pengelolaan data Sistem Informasi Manajemen, data yang digunakan adalah Database Main, table yang digunakan adalah Tabel Kriteria, Tabel Kinerja Supplier, Tabel Hasil Seleksi, Tabel Supplier, Table Spare part, Tabel Memasok

Tahap ke-2 Pencarian nilai optimal tiap kriteria. Pada tahap ini, pengguna memasukkan data bobot kriteria untuk dihitung bobot optimalnya menggunakan algoritma genetika. Hasil dari perhitungan ini diinput secara manual untuk masuk pada tahap ke-3.

Tahap ke-3 Memilih supplier berdasarkan bobot parameter kriteria optimal dari hasil perhitungan Generic Algorythms pada tahap 2. Tabel yang digunakan pada tahap ini adalah Tabel tb_Alternatif, Tabel tb_Sub, Tabel tb_Kriteria, tabel tb_Rel_Kriteria. Hasil pengolahan data menggunakan algoritma MCDM ditampilkan di layar, dan bisa disimpan dalam bentuk printout PDF.

5.4.2. Optimasi pencarian supplier menggunakan *Genetic Algorythms*

Seperti yang telah dijelaskan pada sub bab 3.5 diatas, pada tahap ini *Genetic Algorythms* digunakan untuk mencari bobot optimal yg digunakan untuk penyeleksian menggunakan MCDM berikutnya. Secara ilustratif pada tahap ini ditunjukkan oleh Gambar 5.9 Pada awalnya, untuk tiap parameter diberi bobot random oleh sistem komputer lalu dilakukan operasi GA (Sholihah, 2018) dengan menghitung nilai fitness (Stackoverflow, 2014) yaitu :

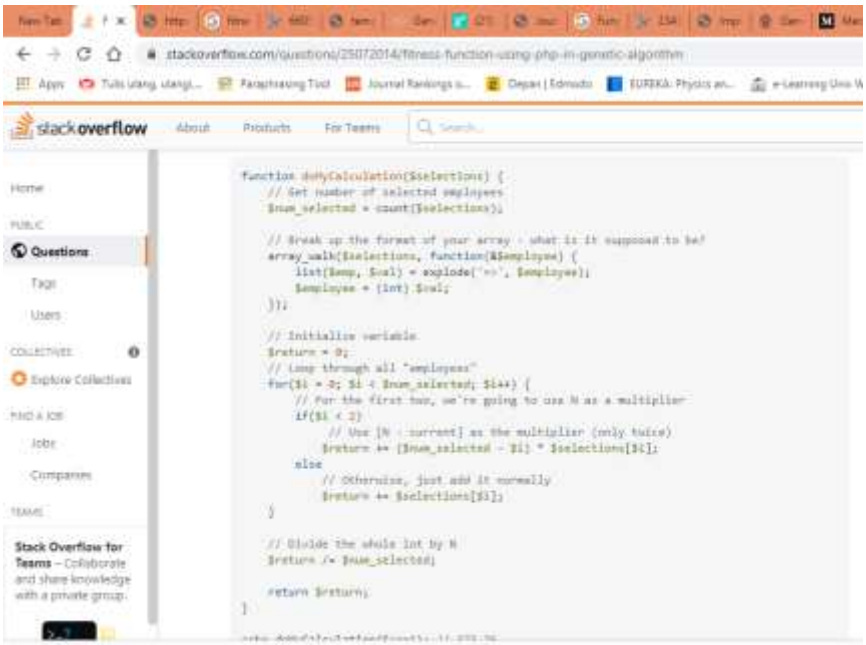
1. Pembentukan Kromosom dan Populasi

Pada pembentukan kromosom awal ini, disusun nilai bobot yang akan dihitung menggunakan fungsi fitness. Kromosom ini berisi nilai bobot yang merupakan data input pada perhitungan GA. Kami menentukan nilai tiap bobot kromosom B01, B02, B03 pada studi kasus bisa menggunakan random array dengan nilai batasi 1-5

2. Fungsi Fitness

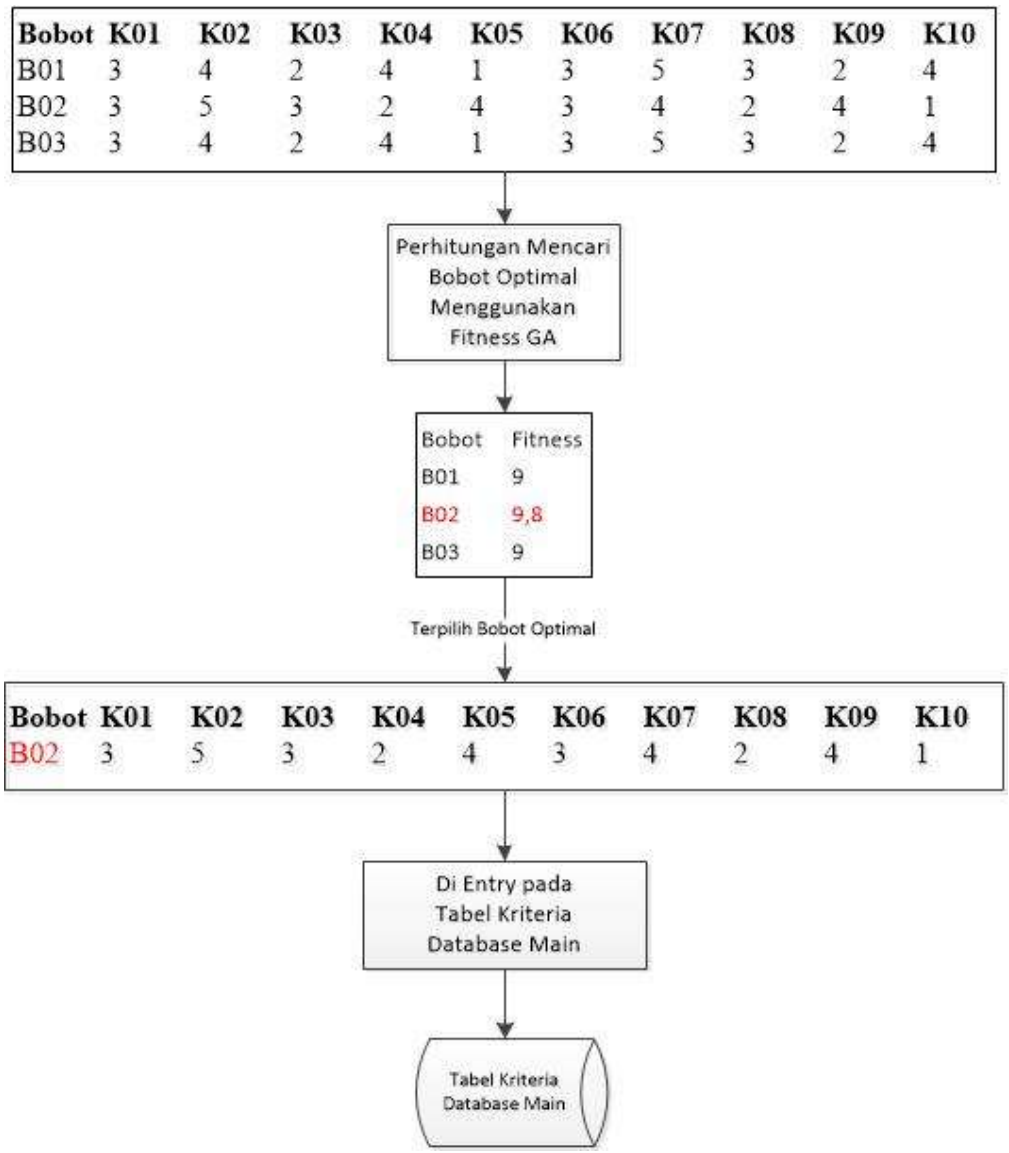
Fungsi fitness dari suatu kromosom adalah nilai kecocokan kromosom terhadap permasalahan. Semakin tinggi nilai fitness, seharusnya solusi tersebut semakin optimal.

Berdasarkan langkah diatas diujicoba pada bobot random dengan langkah sebagai berikut : Didefinisikan dahulu nilai untuk populasi Bobot (B01,B02,B03) (dibatasi 3 alternatif bobot saja agar tidak terlalu lama mencari bobot optimal/fitness). Script coding PHP untuk mencari nilai fitness ditunjukkan oleh gambar 5.8, dan hasilnya ditampilkan pada Tabel 5.3.




Gambar 5. 8 Script Coding PHP untuk memperoleh Nilai Fitness GA

Sumber : Stackoverlflow (Stackoverflow, 2014)




Gambar 5. 9. Proses Entry Bobot Optimal Hasil Perhitungan GA pada Tabel Kriteria Database Main

Tabel 5. 3 Bobot Kriteria

| Bobot | K01 | K02 | K03 | K04 | K05 | K06 | K07 | K08 | K09 | K10 |
|---|---|---|---|---|---|---|---|---|---|---|
| B01 | 3 | 4 | 2 | 4 | 1 | 3 | 5 | 3 | 2 | 4 |
| B02 | 3 | 5 | 3 | 2 | 4 | 3 | 4 | 2 | 4 | 1 |
| B03 | 3 | 4 | 2 | 4 | 1 | 3 | 5 | 3 | 2 | 4 |

Berdasarkan perhitungan menggunakan script PHP diperoleh sebagai berikut :

| Bobot | Fitness |
|---|---|
| B01 | 9 |

B02 9,8

B03 9

Maka yang terpilih adalah bobot dengan nilai fitness tertinggi adalah B02.

Bobot pada indeks B02 ini yang akan diinput pada database dan digunakan untuk menjalankan Pengambilan Keputusan berbasis Multicriteria Decision Making menggunakan metode Fuzzy AHP yang dijelaskan pada sub bab 5.4.3. dibawah ini. Secara lengkap alur input data dari hasil optimasi GA menuju database yang digunakan untuk pengambilan keputusan dengan metode Multicriteria Decision Making ditunjukkan pada gambar 5.9. Proses Entry Bobot Optimal Hasil Perhitungan GA pada Tabel Kriteria Database Main diatas.

### 5.4.3. Pengambilan Keputusan berbasis *Multicriteria Decision Making* Menggunakan Metode *Fuzzy Analytical Hierarchy Process*

Pada langkah awal yang dilakukan untuk memilih pemasok terbaik menggunakan metode F-AHP ialah dengan menyusun struktur hirarki dari permasalahan yang dihadapi. Dalam menyusun hirarki diawali dengan menentukan tujuan (goal) dari permasalahan yang dihadapi, selanjutnya menentukan kriteria dan alternatif. Tujuan permasalahan dalam penelitian ini adalah pemilihan pemasok terbaik. Terdapat 10 kriteria yang digunakan dalam penelitian ini untuk memilih pemasok terbaik, yaitu Kemampuan Manajemen (K1), Harga (K2), Kesadaran Lingkungan (K3), Pengiriman (K4), Layanan (K5), Fleksibilitas (K6), Kemampuan Teknis (K7), Inovatif (K8), Pendekatan Manajemen (K9) dan Letak Geografis (K10). Perhitungan Bobot Prioritas Kriteria

a) Pembuatan matriks perbandingan berpasangan kriteria

Pada tahap ini dilakukan penilaian perbandingan antara satu kriteria dengan kriteria lainnya. Matriks perbandingan berpasangan kriteria dapat dilihat pada tabel berikut. Nilai jumlah pada tabel 5.3 diperoleh dengan cara menjumlahkan nilai perbandingan pada masing-masing kolom.

Tabel 5. 4 Matrix Perbandingan Berpasangan

| | **K1** | **K2** | **K3** | **K4** | **K5** | **K6** | **K7** | **K8** | **K9** | **K10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **K1** | 1 | 0,200 | 3 | 0,333 | 0,333 | 0,333 | 1 | 1,000 | 3 | 0,333 |
| **K2** | 5 | 1 | 7 | 3 | 3 | 3 | 5 | 3 | 5 | 3 |
| **K3** | 0,333 | 0,143 | 1 | 0,200 | 0,200 | 0,200 | 0,333 | 0,200 | 0,333 | 0,333 |
| **K4** | 3,000 | 0,333 | 5 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| **K5** | 3,000 | 0,333 | 5 | 0,333 | 1 | 1 | 3 | 3 | 3 | 3 |
| **K6** | 3,000 | 0,333 | 5 | 0,333 | 1,000 | 1 | 3,000 | 3 | 3 | 3 |
| **K7** | 1,000 | 0,200 | 3 | 0,333 | 0,333 | 0,3333 | 1 | 0,333 | 3 | 0,333 |
| **K8** | 1,000 | 0,333 | 5 | 0,333 | 0,333 | 0,3333 | 3 | 1 | 3 | 3 |
| **K9** | 0,333 | 0,200 | 3 | 0,333 | 0,333 | 0,333 | 0,333 | 0,333 | 1 | 0,333 |
| **K10** | 3,000 | 0,333 | 3 | 0,333 | 0,3333 | 0,3333 | 3 | 0,333 | 3 | 1 |
| **K11** | 20,667 | 3,410 | 40,000 | 6,533 | 9,867 | 9,867 | 22,667 | 15,200 | 27,333 | 17,333 |

b) Penentuan nilai prioritas kriteria

Untuk menentukan nilai prioritas kriteria yaitu dengan membagi nilai masing-masing sel dengan jumlah masing-masing kolom. Setelah diperoleh hasil pembagian masing-masing kolom, maka dapat dihitung nilai prioritas kriteria. Nilai prioritas kriteria dihitung dengan cara membagi nilai jumlah pada masing-masing baris dengan jumlah kriteria.

c) Pengukuran Konsistensi

Dalam mengukur konsistensi dilakukan perhitungan lamda max, CI dan CR. Apabila nilai CR $\leq$ 0,1 maka matrik perbandingan berpasangan dinyatakan konsisten. Nilai vektor prioritas diperoleh dari perkalian matrik perbandingan berpasangan dengan nilai prioritas, sedangkan nilai prioritas diperoleh dari perhitungan sebelumnya. Untuk nilai lamda diperoleh dari hasil pembagian nilai vektor prioritas dengan nilai prioritas. Menghitung nilai lamda max didapatkan dari total lamda dibagi dengan banyaknya kriteria dan menghitung nilai CI dan CR.

Tabel 5. 5 Perhitungan Konsistensi Ratio

| Vektor prioritas | Prioritas | Lamda |
|---|---|---|
| 0,580 | 0,054 | 10,741 |
| 2,854 | 0,255 | 11,187 |
| 0,231 | 0,021 | 10,832 |
| Vektor prioritas | Prioritas | Lamda |
| 2,014 | 0,174 | 11,564 |
| 1,404 | 0,123 | 11,377 |
| 1,404 | 0,123 | 11,377 |
| 0,521 | 0,050 | 10,521 |
| 0,958 | 0,087 | 10,997 |
| 0,380 | 0,036 | 10,539 |
| 0,813 | 0,076 | 10,723 |
| Lamda max | | 10,986 |
| CI | | 0,110 |
| CR | | 0,074 |

Tabel 5. 6 Nilai Sintesis Fuzzy

| | Jumlah Baris | | | Si | | |
|---|---|---|---|---|---|---|
| | l | m | u | l | m | u |
| K1 | 7,333 | 9,067 | 11,500 | 0,050 | 0,080 | 0,133 |
| K2 | 15,000 | 19,500 | 24,000 | 0,102 | 0,171 | 0,277 |
| K3 | 4,583 | 5,552 | 7,333 | 0,031 | 0,049 | 0,085 |
| K4 | 10,500 | 14,667 | 19,000 | 0,072 | 0,129 | 0,219 |
| K5 | 10,000 | 13,333 | 17,000 | 0,068 | 0,117 | 0,196 |
| K6 | 10,000 | 13,333 | 17,000 | 0,068 | 0,117 | 0,196 |
| K7 | 6,833 | 8,733 | 11,500 | 0,047 | 0,077 | 0,133 |
| K8 | 9,000 | 11,667 | 15,000 | 0,061 | 0,103 | 0,173 |
| K9 | 5,833 | 7,567 | 10,500 | 0,040 | 0,067 | 0,121 |
| K10 | 7,500 | 10,333 | 14,000 | 0,051 | 0,091 | 0,162 |
| **Total** | **86,580** | **113,750** | **146,830** | | | |

d) Mengubah nilai matrik perbandingan berpasangan kriteria ke F-AHP

Konversi nilai perbandingan berpasangan AHP ke nilai himpunan *fuzzy* (F-AHP) dilakukan dengan menggunakan TFN.

e) Menentukan nilai sintesis fuzzy $S_i$ prioritas

Berdasarkan tabel 4 jumlah baris l, m, u diperoleh dari penjumlahan nilai l, m, u tiap baris. Nilai sintesis *fuzzy* baris K1 kolom l diperoleh dari hasil bagi antara jumlah baris l kriteria 1 dengan total nilai u pada jumlah baris. Nilai sintesis *fuzzy* baris K1 kolom m diperoleh dari hasil bagi antara jumlah baris m kriteria 1 dengan total nilai m pada jumlah baris, sedangkan nilai sintesis *fuzzy* baris K1 kolom u diperoleh dari hasil bagi antara jumlah baris u kriteria 1 dengan total nilai l pada jumlah baris.

f) Perhitungan nilai vektor F-AHP (V) dan nilai ordinat defuzzifikasi (d')

Proses penghitungan nilai vektor F-AHP dan nilai ordinat *defuzzifikasi* dilakukan dengan persamaan (4), (5), dan (6).

Dari tabel perhitungan $S_i$ table IV, dapat dihitung nilai *v* dan *d'*

$$V_sK1 \geq (V_sK2, V_sK3, V_sK4, V_sK5, V_sK6, V_sK7, V_sK8, V_sK9, V_sK10)$$

$V_sK1 \geq V_sK2$ = 1

$V_sK1 \geq V_sK3$ = $\frac{0{,}50-0{,}85}{(0{,}049-0{,}085)-(0{,}079-0{,}050} = 0{,}529$

$V_sK1 \geq V_sK4$ = 1

$V_sK1 \geq V_sK5$ = 1

$V_sK1 \geq V_sK6 = 1$

$V_sK1 \geq V_sK7 = \frac{0{,}080 - 0{,}133}{(0{,}077-0{,}133)-(0{,}079-0{,}049} = 0{,}966$

$V_sK1 \geq V_sK8 = 1$

$V_sK1 \geq V_sK9 = \frac{0{,}050 - 0{,}162}{(0{,}091-0{,}0{,}162)-(0{,}080-0{,}050} = 0{,}844$

$V_sK1 \geq V_sK10$ = 1

Sehingga diperoleh nilai ordinat *fuzzy* (*d'*)

*d'* ($V_sK1$) = min (1; 0,529; 1; 1; 1; 0,966; 1; 0,844; 1)

Berdasarkan nilai ordinat K1, K2, K3, K4, K5, K6, K7, K8, K9 dan K10, maka nilai bobot vektor *fuzzy* dapat ditentukan dengan menggunakan persamaan 2.8. sebagai berikut:

$W'$ = $(0{,}529; 0; 1; 0{,}141; 0{,}195; 0{,}195; 0{,}577; 0{,}303; 0{,}717; 0{,}444)^T$

$\sum W'$ = 4,103

g) Normalisasi nilai bobot vektor fuzzy (W)

Normalisasi nilai bobot vektor *fuzzy* diperoleh dengan persamaan rumus 2.10, dimana tiap elemen bobot vektor dibagi dengan bobot vektor itu sendiri. Sehingga bobot kriteria (lokal) yang diperoleh adalah 0,129; 0; 0,244; 0,034; 0,048; 0,048; 0,141; 0,074; 0,175; 0,108.

h) Penyelesaian Alternatif

Langkah - langkah penyelesaian alternatif sama dengan langkah penyelesaian pada kriteria. Setiap pemasok dinilai berdasarkan kriteria. Nilai yang diberikan pada pemasok digunakan untuk membandingkan nilai pemasok terhadap kriteria yang dinilai yaitu K1,.,K10. Nilai pemasok dapat dilihat pada tabel 5.7

Tabel 5. 7. Sample Nilai Pemasok

| | K1 | K2 | K3 | K4 | K5 | K6 | K7 | K8 | K9 | K10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Alternatif 1 | 5 | 4 | 3 | 5 | 5 | 4 | 5 | 4 | 4 | 2 |
| Alternatif 2 | 4 | 5 | 4 | 2 | 3 | 3 | 4 | 3 | 4 | 5 |
| Alternatif 3 | 5 | 5 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 4 |

Langkah - langkah penyelesaian alternatif sama dengan langkah penyelesaian pada kriteria. Nilai pemasok terhadap kriteria akan dibandingkan satu per satu ke dalam matrik perbandingan AHP dan F-AHP. Setiap pemasok diinisialisasikan sebagai alternatif A. Berikut matrik perbandingan berpasangan AHP.

Tabel 5. 8 Matrik Perbandingan Berpasangan

| | A1 | A2 | A3 |
|---|---|---|---|
| A1 | 1 | 2 | 1,000 |
| A2 | 0,500 | 1 | 0,500 |

| | | | |
|---|---|---|---|
| A3 | 1,000 | 2,000 | 1 |
| Total | 2,500 | 5,000 | 2,500 |

i) Mengubah nilai matrik perbandingan berpasangan alternatif ke F-AHP

Dari tabel VI nilai perbandingan berpasangan diubah ke dalam nilai himpunan fuzzy (F-AHP). Matrik perbandingan berpasangan alternatif F-AHP dapat dilihat pada table 5.9

Tabel 5. 9 Matrix Perbandingan TFN

| TFN | A1 | | | A2 | | | A3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | l | m | u | l | m | u | l | m | u |
| A1 | 1 | 1 | 1 | 2/3 | 1 | 2 | 2/3 | 1 | 2 |
| A2 | 1/2 | 1 | 1 1/2 | 1 | 1 | 1 | 1 | 1 | 1 |
| A3 | 1/2 | 1 | 1 1/2 | 1 | 1 | 1 | 1 | 1 | 1 |

j) Menentukan nilai sintesis fuzzy $S_i$ prioritas

Nilai sintesis *fuzzy* diperoleh dari pengolahan data pada tabel 5.10, sehingga diperoleh nilai sintesis ($S_i$) pada tabel 5.9

Tabel 5. 10 Nilai Sintesis Fuzzy

| | Jumlah Baris | | | Si | | |
|---|---|---|---|---|---|---|
| | l | m | u | l | m | u |
| A1 | 2,333 | 3,000 | 5,000 | 0,194 | 0,333 | 0,682 |
| A2 | 2,500 | 3,000 | 3,500 | 0,208 | 0,333 | 0,477 |
| A3 | 2,500 | 3,000 | 3,500 | 0,208 | 0,333 | 0,477 |
| Total | 7,333 | 9,000 | 12,000 | | | |

k) Perhitungan nilai vektor F-AHP (V) dan nilai ordinat defuzzifikasi (d')

1) $V_sA1 \geq (V_sA2, V_sA3)$

$V_sA1 \geq V_sA2 = 1$

$V_sA1 \geq V_sA3 = 1$

Sehingga diperoleh nilai ordinat *fuzzy* (*d'*)

*d'* ($V_sA1$) = min (1; 1)

2) $V_sA2 \geq (V_sA1, V_sA3)$

$V_sA2 \geq V_sA1 = 1$

$V_sA2 \geq V_sA3 = 1$

Sehingga diperoleh nilai ordinat *fuzzy* (*d'*)

*d'* ($V_sK2$) = min (1; 1)

3) $V_sA3 \geq (V_sA1, V_sA2)$

$V_sA3 \geq V_sA1 = 1$

$V_sA3 \geq V_sA2 = 1$

Sehingga diperoleh nilai ordinat *fuzzy* (*d'*)

d' ($V_sA3$) = min (1; 1)

Dari ordinat nilai A1, A2 dan A3 dapat ditentukan nilai bobot vektor fuzzy sebagai berikut.

$W'$ = $(1; 1; 1)^T$

$\sum W'$ = 3

Normalisasi nilai bobot vektor fuzzy (W)

Dari perhitungan alternatif terhadap kriteria di atas diperoleh bobot prioritas masing-masing alternatif (pemasok), yaitu bobot A1 = 0,333, bobot A2 = 0,333 dan bobot A3 = 0,333.

l) Perangkingan alternatif dan hasil keputusan

Perangkingan alternatif merupakan langkah untuk mendapatkan keputusan akhir. Pada tahap ini, dilakukan perhitungan nilai bobot global dengan cara mengalikan bobot (W) prioritas masing-masing alternatif dengan bobot prioritas lokal kriteria dan dijumlahkan hasil perkalian tiap alternatif. Hasil penjumlahan bobot menghasilkan bobot global yang kemudian dirangkingkan dan diperoleh pemasok terbaik. Berikut merupakan tabel 5.11 hasil akhir penentuan pemasok terbaik.

Tabel 5. 11. Tabel Perangkingan Alternatif

| Global | K1 | K2 | K3 | K4 | K5 | K6 | K7 | K8 | K9 | K10 | Weight | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bobot (W) | 0,129 | 0,000 | 0,244 | 0,034 | 0,048 | 0,048 | 0,141 | 0,074 | 0,175 | 0,108 | | |
| | Alternatif | | | | | | | | | | | |
| A1 | 0,333 | 0,333 | 0,333 | 0,200 | 0,297 | 0,333 | 0,297 | 0,333 | 0,333 | 0,531 | 0,343 | 1 |
| A2 | 0,333 | 0,333 | 0,333 | 0,531 | 0,366 | 0,333 | 0,337 | 0,333 | 0,333 | 0,200 | 0,328 | 3 |
| A3 | 0,333 | 0,333 | 0,333 | 0,268 | 0,337 | 0,333 | 0,366 | 0,333 | 0,333 | 0,268 | 0,329 | 2 |

Berdasarkan perhitungan menggunakan *fuzzy* AHP didapatkan bobot global masing-masing alternatif (pemasok), yaitu A1 = 0,343; A2 = 0,328 dan A3 = 0,329. Bobot global masing-masing alternatif digunakan untuk menentukan rangking alternatif terbaik, dimana alternatif dengan bobot global tertinggi akan mendapatkan rangking terbaik.

## 5.5. Pembahasan

Integrasi data spare part produk traktor dengan data supplier dicapai dengan bantuan teori :

a. *BoM* yang digunakan untuk merincikan kebutuhan spare part secara detail, dan mencatatnya dalam media tabel database kemudian merelasikan tabel spare part tersebut dengan data supplier.
b. Grup teknologi digunakan untuk mempermudah pengelolaan database spare part, yaitu untuk menyusun pengkodean spare part *(Code Part Number)*
c. Keseluruhan database yang terintegrasi tersebut pada akhirnya dikembangkan dan dikelola dalam lingkungan database relasional dengan software DBMS *(Database Management System) MySQL*, dan bahasa pemrograman berbasis web *PHP 7*.

Mengingat watak dinamis pada data tersebut, maka untuk memudahkan manajemen data dikembangkan user interface yang terdiri form dan report. Melalui form user dapat mengedit dan melihat data yang ada pada sistem database utama yang berisi tabel spare part, tabel kinerja supplier database supplier.

Untuk menarik laporan berupa data yang diperlukan atau untuk kebutuhan analisa, dibuat query dengan bahasa SQL yang hasilnya ditampung dalam suatu tabel dan ditampilkan dalam bentuk report.

Untuk optimasi pemilihan supplier, maka faktor yang diperhitungkan adalah:

a. Kemampuan manajemen
b. Harga

c. Kesadaran lingkungan
d. Kinerja pengiriman
e. Service (Layanan)
f. Fleksibilitas
g. Kemampuan teknis
h. Inovatif
i. Pendekatan manajemen
j. Lokasi geografis

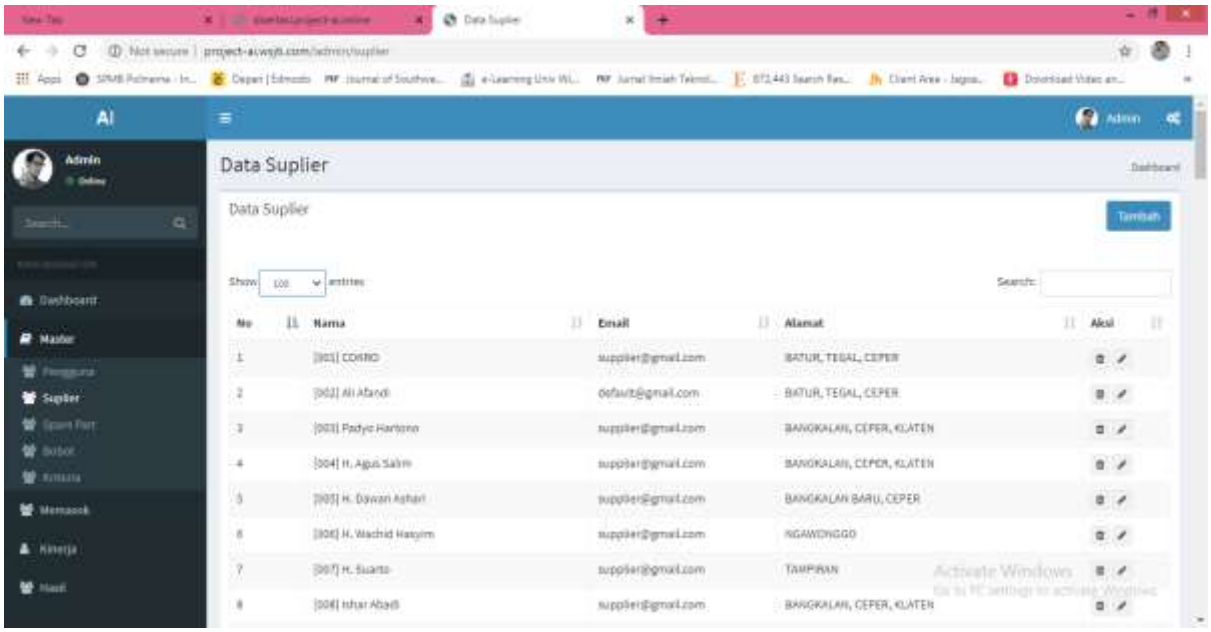
Kemudian dibuatkan sebuah fungsi optimasi supplier dengan *Genetic algorythm* untuk menerima parameter/faktor diatas lalu dihitung dengan metode *multicriteria decision making* sehingga menghasilkan supplier yang terpilih.

Prototipe ini mempunyai kelebihan berupa integrasi data kinerja supplier dalam bentuk sistem database yang bisa diperbarui, dan fungsi optimasi *Genetic Algorythms* yang bisa diakses secara online. Adapun kelemahan dari asitektur integrasi ini adalah belum bisa diakses melalui dawai seluler, dan masih tersedia dalam Bahasa Indonesia.

5.6. Hasil Tampilan Antarmuka Prototipe Pemilihan Supplier Berbasis Web

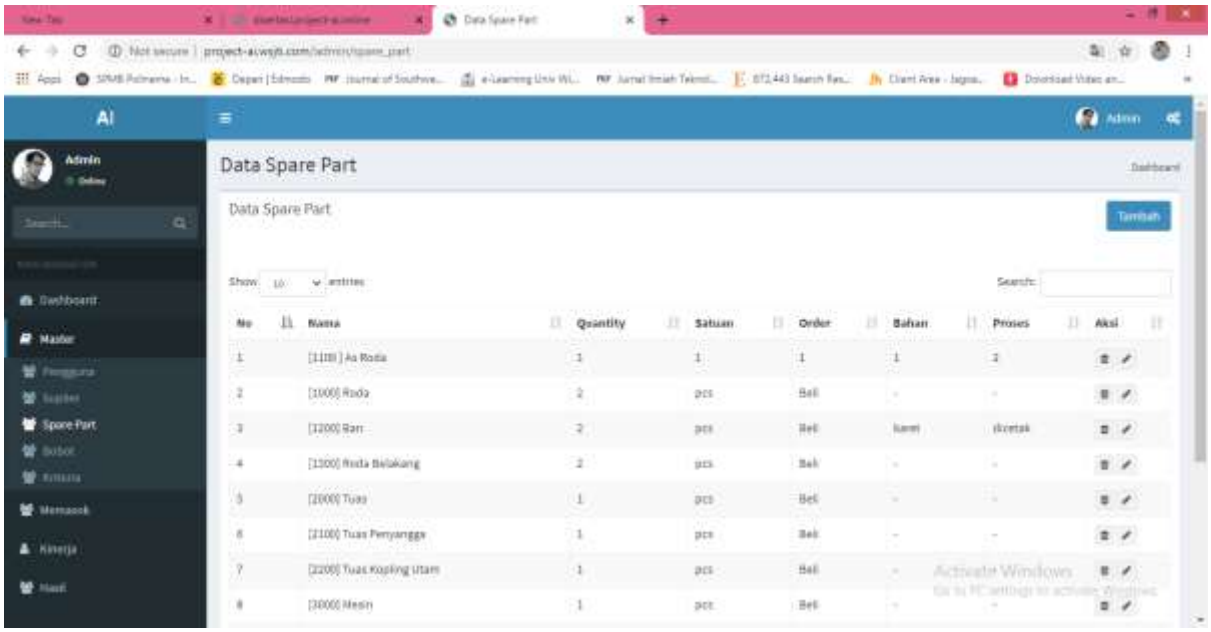
Seperti yang sudah dijelaskan pada sub bab 5.1 sampai dengan 5.8, pada sub Bab
Situs ini bisa diakses online di http://disertasi.project-ai.my.id,

Secara umum aplikasi web tersebut bisa ditampilkan pada beberapa gambar di bawah ini :
Tampilan antarmuka pada data supplier ditunjukkan pada gambar 5.8



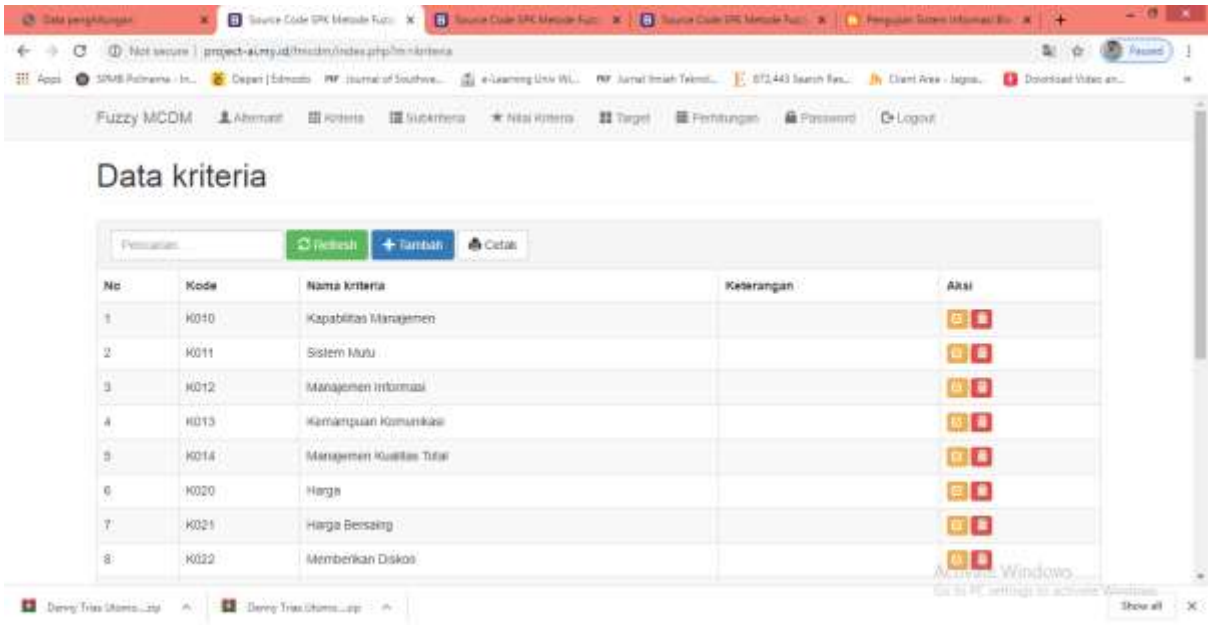

Gambar 5. 10. Data Supplier

Tampilan antar muka untuk data spare part sesuai struktur produk bisa diamati pada gambar 5.9



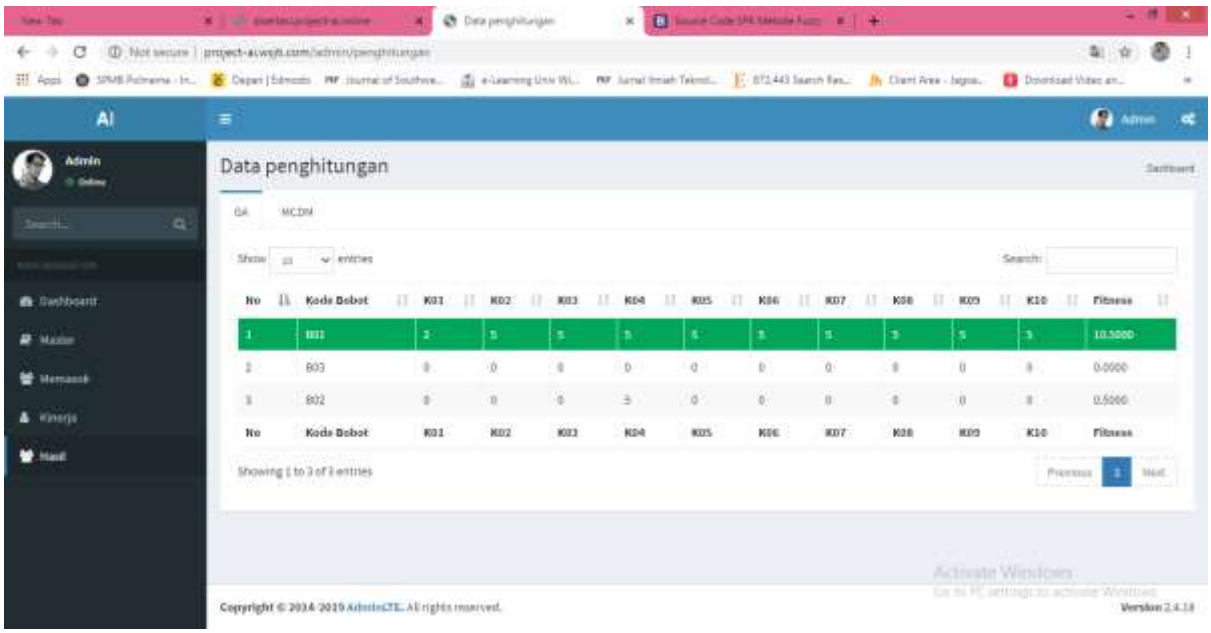

Gambar 5. 11. Data Spare Part  Sesuai Struktur Produk

Tampilan antarmuka pada data kriteria bisa dilihat pada Gambar 5.10



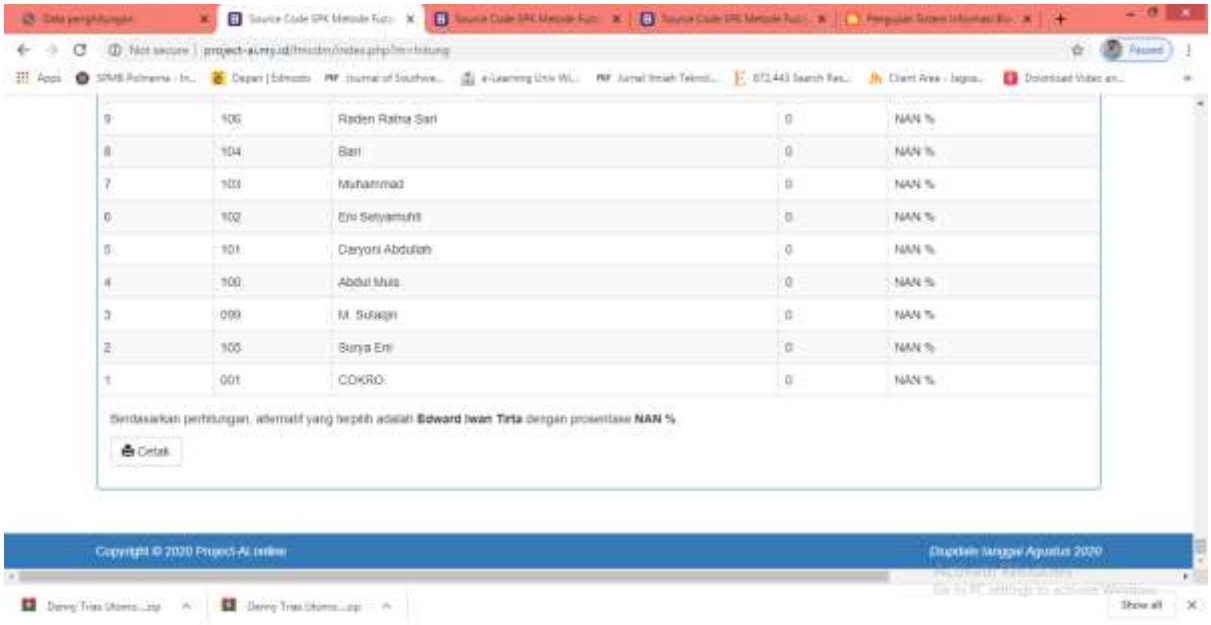

Gambar 5. 12. Data Kriteria

Tampilan antarmuka Data Perhitungan Optimasi Bobot algoritma genetika ada pada Gambar 5.11




Gambar 5. 13. Data Perhitungan Bobot Optimal Menggunakan *Genetic Algorthm*

Tampilan antarmuka hasil seleksi supplier terlihat pada Gambar 5.12

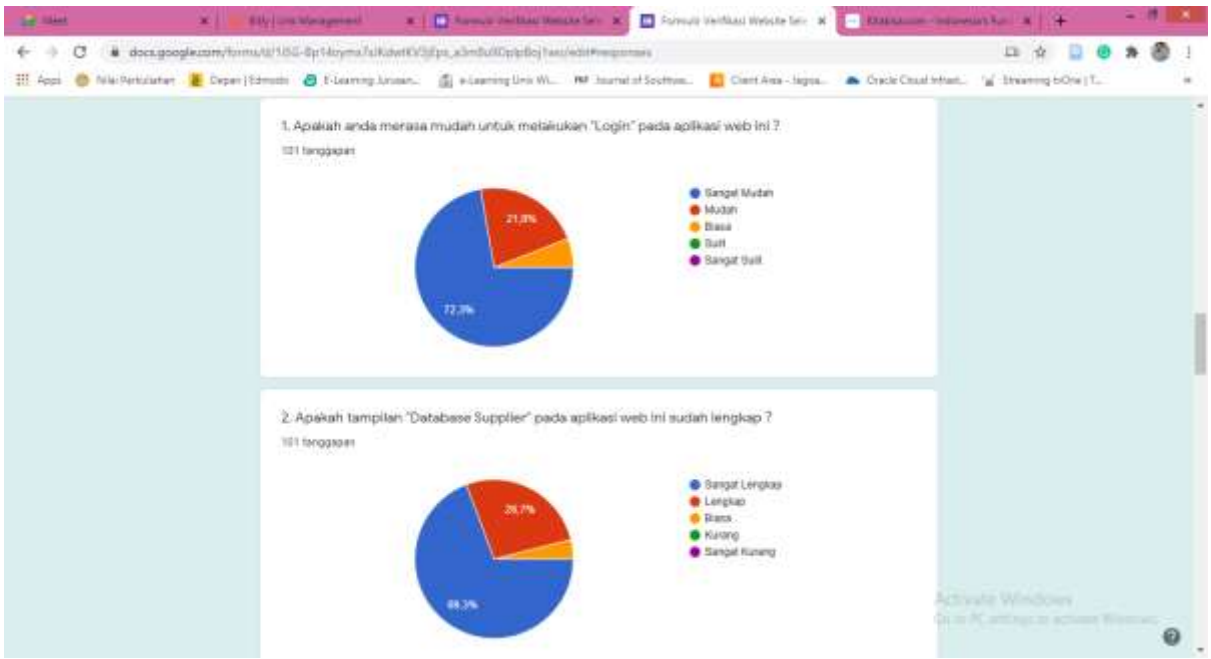


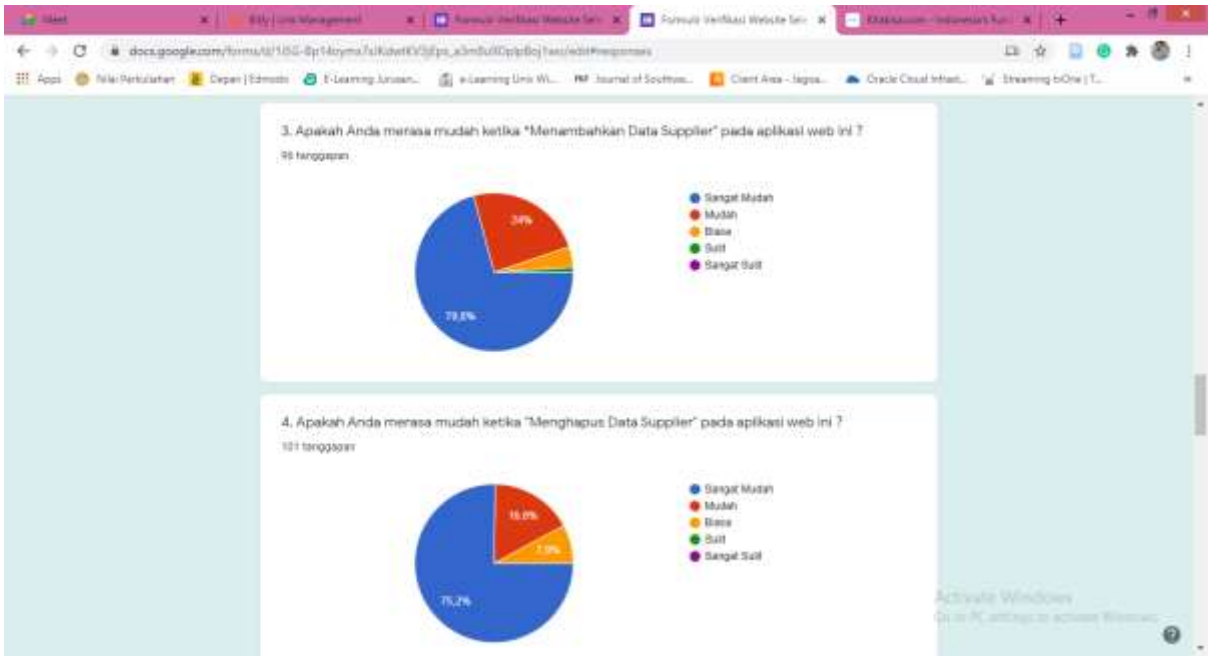

Gambar 5. 14. Hasil Seleksi Supplier

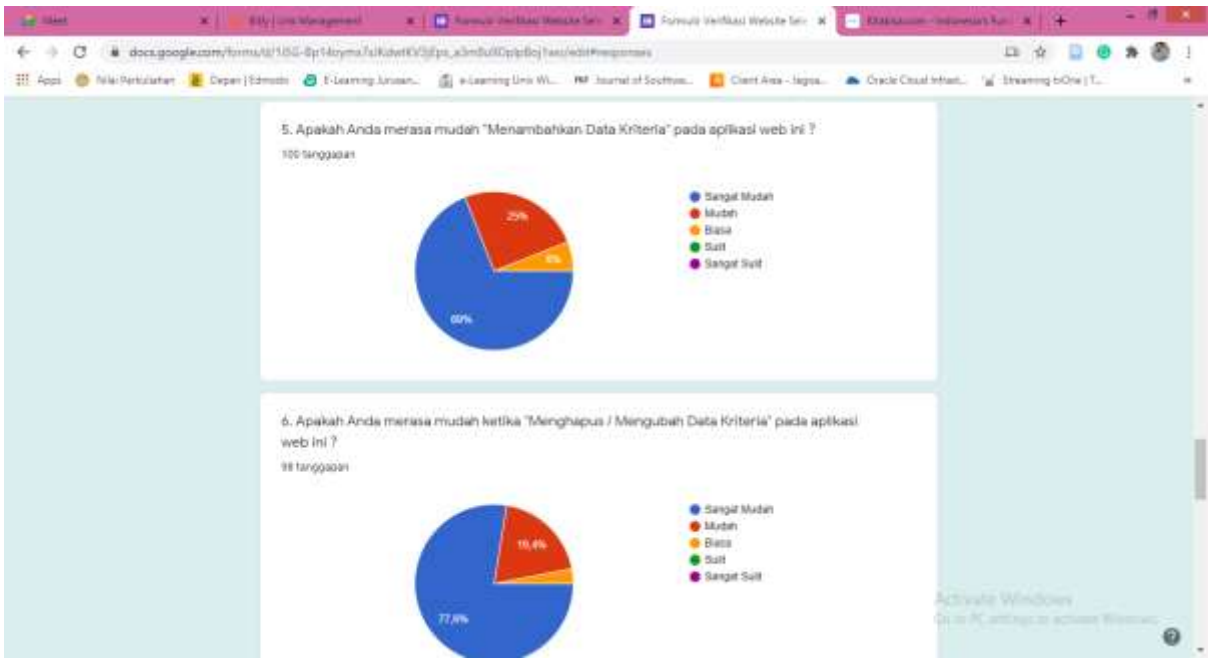
5.7.Verifikasi Sistem

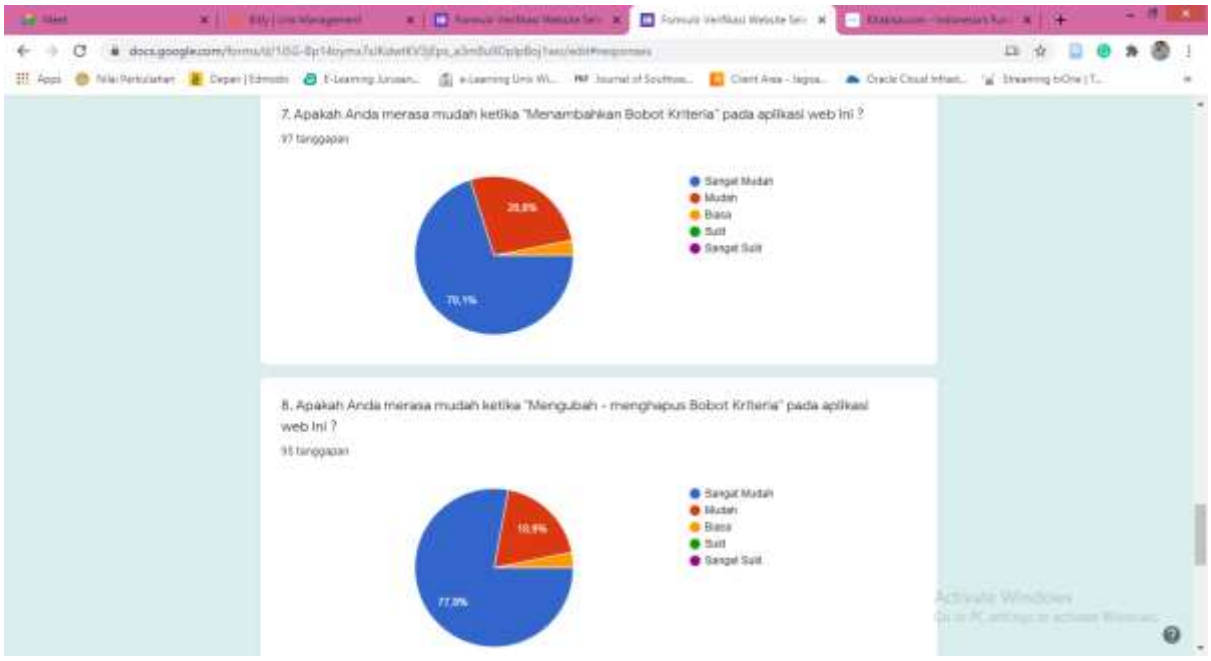
Berdasarkan hasil survey secara online melalui aplikasi Google Form dengan 101 responden, diperoleh hasil sebagai berikut : Sangat mudah" dan "Mudah" atau "Sangat lengkap" dan "Lengkap" atau "Sangat tepat" dan "Tepat" $\geq$ **80 %**, ini menunjukkan bahwa aplikasi / web yang dihasilkan dalam penelitian ini sesuai dengan harapan IKM pengguna (*Verified*).

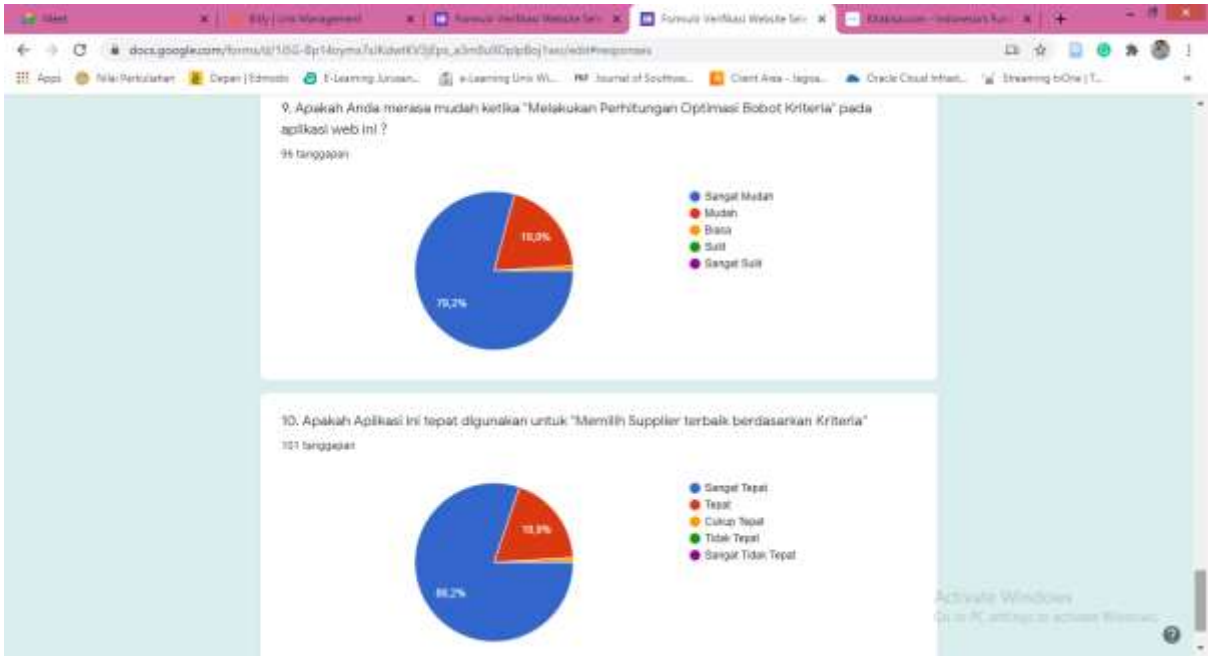
Secara rinci disajikan pada Grafik berikut ini




3. Apakah Anda merasa mudah ketika "Menambahkan Data Supplier" pada aplikasi web ini ?
98 tanggapan
Sangat Mudah
Mudah
Biasa
Sulit
Sangat Sulit
4. Apakah Anda merasa mudah ketika "Menghapus Data Supplier" pada aplikasi web ini ?
101 tanggapan
Sangat Mudah
Mudah
Biasa
Sulit
Sangat Sulit


5. Apakah Anda merasa mudah "Menambahkan Data Kriteria" pada aplikasi web ini ?
100 tanggapan
Sangat Mudah
Mudah
Biasa
Sulit
Sangat Sulit
6. Apakah Anda merasa mudah ketika "Menghapus / Mengubah Data Kriteria" pada aplikasi web ini ?
98 tanggapan
Sangat Mudah
Mudah
Biasa
Sulit
Sangat Sulit


7. Apakah Anda merasa mudah ketika "Menambahkan Bobot Kriteria" pada aplikasi web ini ?
97 tanggapan
20,6%
79,1%
Sangat Mudah
Mudah
Biasa
Sulit
Sangat Sulit
8. Apakah Anda merasa mudah ketika "Mengubah - menghapus Bobot Kriteria" pada aplikasi web ini ?
95 tanggapan
10,5%
77,9%
Sangat Mudah
Mudah
Biasa
Sulit
Sangat Sulit


9. Apakah Anda merasa mudah ketika "Melakukan Perhitungan Optimasi Bobot Kriteria" pada aplikasi web ini ?
96 tanggapan
10,0%
79,2%
Sangat Mudah
Mudah
Biasa
Sulit
Sangat Sulit
10. Apakah Aplikasi ini tepat digunakan untuk "Memilih Supplier terbaik berdasarkan Kriteria"
101 tanggapan
10,9%
89,2%
Sangat Tepat
Tepat
Cukup Tepat
Tidak Tepat
Sangat Tidak Tepat

# BAB 6

# PENUTUP

## 6.1. Kesimpulan

Penelitian ini menghasilkan sebuah alternatif solusi dalam memilih supplier berbasis web dengan cara mengintegrasikan database supplier, database suku cadang, dan database kriteria untuk memilih supplier pada industri manufaktur traktor tangan menggunakan *Bill of Material, Group Technology, Genetic Algorythms, dan Multi Criteria Decision Making,* yang secara detil bisa disimpulkan sebagai berikut :

1. Telah diidentifikasi faktor utama dalam memilih pemasok spare parts pada industri traktor tangan yang terdiri atas 10 faktor utama yaitu : Kemampuan manajemen, Harga, Kesadaran lingkungan, Kinerja pengiriman, Service (Layanan), Fleksibilitas, Kemampuan teknis, Inovatif, Pendekatan manajemen, Lokasi geografis
2. Atas dasar BoM dan faktor faktor utama pemilihan supplier dirancang metode baru berbasis database relasional untuk menyimpan data spare parts traktor dan data supplier yang baik untuk memilih supplier yang terdiri atas tabel-tabel: Tabel Supplier, Tabel Spare Part, Tabel Kinerja Supplier, Tabel Kriteria, Tabel Hasil Seleksi Supplier, Tabel Memasok
3. Telah diintegrasikan database spare parts dan supplier dengan metode optimasi pemilihan supplier menggunakan Metode *Genetic Algorythms* dan *Multicriteria Decision Making* dengan arsitektur sebagai berikut :
    a. Membangun basis pengetahuan dengan cara membuat desain *Bill of Material* untuk menyusun Struktur Produk traktor tangan,
    b. Pemanfaatan *Group Technology* untuk menyusun tabel bahan baku berdasarkan struktur produk serta untuk mendesain *Primary Key* yang digunakan sebagai *Code Part Number*
    c. Membuat desain database berdasarkan Struktur Produk dan GT, maka disusun database diagram sebagai *Logical Database Design* dan *Physical Database* menggunakan *MySQL*.
    d. Membangun Sistem Informasi Supplier berbasis web dalam lingkungan database terintegrasi menggunakan bahasa pemrograman *PHP*.
    e. Menampilkan hasil pemilihan daftar supplier terangking yang sesuai kriteria

f. Telah berhasil dibangun prototipe aplikasi yang berbasis web untuk menguji temuan diatas dan bisa diakses melalui laman http://disertasi.project-ai.my.id. Berdasarkan hasil survey secara online melalui aplikasi Google Form dengan 101 responden, diperoleh hasil sebagai berikut : Sangat mudah" dan "Mudah" atau "Sangat lengkap" dan "Lengkap" atau "Sangat tepat" dan "Tepat" $\geq$ **80 %**, ini menunjukkan bahwa aplikasi / web yang dihasilkan dalam penelitian ini sesuai dengan harapan IKM pengguna *(Verified).*

## 6.2. Saran

Dari penelitian disertasi terhadap metode baru untuk memilih pemasok, maka alternatif solusi pemilihan supplier berbasis web menggunakan metode *computational intelegence*, sudah menunjukkan kesesuaian antara kebutuhan pemilihan supplier dengan kebutuhan ketersediaan bahan baku. Namun penelitian ini masih memerlukan adanya pengembangan dan penyempurnaan antara lain sebagai berikut :

1. Saran yang bersifat aplikatip yang ditujukan bagi industri: mengingat aplikasi yang dikembangkan masih bersifat prototipe, maka sebaiknya aplikasi ini dikembangkan lebih lanjut menjadi aplikasi yang profesional yang akan bermanfaat bagi industri di Indonesia.
2. Saran yang bersifat akademik bagi penelitian selanjutnya adalah :
   a. Diperlukan adanya penelitian lanjutan untuk menguji kemungkinan prototipe sistem pemilihan supplier yang dikembangkan ini dapat digunakan pada obyek industri manufaktur selain traktor tangan.
   b. Diperlukan penelitian lanjutan yang memanfaatkan metode-metode pemilihan supplier yang lain, misalnya menggunakan metode *Machine Learning*, disamping metode optimasi lainnya yang berbasis *Artificial Intelligent* seperti *Fuzzy, dan Neural Network*

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# LAMPIRAN

# LAMPIRAN A TABEL PUBLIKASI TERKAIT DISERTASI

# LAMPIRAN B GAMBAR TEKNIK HAND TRACTOR

# LAMPIRAN C DAFTAR SUPPLIER BAHAN BAKU DI CEPER

# LAMPIRAN D DATA DICTIONARY

# LAMPIRAN E PUBLIKASI JURNAL INTERNASIONAL JIAOTONG

# LAMPIRAN F SEMINAR NASIONAL ICEEBUS 2016

# LAMPIRAN G PUBLIKASI KEDUA EUREKA : SCIENCE AND ENGINEERING

# LAMPIRAN H ICOMERA UB 2020

# LAMPIRAN I KORESPONDENSI JSJU 2020

# LAMPIRAN J SURAT KETERANGAN BEBAS PLAGIASI DISERTASI

# LAMPIRAN A TABEL PUBLIKASI TERKAIT DISERTASI

## 1. Bill of Material

| No | Judul | Penulis | Publikasi | Abstrak |
|---|---|---|---|---|
| 1 | A unified bill of material based on STEP/XML<br>Judul Rapat : International Conference on Computer Supported Cooperative Work in Design | (Zhu et al., 2006) | Springer 2006 | Bill of Material (BOM) is of a great importance in the dynamic allied enterprises during the product life cycle. A unified BOM method was proposed in the paper in order to bridge the gap between the different forms of BOM. After analyzing the information flow from engineering BOM to manufacturing BOM, the system framework was established based on STEP and XML standards which can secure the product data's uniformity in a collaboration environment; and the implementing method and platform are also introduced. A case study has been conducted and shown that it is reasonable and feasible to tackle the multi-view issue of BOM and provide the integrity, conformability and instantaneity of product data. |
| 2 | Collaboration bill of material | (Ramankutty et al., 2003) | Jan 9 2003 | The present invention provides a software engine, a CBOM (collaboration bill of materials), to automate the collaboration process on a BOM that is distributed over the supply chain network and the demand chain network. In one embodiment of the invention, the CBOM comprises a rules engine, an optimization engine, an applications Server and a database Server. The rules engine implements rule-based decision making functions. The optimization engine of the CBOM allows the distributed system to resolve routine problems that may reoccur on a regular basis and provide a preferred, well-tested and unambiguous resolution to the routine problems. In one embodiment of the invention, the CBOM monitors for an arrival of an input or an event entered by a business party in the distributed |

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|---|---|---|---|---|
| | | | | production system. When an input is received by the CBOM, the CBOM performs an intelligent decision making by deter mining whether the input represents an out-of-tolerance case. If the input represents an out-of-tolerance case, the CBOM notifies a user or other business parties across the distributed system of difficulties and delays in production. If the input does not represent an out-of-tolerance case, the optimization engine of the CBOM crafts a corrective action in response to the input. |
| 3 | A tabu list-based algorithm for capacitated multilevel lot-sizing with alternate bills of materials and co-production environments | (Romero-Conrado et al., 2019) | Applied Sciences, 2019 | The definition of lot sizes represents one of the most important decisions in production planning. Lot-sizingturnsintoanincreasinglycomplexsetofdecisionsthatrequiresefficientsolution approaches,inresponsetothetime-consumingexactmethods(LP,MIP). Thispaperaimstoproposea Tabu list-based algorithm (TLBA) as an alternative to the Generic Materials and Operations Planning (GMOP) model. The algorithm considers a multi-level, multi-item planning structure. It is initialized using a lot-for-lot (LxL) method and candidate solutions are evaluated through an iterative Material Requirements Planning (MRP) procedure. Three different sizes of test instances are defined and betterresultsareobtainedinthelargeandmedium-sizeproblems,withminimumaveragegapsclose to 10.5%. |
| 4. | A Review on Automatic Bill of Material Generation and Visual Inspection on PCBs | (Azhagan et al., 2019) | ASM International, 2019 | The theme for the 2019 conference is Novel Computing Architectures. Papers will include discussions on the advent of Artificial Intelligence and the promise of quantum computing that are driving disruptive computing architectures; Neuromorphic chip designs on one hand, and Quantum Bits on the |

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| | | | | other, still in R&D, will introduce new computing circuitry and memory elements, novel materials, and different test methodologies. These novel computing architectures will require further innovation which is best achieved through a collaborative Failure Analysis community composed of chip manufacturers, tool vendors, and universities. |
| 5. | BOM (bill-of-material)-Based Structured Specification Generating Method | (Kao et al., 2020) | feb 6 2020, Arcare Innova Corp | A BOM (bill-of-material)-based structured software specification generating method is provided and includes the steps of: declaring a system architecture and an execution flow, declaring a plurality of elements, each of the elements being a programmable unit, generating a plurality of non-repetitive part numbers by a part number generator, each of the part numbers being correspondent to each of the elements which forming a plurality of forms, then both the system architecture and the execution flow representing the relationship between each two of the plurality of forms, defining characteristics of the plurality of elements for, and generating a BOM-based structured specification. |
| 6. | Design and implementation of intelligent manufacturing project management system based on bill of material | (Zhou & Cao, 2019) | Cluster Computing, 2019 | In order to meet the needs of manufacturing enterprises in materials management, improve the market competitiveness of enterprises, and realize the scientific management of modern enterprise, intelligent manufacturing engineering management system based on bill of material (BOM) was developed and designed. In this study, the concept and role of BOM are described in detail, the theory of intelligent manufacturing theory is explained, and the BOM classification method is introduced. |

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| | | | | In addition, a new BOM coding standard and method is applied to the original BOM code. This technology introduces the processing technology into the code, which effectively improves the readability of the code and solves the old garbled phenomenon. At the same time, an improved BOM quality tracking model was proposed. In this model, quality tracking of the whole process is implemented. The model can determine the origin of quality in the aspects of processing technology, processing workshop, production batch, purchasing batch, material supplier and so on, so as to provide reference for solving the problem. |
| 7. | Generating a Daily Bill of Materials at Level of Development 400 Using the Smallest Workface Boundary | (Song & Fischer, 2020) | Journal of Construction Engineering and Management, 2020 | Observations and sample tests at five construction sites showed that the time required for generating a daily bill of materials (BOM) is within the range of 12–68 min. However, 20 foremen interviewed at the sites stated that, in reality, they cannot spend more than 2–3 min per day generating a daily BOM, although this information would be helpful for field control. To meet this time requirement, this study uses a building information model at level of development (LOD) 400, i.e., the fabrication level, and a concept referred to as the smallest workface boundary (SWFB), which is the boundary that encapsulates a set of LOD400 objects in the smallest workable unit to overcome their high granularity. This research also presents four types of rules to automate the generation of SWFBs to the extent possible from LOD400 objects. The SWFB concept and rules are incorporated into a protype to aid a foreman in quickly generating a daily BOM with LOD400 objects. A methodology |

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| | | | | that a foreman can use with the prototype is also provided. For validation, field experiments were conducted at sites in Abu Dhabi, Stockholm, and Lima. With the latest version of the prototype, the time requirement (i.e., not requiring more than 2–3 min per day) was met with an average of 59 s. |
| 8. | Measurement-based modeling of a DC-DC converter for the bill of material prediction | (Bianchi, 2020) | Magistrali biennali , 2020 | The topic of the project is the modeling of a DC-DC converter that allows to predict its behavior. The idea is to create a systematic methodology that reduces the amount of time, costs and complexity of the stability assessment. the procedure exploits both a set of measures and a mathematical model. The mathematical model has to model only the well known part of the circuit, while the measures has the role to cover the rest with a blackbox approach. |
| 9. | Product family formation by matching Bill-of-Materials trees | (Kashkoush & ElMaraghy, 2016) | CIRP Journal of Manufacturing Science and Technology , 2016 | Formation of product families is of great importance for manufacturing systems which rely on commonality and similarity between products for improving efficiency and productivity. Existing techniques for product family formation are based on similarity measures such as components commonality but none of them consider similarity of the product structure which directly affects the assembly system configuration and the sequence of assembly operations. A novel Bill-of-Materials (BOM) trees matching integer programming model is introduced to address commonality of components as well as their hierarchical assembly structure. A product Bill-of-Materials is a structured tree representing its components and their assembly relationships. BOMs are traditionally used for Material Requirement Planning (MRP); however, they have other useful |

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| | | | | applications in product modeling and variety management. A product BOM trees matching model, inspired by well-established techniques used in the field of biology for comparing phylogenetic trees, has been developed. Hierarchical clustering is applied to form groups of product families based on the pair-wise similarities obtained by matching BOM trees. The proposed method is applied to a case study of six centrifugal pumps for demonstration and analysis. The benefit of considering structural similarity in family formation for assembly products, in terms of having a better utilized assembly process when compared to the grouping based on plain component commonality, is highlighted. |
| 10. | Implementasi DES (Data Encryption Standard) Untuk Penyandian Data Bill Of Material pada Divisi Produksi PT. Siantar Top, Tbk | (Ginting et al., 2019) | Jurnal SAINTIKOM (Jurnal Sains Manajemen Informatika dan Komputer) | *Bill of Material* (BOM) memuat data komposisi produk dan juga takaran dalam proses produksi, data ini bisa juga disebut seperti resep. Data ini merupakan salah satu aspek terpenting karena menyangkut rasa dan kualitas produk. Pentingnya data BOM ini biasanya menjadi sasaran bagi para pesaing dunia usaha untuk disalin dan dapat menghasilkan produk sama baiknya ataupun lebih baik lagi. Untuk keamanan data BOM selama ini adalah dengan membatasi<br>akses beberapa pengguna dan ha nya pengguna yang berkepentingan saja yang dapat mengakses data ini. Dalam data salinan ini tidak semua material dicantumkan dan beberapa material rahasia di ganti nama menjadi nama unik. Namun keadaan tersebut dianggap kurang efektif mengingat banyak produk yang dihasilkan. Oleh sebab itu, dibuatlah sebuah sistem keamanan data yang memuat informasi BOM tersebut baik data asli maupun data |

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| | | | | salinan yang dalam pengamanannya memakai algoritma *Data Encryption Standard* (DES) sehingga keamaan data lebih terjaga. |

## 2. Group Technology

| No | Judul | Penulis | Publikasi/ Tahun | Abstrak |
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| 1 | Group Technology Classification From Feature-Based Geometric Models | (Shah & Bhatnagar, 1989) | Manufacturing Review, 1989 | The Design And Implementation Of A System For Group Technology (GT) Coding From Feature-Based Solid Models Is Discussed. The System Consists Of A Feature Modeling Shell For Design By Features And A Feature Mapping Shell For Transforming Design Features To Application-Specific Features. The Authors Have Written About The Modeling And Mapping Shells Previously; This Paper Focuses On Methods For Formalizing Geometric Reasoning For GT Coding And Building A GT Knowledge Base Using The Generic Mapping Shell. The Study Presupposes That A Part Definition Is Already Available In Terms Of Features, But The Combination In Which Features Occur, Their Juxtaposition, And Hierarchy Are Not Known. Taxonomy Codes Are Assigned To Generic Features In Order To Pass The Meaning Of These Features From Design To GT. The Taxonomy Code Contains Information On Major |

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| | | | | Characteristics Such As-Whether The Feature Is External Or Internal, Axisymmetric Or Prismatic, And So On. |
| 2 | CELL FORMATION IN GROUP TECHNOLOGY: REVIEW, EVALUATION AND DIRECTIONS FOR FUTURE RESEARCH* | (Selim et al., 1998) | Computers & Industrial Engineering | This Paper Discusses And Reviews A Fundamental Issue In Cellular Manufacturing--Cell For- Mation. This Problem Is Of Strategic And Operational Importance In That It Affects The Fundamental Struc- Ture And The Overall Layout Of A Cellular Manufacturing System. We First Provide A Comprehensive Mathematical Formulation Of The Cell Formation Problem And Then Propose A Methodology-Based Classi- Fication Of Prior Research. This Classification Is Used In Reviewing The Most Recent Literature On The Cell Formation Problem. Based On A Comparison And Critical Evaluation, We Highlight The Shortcomings Of Current Approaches And Also Outline Directions For Future Research. © 1998 Published By Elsevier Science Ltd. All Rights Reserved |

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| 3 | A Simulation Analysis Of Factors Influencing The Attractiveness Of Group Technology Cellular Layouts | John S. Morris , Richard J. Tersine (Morris & Tersine, 1990) | 1 Dec 1990 Management Science | Group Technology (GT) Is A Multi-Faceted Approach To Batch Production That Includes The Reconfiguration Of Plant Equipment From A Functional Layout To A Series Of Product-Oriented Layouts That Are Referred To As Manufacturing Cells. The Cells Are Dedicated To Process Families Of Parts That Have Similar Machine Operations. The Purported Benefits Of GT Over Traditional Functional Layouts Range From Reduced Work-In-Process Inventory And Throughput Times To Increased Worker Satisfaction And Productivity. However, Recent Simulation Studies Challenge Some Of These Claims Of Superior Performance For Cellular Layouts. This Research Examines The Influence That Factors In A Firm's Operating Environment Have On The Performance Of Cellular Layouts. A Simulation Model Using Hypothetical Shop Data Is Used To Compare A Process Layout To A Cellular Layout Using Mean Throughput Time And Mean Level Of Work-In-Process Inventory |

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| | | | | As Performance Measures. The Operating Variables Analyzed Are (1) The Ratio Of Setup To Process Time, (2) Transfer Time Of Material Between Work Centers, (3) Demand Stability, And (4) The Flow Of Work Within Cells. None Of The Individual Changes In Levels Of Operating Variables Produced A Clear Advantage For Cellular Layouts. However, The Results From These Experiments Were Used To Postulate An "Ideal" Environment For Cellular Layouts. This Environment Is Characterized As Having A High Ratio Of Setup To Process Time, Stable Demand, Unidirectional Flow Of Work Within A Cell, And A Substantial Level Of Material Movement Times Between Process Departments. When All Of These Conditions Are Present, The Cellular Layout Outperforms The Process Layout On Both Performance Measures. |
| 4 | A Comparative Evaluation Of Nine Well-Known Algorithms For Solving The Cell Formation Problem | (Miltenburg & Zhang, 1991) | Journal Of Operations Management/1991 | Nine Algorithms, Developed To Solve The Cell Formation Problem, Are Evaluated And Compared For Their |

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| | In Group Technology | | | Ability To Produce Good Solutions To Large Problems. A Primary Performance Measure And Two Secondary Performance Measures Are Presented For Gauging The Quality Of A Solution To The Cell Formation Problem. Eight Problems From The Open Literature And 60 Randomly Generated, Large Problems Are Analyzed. The Analysis Shows That There Is No Solution Algorithm That Performs Better On All Performance Measures For Problems From Both The Literature And The Randomly Generated Data Sets. One Algorithm, Called The ISNC Algorithm And Based On Clustering Around Seeds, Performs Significantly Better Than All Other Algorithms On The Primary Performance Measure (And Performs Well On The Secondary Measures) For The Randomly Generated Data Set, And Performs Well For The Problems From The Literature. Therefore This Algorithm Appears To The Most Appropriate Algorithm To Use As |

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| | | | | A *General Purpose Solution Algorithm* For CF Problems Having Between 25 And 50 Machines, 35 And 50 Parts, And Densities Between 10 And 20%. (It May Not Be Appropriate For Larger Problems, Since Its Computational And Space Requirements Appear To Be High.) After The ISNC Algorithm, There Is No Significant Difference Between Most Of The Other Algorithms. However. Different Kinds Of Solutions Are Developed By Some Of These Other Algorithms. The Well-Known SC/ROC And ROC/ROC Algorithms Develop Solutions Which Consist Of A Small Number Of Relatively Large Cells. The BEA Algorithm Develops Solutions Which Consist Of Relatively Small Cells (Where Each Machine In The Cell Is Visited By Most Of The Parts Assigned To That Cell) And One Large Cell For Those Parts Not Assigned To The Small Cells. |
| 5 | OPERATIVE GROUP TECHNOLOGY APPLIED TO TOBACCO | (Lucchese et al., 2013) | Texto Contexto Enferm, 2013 | This Descriptive And Exploratory Study Was Performed With The Purpose To Discuss The Use Of Group Operative |

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| | CONTROL PROGRAM | | | Technology As A Coping Strategy In A Tobacco Control Program In The Primary Health Care System Of A Small Municipality In The State Of Goiás, Brazil. The Subjects Were 20 Individuals Who Sought The Primary Health Care Unit On Their Own Account, And The Sample Consisted Of Nine People Who Completed The Treatment. Content Analysis Revealed The Thematic Category: The Path Followed During The Treatment; And Three Subcategories: Revisiting The Desire To Quit Smoking; Feeling The Effects Of Quitting Cigarretes; The Challenges For The Change. The Fagerström Test Showed A Dependence Pattern Of Three Subjects For Each Level: Very High, High And Average. The Cessation Rate For Tobacco Was 78%; Therefore, It Is Recommended That Operative Group Technologies Be Adopted In Group Activitied In The Program. DESCRIPTORS: Smoking. Smoking Cessation. Tobacco |

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| | | | | Use Cessation. Group Processes. |
| 6 | Efficient Solving Of The Group Technology Problem | (Kusiak & Chow, 1987) | Journal Of Manufacturing Systems | In This Paper, Two Formulations Of The Group Technology Problem Are Considered: The Standard Formulation And The Augmented Formulation. The Standard Formulation Is Based On The 0–1 Machine-Incidence Matrix And Does Not Consider Any Costs. In The Augmented Formulation With Each Partj, Cost $C_j$ Is Associated And The Number Of Machines In Each Cell Is Limited To N. This Formulation Allows The Creation Of Machine Cells And Part Families With A Low Degree Of Interaction (Or Without Any Interaction, If Required) By Removing Parts With Low Values Of The Corresponding Costs From The Incidence Matrix. To Solve These Formulations, Tow Very Efficient Algorithms Are Presented. The Cluster Identification Algorithm With The Computational Time Complexity 0(2mn) Finds Optimal Machine Cells And Part Families Provided That The Machine-Part Incidence Matrix |

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| | | | | Has The Block Diagonal Structure Embedded. This Appears To Be The Most Efficient Algorithm Developed To Date. The Cost Analysis Algorithm Is Designed To Solve The Augmented Group Technology Problem. Its Computational Complexity Is 0(2 Mn + Nlogn). The Two Algorithms Are Illustrated In Numerical Examples. |
| 6 | The Application Of Group Technology Concept For Implementing SPC In Small Batch Manufacture | Mamoun Al-Salti, Anthony Statham | International Journal Of Quality & Reliability Management, 1994 | The Use Of Statistical Process Control (SPC) Techniques For Monitoring Manufacturing Processes In Mass Production Is Relatively Easy. In Small-Batch Manufacture, However, Such Techniques Can Be Difficult To Implement Due To Lack Of Sufficient Data To Establish Control Decisions For Control Charts. Most Of The Early Proposed Solutions Emphasized The Product Rather Than The Process, Whereas Many Of The Recently Developed Approaches Favoured Monitoring The Process And Not The Product. All Such Approaches Suggest The Use Of Data Transformation. The |

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| | | | | Aim Is To Normalize The Differences In The Process Mean And The Variability For Different Components. Once An Appropriate Transformation Is Made, Then Sample Data Related To Different Components Can Be Plotted On The Same Chart Using Sample Statistics Of The Transformed Data. An Important Part Of Transformation Is The Determination Of Process Parameters For The Component. Several Methods For Determining Such Parameters Have Already Been Suggested In The Literature. Presents An Alternative Method For Estimating The Process Parameters, Based On The Group Technology (GT) Concept. Generally Speaking, The Methodology Consists Of Four Steps, I.E. Classification And Coding (C&C), Family Formation, Retrieving Data, And Estimating The Process Parameters. Discusses The Characteristics Of A C&C System For SPC And Presents The Details Of Its Structure. Finally, Based On The |

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| | | | | Proposed Structure, Uses A Flowchart To Explain The Procedure Along With A Practical Application |
| 7 | Group Technology In A Hybrid Flowshop Environment: A Case Study | (Andrés et al., 2005) | European Journal Of Operational Research, 2005 | |
| 8 | Group Technology: An Integrated Planning And Implementation Concept For Small And Medium Batch Production | (Arn, 2012) | Springer Science & Business Media, 2012 | |
| 9 | Application Of Neural Networks To Group Technology | Caudell,Thomas P. ,. Smith, Scott D. G. .,Johnson, G. C. ., Wunsch, Donald C., II (Caudell et al., 1991) | Applications Of Artificial Neural Networks II | Adaptive Resonance Theory (ART) Neural Networks Are Being Developed For Application To The Industrial Engineering Problem Of Group Technology--The Reuse Of Engineering Designs. Two- And Three-Dimensional Representations Of Engineering Designs Are Input To ART-1 Neural Networks To Produce Groups Or Families Of Similar Parts. These Representations, In Their Basic Form, Amount To Bit Maps Of The Part, And Can Become Very Large When The Part Is Represented In High Resolution. This Paper Describes An Enhancement To An Algorithmic Form Of ART-1 That Allows It To Operate Directly On Compressed Input |

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| | | | | Representations And To Generate Compressed Memory Templates. The Performance Of This Compressed Algorithm Is Compared To That Of The Regular Algorithm On Real Engineering Designs And A Significant Savings In Memory Storage As Well As A Speed Up In Execution Is Observed. In Additions, A `Neural Database" System Under Development Is Described. This System Demonstrates The Feasibility Of Training An ART-1 Network To First Cluster Designs Into Families, And Then To Recall The Family When Presented A Similar Design. This Application Is Of Large Practical Value To Industry, Making It Possible To Avoid Duplication Of Design Efforts. |
| 10 | Group Technology: Applications To Production Management | (Ham et al., 2012) | Springer Science & Business Media, 2012 | |
| 13 | Machine-Component Cell Formation In Group Technology: MACE | (Waghodekar & Sahu, 1984) | The International Journal Of Production Research | |
| 14 | A Comparative Evaluation Of Nine Well-Known Algorithms For Solving The Cell | (Miltenburg & Zhang, 1991) | Journal Of Operations Management | Nine Algorithms, Developed To Solve The Cell Formation Problem, Are Evaluated And |

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| | Formation Problem In Group Technology | | | Compared For Their Ability To Produce Good Solutions To Large Problems. A Primary Performance Measure And Two Secondary Performance Measures Are Presented For Gauging The Quality Of A Solution To The Cell Formation Problem. Eight Problems From The Open Literature And 60 Randomly Generated, Large Problems Are Analyzed. The Analysis Shows That There Is No Solution Algorithm That Performs Better On All Performance Measures For Problems From Both The Literature And The Randomly Generated Data Sets. One Algorithm, Called The ISNC Algorithm And Based On Clustering Around Seeds, Performs Significantly Better Than All Other Algorithms On The Primary Performance Measure (And Performs Well On The Secondary Measures) For The Randomly Generated Data Set, And Performs Well For The Problems From The Literature. Therefore This Algorithm Appears To The Most Appropriate |

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| | | | | Algorithm To Use As A *General Purpose Solution Algorithm* For CF Problems Having Between 25 And 50 Machines, 35 And 50 Parts, And Densities Between 10 And 20%. (It May Not Be Appropriate For Larger Problems, Since Its Computational And Space Requirements Appear To Be High.) After The ISNC Algorithm, There Is No Significant Difference Between Most Of The Other Algorithms. However. Different Kinds Of Solutions Are Developed By Some Of These Other Algorithms. The Well-Known SC/ROC And ROC/ROC Algorithms Develop Solutions Which Consist Of A Small Number Of Relatively Large Cells. The BEA Algorithm Develops Solutions Which Consist Of Relatively Small Cells (Where Each Machine In The Cell Is Visited By Most Of The Parts Assigned To That Cell) And One Large Cell For Those Parts Not Assigned To The Small Cells |
| 15 | Efficient Solving Of The Group Technology Problem | (Kusiak & Chow, 1987) | Journal Of Manufacturing Systems, 1987 | In This Paper, Two Formulations Of The Group Technology Problem Are Considered: The |

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| | | | | Standard Formulation And The Augmented Formulation. The Standard Formulation Is Based On The 0–1 Machine-Incidence Matrix And Does Not Consider Any Costs. In The Augmented Formulation With Each Partj, Cost $C_j$ Is Associated And The Number Of Machines In Each Cell Is Limited To N. This Formulation Allows The Creation Of Machine Cells And Part Families With A Low Degree Of Interaction (Or Without Any Interaction, If Required) By Removing Parts With Low Values Of The Corresponding Costs From The Incidence Matrix.<br>To Solve These Formulations, Tow Very Efficient Algorithms Are Presented. The Cluster Identification Algorithm With The Computational Time Complexity 0(2mn) Finds Optimal Machine Cells And Part Families Provided That The Machine-Part Incidence Matrix Has The Block Diagonal Structure Embedded. This Appears To Be The Most Efficient Algorithm Developed To Date. The Cost |

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| | | | | Analysis Algorithm Is Designed To Solve The Augmented Group Technology Problem. Its Computational Complexity Is 0(2 Mn + Nlogn). The Two Algorithms Are Illustrated In Numerical Examples. |
| 16 | A Branch-And-Bound Algorithm For Solving The Group Technology Problem | (Kusiak & Cheng, 1990) | Annals Of Operations Research,1990 | In This Paper, The Group Technology Problem (GT) With Bottleneck Parts And The Problem With Bottleneck Machines Are Considered. To Solve The Two Problems, A Branchand- Bound Algorithm Is Presented. Two Branching Schemes Are Developed. The Computational Results For Several Test Problems Used In The Literature Are Reported |
| 17 | Branching Algorithms For Solving The Group Technology Problem | (Kusiak, 1991) | Journal Of Manufacturing Systems,1991 | In This Paper, A Group Technology (GT) Problem With Bottleneck Parts And Bottleneck Machines Is Considered. Three Heuristic Algorithms Based On Different Branching Schemes Are Developed. Each Algorithm Uses The Cluster Identification Concept. The First Algorithm Solves An Unconstraint GT Problem. The Second Heuristic Considers A Constraint Restricting The Number Of |

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| | | | | Machines In Each Cell. The Third Algorithm Screens Machines And Parts To Identify Bottlenecks. The Algorithms Are Illustrated With Numerical Examples And An Industrial Case Study. |
| 18 | A Group Technology Based Methodology For Machine Cell Formation In A Computer Integrated Manufacturing Environment | (Kamrani & Parsaei, 1993) | Computers & Industrial Engineering,1993 | A New Two-Phase Methodology Is Developed To Form Machine Cells In A Computer Integrated Manufacturing Environment Using Dissimilarity Measure Between Design And Manufacturing Attributes Of Parts. An 18-Digit Classification And Coding Method Is Developed. The First Phase Of The Methodology Enables The Decision Maker To Assign Priority To The Attributes In Order To Group Parts Into Part Families. In The Second Phase, Machines Are Grouped Into Manufacturing Cells Based On Relevant Operational Costs. A Comprehensive Software Package, KAMCELL Is Developed Which Can Be Used As A Tool For Model Development And Analysis. |
| | Machine Dedication And Process Flexibility | (Jensen et al., 1996) | Journal Of Operations Management, 1996 | This Study Investigates Changes In Inventory And |

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| | In A Group Technology Environment | | | Customer Service Performance Of A Job-Shop That Desires To Adopt A Group Technology (GT) Philosophy In Its Shop Floor Operations. Simulation Methodology Is Pursued To Explore Tradeoffs In Shop Performance Between The Routing Flexibility Of Non-Dedicated Machines In A Functional Job-Shop And The Setup Efficiency Of Dedicated Machines In Shops That Have Machine Cell Layouts. Further, Traditional And GT-Based Scheduling Procedures Are Investigated In These Different Shops To Determine The Conditions Under Which A GT Philosophy May Be Profitably Employed Only In Layout Decisions, Only In Scheduling Decisions, Or In Both Layout And Scheduling Decisions. Results From This Study Show That Shop Layout Choice Is Not A Simple Decision That Can Capitalize Either On The High Routing Flexibility Of The Functional Job-Shop Or On The Setup Efficiency Advantages Of A Cell Shop. The Tradeoffs Between |

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| | | | | Routing Flexibility And Setup Efficiency Must Be Made Carefully. The Impact Of Demand Variability On Performance Is Also Dependent On The Type Of Layout. In General, Product Volume Variability More Adversely Affects The Performance Of Functional Job-Shops, While Product Mix Variability Has Greater Impact On The Performance Of Cell Shops. Finally, Sensitivity Analysis Is Performed To Show That Maintaining Balance Between The Utilization Of Machines Is A Major Determinant Of Performance, And Consequently The Best Layout. |
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**3. Genetic Algorythms**

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| | Algoritma Genetika untuk Optimasi Komposisi Makanan Bagi Penderita Hipertensi | (Purnomo et al., 2019) | Jurnal Teknologi dan Sistem Komputer | Hypertension can be prevented and handled by eating nutritious foods with the right composition. The genetic algorithm can be used to optimize the food composition for people with hypertension. Data used include sex, age, weight, height, activity type, stress level, and patient hypertension level. This study uses a |

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| | | | | reproduction method that is good enough to be applied to integer chromosome representations so that the search results provided are not local optimum solutions. The testing results show that the best genetic algorithm parameters are as follows population size is 15 with average fitness 20.97, the generation number is 40 with average fitness 50.10, and combination crossover rate and mutation rate are 0.3 and 0.7 with average fitness 41.67. The solution obtained is the optimal food composition for people with hypertension. |
| | Genetic Algorithm for Relational Database Optimization in Reducing Query Execution Time | (Hidayat et al., 2018) | Scientific Journal of Informatics | The relational database is defined as the database by connecting between tables. Each table has a collection of information. The information is processed in the database by using queries, such as data retrieval, data storage, and data conversion. If the information in the table or data has a large size, then the query process to process the database becomes slow. In this paper, Genetic Algorithm is used to process queries in order to optimize and reduce query execution time. The results obtained are query execution with genetic algorithm |

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| | | | | optimization to show the best execution time. The genetic algorithm processes the query by changing the structure of the relation and rearranging it. The fitness value generated from the genetic algorithm becomes the best solution. The fitness used is the highest fitness of each experiment results. In this experiment, the database used is MySQL sample database which is named as employees. The database has a total of over 3,000,000 rows in 6 tables. Queries are designed by using 5 relations in the form of a left deep tree. The execution time of the query is 8.14247 seconds and the execution time after the optimization of the genetic algorithm is 6.08535 seconds with the fitness value of 0.90509. The time generated after optimization of the genetic algorithm is reduced by 25.3%. It shows that genetic algorithm can reduce query execution time by optimizing query in the part of relation. Therefore, query optimization with genetic algorithm can be an alternative solution and can be used to maximize query performance. |

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| 2 | IMPLEMENTATION OF GENETIC ALGORITHM FOR STUDENT PLACEMENT PROCESS OF COMMUNITY DEVELOPMENT PROGRAM IN UNIVERSITAS GADJAH MADA | (Arfandi, n.d.) | | Community Development Program (CDP) is a required subject in Universitas Gadjah Mada for undergraduate students to earn a bachelor's degree. One of the big problem in CDP implementation is student placement process into available thematic units. Each unit as much as possible filled by students which have balanced composition based on specified criteria. Balances in gender ratio and clusters composition are needed to have an objective assigned team students in a unit. In this paper, a genetic algorithm is proposed to solve this placement problem. The results of this paper is a simulation in CDP student placement process which using genetic algorithm to produce recommendation units which have good composition. |
| 3 | Improving Floating Search Feature Selection using Genetic Algorithm | (Homsapaya & Sornil, 2017) | Journal of ICT Research and Applications | Classification, a process for predicting the class of a given input data, is one of the most fundamental tasks in data mining. Classification performance is negatively affected by noisy data and therefore selecting features relevant to the problem is a critical step in classification, especially when applied to large |

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| | | | | datasets. In this article, a novel filter-based floating search technique for feature selection to select an optimal set of features for classification purposes is proposed. A genetic algorithm is employed to improve the quality of the features selected by the floating search method in each iteration. A criterion function is applied to select relevant and high-quality features that can improve classification accuracy. The proposed method was evaluated using 20 standard machine learning datasets of various size and complexity. The results show that the proposed method is effective in general across different classifiers and performs well in comparison with recently reported techniques. In addition, the application of the proposed method with support vector machine provides the best performance among the classifiers studied and outperformed previous researches with the majority of data sets. |
| 4 | Optimasi Penempatan Bank Capacitor Pada Penyulang H5 Menggunakan Metode Genetic Algorithm (GA) | (Muslimin, 2015) | Informatika Mulawarman : Jurnal Ilmiah Ilmu Komputer | Penyaluran daya listrik pada sistem tenaga listrik merupakan hal yang perlu diperhatikan, agar tegangan di sepanjang saluran tetap terjaga dalam batas-batas yang diizinkan. Pada penelitian ini |

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| | | | | pemasangan bank capacitor pada penyulang H5 dimaksudkan untuk mengkompensasi drop tegangan dan rugi-rugi daya yang terjadi di sepanjang penyulang H5 tersebut. Untuk mendapatkan hasil kompensasi yang optimal, maka dilakukan optimasi lokasi penempatan dan kapasitas bank capacitor dengan menggunakan metode Genetic Algorithm (GA). Untuk mengetahui besar kompensasi drop tegangan dan rugi-rugi daya yang terjadi pada penyulang H5 tersebut, maka selanjutnya dilakukan analisis aliran daya (load flow) dengan menggunakan metode Newton-Raphson. Dari hasil optimasi lokasi penempatan dan kapasitas bank capacitor maka diperoleh lokasi penempatan bank capacitor pada bus 38 dengan kapasitas 1.6 MVAR. Kemudian dari hasil analisis aliran daya (load flow) diperoleh kompensasi drop tegangan dari 11% turun menjadi 4%. Sedangkan kompensasi rugi-rugi daya aktif 0.336 MW turun menjadi 0.191 MW dan rugi-rugi daya reaktif dari 0.730 MVAR turun menjadi 0.518 MVAR. |
| 5 | OPTIMASI TATA LETAK BARANG | (Kurniawan et al., 2010) | | Untuk mendapatkan penyusunan kotak yang |

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| | PADA RUANG TIGA DIMENSI DENGAN MENGGUNAKAN ALGORITMA GENETIKA | | | optimal dalam sebuah ruangan adalah hal yang cukup rumit. Terdapat berbagai aspek yang saling berkaitan dan harus dilibatkan dalam penyusunan ini yang antara lain adalah besarnya dimensi ruangan yang digunakan sebagai batasan dari penyusunan kotak-kotak, distribusi penyusunan kotak yang diharapkan adalah yang memenuhi semua titik koordinat dalam ruangan, kemudian penyusunan kotak ini akan semakin rumit jika melibatkan titik berat dari masing-masing massa kotak. Permasalahan penyusunan kotak ini, dapat dilihat dari sisi kotak, yaitu kemungkinan-kemungkinan dari urutan kotak terhadap ruangan. Dari aspek-aspek diatas, dalam penyusunan tata letak kotak ini terdapat banyak kemungkinan yang selayaknya dicoba untuk menemukan penyusunan yang terbaik. Salah satu metode yang dapat digunakan untuk menyelesaikan permasalahan tersebut adalah dengan menggunakan algoritma genetika Algoritma genetika merupakan algoritma yang menggunakan pendekatan heuristik |

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| | | | | dalam menyelesaikan masalah kombinatorial yang kompleks. Dengan menggunakan algoritma genetika beserta operatornya seperti reproduksi, pindah silang serta mutasi diperoleh kondisi dimana terjadinya kombinasi terbaik untuk urutan letak barang terhadap ruangan dengan terpenuhinya jumlah titik koordinat ruangan yang terbesar |
| ( | Penerapan Genetic Algorithm Untuk Optimasi Peningkatan Laba Persediaan Produksi Pakaian | (Jocom et al., n.d.) | | Clothes as one of human need, in which the demand of clothing from time to time may increase or decrease. With the uncertainty of market demand for clothing making clothing sales into a promising business if appropriate in meeting market needs. Distro is an individual business or a group engaged in the production, marketing, and sales of clothing specifically for young people. The success of the distro is measured by the amount of profit from clothing sales. Production design is one such factor. The problem will become more complex when there are many types of clothing sold, many sizes, and little capital in a month. Genetic algorithm is a meta-heuristic method that can solve the problem of clothing production. Proper fitness formula |

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| | | | | formulation can provide a value of chromosomes in the genetic algorithm, so the genetic algorithm can work best to solve production planning problems. The correct genetic algorithm parameters can give maximum results. The test showed the best results at the iteration of 75, the number of chromosomes by 425, the crossover rate of 0.9, and the mutation rate of 0.1. This study provides that genetic algorithm can solve complexity problems of production planning. |
| 1 | PENJADWALAN 20 JOB 8 MESIN DENGAN METODE GENETIC ALGORITHM (GA) | (Rochman & Ferdian, 2013) | Spektrum Industri | Penelitian ini merupakan perluasan dari penelitian sebelumnya yang dilakukan oleh Iskandar (2013) dengan judul "IMPLEMENTASI PENJADWALAN MESIN JOB SHOP DENGAN METODE HEURISTIC DISPATCHING RULES DI CV BOEING TEKNIK MANDIRI". Pada penelitian tersebut dilakukan penjadwalan mesin job shop dengan menggunakan metode Heuristic Dispatching Rules. Tujuan dari penelitian ini adalah untuk melakukan penjadwalan mesin job shop dengan menggunakan metode |

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| | | | | Genetic Algorithm dan membandingkan hasil yang didapat dengan hasil penjadwalan yang dilakukan Iskandar (2013) dengan metode Heuristic Dispatching Rules. Setelah dilakukan proses pengolahan data dengan menggunakan metode Genetic Algorithm selama 27 menit 33 detik, didapatkan hasil penjadwalan untuk kriteria Cmax (Completion Time Maximum) sebesar 2391,017 menit, kriteria Fmax (Flow Time Maximum) sebesar 2391,017 menit, kriteria Lmax (Lateness Maximum) sebesar -151,05 menit dan kriteria Tmax (Tardiness Maximum) sebesar 0 menit. Dibandingkan dengan hasil penjadwalan awal yang dilakukan oleh CV Boeing Teknik Mandiri, penjadwalan dengan menggunakan metode Genetic Algorithm dapat menghasilkan efisiensi sebesar 5,25% dalam kriteria Cmax serta Fmax. Untuk kriteria Lmax metode Genetic Algorithm menghasilkan efisiensi sebesar 106,2%.<br>Kata Kunci: Penjadwalan mesin, Job Shop, Metode Heuristic Dispatching Rules, Genetic Algorithm. |

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| 8 | PENYELESAIAN MASALAH PENJADWALAN FLOWSHOP DENGAN MODIFIED GENETIC ALGORITHM | (Herawatie et al., 2015) | Prosiding Seminar Ilmiah Nasional Teknologi Komputer | Flowshop Scheduling Problem (FSP) merupakan salah satu timetabling/scheduling problem. Masalah ini merupakan masalah perencanaan berbasis waktu dan optimasi kombinatorial. Penjadwalan flowshop merupakan sebuah permasalahan perencanaan produksi dengan n-job (item, tugas, dan lainlain) yang harus diproses dalam urutan yang sama pada setiap m-mesin. Masing-masing job mempunyai processing time yang berbeda untuk mesin yang berbeda. Tujuan dari penjadwalan ini adalah untuk mendapatkan urutan dari job-job untuk menminimalkan makespan. Salah satu metode heuritik yang sering digunakan adalah Algoritma genetika (Genetic Algorithm atau GA). Algoritma ini merupakan yang cenderung diselesaikan dengan kerjasama dari pencarian dan heuristik, yang mengarah pada solusi yang memuaskan tetapi sub – optimal. Modified Genetic Algorithm (MGA)) merupakan algoritma genetika yang skema seleksi, crossover, dan strategi mutasnya telah dimodifikasi. MGA ini bertujuan untuk menghindari optimal lokal, dan menemukan |

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| | | | | solusi optimal secara efisien. Penelitian ini bertujuan untuk membandingkan keefektifan metode MGA dalam menyelesaikan masalah flowshop scheduling. Untuk penelitiam ini digunakan seleksi elitism, partial schedule exchange crossover, dan simple inversion mutation (SIM). Dengan menggunakan tiga set data, ditunjukkan bahwa MGA lebih efisien dalam menentukan himpunan solusi layak daripada GA |
| 9 | The Implemetation genetic algorithm Timun Mas Game | (Permatasari & Nasrullah, 2019) | JOURNAL OF APPLIED MULTIMEDIA AND NETWORKING | Timun Mas Game was inspired by a fairy tales story from Cental Java. It is fairy tale of Timun Mas. This game will makes the player has an experience and missions as Mbok Sarni who is the part of the original storyline. Therefore the game genre is Role Playing Game (RPG). The game story has 2 missions, first the player needs to plant the seed of Timun and collect all magical weapons to attack Buto Ijo.<br>In this undergraduated thesis, the author designed the first mission of Timun Mas Game, which is planting the seed of Timun Mas until it was grow up The Planting activities are watering and fertilizing seeds until it is grow up to golden Cucumber. During the planting |

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| | | | | process, there will be rats as pest that attack the growth of seed. Player need to eliminate the pest by using the hammer that provide from system. The pest is a NPC (Non Player Character) that was controlled by an artificial Intelligence using a monodevelop while the game environment is built with unity 5.4.1f1 (64-bit) game engine.<br>The type of artificial intelligent that was used to create an intelligence system is Genetic Algorithm (GA). It has a function to maximize genes in the chromosome strength on the NPC including attack power, speed of movement, and health point of the pest which is affected by player behaviour/action. The dynamic changes of pest's strength will affected the difficulty level of the game that will be useful to make a good experience for the player as the main goal of this research. |

## 4. Multi Criteria Decision Making

| No | Judul | Penulis | Publikasi | Abstrak |
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| 1 | Intuitionistic fuzzy interpretations of multi-criteria multi-person and multi-measurement tool decision making | Krassimir Atanassov Gabriella Pasi, Ronald Yager | International Journal of Systems Science, 2005 | Intuitionistic fuzzy sets are extensions of fuzzy sets. Their elements have two degrees – a degree of membership and a degree of non-membership so that their sum is smaller or equal to 1. Intuitionistic fuzzy interpretations of the processes of multi-person and of multi-measurement tool multi-criteria decision makings are discussed in this paper. |
| 2 | A multi-criteria decision making approach for location planning for urban distribution centers under uncertainty | AnjaliAwasthi[1] S.S.Chauhan[2]S.K.Goyal | Mathematical and Computer Modelling, 2011 | Location planning for urban distribution centers is vital in saving distribution costs and minimizing traffic congestion arising from goods movement in urban areas. In this paper, we present a multi-criteria decision making approach for location planning for urban distribution centers under uncertainty. The proposed approach involves identification of potential locations, selection of evaluation criteria, |

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| | | | | use of fuzzy theory to quantify criteria values under uncertainty and application of fuzzy TOPSIS to evaluate and select the best location for implementing an urban distribution center. Sensitivity analysis is performed to determine the influence of criteria weights on location planning decisions for urban distribution centers. The strength of the proposed work is the ability to deal with uncertainty arising due to a lack of real data in location planning for new urban distribution centers. The proposed approach can be practically applied by logistics operators in deciding on the location of new distribution centers considering the sustainable freight regulations proposed by municipal administrations. A numerical application is provided to illustrate the approach. |

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| 3 | Combining GIS with fuzzy multicriteria decision-making for landfill siting in a fast-growing urban region | Ni-BinChang[a]-G.Parvathinathan[a]-Jeff B.Breeden[a] | Journal of environmental management, 2008 | Landfill siting is a difficult, complex, tedious, and protracted process requiring evaluation of many different criteria. This paper presents a fuzzy multicriteria decision analysis alongside with a geospatial analysis for the selection of landfill sites. It employs a two-stage analysis synergistically to form a spatial decision support system (SDSS) for waste management in a fast-growing urban region, south Texas. The first-stage analysis makes use of the thematic maps in Geographical information system (GIS) in conjunction with environmental, biophysical, ecological, and socioeconomic variables leading to support the second-stage analysis using the fuzzy multicriteria decision-making (FMCDM) as a tool. It differs from the conventional methods of integrating GIS with MCDM for |

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| | | | | landfill selection because the approach follows two sequential steps rather than a full-integrated scheme. The case study was made for the city of Harlingen in south Texas, which is rapidly evolving into a large urban area due to its vantage position near the US–Mexico borderlands. The purpose of GIS was to perform an initial screening process to eliminate unsuitable land followed by utilization of FMCDM method to identify the most suitable site using the information provided by the regional experts with reference to five chosen criteria. Research findings show that the proposed SDSS may aid in recognizing the pros and cons of potential areas for the localization of landfill sites in any study region. Based on initial GIS screening and final FMCDM assessment, "site 1" was selected as |

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| | | | | the most suitable site for the new landfill in the suburban area of the City of Harlingen. Sensitivity analysis was performed using Monte Carlo simulation where the decision weights associated with all criteria were varied to investigate their relative impacts on the rank ordering of the potential sites in the second stage. Despite variations of the decision weights within a range of 20%, it shows that "site 1" remains its comparative advantage in the final site selection process. |
| 4 | A fuzzy multi-criteria decision making model for supplier selection | DoraidDalalah MohammedHayajneh FarhanBatieha[b] | Expert systems with applications, 2011 | This paper presents a hybrid fuzzy model for group Multi Criteria Decision Making (MCDM). A modified fuzzy DEMATEL model is presented to deal with the influential relationship between the evaluation criteria. The modified DEMATEL captures such relationship and divides the criteria into two groups, particularly, the |

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| | | | | cause group and the effect group. The cause group has an influence on the effect group where such influence is used to estimate the criteria weights. In addition, a modified TOPSIS model is proposed to evaluate the criteria against each alternative. Here, a fuzzy distance measure is used in which the distance from the Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS) are calculated. The resulted distances were used to calculate the similarity to Ideal and Anti-ideal points. Later, an optimal membership degree (closeness coefficient) of each alternative is computed to estimate to which extent an alternative belongs to both FPIS and FNIS. The closer the degree of membership to FPIS and the farther from FNIS the more preferred the alternative. The membership degree is obtained |

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| | | | | by the optimization of a defined objective function that measures the degree to which an alternative is similar/dissimilar to the Ideal/Anti-Ideal solutions. The closeness coefficient is used to rank the alternatives. To better have a high contrast between the ranks of alternatives an optimization problem was introduced and solved to maximize the contrast. The presented hybrid model was applied on an industrial case study for the selection of cans supplier/suppliers at Nutridar Factory in Amman-Jordan to demonstrate the proposed model. Finally a sensitivity analysis is introduced to verify the resulting ranks of the available suppliers via testing different values of the used parameters. The sensitivity analysis has shown robust and valid results that are close to real preferences of |

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| | | | | the consulted experts. **Research highlights** ► A hybrid fuzzy multi-criteria group decision making model has been developed based on fuzzy set theory. ► A modified fuzzy DEMATEL model is presented to deal with the influential relationships. ► A modified TPSIS model is proposed to evaluate the criteria against each alternative. ► The hybrid model was applied on an industrial case study for the selection of cans suppliers at Nutridar Factory in Amman-Jordan. ► It was noticed that the hybrid model has a good potential to deal with linguistic and fuzzy evaluations with no need to strictly determine the criteria weights. |
| 5 | Multi-criteria decision making in Pythagorean fuzzy environment | Liguo Fei[1] & Yong Deng[1] | Applied Intelligence, 2020 | Pythagorean fuzzy set, initially extended by Yager from intuitionistic fuzzy set, is capable of modeling information with more uncertainties in the process of |

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| | | | | multi-criteria decision making (MCDM), thus can be used on wider range of conditions. The fuzzy decision analysis of this paper is mainly built upon two expressions in Pythagorean fuzzy environment, named Pythagorean fuzzy number (PFN) and interval-valued Pythagorean fuzzy number (IVPFN), respectively. We initiate a novel axiomatic definition of Pythagorean fuzzy distance measurement, including PFNs and IVPFNs. After that, corresponding theorems are put forward and then proved. Based on the defined distance measurements, the closeness indexes are developed for both expressions, inspired by the idea of technique for order preference by similarity to ideal solution (TOPSIS) approach. After these basic definitions have been established, the hierarchical |

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| | | | | decision approach is presented to handle MCDM problems under Pythagorean fuzzy environment. To address hierarchical decision issues, the closeness index-based score function is defined to calculate the score of each permutation for the optimal alternative. To determine criterion weights, a new method based on the proposed similarity measure and aggregation operator of PFNs and IVPFNs is presented according to Pythagorean fuzzy information from decision matrix, rather than being provided in advance by decision makers, which can effectively reduce human subjectivity. An experimental case is then conducted to demonstrate the applicability and flexibility of the proposed decision approach. Finally, extension forms of Pythagorean fuzzy decision approach for heterogeneous |

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| | | | | information are briefly introduced to show its potentials on further applications in other processing fields with information uncertainties. |
| 6 | Extended TOPSIS method for multi-criteria group decision-making problems under cubic intuitionistic fuzzy environment | H. Gargand G. Kaur | Scientia Iranica, 2020 | The objective of this work is to present a novel Multi-Criteria Group Decision-Making (MCGDM) method under the Cubic Intuitionistic Fuzzy (CIF) environment byintegrating it with the extended TOPSIS method. In the existing studies, uncertainties,which are present in the data, are handled with either Interval-Valued Intuitionistic FuzzySets (IVIFS) or Intuitionistic Fuzzy Set (IFS) information, which may lose some usefulinformation of alternatives. On the other hand, CIF Set (CIFS) handles the uncertaintiesby considering both the IVIFS and IFS simultaneously. Thus, motivated by this, in |

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| | | | | thepresent work, some series of distance measures between the pairs of CIFSs were presented,and their various relationships were investigated. Further, under this environment, a groupdecision-making method based on the proposed measure was presented by considering thedi erent priority pairs of the decision-makers. A practical example was provided to verifythe developed approach and, demonstrate its practicality and feasibility, their results werecompared with those of the several existing approaches |
| 7 | Multi criteria decision making approache s for green supplier evaluation and selection: a literature review | KannanGovin, SivakumarRajendran[a] JosephSarkis[b] P.Murugesan[a] | Journal of Cleaner Production, 2015 | A large and growing body of literature to supplier evaluation and selection exists. Literature on green supplier evaluation that considers environmental factors are relatively limited. Recently, in supply chain management decision making, |

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| | | | | approaches for evaluating green supplier performance have used both qualitative and quantitative environmental data. Given this evolving research field, the goal and purpose of this paper is to analyze research in international scientific journals and international conference proceedings that focus on green supplier selection. We propose the following questions that will be answered: (i) which selection approaches are commonly applied?, (ii) what environmental and other selection criteria for green supplier management are popular?, (iii) and what limitations exist? Published research from 1997 to 2011 is structurally reviewed based on the first two questions. We find that the applied techniques are mostly fuzzy based single model approaches. The most common criterion |

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| | | | | considered for green supplier selection was "environmental management systems". A further critical analysis is completed and gaps in the current literature are identified. These gaps help us to identify improvements for green supplier selection process and possible future directions. |
| 8 | Design of coordinated energy and environmental policies: use of multi-criteria decision-making | Lorna AGreening[a] SteveBernow[b]* | Energy policy, 2004 | Conventional economic modeling tools that depend upon one criterion to select among possible alternatives for inclusion in an energy or environmental policy have limitations. Formulation of both sets of policies involves large numbers of stakeholders with differing views and preferences. Those views and preferences cannot always be determined in advance or with certainty since many of the attributes of these policy alternatives are non-market valued. The use of |

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| | | | | multi-criteria decision-making (MCDM) methods in an integrated assessment (IA) framework offers a far better alternative to cost/benefit and similar methods. To facilitate understanding of MCDM methods, we offer a typology for this broad class of models, suggest some of the types of problems that may be analyzed with these methods, and recommend the implementation of several MCDM methods in currently evolving IA frameworks. Depending upon the choice of method from this family of methods, a wide range of attributes associated with multi-pollutant reduction and energy system development strategies, and a diversity of stakeholder preferences may be incorporated into the analysis. The resulting policy space can then provide a basis for comparison and |

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| | | | | selection of policy alternatives in a political or negotiated process. |
| 9 | Multi-criteria decision making approaches for supplier evaluation and selection: A literature review | William Ho*, Xiaowei Xu and Prasanta K. Dey | European Journal of operational research, 2010 | Supplier evaluation and selection problem has been studied extensively. Various decision making approaches have been proposed to tackle the problem. In contemporary supply chain management, the performance of potential suppliers is evaluated against multiple criteria rather than considering a single factor – cost. This paper reviews the literature of the multi-criteria decision making approaches for supplier evaluation and selection. Related articles appearing in the international journals from 2000 to 2008 are gathered and analyzed so that the following three questions can be answered: (i) which approaches were prevalently applied? (ii) which evaluating criteria were paid more attention to? (iii) is |

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| | | | | there any inadequacy of the approaches? Based on the inadequacy, i f a n y, some improvements and possible future work are recommended. This research not only provides evidence that the multi-criteria decision making approaches are better than the traditional cost-based approach, but also aids the researchers and decision makers in applying the approaches effectively. |
| 10 | A review of applicatio n of multi-criteria decision making methods in constructi on | Daniel Jato-Espinoa, Elena Castillo-Lopezb, Jorge Rodriguez-Hernandeza*, Juan Carlos Canteras-Jordanac | Automation in Construction | Construction is an area of study wherein making decisions adequately can mean the difference between success and failure. Moreover, most of the activities belonging to this sector involve taking into account a large number of conflicting aspects, which hinders their management as a whole. Multi-criteria decision making analysis arose to model complex problems like these. This |

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| | | | | paper reviews the application of 22 different methods belonging to this discipline in various areas of the construction industry clustered in 11 categories. The most significant methods are briefly discussed, pointing out their principal strengths and limitations. Furthermore, the data gathered while performing the paper are statistically analysed to identify different trends concerning the use of these techniques. The review shows their usefulness in characterizing very different decision making environments, highlighting the reliability acquired by the most pragmatic and widespread methods and the emergent tendency to use some of themin combination |
| 11 | Aggregation operators on intuitionistic trapezoidal fuzzy | Wang Jianqiang ; Zhang Zhong | Journal of Systems Engineering and Electronics | Intuitionistic trapezoidal fuzzy numbers and their operational laws are defined. Based on these operational laws, some aggregation |

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| | number and its applicatio n to multi-criteria decision making problems | | | operators, including intuitionistic trapezoidal fuzzy weighted arithmetic averaging operator and weighted geometric averaging operator are proposed. Expected values, score function, and accuracy function of intuitionitsic trapezoidal fuzzy numbers are defined. Based on these, a kind of intuitionistic trapezoidal fuzzy multi-criteria decision making method is proposed. By using these aggregation operators, criteria values are aggregated and integrated intuitionistic trapezoidal fuzzy numbers of alternatives are attained. By comparing score function and accuracy function values of integrated fuzzy numbers, a ranking of the whole alternative set can be attained. An example is given to show the feasibility and availability of the method. |

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| 12 | A review of multi-criteria decision-making methods for infrastructure management | Solomon Tesfamariam | Structure and Infrastructure Engineering | In infrastructure management, multi-criteria decision-making (MCDM) has emerged as a decision support tool to integrate various technical information and stakeholder values. Different MCDM techniques and tools have been developed. This paper presents a comprehensive review on the application of MCDM literature in the field of infrastructure management. Approximately 300 published papers were identified that report MCDM applications in the field of infrastructure management during 1980–2012. The reviewed papers are classified into application to the type of infrastructure (e.g. bridges and pipes), and prevalent decision or intervention (e.g. repair and rehabilitate). In addition, the papers were also classified according to |

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| | | | | MCDM methods used in the analysis. The paper provides taxonomy of those articles and identifies trends and new developments in MCDM methods. The results suggest that there is a significant growth in MCDM applications in infrastructure management applications of MCDM over the last decade. It has also been noted that many decision support tools based on multiple MCDM methods have been successfully used for infrastructure management. |
| 13 | Fuzzy multi-criteria decision making: theory and applications with recent developments | Golam Kabir, Rehan Sadiq & Solomon Tesfamariam | Springer Science & Business Media | In infrastructure management, multi-criteria decision-making (MCDM) has emerged as a decision support tool to integrate various technical information and stakeholder values. Different MCDM techniques and tools have been developed. This paper presents a comprehensive review on the application of MCDM literature |

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| | | | | in the field of infrastructure management. Approximately 300 published papers were identified that report MCDM applications in the field of infrastructure management during 1980–2012. The reviewed papers are classified into application to the type of infrastructure (e.g. bridges and pipes), and prevalent decision or intervention (e.g. repair and rehabilitate). In addition, the papers were also classified according to MCDM methods used in the analysis. The paper provides taxonomy of those articles and identifies trends and new developments in MCDM methods. The results suggest that there is a significant growth in MCDM applications in infrastructure management applications of MCDM over the last decade. It has also been noted |

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| | | | | that many decision support tools based on multiple MCDM methods have been successfully used for infrastructure management. |
| 14 | Fuzzy multicriteria decision-making: a literature review | Cengiz kahram | International journal of computational intelligence systems, 2015 | |
| | Integrated fuzzy multi criteria decision making method and multi-objective programming approach for supplier selection and order allocation in a green supply chain | Devika Kannana,*, Roohollah Khodaverdib, Laya Olfatb, Ahmad Jafarianb, Ali Diabat | Journal of Cleaner production, 2013 | An organization's environmental performance is affected by its suppliers'environmental performance,and selecting green suppliers is a strategic decision in order to be more competitive in today's globalmarket. The supplier selection problem involves several quantitative and qualitative criteria. In thesupplier selection process, if suppliers have limited capacity or other constraints, it is necessary todetermine the best supplier and order quantity of each supplier. In this paper, we present an integratedapproach, of fuzzy multi attribute utility theory and multi- |

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| | | | | objective programming, for rating andselecting the best green suppliers according to economic and environmental criteria and then allocatingthe optimum order quantities among them. Atfirst, the fuzzy analytic hierarchy process and fuzzytechnique for order preference by similarity to ideal solution is applied in order to analyze the impor-tance of multiple criteria by incorporating experts'opinion and to determine the best green suppliers.Next, multi-objective linear programming is used to consider and to formulate various constraints suchas quality control, capacity, and other objectives. The objective of the mathematical model is simulta-neously to maximize the total value of purchasing and to minimize the total cost of purchasing. To handlethe subjectivity of |

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| | | | | decision makers'preference s, fuzzy logic has been applied. The efficiency andapplication of the proposed approach has been illustrated with a case study in an automobilemanufa cturing company. The obtained results helpfirms establish a systematic approach for tacklinggreen supplier selection and order allocation problems in a realistic situation. Finally managerial im-plications, conclusions, and directions for additional research are introduced |
| 15 | Fuzzy multi-criteria decision-making procedure for evaluating advanced manufactu ring system investment s | E. Ertugrul Karsak*, Ethem Tolga | International journal of production economics, 2001 | bstractIn this paper, a fuzzy decision algorithm is proposed to select the most suitable advanced manufacturing system (AMS)alternative from a set of mutually exclusive alternatives. Both economic evaluation criterion and strategic criteria such as#exibility, quality improvement, which are not quantitative in |

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| | | | | nature, are considered for selection. The economic aspectsof the AMS selection process are addressed using the fuzzy discounted cash#ow analysis. The decision algorithmaggregates the experts'preference ratings for the economic and strategic criteria weights, and the suitability of AMSinvestment alternatives versus the selection criteria to calculate fuzzy suitability indices. The fuzzy indices are then usedto rank the AMS investment alternatives. Triangular fuzzy numbers are used throughout the analysis to quantify thevagueness inherent in the"nancial estimates such as periodic cash#ows, interest rate and in#ation rates, experts'linguistic assessments for strategic justi"cation criteria, and importance weight of each criterion. A |

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| | | | | comprehensivenu merical example is provided to illustrate the results of the analysis |
| 16 | Multi-criteria decision making methods for determining computer preference index | Maznah Mat Kasim1, Haslinda Ibrahim 2 , Mahmoud S. Bataineh | Journal of Information and Communication Technology | In helping consumers to make a wise decision in purchasing a personal computer (PC), the use of multi-criteria decision analysis methods is a way to provide ranking of the attributes of PCs and to construct the computer preference index (CPI). This paper employs the Rank Ordered Centroid (ROC) method to do the ranking. The findings reveal that the most important attribute is the CPU, followed by the hard drive, the price, the memory card, the warranty, the size, the screen resolution, the Ethernet, the weight and the DVD. Whilst, the CPI is constructed by using a Multi-Criteria Decision Making (MCDM), called the Simple Additive Weighting (SAW) method. Analysis of data from 25 PCs from four |

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| | | | | brands, Toshiba, Dell, HP Compaq and Acer, presents the CPI. The resulted CPI shows that two HP Compaq models, Presario V3632 and V3653 are preferred most, while, Acer Aspire 4920-5AA0516MI is the least preferred. |
| 17 | Application of multicriteria decision analysis in environmental decision making | Gregory A. Kiker, Todd S. Bridges Arun Varghese Thomas P. Seager Igor Linkov | Integrated Environmental Assessment and Management: An International Journal, 2005 | Decision making in environmental projects can be complex and seemingly intractable, principally because of the inherent trade-offs between sociopolitical, environmental, ecological, and economic factors. The selection of appropriate remedial and abatement strategies for contaminated sites, land use planning, and regulatory processes often involves multiple additional criteria such as the distribution of costs and benefits, environmental impacts for different populations, safety, ecological risk, or human values. Some of |

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| | | | | these criteria cannot be easily condensed into a monetary value, partly because environmental concerns often involve ethical and moral principles that may not be related to any economic use or value. Furthermore, even if it were possible to aggregate multiple criteria rankings into a common unit, this approach would not always be desirable because the ability to track conflicting stakeholder preferences may be lost in the process. Consequently, selecting from among many different alternatives often involves making trade-offs that fail to satisfy 1 or more stakeholder groups. Nevertheless, considerable research in the area of multicriteria decision analysis (MCDA) has made available practical methods for applying scientific decision theoretical approaches to |

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| | | | | complex multicriteria problems. This paper presents a review of the available literature and provides recommendations for applying MCDA techniques in environmental projects. A generalized framework for decision analysis is proposed to highlight the fundamental ingredients for more structured and tractable environmental decision making. |
| 18 | A review of multi criteria decision making (MCDM) towards sustainable renewable energy development | bhishek Kumara,⋆, Bikash Sahb, Arvind R. Singhc, Yan Denga, Xiangning Hea, Praveen Kumarb, | Renewable and Sustainable Energy Reviews,2017 | In the current era of sustainable development, energy planning has become complex due to the involvement ofmultiple benchmarks like technical, social, economic and environmental. This in turn puts major constraints fordecision makers to optimize energy alternatives independently and discretely especially in case of ruralcommunities. In addition, topographical limitations concerning renewable energy |

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| | | | | systems which are mostlydistributed in nature, the energy planning becomes more complicated. In such cases, decision analysis plays avital role for designing such systems by considering various criteria and objectives even at disintegrated levels ofelectrification. Multiple criteria decision making (MCDM) is a branch of operational research dealing withfinding optimal results in complex scenarios including various indicators, conflicting objectives and criteria.This tool is becoming popular in thefield of energy planning due to theflexibility it provides to the decisionmakers to take decisions while considering all the criteria and objectives simultaneously. This article developsan insight into various MCDM techniques, progress made by |

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| | | | | considering renewable energy applications overMCDM methods and future prospects in this area. An extensive review in the sphere of sustainable energy hasbeen performed by utilizing MCDM technique |
| 19 | Multi-criteria decision making on strategic selection of wind farms | Amy H.I. Leea, Hsing Hung Chenb,*, He-Yau Kang | Renewable Energy, 2019 | With maturity of advanced technologies and urgent requirement for maintaining a healthy environmentwith reasonable price, China is moving toward a trend of generating electricity from renewable windresources. How to select a suitable wind farm becomes an important focus for stakeholders. This paperfirst briefly introduces wind farm and then develops its critical success criteria. A new multi-criteriadecision-making (MCDM) model, based on the analytic hierarchy process (AHP) associated with benefits,opportunities, costs and risks |

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| | | | | (BOCR), is proposed to help select a suitable wind farm project. Multiplefactors that affect the success of wind farm operations are analyzed by taking into account experts'opinions, and a performance ranking of the wind farms is generated |
| 20 | Multi-criteria decision-making methods based on intuitionistic fuzzy sets | Hua-WenLiu[ab]Guo-JunWang[a] | European Journal of Operational Research, 2007 | In this paper we present new methods for solving multi-criteria decision-making problem in an intuitionistic fuzzy environment. First, we define an evaluation function for the decision-making problem to measure the degrees to which alternatives satisfy and do not satisfy the decision-maker's requirement. Then, we introduce and discuss the concept of intuitionistic fuzzy point operators. By using the intuitionistic fuzzy point operators, we can reduce the degree of uncertainty of the elements in a universe |

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| | | | | corresponding to an intuitionistic fuzzy set. Furthermore, a series of new score functions are defined for multi-criteria decision-making problem based on the intuitionistic fuzzy point operators and the evaluation function and their effectiveness and advantage are illustrated by examples |
| 21 | Multi-criteria decision-making method based on interval-valued intuitionistic fuzzy sets | V.Lakshmana Gomathi Nayagam[a]S.Muralikrishnan[b]Geetha Sivaraman[c] | Expert Systems with Applications | Out of several generalizations of fuzzy set theory for various objectives, the notions introduced by Atanassov, 1983, Atanassov and Gargov, 1989 in defining intuitionistic fuzzy sets and interval-valued intuitionistic fuzzy sets are interesting and very useful in modeling real life problems. Ranking of interval-valued intuitionistic fuzzy sets plays a vital role in decision-making, data analysis, artificial intelligence and socioeconomic system and it was studied in Xu, 2007c, Xu and Chen, 2007a, Ye, 2009. In this paper a new method for |

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| | | | | ranking interval-valued intuitionistic fuzzy sets has been introduced and studied. The method is illustrated by numerical examples and compared with other methods. And then a new method for handling multi-criteria fuzzy decision-making problems based on interval-valued intuitionistic fuzzy sets is presented in which criterion values for alternatives are interval-valued intuitionistic fuzzy sets. The method proposed here can provide a useful way to efficiently help the decision-maker to make his decision. An illustrative example is given to verify the developed approach and to demonstrate its practicality and effectiveness. |
| 22 | Application of multi-criteria decision making to sustainable energy planning | S.D. Pohekar, M. Ramachandran | Renewable and sustainable energy reviews, 2004 | Multi-Criteria Decision Making (MCDM) techniques are gaining popularity in sustain-able energy management. The techniques provide |

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| | —A review | | | solutions to the problems involving con-flicting and multiple objectives. Several methods based on weighted averages, prioritysetting, outranking, fuzzy principles and their combinations are employed for energy plan-ning decisions. A review of more than 90 published papers is presented here to analyze theapplicability of various methods discussed. A classification on application areas and the yearof application is presented to highlight the trends. It is observed that Analytical HierarchyProcess is the most popular technique followed by outranking techniques PROMETHEEand ELECTRE. Validation of results with multiple methods, development of interactivedecision support systems and application of fuzzy methods to tackle uncertainties in the |

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| | | | | datais observed in the published literature |
| 23 | Pythagorean fuzzy TODIM approach to multi-criteria decision making | PeijiaRenZeshuiXuXunjieGou | Applied Soft Computing, 2016 | Recently, the TODIM (an acronym in Portuguese for Interactive Multi-criteria Decision Making) approach, which can characterize the decision makers' psychological behaviours under risk, has been introduced to handle multi-criteria decision making (MCDM) problems. Moreover, Pythagorean fuzzy set is an effective tool for depicting uncertainty of the MCDM problems. In this paper, based on the prospect theory, we first extend the TODIM approach to solve the MCDM problems with Pythagorean fuzzy information. Then, we conduct simulation tests to analyze how the risk attitudes of the decision makers exert the influence on the results of MCDM under uncertainty. Finally, a case study on selecting the governor of Asian Infrastructure |

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| | | | | Investment Bank is made to show the applicability of the proposed approach. |
| 24 | Best-worst multi-criteria decision-making method: Some properties and a linear model | PeijiaRenZeshuiXuXunjieGou | Omega, 2016 | Recently, the TODIM (an acronym in Portuguese for Interactive Multi-criteria Decision Making) approach, which can characterize the decision makers' psychological behaviours under risk, has been introduced to handle multi-criteria decision making (MCDM) problems. Moreover, Pythagorean fuzzy set is an effective tool for depicting uncertainty of the MCDM problems. In this paper, based on the prospect theory, we first extend the TODIM approach to solve the MCDM problems with Pythagorean fuzzy information. Then, we conduct simulation tests to analyze how the risk attitudes of the decision makers exert the influence on the results of MCDM under uncertainty. Finally, a case study on selecting the governor of |

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| | | | | Asian Infrastructure Investment Bank is made to show the applicability of the proposed approach. |
| 25 | Multi-criteria decision-making in the selection of a renewable energy project in spain: The Vikor method | J .R. San Cristóba | Renewable energy, 2011 | One of the characteristics of the Spanish energy system is its high degree of dependence on imports. In2005, the Spanish government approved the new Renewable Energy Plan in the following sectors:Windpower, Hydroelectric, Solar Thermal, Solar Thermo-electric, Photovoltaic, Biomass, Biogas andBiofuels. The aim of the Plan is to make it possible to reach the target of 12% of primary energy being metfrom renewable sources by 2010. When selecting one from various Renewable Energy investmentprojects different groups of decision-makers become involved in the process. Decision-making has totake into consideration several conflicting objectives because of the increasingly |

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| | | | | complex social,economic, technological, and environmental factors that are present. Traditional single-criterion deci-sion-making is no longer able to handle these problems. The Compromise Ranking method, also knownas the VIKOR method, introduces the Multi-criteria ranking index based on the particular measure of“closeness”to the“ideal”solution. In this paper, we apply the method in the selection of a RenewableEnergy project corresponding to the Renewable Energy Plan launched by the Spanish Government. Themethod is combined with the Analytical Hierarchy Process method for weighting the importance of thedifferent criteria, which allows decision-makers to assign these values based on their preferences. Theresults show |

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| | | | | that the Biomass plant option (Co-combustion in a conventional power plant) is the bestchoice, followed by the Wind power and Solar Thermo-electric alternatives |
| 26 | Renewables in the EU after 2020: a multi-criteria decision analysis in the context of the policy formation process | Simone Steinhilber, Jutta Geldermann & Martin Wietschel | EURO Journal on Decision Processes, 2016 | the policy problem of a post-2020 renewables policy framework for the EU is analysed using the multi-criteria decision aid method PROMETHEE, and put into a wider context of the policy formation process using the Multiple Streams Approach. The political debate includes two policy items: Firstly, the EU climate and energy target structure for 2030; and secondly, if the decision is taken for a new renewables target in 2030, whether and to which degree a future renewables support scheme should be harmonised on European level. Analysing 16 future policy pathways in detail, assuming three |

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| | | | | different decision maker prototypes, we conclude that if a 2030 renewables target exists, policy pathways with lower degrees of harmonisation are more likely to be implemented. The combined application of Kingdon's Multiple Streams Approach with PROMETHEE to this policy formation process illustrates how the two methods complement each other. While Kingdon's approach takes a broader view and is able to explain seemingly irrational behaviour of policy entrepreneurs, PROMETHEE is suitable for analysing one section of the policy formation process in more detail, namely the identification, discussion, and selection of policy alternatives. |
| 27 | Intuitionistic fuzzy Choquet integral operator for multi-criteria | ChunqiaoTanXiaohongChen | Expert Systems with Applications, 2010 | For the real decision making problems, most criteria have inter-dependent or interactive characteristics so that it is not |

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| | decision making | | | suitable for us to aggregate them by traditional aggregation operators based on additive measures. Thus, to approximate the human subjective decision making process, it would be more suitable to apply fuzzy measures, where it is not necessary to assume additivity and independence among decision making criteria. In this paper, an intuitionistic fuzzy Choquet integral is proposed for multiple criteria decision making, where interactions phenomena among the decision making criteria are considered. First, we introduced two operational laws on intuitionistic fuzzy values. Then, based on these operational laws, intuitionistic fuzzy Choquet integral operator is proposed. Moreover, some of its properties are investigated. It is shown that the intuitionistic fuzzy Choquet integral operator can be represented by some special t-norms and t- |

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| | | | | conorms, and it is also a generalization of the intuitionistic fuzzy OWA operator and intuitionistic fuzzy weighted averaging operator. Further, the procedure and algorithm of multi-criteria decision making based on intuitionistic fuzzy Choquet integral operator is given under uncertain environment. Finally, a practical example is provided to illustrate the developed approaches. |
| 28 | Assessing Euro 2020 strategy using multi-criteria decision making methods: VIKOR and TOPSIS | Seyyide Dogan & Deniz Kocak Hasan Ture | Social Indicators Research , 2019 | The European Union (EU) 2020 Strategy aims at forming the conditions for smart, sustainable and inclusive growth targets. Assessment of the EU countries' situation is of vital importance in attaining the EU 2020 Strategy. This paper presents an impartial evaluation of the performance of 27 EU member countries in terms of each EU 2020 Strategy. For the basis of the evaluation, we |

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| | | | | propose an effective and easily practicable measure for ranking and monitoring the countries according to their performance by using the VIKOR and the TOPSIS methods, multi-criteria decision making (MCDM) methods, which allows for the integration of the 22 indicators, and be capable of considering such a broad spectrum of criteria including various economic, financial, demographic, educational and innovational. Our study provides a comparative analysis of the above-two methods. The contribution of the study to the literature is that these methods can be applied for assessing countries in terms of the EU 2020 Strategy which have the multi–dimensionality targets. The results point out new EU member countries such as Slovenia and Romania have attained higher scores than many |

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| | | | | of the 15 EU countries. |
| 29 | Product-driven supply chain selection using integrated multi-criteria decision-making methodology | geWanga, Samuel H. Huangb,*, John P. Dismukesa | International journal of production economics., 2004 | Effective supply chain design calls for robust analytical models and design tools. Previous works in thisarea are mostly Operation Research oriented without considering manufacturing aspects. Recently, researchershave begun to realize that the decision and integration effort in supply chain design should be driven by themanufactured product, specifically, product characteristics and product life cycle. In addition, decision-makingprocesses should be guided by a comprehensive set of performance metrics. In this paper, we relateproduct characteristics to supply chain strategy and adopt supply chain operations reference (SCOR) modellevel I performance metrics as the decision criteria. An integrated |

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| | | | | analytic hierarchy process (AHP) and preemptivegoal programming (PGP) based multi-criteria decision-making methodology is then developed to take intoaccount both qualitative and quantitative factors in supplier selection. While the AHP process matches productcharacteristics with supplier characteristics (using supplier ratings derived from pairwise comparisons) to qualitativelydetermine supply chain strategy, PGP mathematically determines the optimal order quantity from the chosen suppliers.Since PGP uses AHP ratings as input, the variations of pairwise comparisons in AHP will influence the final orderquantity. Therefore, users of this methodology should put greater emphasis on the AHP progress to ensure the accuracyof supplier ratings.r2003 |

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| | | | | Elsevier B.V. All rights reserved |
| 30 | A fuzzy multi-criteria decision-making model for trigenerati on system | Jiang-JiangWangYou-YinJingChun-FaZhangGuo-HuaShiXu-TaoZhang | Energy Policy, 20008 | The decision making for trigeneration systems is a compositive project and it should be evaluated and compared in a multi-criteria analysis method. This paper presents a fuzzy multi-criteria decision-making model (FMCDM) for trigeneration systems selection and evaluation. The multi-criteria decision-making methods are briefly reviewed combining the general decision-making process. Then the fuzzy set theory, weighting method and the FMCDM model are presented. Finally, several kinds of trigeneration systems, whose dynamical sources are, respectively stirling engine, gas turbine, gas engine and solid oxide fuel cell, are compared and evaluated with a separate generation system. The case for selecting the optimal |

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| | | | | trigeneration system applied to a residential building is assessed from the technical, economical, environmental and social aspects, and the FMCDM model combining analytic hierarchical process is applied to the trigeneration case to demonstrate the decision-making process and effectiveness of proposed model. The results show that the gas engine plus lithium bromide absorption water heater/chiller unit for the residential building is the best scheme in the five options. |
| 31 | Review on multi-criteria decision analysis aid in sustainable energy decision-making | Jiang-JiangWangYou-YinJingChun-FaZhangJun-HongZhao | Renewable and sustainable energy reviews, 2009 | Multi-criteria decision analysis (MCDA) methods have become increasingly popular in decision-making for sustainable energy because of the multi-dimensionality of the sustainability goal and the complexity of socio-economic and biophysical systems. This article reviewed the corresponding |

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| | | | | methods in different stages of multi-criteria decision-making for sustainable energy, i.e., criteria selection, criteria weighting, evaluation, and final aggregation. The criteria of energy supply systems are summarized from technical, economic, environmental and social aspects. The weighting methods of criteria are classified into three categories: subjective weighting, objective weighting and combination weighting methods. Several methods based on weighted sum, priority setting, outranking, fuzzy set methodology and their combinations are employed for energy decision-making. It is observed that the investment cost locates the first place in all evaluation criteria and $CO_2$ emission follows closely because of more focuses on environment protection, equal |

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| | | | | criteria weights are still the most popular weighting method, analytical hierarchy process is the most popular comprehensive MCDA method, and the aggregation methods are helpful to get the rational result in sustainable energy decision-making. |
| 32 | Introduction to multi-criteria decision making and the evidential reasoning approach | Ronald R. Yager | Manchester School of Management Manchester, 2001 | We first look at some nonstandard fuzzy sets, intuitionistic, and interval-valued fuzzy sets. We note both these allow a degree of commitment of less then one in assigning membership. We look at the formulation of the negation for these sets and show its expression in terms of the standard complement with respect to the degree of commitment. We then consider the complement operation. We describe its properties and look at alternative definitions of complement operations. We then focus on the Pythagorean complement. |

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| | | | | Using this complement, we introduce a class of nonstandard Pythagorean fuzzy subsets whose membership grades are pairs, (a, b) satisfying the requirement $a^2 + b^2 \leq 1$. We introduce a variety of aggregation operations for these Pythagorean fuzzy subsets. We then look at multicriteria decision making in the case where the criteria satisfaction are expressed using Pythagorean membership grades. The issue of having to choose a best alternative in multicriteria decision making leads us to consider the problem of comparing Pythagorean membership grades. View less |
| 33 | A multicriteria decision-making method using aggregation operators for simplified | KaiZhang[a]JianmingZhan[a]Wei-ZhiWu[bc] | Journal of Intelligent & Fuzzy Systems, 2020 | By means of a fuzzy coimplication operator and a triangular conorm , we set forth two pairs of -fuzzy rough set models, which are generalizations of fuzzy rough sets. Then, according to |

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| | neutrosophic sets | | | the classifications of the coimplication operators (*R*-coimplicators and *T*-coimplicators), we investigate relationships among our proposed models and some existing rough set models. In this paper, by the idea of the PROMETHEE method, we apply -fuzzy rough set models to make decisions with evaluation of fuzzy information. An example illustrates the feasibility and effectiveness of our proposed method to solve practical problems. By comparing the ranking results of the existing methods and our proposed method, we observe that the optimal selected alternative is the same, which means that there is a consistency among our proposed decision-making method and the existing methods. In addition, we find that the traditional methods may fail in some practical |

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| | | | | situations while our proposed method is still valid. |
| 34 | Multi-criteria decision aid in financial decision making: methodologies and literature review | Constantin Zopounidis<br>Michael Doumpos | Journal of Multi-Criteria Decision Analysis, 2002 | Over the past decades the complexity of financial decisions has increased rapidly, thus highlighting the importance of developing and implementing sophisticated and efficient quantitative analysis techniques for supporting and aiding financial decision making. Multi-criteria decision aid (MCDA), an advanced field of operations research, provides financial decision makers (DMs) and analysts a wide range of methodologies, which are well suited to the complexity of financial decision problems. The aim of this paper is to provide an in-depth presentation of the contributions of MCDA in the field of finance, focusing on the methods used and their real-world applications. Copyright © 2003 |

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| | | | | John Wiley & Sons, Ltd. |
| 35 | A multicriteria decision-making methodusing aggregation operators for simplified neutrosophic sets | Jun Ye | Journal of Intelligent & Fuzzy Systems, 2014 | The paper introduces the concept of simplified neutrosophic sets (SNSs), which are a subclass of neutrosophic sets, anddefines the operational laws of SNSs. Then, we propose some aggregation operators, including a simplified neutrosophic weightedarithmetic average operator and a simplified neutrosophic weighted geometric average operator. Based on the two aggregationoperators and cosine similarity measure for SNSs, a multicriteria decision-making method is established in which the evaluationvalues of alternatives with respective to criteria are represented by the form of SNSs. The ranking order of alternatives is performedthrough the cosine similarity measure between an alternative and the ideal alternative |

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| | | | | and the best one(s) can be determined aswell. Finally, a numerical example shows the application of the proposed method |
| 36 | Novel fuzzy rough set models and corresponding applications to multi-criteria decision-making | KaiZhang[a]JianmingZhan[a]Wei-ZhiWu[bc] | Fuzzy Sets and Systems, 2020 | By means of a fuzzy coimplication operator and a triangular conorm , we set forth two pairs of -fuzzy rough set models, which are generalizations of fuzzy rough sets. Then, according to the classifications of the coimplication operators (*R*-coimplicators and *T*-coimplicators), we investigate relationships among our proposed models and some existing rough set models. In this paper, by the idea of the PROMETHEE method, we apply -fuzzy rough set models to make decisions with evaluation of fuzzy information. An example illustrates the feasibility and effectiveness of our proposed method to solve practical problems. By comparing the ranking results of the existing methods and our |

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| | | | | proposed method, we observe that the optimal selected alternative is the same, which means that there is a consistency among our proposed decision-making method and the existing methods. In addition, we find that the traditional methods may fail in some practical situations while our proposed method is still valid. |
| 37 | Multi-criteria decision aid in financial decision making: methodologies and literature review | Michael Doumpos<br>Constantin Zopounidis | Journal of Multi-Criteria Decision Analysis | Over the past decades the complexity of financial decisions has increased rapidly, thus highlighting the importance of developing and implementing sophisticated and efficient quantitative analysis techniques for supporting and aiding financial decision making. Multi-criteria decision aid (MCDA), an advanced field of operations research, provides financial decision makers (DMs) and analysts a wide range of methodologies, which are well suited to the complexity of |

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| | | | | financial decision problems. The aim of this paper is to provide an in-depth presentation of the contributions of MCDA in the field of finance, focusing on the methods used and their real-world applications. |

**5. Sistem Seleksi Supplier**

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| 1. | Evaluating suppliers to include green supplier development programs via fuzzy c-means and VIKOR methods | (Akman, 2015) | Computers & Industrial Engineering , 2015 | Green supplier development has became necessity as organizations increasingly compete on environmental supply chain capabilities. This paper aims to determine green/environmental performance of supplier, and define which suppliers need to improve their conditions about environmental issues, and identify which suppliers should be included to green supplier development programs to enhance their environmental performance. Therefore, primarily, performance criteria and green supplier evaluation criteria were determined via a survey, then factor analysis was conducted to evaluate validity of factors. Then two step clustering was performed by using c-means clustering method. In the first step of clustering, all suppliers of a firm |

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| | | | | performing in automobile industry were clustered according to criteria-delivery, quality, cost and service. Thus best performing suppliers were determined. In the second step of clustering, best performing suppliers determined in the first step of clustering were evaluated with environmental/green criteria. As a result of clustering, best performing suppliers were splitted to three groups according to green criteria-good, medium, poor. Lastly, suppliers within the poor group were sequenced by using VIKOR method in order to include green supplier development programs. |
| 2. | Analytic network process and multi-period goal programming integration in purchasing decisions | (Aktar Demirtas & Ustun, 2009) | Computers & Industrial Engineering , 2009 | This paper presents a multi-period inventory lot sizing scenario, where there is single product and multiple suppliers. By considering multi-period planning horizon, an integrated approach of Archimedean Goal Programming (AGP) and Analytic Network Process (ANP) is suggested. This integrated approach proposes a two-stage mathematical model to evaluate the suppliers and to determine their periodic shipment allocations given a number of tangible and intangible criteria. In the evaluation stage, the suppliers are evaluated |

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| | | | | according to 14 criteria that are involved in four control hierarchies; benefit, opportunity, cost and risk (BOCR). In the shipment stage, a multi objective mixed integer linear programming (MOMILP) model is described to solve the order allocation problem. This MOMILP model is suggested to achieve target values of periodic goals: budget, aggregate quality, total value of purchasing (TVP) and demand over the planning horizon, without exceeding vendor production capacities. This multi-period model is solved by using AGP. Finally some computational experiments are conducted to test the performance of the proposed method. |
| 3 | Supply chain optimization under risk and uncertainty: A case study for high-end server manufacturing | (Aqlan & Lam, 2016) | Computers & Industrial Engineering, 2016 | This paper presents an approach and a software application for supply chain optimization under risk and uncertainty. The proposed approach combines simulation and optimization techniques for managing risks in supply chains. A multi-objective optimization model is developed which considers the deterministic features of the supply chain. A simulation model is used to represent the stochastic features of the supply chain. Both models communicate to achieve the best values |

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| | | | | for profit, lead time and risk reduction by selecting a combination of mitigation strategies and allocating orders and inventory. A case study from a high-end server manufacturing environment is used to demonstrate the validity of the proposed approach. The analytical results show clear trade-offs among the three objectives where changing the risk reduction goal value will affect the total profit and lead time. The proposed approach helps decision makers identify the best risk mitigation strategies and allocate inventory and customer orders effectively. |
| 4 | A hybrid approach to concept selection through fuzzy analytic network process | (Ayağ & Özdemir, 2009) | Computers & Industrial Engineering, 2009 | Evaluating conceptual design alternatives in a new product development (NPD) environment has been one of the most critical issues for many companies which try to survive in the fast-growing world markets. Therefore, most companies have used various methods to successfully carry out this difficult and time-consuming evaluation process. Of these methods, analytic hierarchy process (AHP) has been widely used in multiple-criteria decision-making (MCDM) problems. But, in this study, we used analytical network |

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| | | | | process (ANP), a more general form of AHP, instead of AHP due to the fact that AHP cannot accommodate the variety of interactions, dependencies and feedback between higher and lower level elements. Furthermore, in some cases, due to the vagueness and uncertainty on the judgments of a decision-maker, the crisp pairwise comparison in the conventional ANP is insufficient and imprecise to capture the right judgments of the decision-maker. Therefore, a fuzzy logic is introduced in the pairwise comparison of ANP to make up for this deficiency in the conventional ANP, and is called as fuzzy ANP. In short, in this paper, a fuzzy ANP-based approach is proposed to evaluate a set of conceptual design alternatives developed in a NPD environment in order to reach to the best one satisfying both the needs and expectations of customers, and the engineering specifications of company. In addition, a numerical example is presented to illustrate the proposed approach. |
| 5 | Vertical collaboration in the semiconductor industry: A | (Bahinipati & Deshmukh, 2012) | Computers & Industrial Engineering | Vertical collaboration problem focuses on integrating and modeling the decision problems of the suppliers and buyers |

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| | decision framework for supply chain relationships | | | together with the market intermediary by identifying the inefficiencies in the traditional marketplace and aligning the incentives of members in the e-marketplace. The present work develops and solves real life e-marketplace models for complex buyers–suppliers procurement problems by estimating the order quantities in the collaborated supply chain. The newsvendor framework considers demand to be independent of the selling price as is generally the case in the semiconductor industry supply chain dealing with techno-savvy customers. The vertical collaboration process would be more effective if the length of the planning horizon and order size is considered as a negotiation parameter between the buyer and supplier. It is observed that the supplier's expected profit function increases with the buyers' ordering quantity, which is important in characterizing the general structure of the collaboration scheme of the supply chain. |
| 5 | Horizontal collaboration in semiconductor manufacturin | (Bahinipati et al., 2009) | Computers & Industrial Engineering, 2009 | This paper aims to provide a generic quantitative model to comprehensively assess the degree of collaboration with |

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| | g industry supply chain: An evaluation of collaboration intensity index | | | individual horizontal collaboration initiatives with a view to check feasibility for satisfying the customer requirements. The analytic hierarchy process–fuzzy logic model (AHP–FLM) approach is chosen for developing the model, a method that is often used to tackle complex strategic decision making that calls for subjective judgment based on well-established logical reasoning, rather than on simple feeling and intuition. In the process, the complex and unstructured problem for 'compatibility test' is broken down into elements, and then a customized hierarchy structure is set up to demonstrate the relationship between different hierarchy levels and among these elements. Each element may have a different level of importance for the horizontal collaboration. A fuzzy rule based collaboration intensity index (CII) is developed to build up the relationships among these evaluation attributes. Synthesizing the generic relative importance and the forecasted degree of collaboration, the proposed approach can determine the success of the collaboration initiative. An illustrative |

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| | | | | example of a semiconductor industry supply chain (SSC) member that intends to partner with a potential and competing candidate enterprise is developed to demonstrate the applicability of the proposed fuzzy strategic alliance selection framework and to measure the effectiveness of a horizontal collaboration initiative. |
| 6 | A new integrated intuitionistic fuzzy group decision making approach for product development partner selection | (Büyüközkan & Güleryüz, n.d.) | Computers & Industrial Engineering , 2016 | Globally, customers are getting increasingly demanding in terms of quality, price and performance of products and are asking for shorter product development periods with more predictable cycles. These market pressures drive firms to collaborate with possible partners in product development (PD) processes. Nevertheless, choosing the suitable partner for an effective PD is a challenging, complex decision. This study proposes a combined Intuitionistic Fuzzy (IF) Group Decision Making (GDM) model that consists of the Intuitionistic Fuzzy Analytic Hierarchy Process (IF-AHP) and Intuitionistic Fuzzy Technique for Order Preference by Similarity to Ideal Solution (IF-TOPSIS) methods for effectively evaluating PD partners. In order to |

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| | | | | obtain a more complete evaluation and more precise results, IF-AHP is used for determining criteria weights, whereas IF-TOPSIS methodology is conducted for ranking partner alternatives. This study contributes to partner selection and IF set literature by providing a combined framework based on IF-AHP and IF-TOPSIS with GDM methodology for the first time. To assess the validity of the proposed integrated IF GDM approach, a case study is also provided. This study contributes to literature as it provides a better insight into the theoretical ground of the PD partner selection problem. It also supports organizations which aim to improve their PD evaluation systems. |
| 8 | Collaborative networked organizations – Concepts and practice in manufacturing enterprises | Luis M.Camarinha Matos HamidehAfsarmanesh NathalieGaleano ArturoMolina[c] (Camarinha-Matos et al., 2009) | Computers & Industrial Engineering, 2009 | Participation in networks has nowadays become very important for any organization that strives to achieve a differentiated competitive advantage, especially if the company is small or medium sized. Collaboration is a key issue to rapidly answer market demands in a manufacturing company, through sharing competencies and resources. The collaborative networked organizations (CNO) area focuses on this type of organizational models that use ICT for |

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| | | | | supporting the development of collaborative business opportunities. This paper describes the key concepts related to CNOs, provides a high level classification of collaborative networks, and presents some application cases in the manufacturing industry. Finally a holistic research initiative addressing key challenges in the area is presented and a discussion of the CNO paradigm contribution to the challenges faced by manufacturing systems is made. |
| 9 | Supplier selection and supply quantity allocation of common and non-common parts with multiple criteria under multiple products | Z.H.CheH.S.Wang (Che & Wang, 2008) | Computers & Industrial Engineering , 2008 | With limited capacity of suppliers, how to reduce the total operating cost of the enterprise by determining the most suitable production capacity allocation has become the major issue faced by various enterprises in producing multiple types of products. In addition, when manufacturing multiple types of products, due to the high demand of common and non-common parts, which is applicable to various products, enterprises will place special emphasis on the procurement of common and non-common parts, to select most suitable suppliers of parts with the highest quality and minimum time and costs, in order to cut down on |

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| | | | | operating costs of enterprises. This research first lists parts of various products through bill of material (BOM), and constructs an optimal mathematical model suitable for multi-phase products' parts, in order to assess the assembling relationship of various parts; it makes use of the linkage among those to select the supplier of common and non-common parts when assessing multiple products. Then considering the limited production capacity of suppliers, it selects the best combination of suppliers of special common and non-common parts. To solve the optimal mathematical model, a genetic algorithm (GA) is proposed to find the acceptable results of the supply selection and quantity allocation problem. It then provides a benchmark for enterprise in current diversified market to purchase and assess common and non-common parts, and makes such benchmark a normal standard for selection of suppliers in the future. |
| 10 | Application of quality function deployment in the semiconducto | Chee-ChengChen (Chen, 2010) | Computers & Industrial Engineering , 2010 | In quality function deployment (QFD), the voice of the customer (VOC) is the critical factor in developing and producing a product that will meet or exceed |

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| | r industry: A case study | | | customer requirements. This study integrates quality function deployment (QFD), management techniques to optimise product-design investment, process improvement, and phase-into meet customer requirements and company goals. QFD uses systematic multi-level development and evaluation to translate customer requirements into the design of product characteristics and manufacturing processes that will satisfy the customer and minimise potential failure costs. 'Process management', which is one of the pivotal Six Sigma implementation criteria, is used to construct an 'integrated product and process development' (IPPD) model by product type to enhance the effectiveness of QFD. This model, combined with a company's customer satisfaction strategy and QFD techniques, provides process management through built-in IPPD and appropriate changes in organisational culture. This paper presents a case study from the semiconductor industry to demonstrate the model's applicability and suitability. |
| 11 | Overall Wafer Effectiveness (OWE): A | Chen-FuChien[a]Chia-YuHsu[b]Kuo-HaoChang[a] (Chien et al., 2013) | Computers & Industrial Engineering, 2013 | As semiconductor industry reached nanotechnology generation and consumer |

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| | novel industry standard for semiconductor ecosystem as a whole | | | electronics era, the competition is no longer among individual semiconductor companies. Indeed, the collaborations among horizontally specialized value providers are critical for the success of the companies as well as the whole ecosystem. This paper aims to propose a novel index, i.e., Overall Wafer Effectiveness (OWE), to measure wafer productivity and drive various improvement directions for semiconductor ecosystem as a whole. Furthermore, the proposed OWE can be easily extended to incorporate additional attributes such as mask-field-utilization, throughput, and yield for effective management. We conducted a number of case studies in real settings. The results have shown that OWE can be employed as a semiconductor industry standard to drive collaborative efforts among IC designers, equipment vendors, and manufacturers in the ecosystem to enhance total wafer effectiveness. This paper concludes with discussions on value propositions of proposed OWE indices and future research directions. |
| 12 | A comparative study on the | Yon-ChunChou[a]Wen-ChiSung[a]GraceLin[b]JohnJahn[c] | Computers & Industrial Engineering | Competition in global supply chains has become so severe that |

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| | performance of timing and sizing models of capacity expansion under volatile demand growth and finite equipment lifetime☆ | (Chou et al., 2014) | | many suppliers in the high-tech manufacturing industry must shoulder high risk but have negative return on assets. While the literature is abundant with capacity models, there is a need for further research on capacity investment, especially in selecting and correctly using the right model. For a firm with lasting manufacturing operation, capacity expansion has two aspects: the timing and sizing of each expansion. The aim of a sizing method is to determine the scale of capacity expansion and that of a timing method is to determine the right time of the next expansion. The majority of capacity models in the literature can be classified as sizing models. In contrast, timing models have not received as much attention. In this paper, we compare the performance of the two types of models under volatile demand growth in order to find out the more appropriate type for the high-tech manufacturing environment. An empirical analysis of semiconductor demand is first presented. We find that the geometric Brownian motion process is appropriate for characterizing the volatility of demand |

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| | | | | growth. Based on this finding, simulation is used to compare a canonical timing and a canonical sizing models in various scenarios of demand growth, demand volatility and profit margin. We also advocate using profitability as a capacity investment criterion, in addition to the demand-satisfying criterion that is commonly used in the literature. Simulation results show that the timing model outperforms the sizing model. Finally, the behavior of the timing model is characterized as an aggressive method that can be used to exploit demand volatility for an advantage. |
| 13 | Evaluating suppliers via a multiple levels multiple criteria decision making method under fuzzy environment | Ta-ChungChuRanganathVarma | Computers & Industrial Engineering, 2012 | Suppliers are an important component of the supply chain. Their ability and performance are what largely determine the success or failure of the supply chain. Thus the evaluation of suppliers has become a very important part of the supply chain management of a company. This paper suggests a multiple levels multiple criteria decision making (MCDM) model under fuzzy environment to evaluate and select suppliers, where a general hierarchical structure is developed to depict the relationship among parent criteria and |

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| | | | | their sub-criteria and sub-sub-criteria and so on. These criteria are classified into quantitative and qualitative ones. The ratings of alternatives versus qualitative criteria and the importance weights of all criteria in the hierarchical structure are assessed in linguistic values represented by triangular fuzzy numbers. The ranking approach of center of area is suggested to rank all the fuzzy numbers before their weighted ratings aggregation. The final evaluation values of alternatives can then be obtained through the additive weighted ratings from the last to the first level in the criteria structure. Finally a numerical example demonstrates the feasibility of the proposed model. |
| 14 | Modeling risk in a Design for Supply Chain problem | ErinClaypool[a]Bryan A.Norman[a]Kim LaScolaNeedy[b] | Computers & Industrial Engineering , 2014 | The objective of Design for Supply Chain (DFSC) is to design a supply chain in parallel to designing a new product. Risk is an inherent element of this process. Although supply chain risk models and product development risk models are available, there are few models that consider the combined effect of risk to product development and the supply chain. This gap is filled by the development of a DFSC and risk model that looks at |

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| | | | | design, supply chain and risk concurrently. The model consists of two components. First, a Mixed Integer Programming (MIP) model makes the DFSC decisions while simultaneously considering time-to-market risk, supplier reliability risk and strategic exposure risk. The results from the MIP are then used in the second model component which is a discrete event simulation. The simulation tests the robustness of the MIP solution for supplier capacity risk and demand risk. When a decision maker is potentially facing either of these risks the simulation shows whether it is best to use an alternative solution or proceed with the MIP solution. The model provides analytical results, but also allows decision makers to use their own judgment to select the best option for overall profitability. In conclusion, testing shows that risk mitigation strategies can and should be determined from the DFSC and risk model, but that they will be dependent on the specific design problem being solved. |
| 15 | Combining Bayesian Networks and | IbrahimDoganNezirAydin | Computers & Industrial | In this study, we analyze the supplier selection process by combining |

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| | Total Cost of Ownership method for supplier selection analysis | | Engineering, 2011 | Bayesian Networks (BN) and Total Cost of Ownership (TCO) methods. The proposed approach aims to efficiently incorporate and exploit the buyer's domain-specific information when the buyer has both limited and uncertain information regarding the supplier. This study examines uncertainty from a total cost perspective, with regards to causes of supplier performance and capability on buyer's organization. The proposed approach is assessed and tested in automotive industry for tier-1 supplier for selecting its own suppliers. To efficiently facilitate expert opinions, we form factors to represent and explain various supplier selection criteria and to reduce complexity. The case study in automotive industry shows several advantages of the proposed method. A BN approach facilitates a more insightful evaluation and selection of alternatives given its semantics for decision making. The buyer can also make an accurate cost estimation that are specifically linked with suppliers' performance. Both buyer and supplier have clear vision to reduce costs and to improve the relations. |

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| 16 | Production planning conflict resolution of complex product system in group manufacturing: A novel hybrid approach using ant colony optimization and Shapley value | BaigangDuShunshengGuo | Computers & Industrial Engineering, 2016 | Production planning conflict (PPC) is a key factor leads to production delay in manufacturing system. As production planning of complex product system (CoPS) is more complex than commodity products, some manufacturing enterprises set up a new group manufacturing (GMfg) enterprise to decrease conflict and expand resources deployment. Besides, group members have been forced by customers not only to supply products timely but also to be responsible for product cost. In addition, with conflict resolution of production planning, allocating the conflict resolution profits (CRP) among group members becomes an unsolved issue in GMfg. Hence, a new variant of conflict resolution model named GMfg production planning conflict resolution of CoPS (GPPCR&CoPS) is addressed in this paper. In the proposed approach, a Multi-level progress view (MLPV) model is used to detect the conflict of CoPS. Also, a bi-objective (schedule delay and total cost) is used and the CRP allocation among group members is considered. Moreover, a novel hybrid approach using dual-path searching ant colony optimization (DPS- |

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| | | | | ACO) and Shapley value is proposed to solve the bi-objective problem. Finally, a case study and comparison of performances with ant colony optimization (ACO) and NSGA-II are presented. Experimental results show the proposed method is more preferable in optimal solution searching. |
| 17 | Proceedings of the 19th International Conference on Computers and Industrial Engineering Global manufacturing systems: A model supported by genetic algorithms to optimize production planning | A.ClaudioGaravelli[1]O.GeoffreyOkogbaa[2]NicolaViolante[1] | Computers & Industrial Engineering, 1996 | Global competition emphasizes the benefits of a more coordinated production planning among the subsidiaries of a multinational company (MNC). In this paper, a model for the production assignment of the global demand to the MNC plants is proposed. The solution search, based on total cost optimization, is pursued by genetic algorithms. A simple example is provided to show the model implementation. |
| 18 | Evolutionary techniques for optimization problems in integrated manufacturing system: State-of-the-art-survey | MitsuoGenLinLinHaipengZhang | Computers & Industrial Engineering, 2009 | Integrated manufacturing system (IMS) is a novel manufacturing environment which has been developed for the next generation of manufacturing and processing technologies. It consists of engineering design, process planning, manufacturing, quality management, and storage and retrieval functions. Improving the decision quality in those fields give rise to complex combinatorial optimization problems, unfortunately, most of |

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| | | | | them fall into the class of NP-hard problems. Find a satisfactory solution in an acceptable time play important roles. Evolutionary techniques (ET) have turned out to be potent methods to solve such kind of optimization problems. How to adapt evolutionary technique to the IMS is very challenging but frustrating. Many efforts have been made in order to give an efficient implementation of ET to optimize the specific problems in IMS.<br><br>In this paper, we address four crucial issues in IMS, including design, planning, manufacturing, and distribution. Furthermore, some hot topics in these issues are selected to demonstrate the efficiency of ET's application, such as layout design (LD) problem, flexible job-shop scheduling problem (fJSP), multistage process planning (MPP) problem, and advanced planning and scheduling (APS) problem. First, we formulate a generalized mathematic models for all those problems; several evolutionary algorithms which adapt to the problems have been proposed; some test instances based on the practical problems demonstrate the effectiveness and |

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| | | | | efficiency of our proposed approach. |
| 19 | A multiple-vendor single-buyer integrated inventory model with a variable number of vendors | Christoph H.Glock | Computers & Industrial Engineering , 2011 | Supply chain management is concerned with the coordination of material and information flows in multi-stage production systems. A closer look at the literature reveals that previous research on the coordination of multi-stage production systems has predominantly focused on the sales side of the supply chain, whereas problems that arise on the supply side have often been neglected. This article closes this gap by studying the coordination of a supplier network in an integrated inventory model. Specifically, we consider a buyer sourcing a product from heterogeneous suppliers and tackle both the supplier selection and lot size decision with the objective to minimise total system costs. First, we provide mathematical formulations for the problem under study, and then suggest a two-stage solution procedure to derive a solution. Numerical studies indicate that our solution procedure reduces the total number of supplier combinations that have to be tested for optimality, and that it may support initiatives which aim on increasing the efficiency of the |

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| | | | | supply chain as a heuristic planning tool. |
| 20 | Single sourcing versus dual sourcing under conditions of learning | Christoph H.Glock | Computers & Industrial Engineering , 2012 | This paper considers a buyer who has to decide whether to select a single or two sources of supply for a homogeneous product. The production processes of the suppliers are subject to learning effects, which reduce the production costs and increase the production capacities of the suppliers. This, in turn, enables the suppliers to reduce the sales price, which results in lower acquisition costs at the buyer. As the supplier selection decision influences the individual production quantity of a supplier, the learning effect has to be considered when deciding how many and which suppliers to select. Since the effect of learning on the supplier selection problem has not been investigated in the literature, this paper addresses this limitation and derives models for continuous learning and when learning plateaus. Numerical results indicate that the supplier selection decision can comprehensively influence the learning process for the suppliers and therewith the total costs of the system under study. The results also show that it is not necessarily optimal solely to select the |

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| | | | | supplier with the highest learning rate. |
| 21 | A relationship framework and application in between strategy and operational plans for manufacturing industry | AdemGöleç | Computers & Industrial Engineering ,2015 | The objective of this paper is to develop a system that calculates a company's strategic manufacturing performance using indicator values of competitive priorities classified according to manufacturing players and their weights and to determine strategic operations plans to guide short-term decisions based on performance and indicator values. A framework is designed that measures strategic manufacturing strength and links these competitive priorities to manufacturing strategy to plan operations that are compatible with the manufacturing strategy. This framework is applied in a panel furniture company. Quantitative data are obtained from Enterprise Resource Planning database. This work provides a new, more structured methodology with greater quantification and new insights. It is hoped that this decision support system helps that managers of a company in their strategic operations plans decision-making as they develop manufacturing capabilities against competitors. This study eliminates several gaps between the academic |

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| | | | | literature and current management practice, suggesting that researchers should consider the impact of theory on the process of strategy operations planning. It also offers a way for organizations with respect to determine strategy operations planning according to their current performance measurement systems. This study includes a different approach than those described in the literature because it includes a conceptual model, novel methods used in performance calculation and decision-making related to strategic operations plans. |
| 22 | Issues in environmentally conscious manufacturing and product recovery: a survey | AskinerGungorSurendra MGupta | Computers & Industrial Engineering, 1999 | Environmentally Conscious Manufacturing and Product Recovery (ECMPRO) has become an obligation to the environment and to the society itself, enforced primarily by governmental regulations and customer perspective on environmental issues. This is mainly driven by the escalating deterioration of the environment, e.g. diminishing raw material resources, overflowing waste sites and increasing levels of pollution. ECMPRO involves integrating environmental thinking into new product |

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| | | | | development including design, material selection, manufacturing processes and delivery of the product to the consumers, plus the end-of-life management of the product after its useful life. ECMPRO related issues have found a large following in industry and academia who aim to find solutions to the problems that arise in this newly emerged research area. Problems are widespread including the ones related to life cycle of products, disassembly, material recovery, remanufacturing and pollution prevention. In this paper, we present the development of research in ECMPRO and provide a state-of-the-art survey of published work. |
| 23 | A multi-criteria approach to robust outsourcing decision-making in stochastic manufacturing systems | Gerd J.Hahn[a]TorbenSens[b]CatherineDecouttere[c]Nico J.Vandaele[c] | Computers & Industrial Engineering, 2016 | Manufacturing outsourcing is a key industry trend towards greater operations effectiveness and is related to the discussion of strategic core competencies. We study the issue of contract manufacturing at the strategic–tactical level aiming for robust decisions to accommodate stochastic manufacturing environments and immanent uncertainty of planning parameters. The topic is approached from a multi-criteria decision-making perspective, since service, cost, |

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| | | | | quality, and more long-term value-related aspects need to be considered to arrive at well-balanced decisions. Our contribution is twofold: first, we develop a scenario-based non-parametric ranking approach to determine beneficial outsourcing options at the strategic level. The ranking method uses both model-based Key Performance Indicators (KPIs), which are obtained from a tactical planning model, and non-model-based KPIs that are derived in an independent assessment from multiple stakeholders. Second, we provide an enhanced aggregate planning approach at the tactical level in order to evaluate the performance implications of the strategic outsourcing decisions which in turn serve as the model-based KPIs for the ranking method. A queuing network-based approach is incorporated in the aggregate planning model to anticipate the stochastic behavior of manufacturing systems. An industry-derived case example with distinct outsourcing options is used to highlight the benefits of the approach and to investigate tactical trade-offs when coordinating internal and external manufacturing decisions. |

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| | A systematic supplier selection procedure | AzimHoushyarDavidLyth | Computers & Industrial Engineering, 1992 | One of the most important decisions that the procurement department of any manufacturing organization has to make is the selection of an appropriate supplier. This selection will commit the organization and its resources to an outsider for a long time to come, and any mistake in their selection could adversely affect the stability of the organization. As firms reduce their supply base and enter into long term commitments with suppliers, this decision becomes even more important. In this paper a systematic procedure for supplier selection is presented that influence all the relevant factors into the decision, and classifies them into critical factors, objective factors, and subjective factors. It offers a procedure that can be used to evaluate the supplier's performance. |
| 24 | Real-time capacity requirement planning for make-to-order manufacturing with variable time-window orders | Yi-FengHungChuan-CheHuangYingYeh | Computers & Industrial Engineering, 2013 | In a make-to-stock (MTS) manufacturing environment using material requirement planning (MRP), checking the capacity feasibility of a master production schedule (MPS) requires capacity requirement planning (CRP) that can be easily calculated. The time window of an order is the time interval from its ready date to its due date. |

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| | | | | In a make-to-order (MTO) manufacturing environment, the CRP method checks whether a set of orders with different time windows can be scheduled for timely completion. This corporate-level CRP problem has long perplexed MTO contract manufacturers, such as those in the fashion industry. This study therefore develops an efficient and effective CRP approach that considers orders with variable time windows. Real-time capacity feasibility can be checked on both the corporate planning and detailed operational scheduling levels by applying the preemptive earliest due date (PEDD) rule to a single machine problem. This simple and efficient dispatching rule can assess the impact on capacity consumption each time an inquiry order is received or select a set of pre-prioritized orders that can be feasibly scheduled. The efficiency of a supply chain network is affected by its overall lead time, which includes time spent on order processing, manufacturing, and transportation. The proposed approach significantly reduces the order processing time and enhances supply chain efficiency. |

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| 25 | An available-to-promise system for TFT LCD manufacturing in supply chain | Yi-FengHungChuan-CheHuangYingYeh | Computers & Industrial Engineering, 2020 | This paper presents development of an available-to-promise (ATP) system for thin film transistor liquid crystal display (TFT LCD) manufacturing in global supply chain environment where the worldwide headquarter, distribution centers, and manufacturing facilities are globally networked. ATP activity is simply to give the delivery date promise to customers for their specific orders. However, the ATP process is not simple due to the complexity of supply chain and information integrity. In this paper, we build up a global ATP system architecture whose functions and information flows are comprehensively defined. To do so, we developed an ATP model in a global supply chain for estimating the promising delivery date for new orders, and the capacity available-to-promise (CATP) model for calculating the unused production capacity at shop floor level with given production schedules. We proposed an efficient heuristic for scheduling TFT LCD module assembly process for effectively using the unused capacity at shop floor level. Efficiency of the scheduling system was investigated using |

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| | | | | the data collected in a real TFT LCD manufacturing site. The validity of the proposed ATP system was also explored by comparing with other ATP procedures including the current practice. |
| 26 | An approach for manufacturing strategy development based on fuzzy-QFD | G.Z.JiaM.Bai | Computers & Industrial Engineering, 2011 | Today most research related to manufacturing strategy development concentrates on descriptive processes and conceptual models, and therefore lacks the capability of assessing the supportive degree of manufacturing strategy to competitive priorities, and is also difficult to assess the congruence among various decisions of the manufacturing strategy. This paper proposes an approach for manufacturing strategy development based on quality function deployment (QFD). The study starts by analyzing the process of manufacturing strategy development and the features of QFD. Thereafter, a methodology related to manufacturing strategy development based on QFD is developed, which comprises two stages and eleven steps. This approach uses QFD as a transforming device to link competitive factors with manufacturing decision categories such as structural decision categories and infrastructural |

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| | | | | categories, and uses QFD as a main tool in different stages of manufacturing strategy development process. This paper also integrates fuzzy set theory and house of quality (HOQ) in order to provide a structural tool to capture the inherent imprecision and vagueness of decision-relevant inputs and to facilitate the analysis of decision-relevant QFD information. A case is given to illustrate the utilization of the proposed approach at the end of this paper. |
| 27 | An agent-based framework for global purchasing and manufacturing in a shoe industry | Tae WoonKim[a]Chang SeongKo[a]Byung NamKim[b] | Computers & Industrial Engineering ,2002 | Global competition is forcing the present day industry to produce high quality product more fast and inexpensively. The need for fast information exchange has increased among the remote locations for the cooperation and coordination. In this study, a virtual global manufacturing system in a shoe company is constructed that distributes production schedule among remote places, acts as a bridge between the headquarters and manufacturing plants, distributes tasks and collates different solutions between demand and supply using an agent. It generates an order and a procurement plan. An order-supply agent is proposed and implemented to automate the process of ordering |

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| | | | | and supplying of goods in a shoe making company from the Internet environment. |
| 28 | The use of computers and analytical techniques for production planning and control in the British manufacturing industry | A.K.Kochhar | Computers & Industrial Engineering, 1978 | This paper, based on the results of a survey, reviews the typical computer applications encountered in the manufacturing industry. The use of computers and available operations research techniques, for production planning and control, amongst companies participating in this survey is discussed. Detailed comparisons are made between small and large companies, companies in different Standard Industrial Classification (SIC) categories, and companies with high and low level technology products. Difficulties, encountered by existing users, in implementing their computer systems are outlined. The article concludes with a brief discussion of the impact of computer use on a number of significant measures of performance. |
| 29 | A fuzzy goal programming approach for vendor selection problem in a supply chain | ManojKumar[a]PremVrat[b]R. Shankar[c] | Computers & Industrial Engineering ,2004 | A fuzzy goal programming approach is applied in this paper for solving the vendor selection problem with multiple objectives, in which some of the parameters are fuzzy in nature. A vendor selection problem has been formulated as a fuzzy mixed integer goal programming vendor |

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| | | | | selection problem that includes three primary goals: minimizing the net cost, minimizing the net rejections, and minimizing the net late deliveries subject to realistic constraints regarding buyer's demand, vendors' capacity, vendors' quota flexibility, purchase value of items, budget allocation to individual vendor, etc. An illustration with a data set from a realistic situation is included to demonstrate the effectiveness of the proposed model. The proposed approach has the capability to handle realistic situations in a fuzzy environment and provides a better decision tool for the vendor selection decision in a supply chain. |
| 30 | Computational Intelligence in Design and Manufacturing | | John Wiley & Sons, 2000 | |
| 31 | An evaluation model of buyer–supplier relationships in high-tech industry — The case of an electronic components manufacturer in Taiwan | Amy H.I.Lee[ab]Hsing-JenChang[b]Chun-YuLin[a] | Computers & Industrial Engineering, 2009 | With globalize market, fast-changing technology and shortening product life cycle, businesses are becoming extremely competitive, and a cooperative buyer–supplier relationship is essential for a manufacturer, especially in technology-related industry, to survive and to acquire reasonable profit. Even though the research on various types |

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| | | | | of collaborations between firms is abundant, the research that provides a mathematical model for the selection of the most appropriate relationship form is very limited. The main objective in this study is to base on an electronic components manufacturer in Taiwan to propose an analytical approach to evaluate the forms of buyer–supplier relationship between the manufacturer and its supplier. A model, which applies the analytic network process (ANP) and the benefits, opportunities, costs and risks (BOCR) concept, is constructed to consider various aspects of buyer–supplier relationships. Multiple factors that affect the success of the relationship are analyzed by incorporating experts' opinions on their priority of importance, and a performance ranking of the buyer–supplier forms is obtained. The results shall provide guidance to select the most appropriate form of relationship between the manufacturer and its supplier. The proposed model is systematic, and it is easy to be understood and applied by the management. The model can be tailored and applied by firms in various industries that are making decisions on |

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| | | | | buyer–supplier relationship. |
| 32 | Combining fuzzy weight average with fuzzy inference system for material substitution selection in electric industry | Kuo-PingLin[a]Hung-PinHo[b]Kuo-ChenHung[c]Ping-FengPai[d] | Computers & Industrial Engineering, 2012 | Material selection is a very important issue for an electronics company as it includes many qualitative or quantification factors. The material selection problem is associated with design and manufacturing problems which have been widely investigated. This study develops a hybrid fuzzy decision-making model which combines the fuzzy weight average (FWA) with the fuzzy inference system (FIS) for material substitution selection in the electronics industry. FWA is employed to select a substitute material in an uncertain environment, while FIS is used for reasoning purposes. FWA with α-cuts arithmetic (FWAα-cut) is a popularly technology in decision-making problems. However, FWAα-cut may result in the following unanticipated situations: (1) unclear decision situations; (2) undecided results expressed by fuzzy membership functions; and (3) high computational complexity. Therefore, a fuzzy weight average with the weakest t-norm (FWATω) is designed as an alternative method for group decision making. In contrast to traditional |

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| | | | | FWA methods, FWATω obtains more visible fuzzy results for decision makers with lower computational complexity, and can provide exacter estimation by the weakest t-norm operations in uncertain environment. Thus, the proposed hybrid fuzzy decision-making model imitates an expert's experiences and can estimate substitution purchasing in various statuses. A real material substitution selection case is employed to examine the feasibility of the proposed model; experimental results reveal that the proposed model performs better than the traditional FWA model in coping with material substitution selection problems. |
| 33 | Evaluation of multi-product lean manufacturing systems with setup and erratic demand | Chukwunonyelum EmmanuelOnyeocha[a]JosephKhoury[b]JohnGeraghty[a] | Computers & Industrial Engineering, 2015 | The consideration of demand variability in Multi-Product Lean Manufacturing Environment (MPLME) is an innovation in production system engineering. Manufacturing systems that fail to recognise demand variability generate high Work-In-Process (WIP) and low throughput in MPLME. In response to demand variability, organisations allocate large quantities of Production Authorisation Cards (PAC). A large proportion of PAC |

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| | | | | results in a high WIP level. However, the Shared Kanban Allocation Policy (S-KAP) allows the distribution of PAC among part-types, which minimises WIP in MPLME. Nevertheless, some existing lean manufacturing control strategies referred as Pull Production Control Strategies (PPCS) that have shown improved performance in single-product systems failed to operate S-KAP. The recently developed Basestock–Kanban-CONWIP (BK-CONWIP) strategy has the capability of minimising WIP while maintaining low backlog and volume flexibility. This paper investigates the effects of erratic demand on the performance of PPCS in MPLME. It is shown that S-KAP BK-CONWIP outperforms other PPCS. Finally, it is feasible to design quick-response PPCS for MPLME under erratic demand. |
| 34 | Optimal configuration of cluster supply chains with augmented Lagrange coordination | T.Qu[a]D.X.Nie[ab]X.Chen[a]X.D.Chen[a]Q.Y.Dai[a]George Q.Huang[c] | Computers & Industrial Engineering ,2015 | Enterprises in an industrial cluster could dynamically alliance in the form of cluster supply chains to share inner-cluster resources and services, and respond to the ever-fluctuating customer demands in a cost-effective way. However, an effective and feasible method enabling such dynamic |

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| | | | | cluster supply chain configuration (CSCC) lags behind practice due to the conflict of interests. Researchers are designing All-in-One theoretic models to optimize CSCC with the assumed decision details of all enterprises, while in fact clustered enterprises are seeking effective decentralized decision mechanisms which protect their decision autonomy in the frequently re-configured CSC. A newly emerged multi-disciplinary optimization method, Augmented Lagrangian Coordination (ALC), which supports the open-structure collaboration with strict optimization convergence, is thoroughly investigated in this paper and applied to solve the conflict. Through a complete analysis of CSC's configuration policies in typical stages, a generic CSCC model is proposed and then partitioned into an ALC-based decentralized decision model by the typical decision autonomy distribution in clusters. Clustered enterprises collaborate vertically and laterally along the ALC model through multi-dimensional couplings to achieve the overall consistency and optimality. Results have proved the effectiveness of ALC for CSCC |

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| | | | | problem. A set of sensitivity analysis is also conducted to find out the condition in which an order has to be fulfilled in a CSC and the most appropriate configuration. |
| 35 | Semantic Web for manufacturing, trends and open issues: Toward a state of the art | LuisRamos | Computers & Industrial Engineering, 2015 | Achieving success in modern industry requires the orchestration of the stakeholders of the manufacturing process as well as accessing information distributed along the manufacturing network involved; this latter is a key factor. Many manufacturing approaches have appeared with the aim of speeding up the manufacturing process by means of accessing certain knowledge encoded in a way that makes it reusable. Ontologies and the Semantic Web are emerging technologies proposed for knowledge representation and reasoning, which tend to be adopted in the manufacturing domain in order to deal and to facilitate such tasks. However, we have identified that many of the shortcomings of the proposed technologies have been neglected by some authors, compromising the feasibility of including them into any proposed approach. In this study we aim at describing the most prominent approaches which relate |

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| | | | | manufacturing with knowledge representation. Furthermore some formal aspects of Ontology and Semantic Web technologies will be introduced, with the intention of present a general view that integrates research contributions which combine both approaches in an emerging approach called Semantic Manufacturing. |
| 36 | Designing a decision support system to evaluate and select suppliers using fuzzy analytic network process | JafarRazmiHamedRafieiMahdiHashemi | Computers & Industrial Engineering, 2009 | Recent information and communication developments caused that global organizations spread out their markets throughout the world. In this environment, local exclusive markets have been replaced with global competitive ones. Therefore, organizations must concentrate on their main operations to survive in such an environment. To do so, managers have intended to cooperate with some financial partners in long-term relations. In this paper, the aim is to develop a fuzzy analytic network process (ANP) model to evaluate the potential suppliers and select the best one(s) with respect to the vendor important factors. Additionally, ANP is developed by fuzzy sets theory to cover the indeterminacy of decisions made in this field. The authors have augmented the model |

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| | | | | with a non-linear programming model to elicit eigenvectors from fuzzy comparison matrices. Hybridization of these two concepts can model supplier selection problem in all circumstances and reaches the optimal choice. Finally, a numerical sample is used to validate the proposed model. |
| 37 | The Handbook of Logistics and Distribution Management: Understanding the Supply Chain | Alan Rushton, Phil Croucher, Peter Baker | Kogan Page Publishers,2014 | The Handbook of Logistics and Distribution Management provides an introduction to fundamental elements of modern logistics and distribution. It explores all stages of the supply chain from raw materials through to the final distribution of the finished product. This handbook covers vital areas, including: concepts of logistics and distribution; planning for logistics; procurement and inventory decisions; warehousing and storage; freight transport; and operational management. The 5th edition of The Handbook of Logistics and Distribution Management has been radically updated to reflect the latest advances in logistics and covers new topics studied on academic and professional courses. There are brand new chapters on humanitarian logistics, multichannel fulfillment and reverse |

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| | | | | logistics, as well as detailed discussion of the latest trends and issues that confront logistics. The Handbook of Logistics and Distribution Management is a practical handbook and an essential reference for logistics and supply chain practitioners as well as students undertaking professional examinations and degrees in the field of logistics and supply chain. |
| 38 | Quality-based supplier selection and evaluation using fuzzy data | Ming-HungShu[a]Hsien-ChungWu[b] | Computers & Industrial Engineering , 2009 | Since fuzzy quality data are ubiquitous in the real world, under this fuzzy environment, the supplier selection and evaluation on the basis of the quality criterion is proposed in this paper. The C pk index has been the most popular one used to evaluate the quality of supplier's products. Using fuzzy data collected from $q \geqslant 2$ possible suppliers' products, fuzzy estimates of q suppliers' capability indices C pki ( i = 1 , 2 , … , q ) are obtained according to the form of resolution identity that is a well-known theorem in fuzzy sets theory. Certain optimization problems are formulated and solved to obtain α -level sets for the purpose of constructing the membership functions of fuzzy estimates of C pki . These membership functions are sorted by |

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| | | | | using a fuzzy ranking method to choose the preferable suppliers. Finally, a numerical example is illustrated to present the possible application by incorporating fuzzy data into the quality-based supplier selection and evaluation. |
| 39 | Selection of the optimal configuration for a flexible surface mount assembly system based on the interrelations hips among the flexibility elements | Tsung-NanTsai | Computers & Industrial Engineering ,2014 | Flexibility has been widely recognized as a key competitive factor for manufacturing firms coping with the increasingly turbulent manufacturing environment today. Establishing a flexible surface mount assembly (SMA) system is critical for organizations to achieve a cost-effective assembly and gain competitive advantages in the printed circuit board (PCB) assembly industry. To find a practicable operating strategy, a multi-criteria decision-making framework that combines the analytic network process (ANP) with the consistent fuzzy preference relations (CFPR) is proposed to explore the interrelationships among the six dimensions and twenty-one criteria of manufacturing flexibility and resolve the uncertainty and divergence between decision-makers with the least amount of pairwise comparisons. Based on the results of prior |

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| | | | | analysis, an optimum configuration of a flexible SMA system is suggested for the capacity investment intended by a Taiwan electronics manufacturing service (EMS) provider to quickly respond to dynamic production requirements. |
| 40 | Selection of optimal supplier in supply chain management strategy with analytic network process and choquet integral | TsengMing-Lang[a]Jui HsiangChiang[b]Lawrence W.Lan[c] | Computers & Industrial Engineering , 2009 | Selection of appropriate suppliers in supply chain management strategy (SCMS) is a challenging issue because it requires battery of evaluation criteria/attributes, which are characterized with complexity, elusiveness, and uncertainty in nature. This paper proposes a novel hierarchical evaluation framework to assist the expert group to select the optimal supplier in SCMS. The rationales for the evaluation framework are based upon (i) multi-criteria decision making (MCDM) analysis that can select the most appropriate alternative from a finite set of alternatives with reference to multiple conflicting criteria, (ii) analytic network process (ANP) technique that can simultaneously take into account the relationships of feedback and dependence of criteria, and (iii) choquet integral—a non-additive fuzzy integral that can eliminate the interactivity of expert |

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| | | | | subjective judgment problems. A case PCB manufacturing firm is studied and the results indicated that the proposed evaluation framework is simple and reasonable to identify the primary criteria influencing the SCMS, and it is effective to determine the optimal supplier even with the interactive and interdependent criteria/attributes. This hierarchical evaluation framework provides a complete picture in SCMS contexts to both researchers and practitioners. |
| 41 | Decision Suppot System and Intelligent System | | Pearson Education, Inc, Upper Saddle River, New Jersey, 2005 | |
| 42 | An integrated DEMATEL and Fuzzy ANP techniques for evaluation and selection of outsourcing provider for a telecommunication company | ÖzerUygun[a]HasanKaçamak[b1]Ünal AtakanKahraman[a2] | Computers & Industrial Engineering, 2015 | In recent years, strategy aspects related to core competency, risk analysis and organizational flexibility especially have been growing. This trend has led researchers and industries to become more interested in the multi-criteria decision making (MCDM) models for selecting outsourcing providers. The efficiency of decision-making mostly depends on the ability of decision-makers analyzing the complex cause and effect relationship between criteria and taking effective actions based |

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| | | | | on the analysis. Using an analytical method to select the most eligible outsourcing provider is significant for a company which desires to improve its competitiveness. In this study, a fuzzy integrated multi-criteria decision making method for evaluation and determination of an outsourcing provider for a telecommunication company is analyzed by using DEMATEL and Fuzzy ANP multi-criteria decision making techniques. First, DEMATEL method is used in order to put forward the interrelationship among the main criteria which are determined in the study for outsourcing selection process. Then, local weights of the sub-criteria and sub-subcriteria are calculated by Fuzzy ANP approach on the basis of cause-effect relationships that are exposed through DEMATEL method. The local weights are put into ANP supermatrix, and calculations are implemented to select out the most eligible outsourcing provider. |
| 43 | Using quality function deployment for collaborative product design and optimal | Chih-HsuanWangJiun-NanChen | Computers & Industrial Engineering , 2012 | In response to fast-growing and rapidly-changing markets, launching new products faster than competitors cannot only assist firms in acquiring larger market share but also reducing development |

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| | selection of module mix | | | lead time, significantly. However, owing to its intrinsically uncertain properties of managing NPD (new product development), manufacturing companies often struggle with the dilemma of increasing product variety or controlling manufacturing complexity. In this study, a fuzzy MCDM (multi-criteria decision making) based QFD (quality function deployment) which integrates fuzzy Delphi, fuzzy DEMATEL (decision making trial and evaluation laboratory), with LIP (linear integer programming) is proposed to assist an enterprise in fulfilling collaborative product design and optimal selection of module mix when aiming at multi-segments. In particular, Fuzzy Delphi is adopted to gather marketing information from invited customers and their assessments of marketing requirements are pooled to reach a consensus; fuzzy DEMATEL is utilized to derive the priorities of technical attributes in a market-oriented manner; and LIP is used to maximize product capability with consideration of supplier's budget constraints of manufacturing resources. Furthermore, a real case |

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| | | | | study on developing various types of sport and water digital cameras is demonstrated to validate the proposed approach. |
| 44 | A decision framework for supplier rating and purchase allocation: A case in the semiconductor industry | Jing-RungYuChao-ChiaTsai | Computers & Industrial Engineering, 2008 | By using a case study of the semiconductor industry, this paper proposes a framework which integrates the analytic hierarchy process (AHP) and integer programming to rate suppliers' performance regarding incoming raw materials in the context of supplier management and then to allocate periodical purchases. Our findings are such that the rating weights of primary criteria and sub-criteria for each supplier should be flexibly considered in peak and off seasons to meet actual requirements. However, the current practical method rates the suppliers subjectively using fixed weights regardless of peak or off seasons. Therefore, how to develop an objective and flexible method for reviewing each criterion is grounded in empirical work. A detailed case study is presented in which five wafer suppliers are evaluated. The outcomes of peak and off seasons by the AHP reflect the practical strategy and tradeoffs of decision makers while rating suppliers via five perspectives of quality: cost, delivery, service, |

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| | | | | and environment (QCDSE). Additionally, the average cost per wafer is shown to be reduced by $0.455, which increases the gross margin, most notably, in the off season. Results indicate that the proposed methodology can lead to substantial improvements in supplier management. |
| 45 | A fuzzy group quality function deployment model for e-CRM framework assessment in agile manufacturing | FaramakZandi[a]MadjidTavana[b] | Computers & Industrial Engineering, 2011 | The rapid growth of the Internet and the expansion of electronic commerce applications in manufacturing have given rise to electronic customer relationship management (e-CRM) which enhances the overall customer satisfaction. However, when confronted by the range of e-CRM methods, manufacturing companies struggle to identify the one most appropriate to their needs. This paper presents a novel structured approach to evaluate and select the best agile e-CRM framework in a rapidly changing manufacturing environment. The e-CRM frameworks are evaluated with respect to their customer and financial oriented features to achieve manufacturing agility. Initially, the e-CRM frameworks are prioritized according to their financial oriented characteristics using a fuzzy group real options |

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| | | | | analysis (ROA) model. Next, the e-CRM frameworks are ranked according to their customer oriented characteristics using a hybrid fuzzy group permutation and a four-phase fuzzy quality function deployment (QFD) model with respect to three main perspectives of agile manufacturing (i.e., strategic, operational and functional agilities). Finally, the best agile e-CRM framework is selected using a technique for order preference by similarity to the ideal solution (TOPSIS) model. We also present a case study to demonstrate the applicability of the proposed approach and exhibit the efficacy of the procedures and algorithms. |

# LAMPIRAN B GAMBAR TEKNIK HAND TRACTOR

# DESAIN TRAKTOR TANGAN



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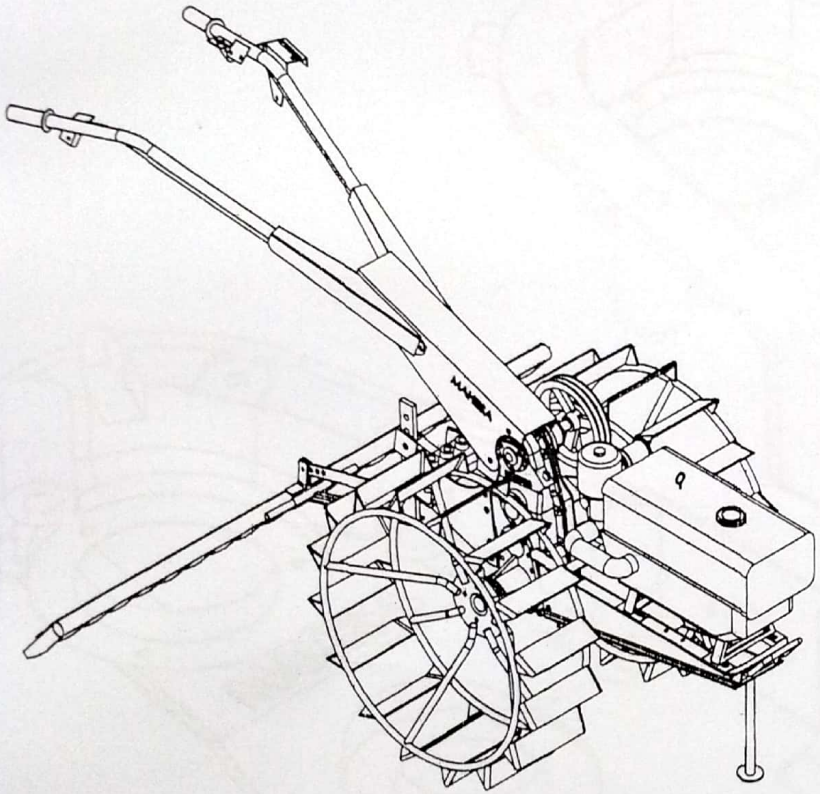

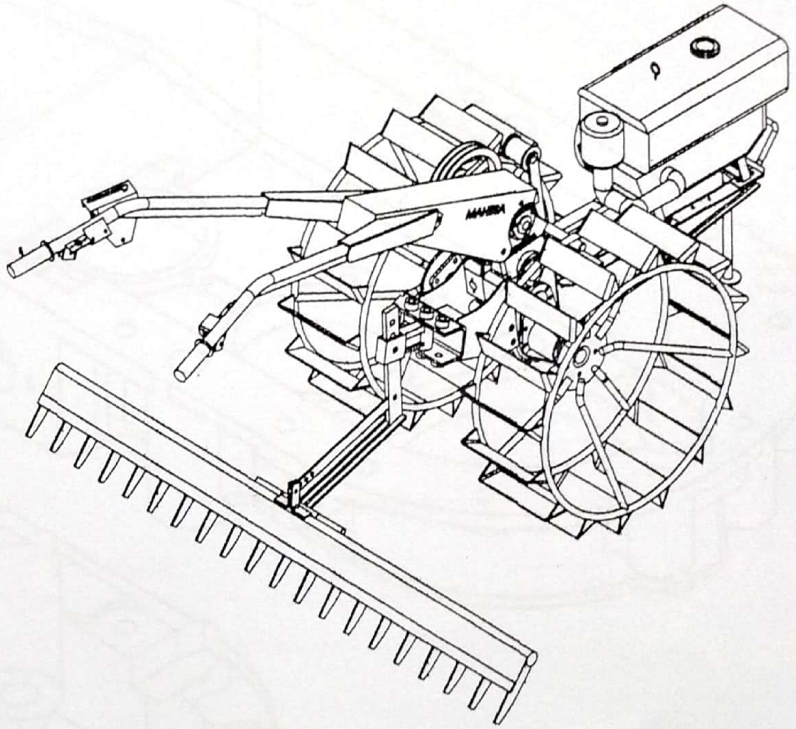

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GEAR CASEL

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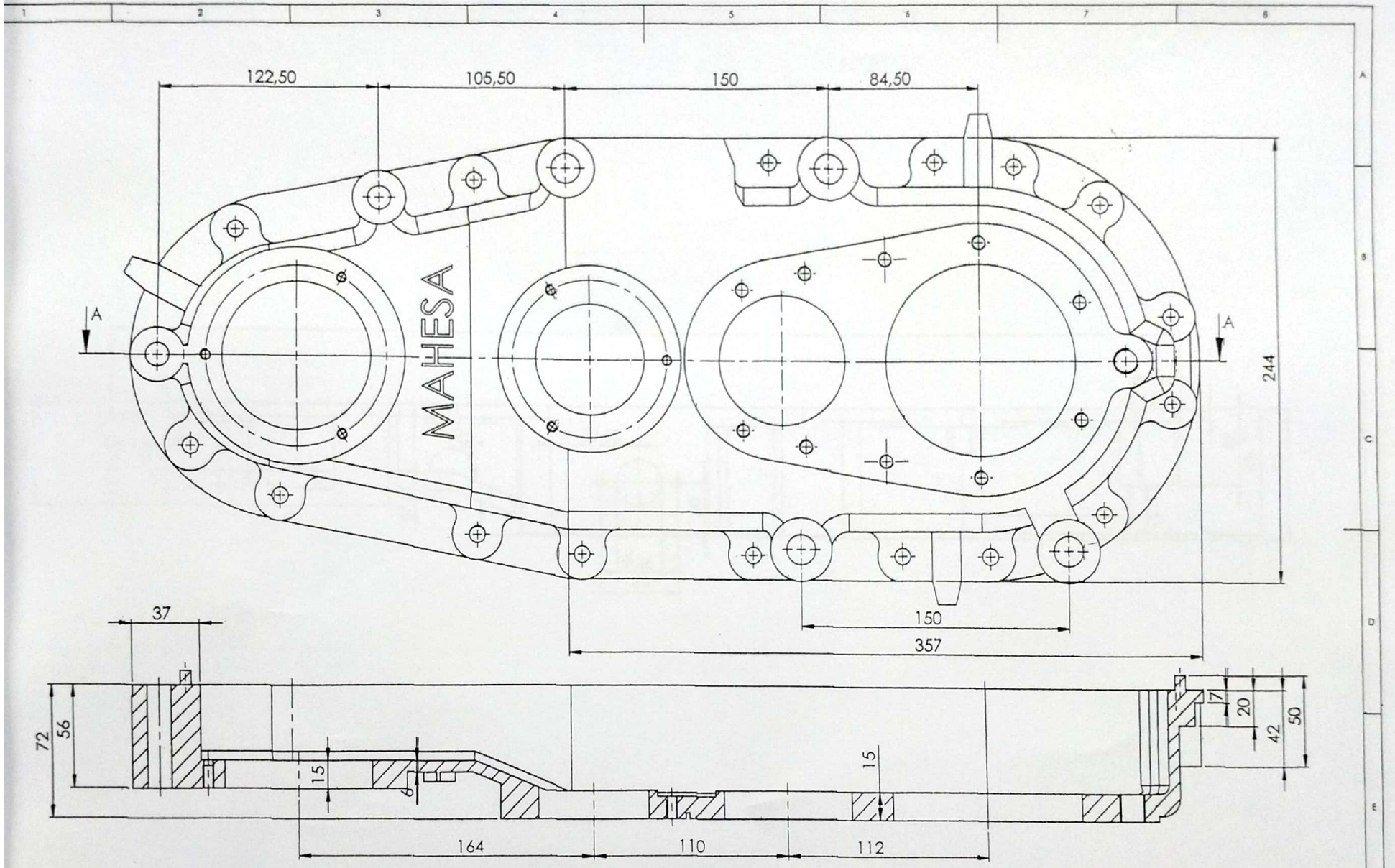


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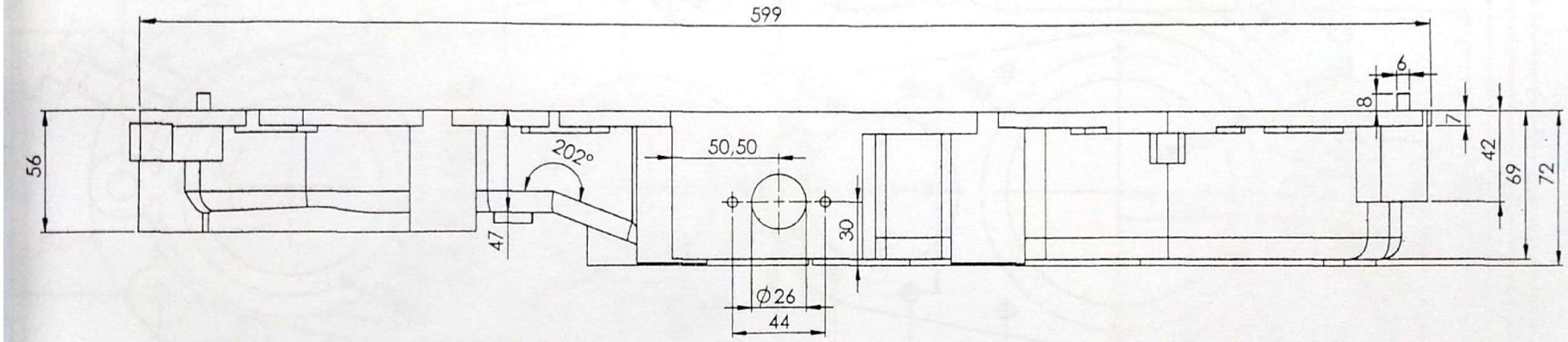


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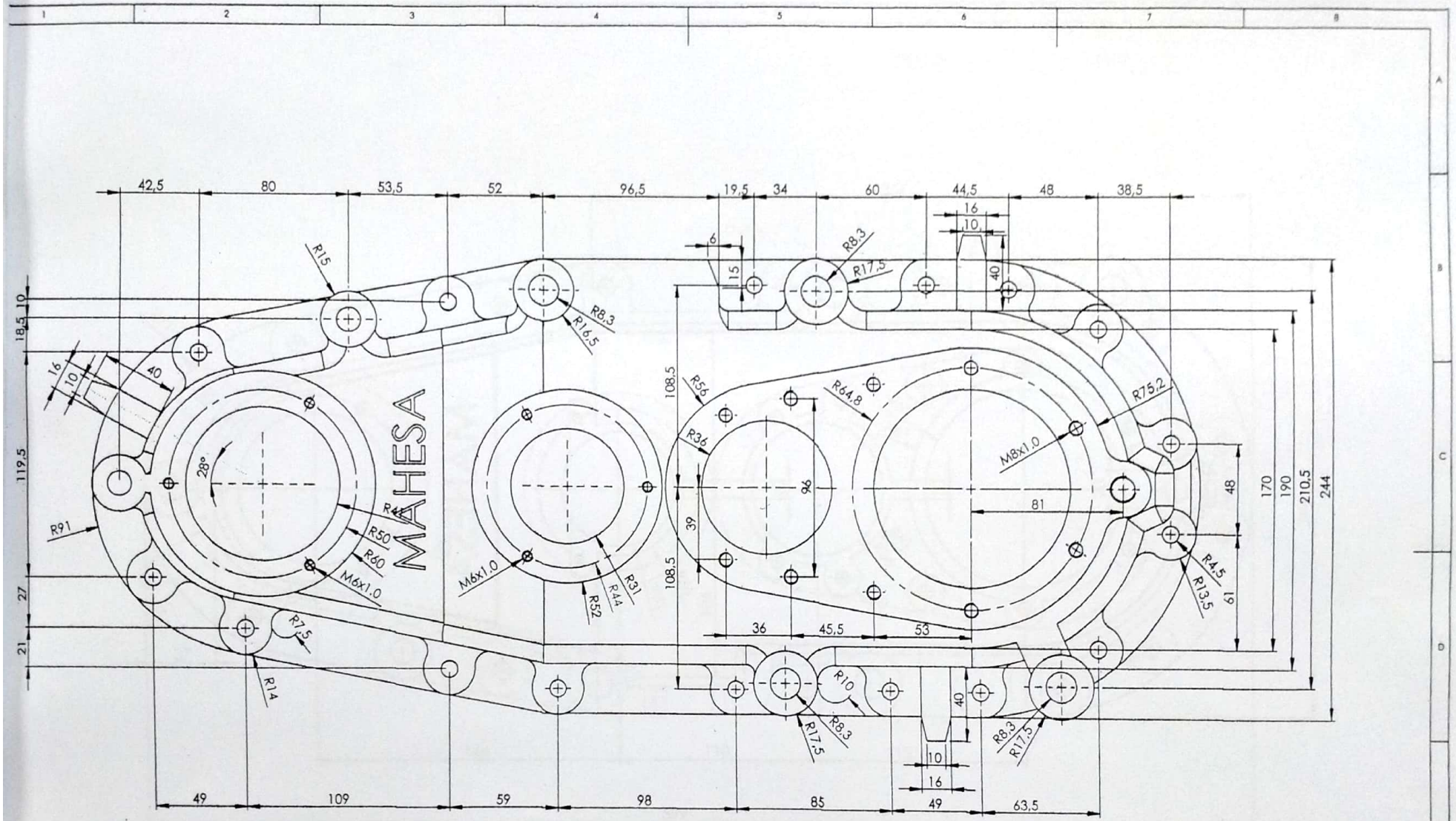


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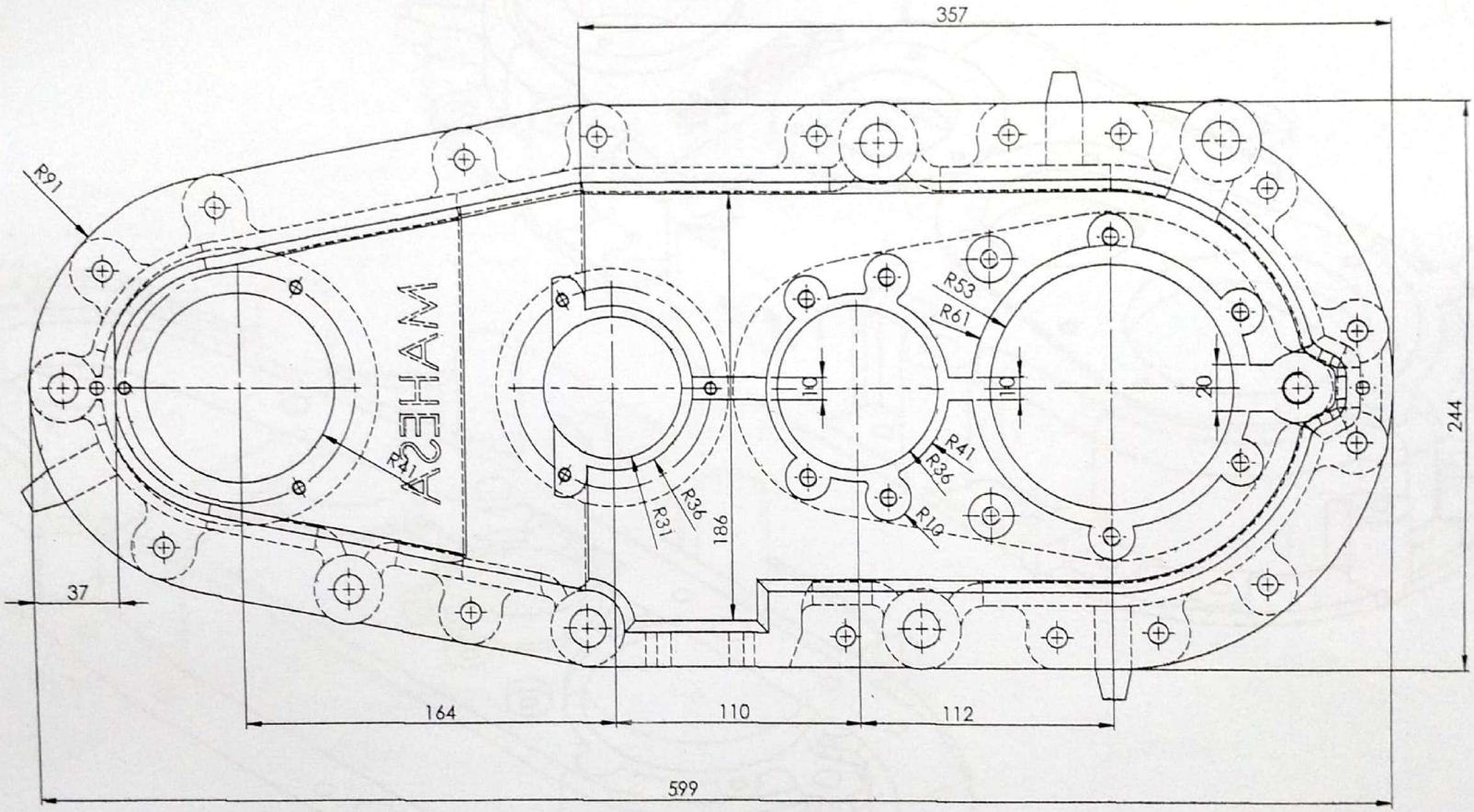


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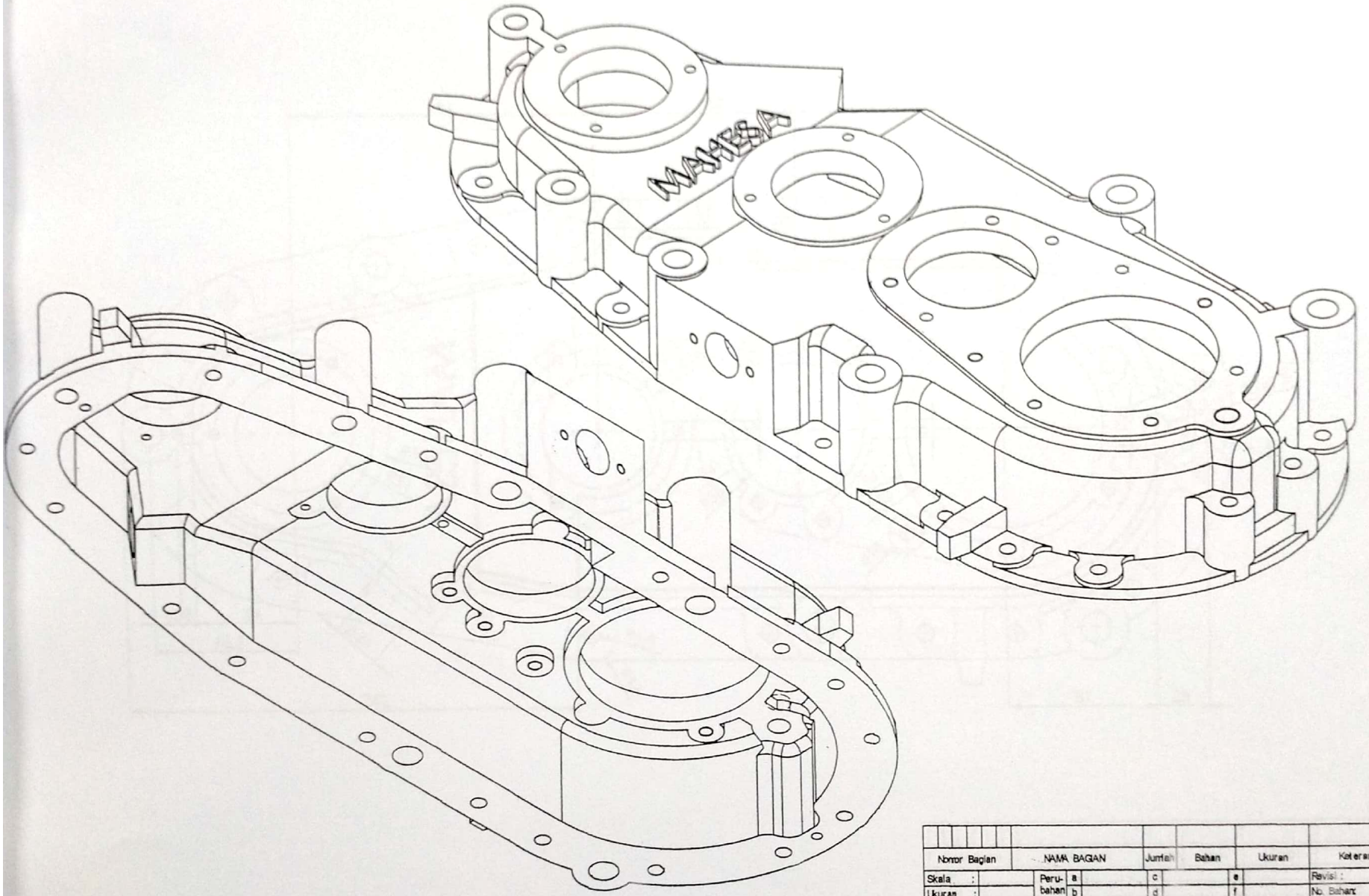


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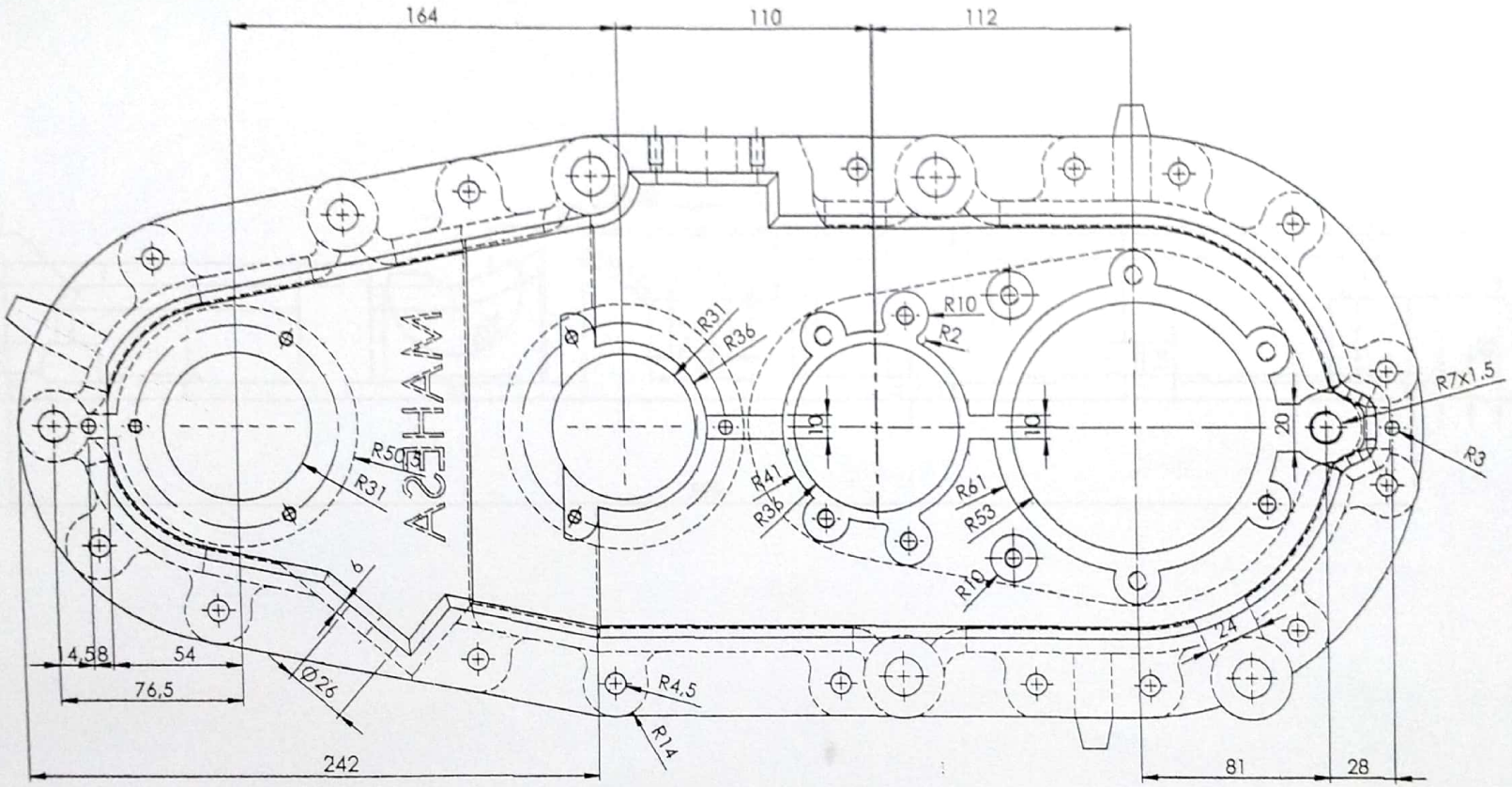


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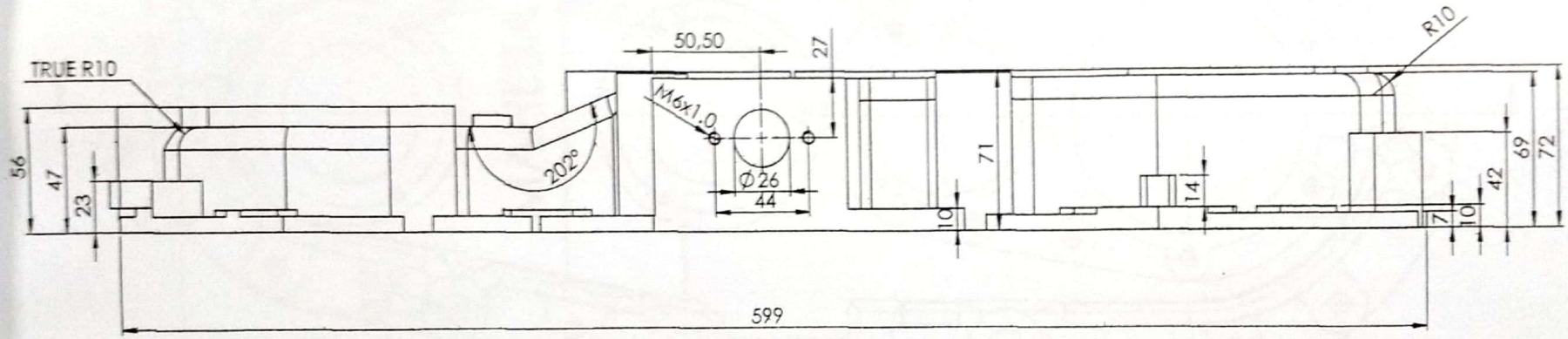


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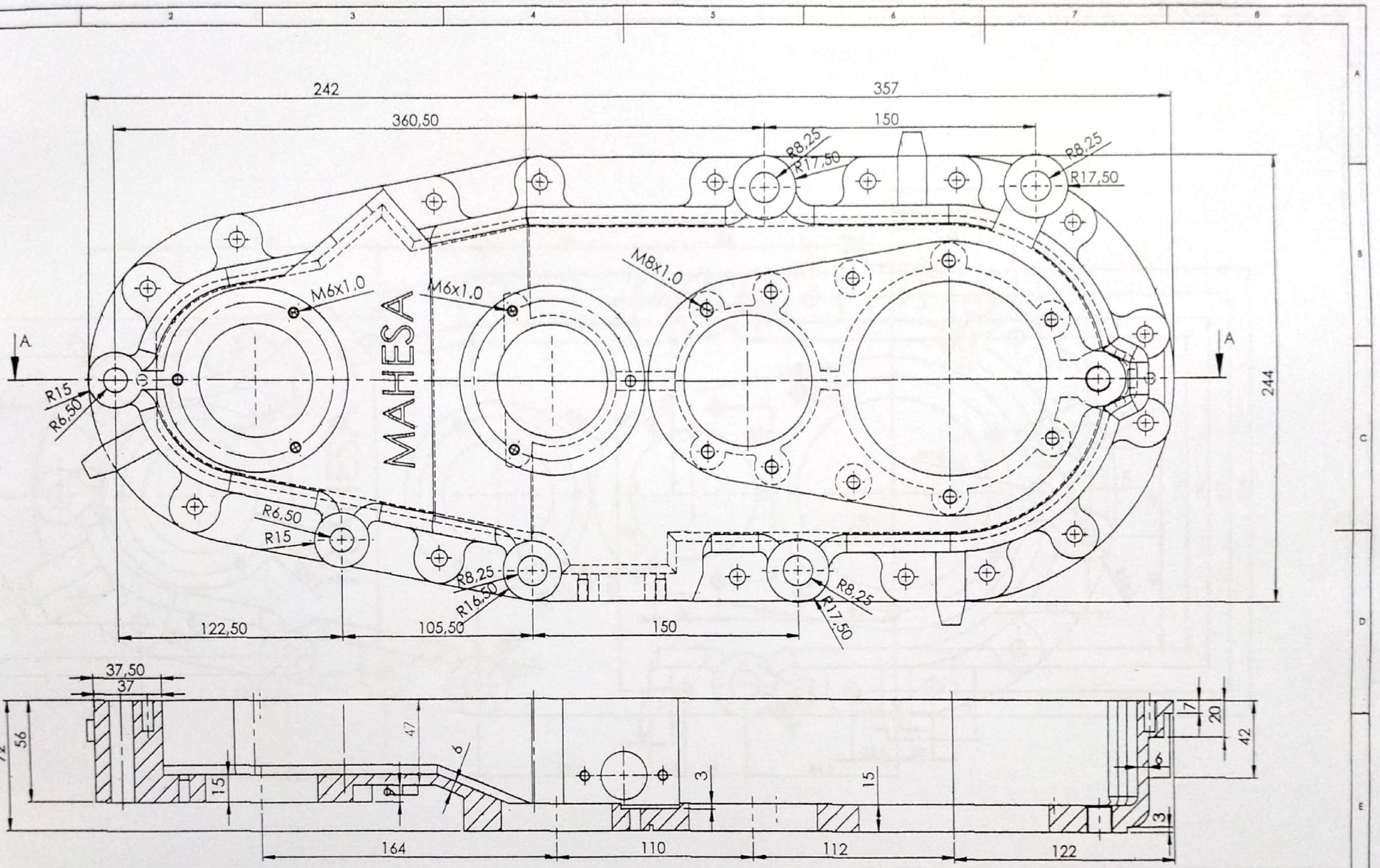


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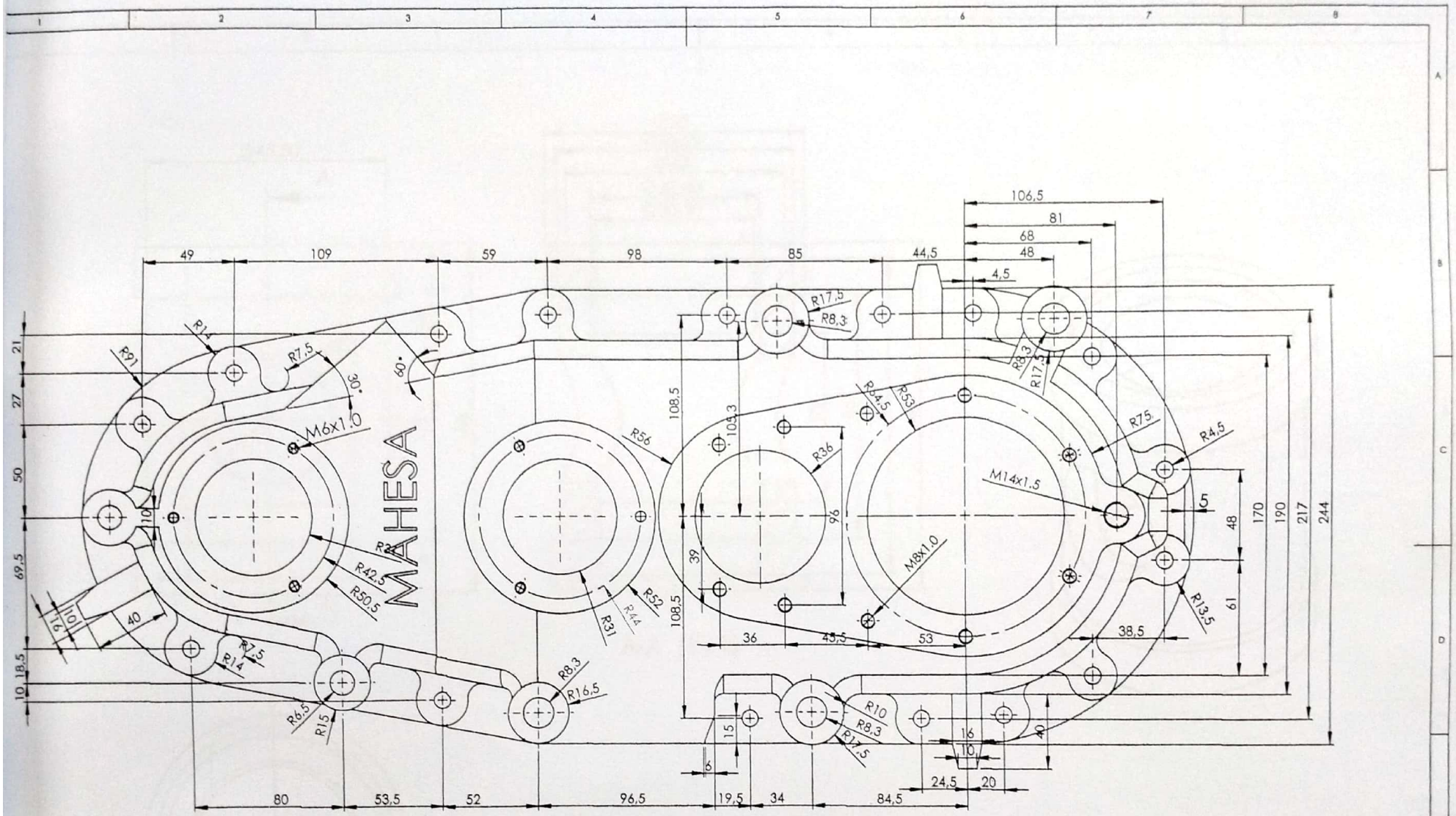


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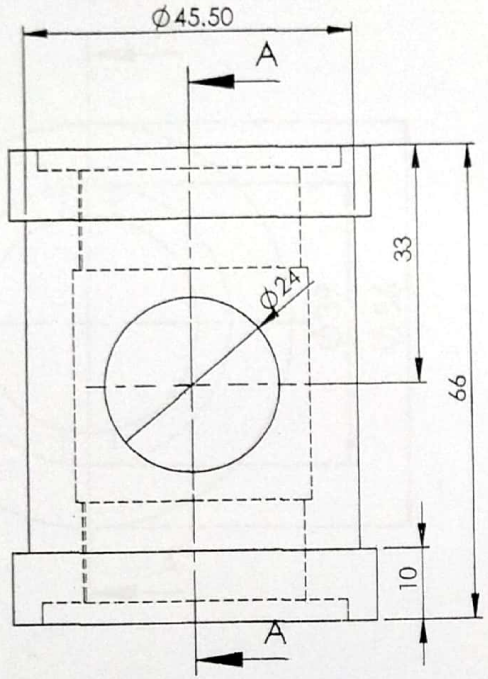


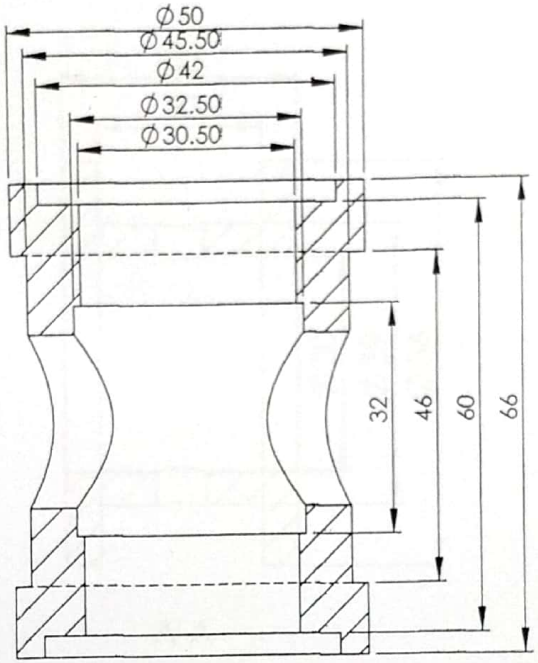


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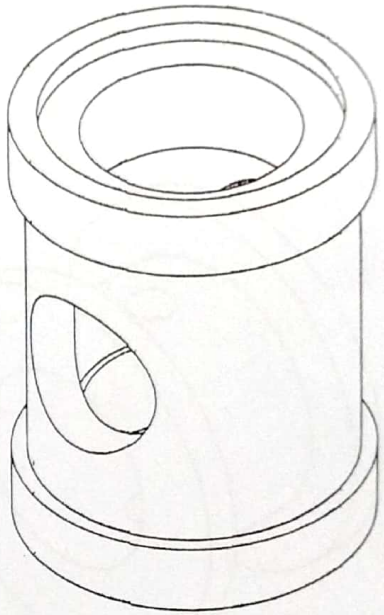

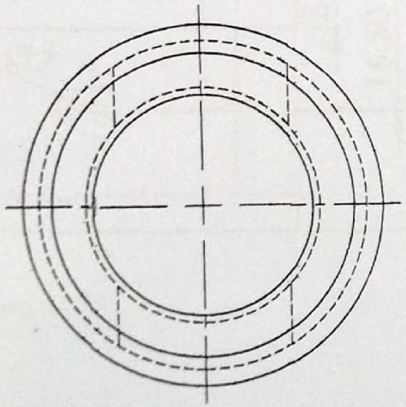

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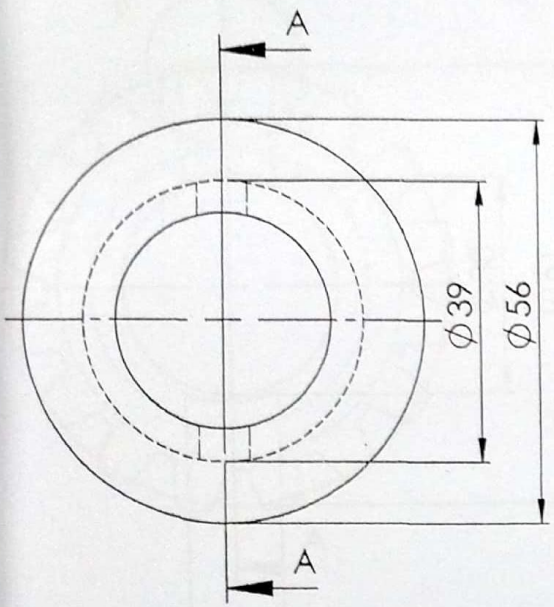


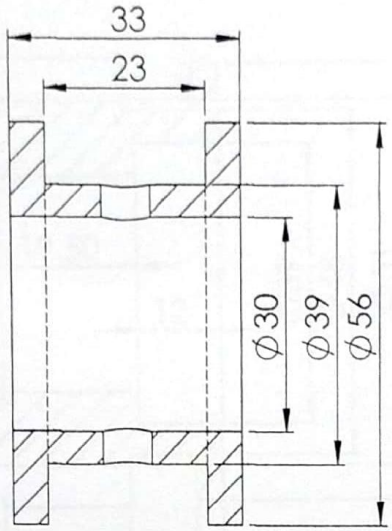


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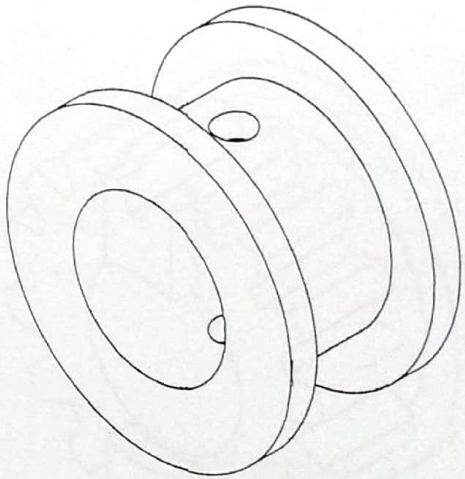

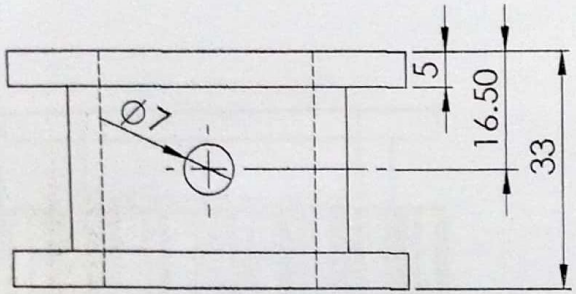


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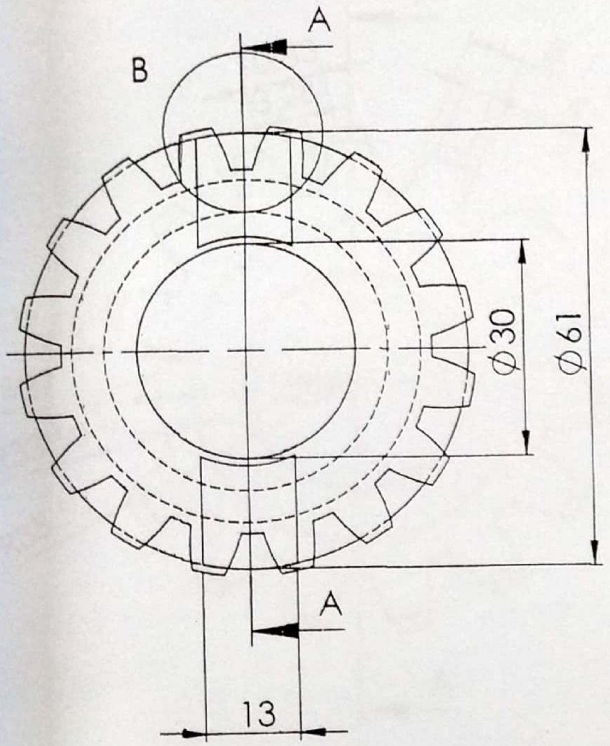
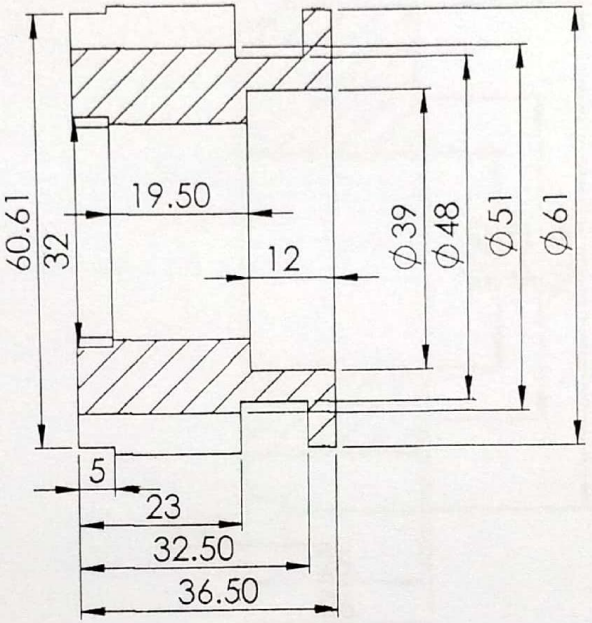
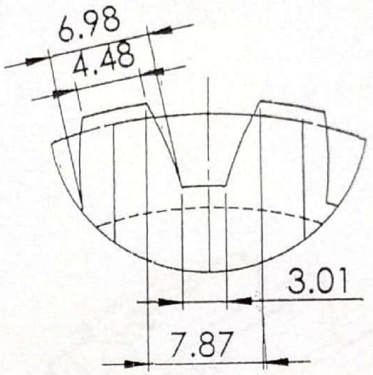



A-A

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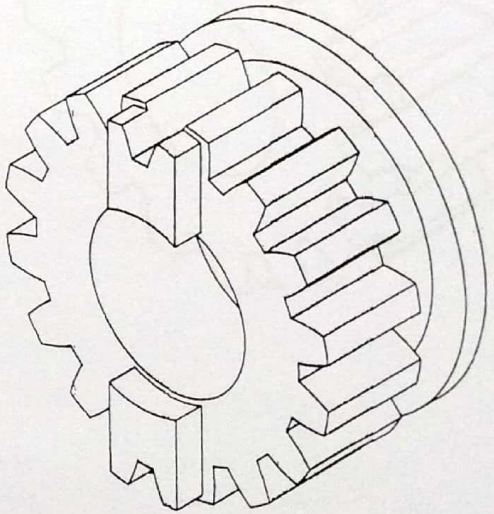

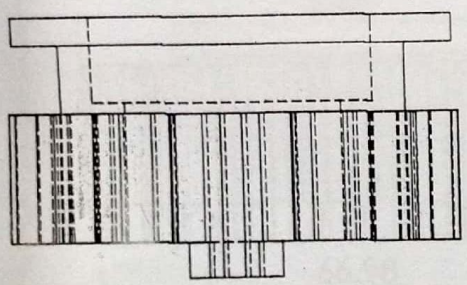

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| Ukuran : | b | d | f | | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 3 | | | Digambar | @rif s |
| | | | | Diperiksa | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER Batur, Tegairejo, Ceper, Klaten, Jawa Tengah 57465 Tlp. (0272-552968) Fax. (0272 - 552968) | | | Disetujui | |
| | | | | No. Gambar : | A4 |
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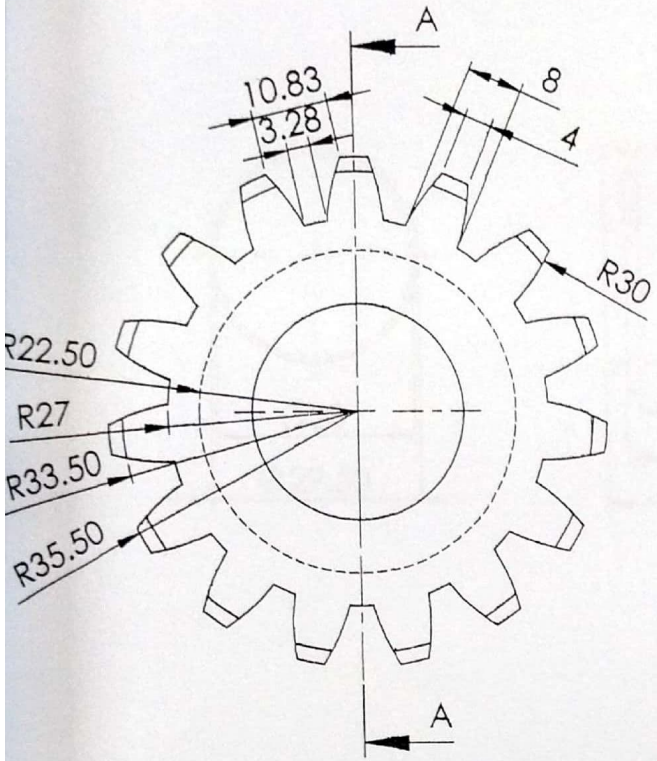


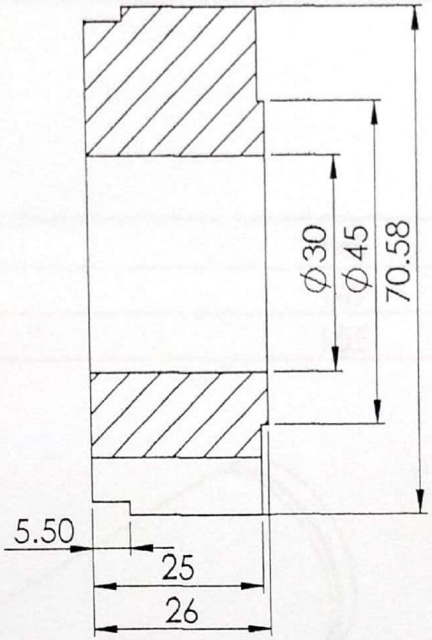


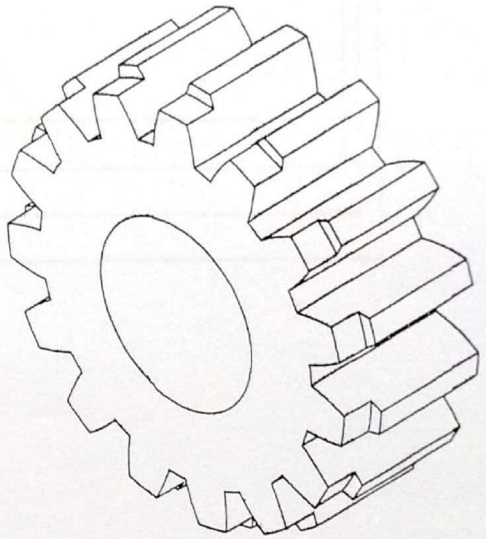

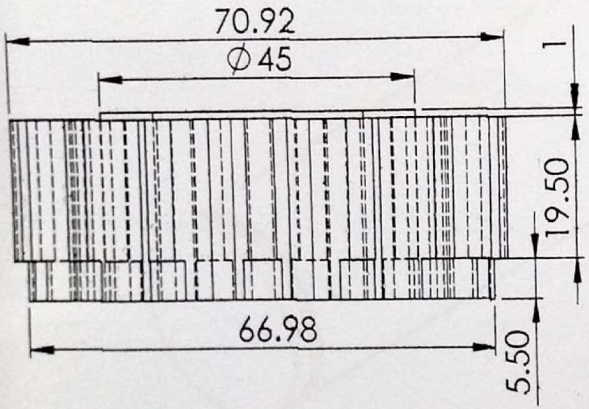


A-A

| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
|---|---|---|---|---|---|
| Skala : | Perubahan a | c | e | | Revisi : |
| Ukuran : | b | d | f | | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 4 | | | Digambar @rif s | |
| | | | | Diperiksa | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER Batur, Tegalrejo, Ceper, Klaten, Jawa Tengah 57465 Tlp. (0272-552965) Fax. (0272 - 552968) | | | Disetujui | |
| | | | | No. Gambar : | A4 |
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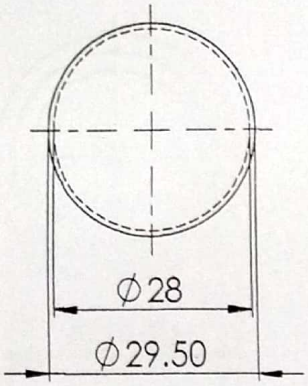


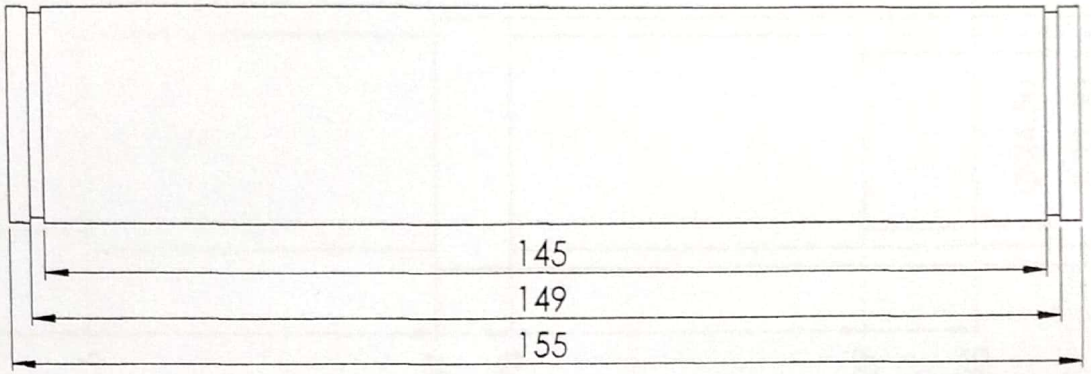


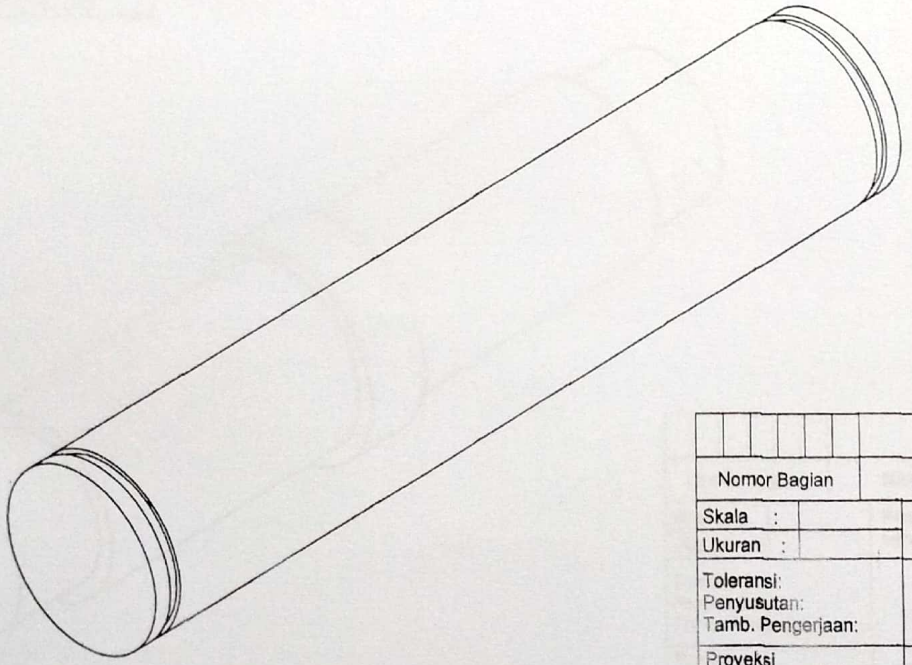

| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
|---|---|---|---|---|---|
| Skala : | Peru-bahan a | c | e | | Revisi : |
| Ukuran : | b | d | f | | No. Bahan: |

Toleransi:
Penyusutan:
Tamb. Pengerjaan:

PART 5

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| Digambar | @rif s | |
| Diperiksa | | |
| Disetujui | | |
| No. Gambar : | | A4 |
| Berat : | | SHEET 1/1 |

Proyeksi

POLITEKNIK MANUFAKTUR CEPER
Batur, Tegalrejo, Ceper, Klaten, Jawa Tengah 57465
Tlp. (0272-552968) Fax. (0272 - 552968)

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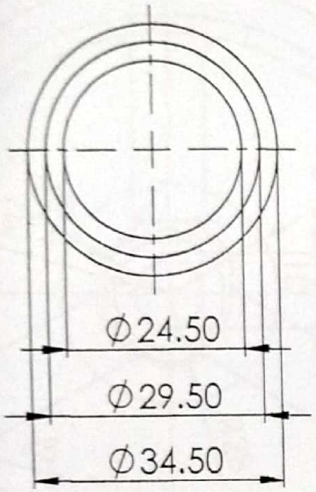


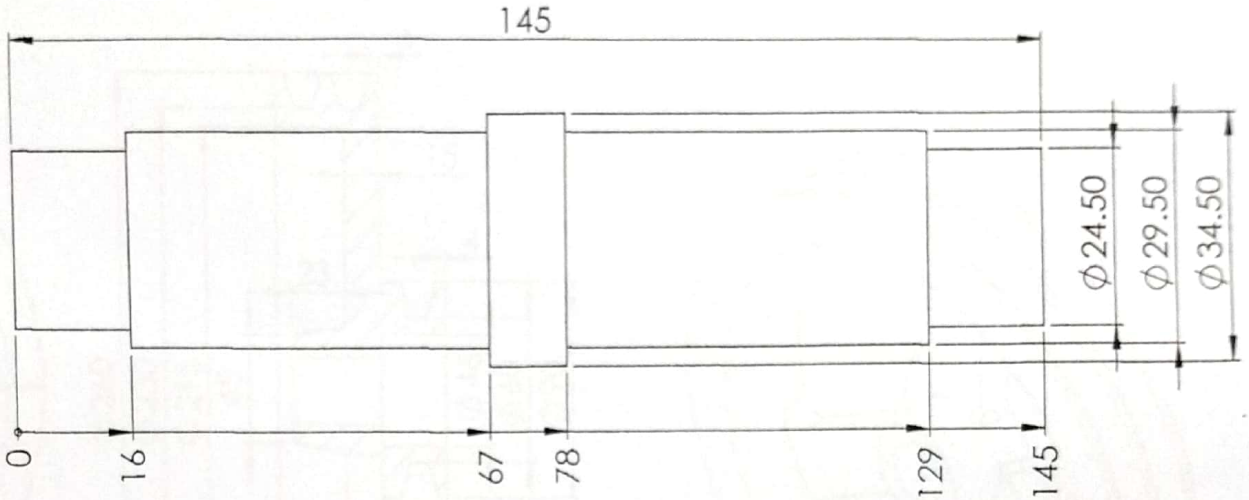


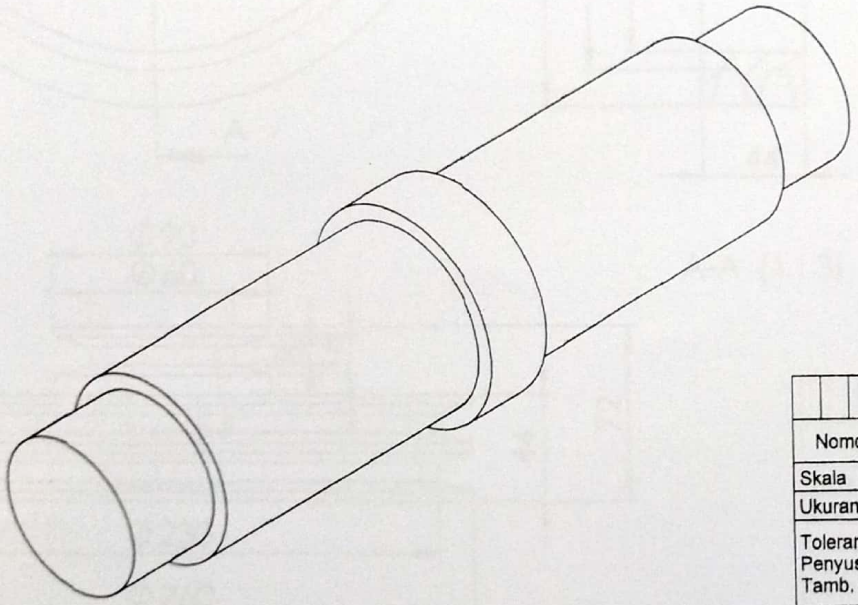

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|---|---|---|---|---|---|
| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
| Skala : | Perubahan a | c | e | | Revisi : |
| Ukuran : | b | d | f | | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 6 | | | Digambar | @rif s |
| | | | | Diperiksa | |
| | | | | Disetujui | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER Batur, Tegalrejo, Ceper, Klaten, Jawa Tengah 57465 Tlp. (0272-552968) Fax. (0272 - 552968) | | | No. Gambar : | A4 |
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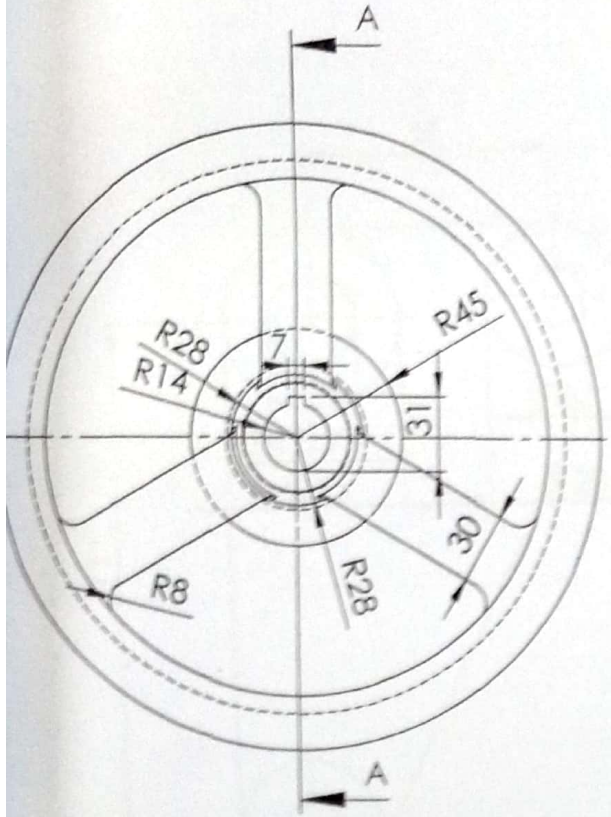


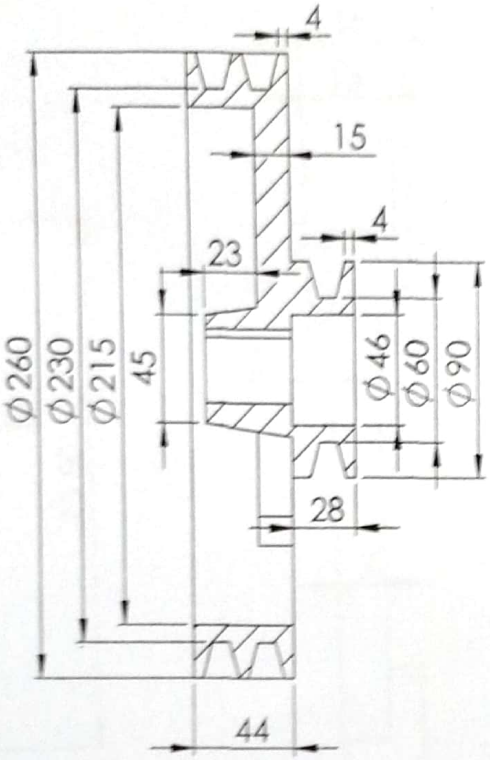


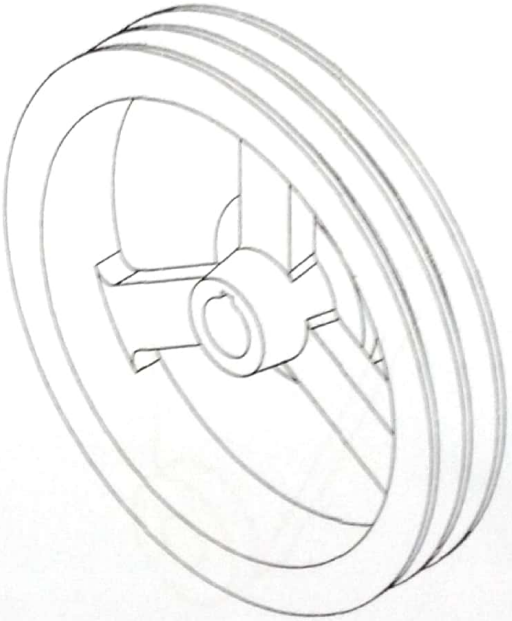

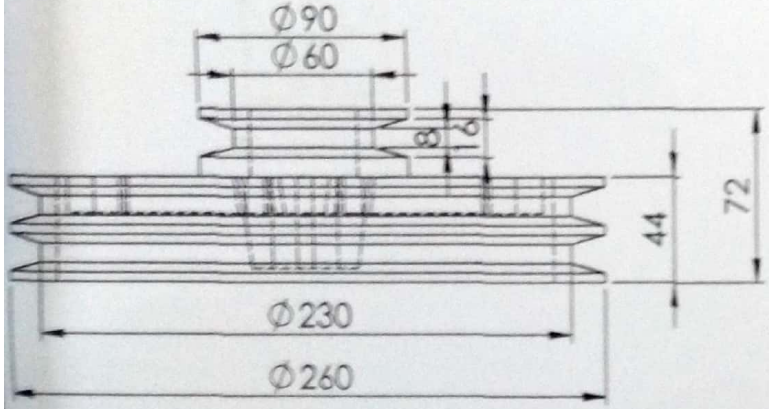


A-A (1 : 3)

| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
|---|---|---|---|---|---|
| Skala : | Perubahan a | c | e | | Revisi : |
| Ukuran : | b | d | f | | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 7 | | | Digambar | Arif s |
| | | | | Diperiksa | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER | | | Disetujui | |
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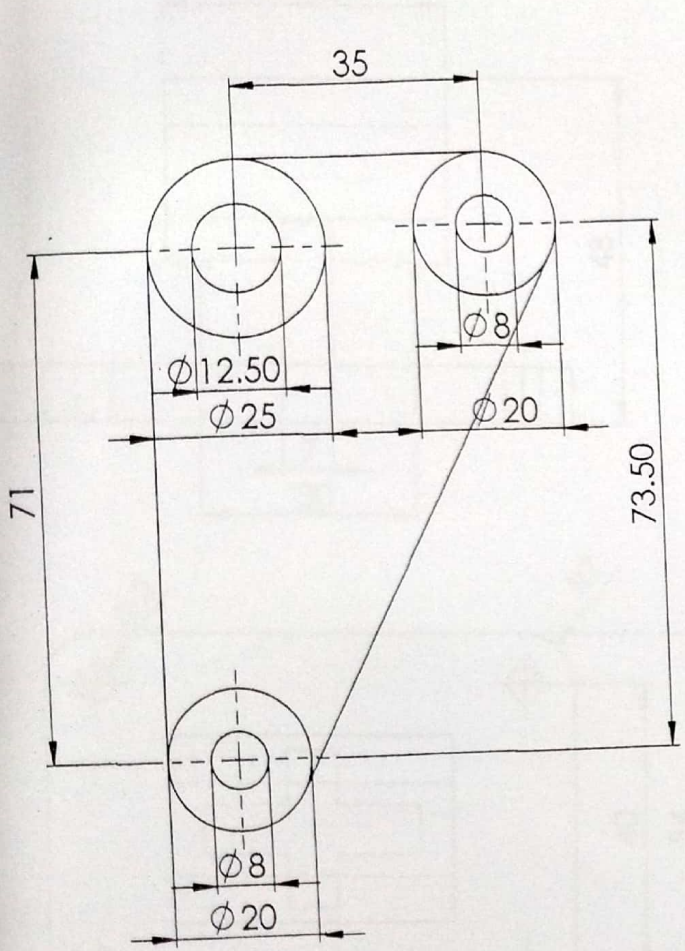


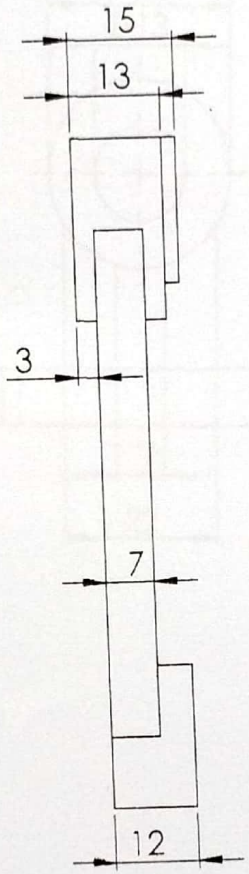


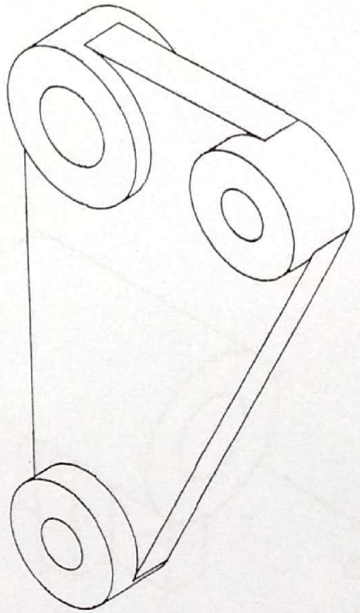

| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
|---|---|---|---|---|---|
| Skala : | Perubahan a | c | e | | Revisi : |
| Ukuran : | b | d | f | | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 8 | | | Digambar | @rif s |
| | | | | Diperiksa | |
| | | | | Disetujui | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER Baiur, Tegalrejo, Ceper, Klaten, Jawa Tengah 57465 Tlp. (0272-552968) Fax. (0272 - 552968) | | | No. Gambar : | A4 |
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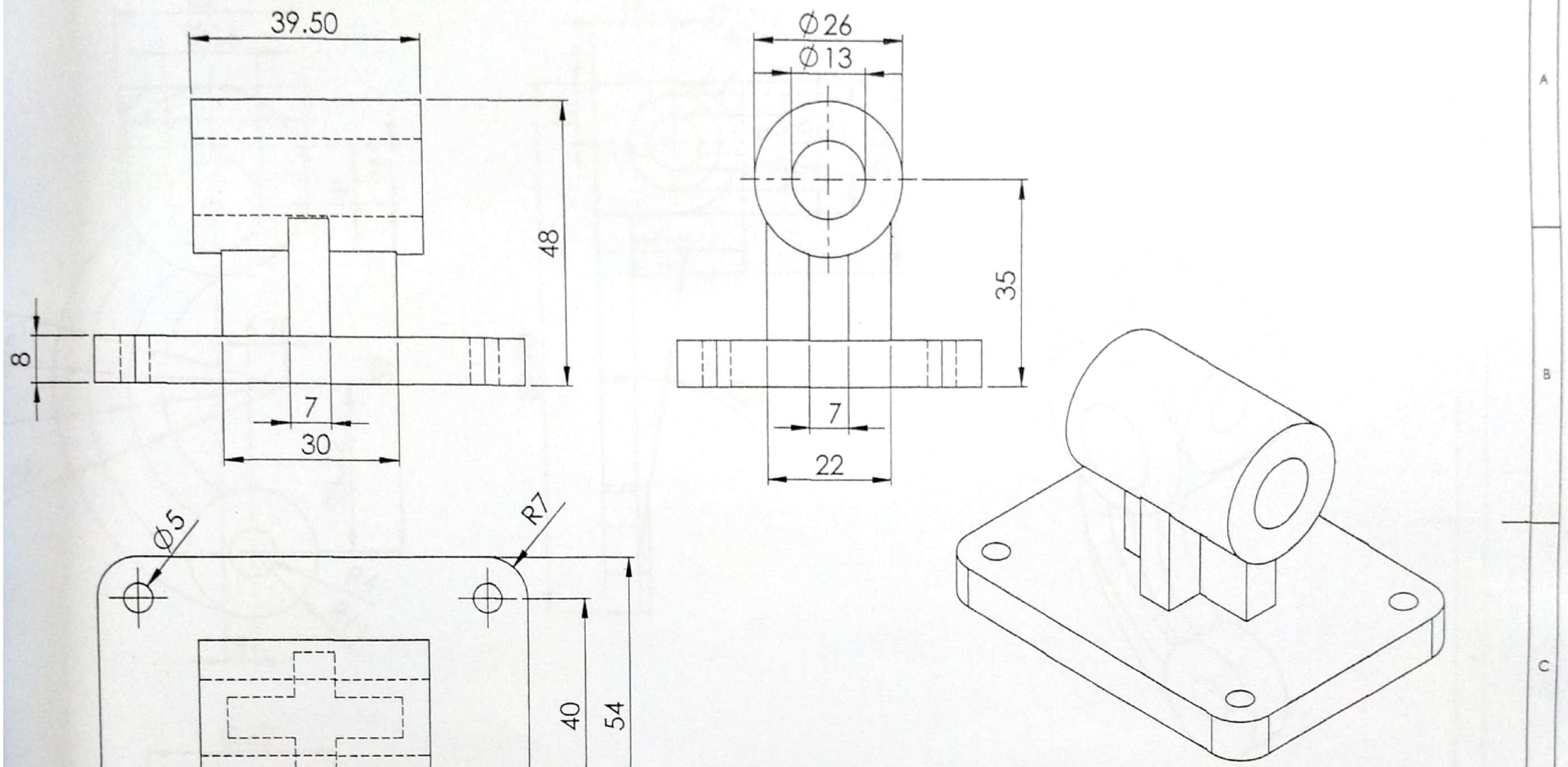


| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
|---|---|---|---|---|---|
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| Ukuran : | b | d | f | | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 9 | | | Digambar Grif s<br>Diperiksa<br>Disetujui | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER<br>Batur, Tegalrejo, Ceper, Klaten, Jawa Tengah 57465<br>Telp. (0272-552968) Fax. (0272 - 552968) | | | No. Gambar : | A4 |
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| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan | |
| Skala : | Peru- a | | | | Revisi : | |
| Ukuran : | bahan b | c | e | | No. Bahan: | |
| Toleransi: | | d | f | | Digambar | @rif s |
| Penyusutan: | | | | | Diperiksa | |
| Tamb. Pengerjaan: | | | | | Disetujui | |
| Proyeksi | | | | | No. Gambar : | |
| | | | | | Berat : | |

POLITEKNIK MANUFAKTUR CEPER
Baron, Tegalrejo, Ceper, Klaten, Jawa Tengah 57465
Telp. (0272-3352960) Fax. (0272-3352960)

PART 10

A4

SHEET 1/1

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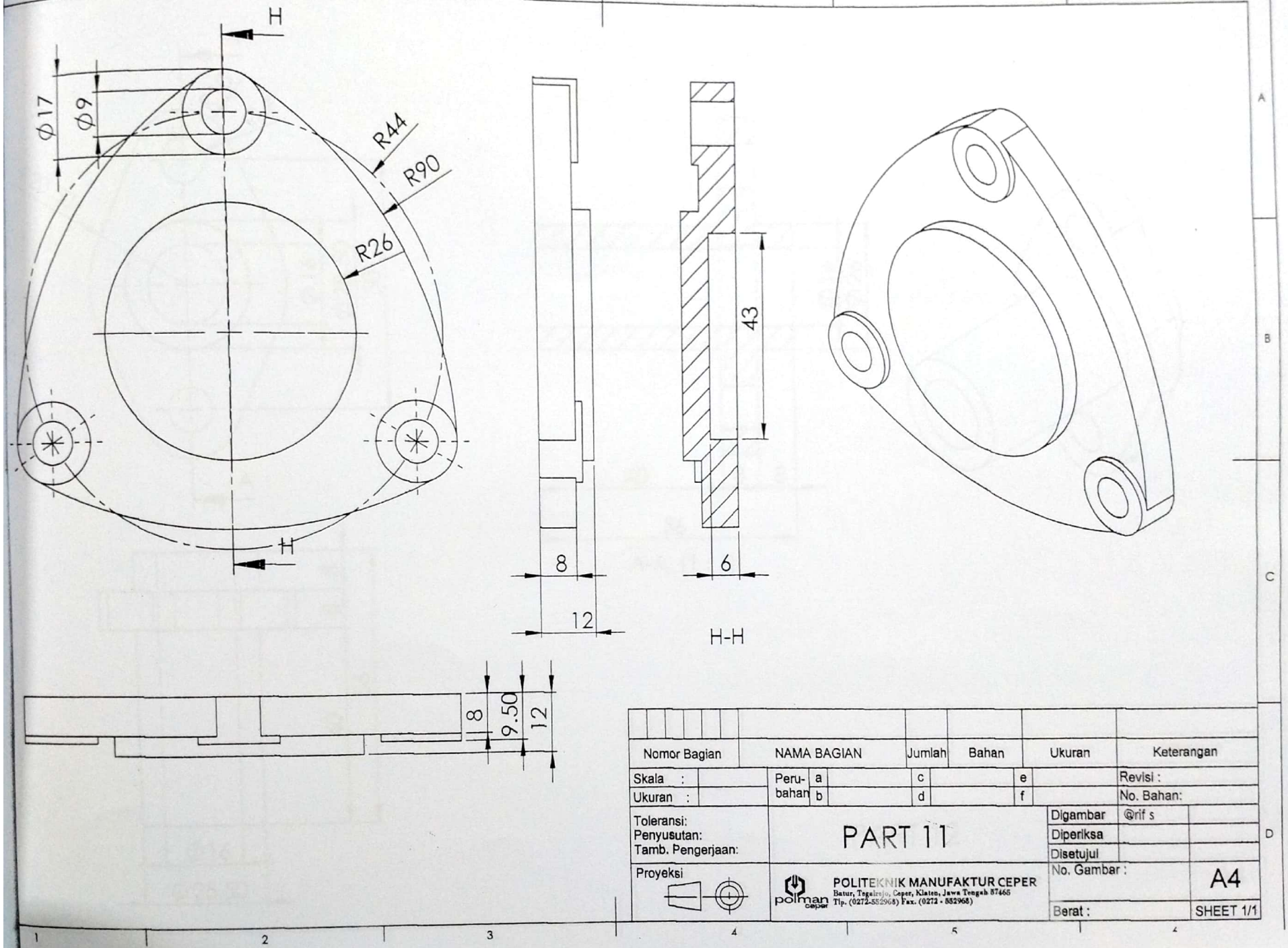


| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
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| Ukuran : | b | d | f | | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 11 | | | Digambar @rif s | |
| | | | | Diperiksa | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER Batur, Tegalrejo, Ceper, Klaten, Jawa Tengah 57465 Tlp. (0272-552968) Fax. (0272 - 552968) | | | Disetujui | |
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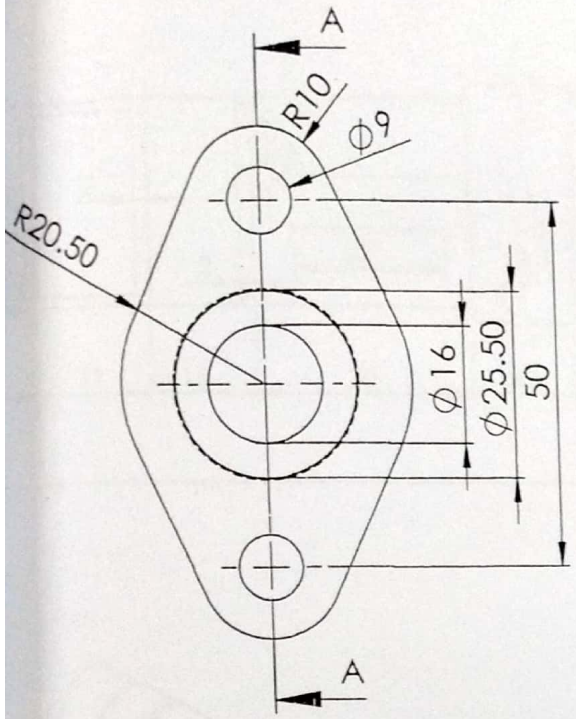


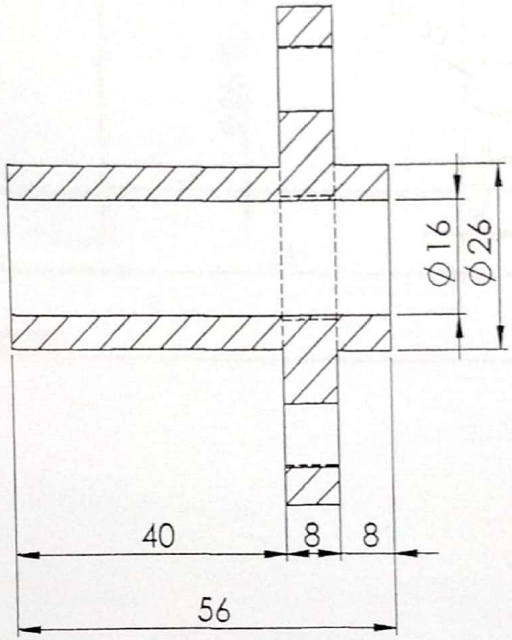


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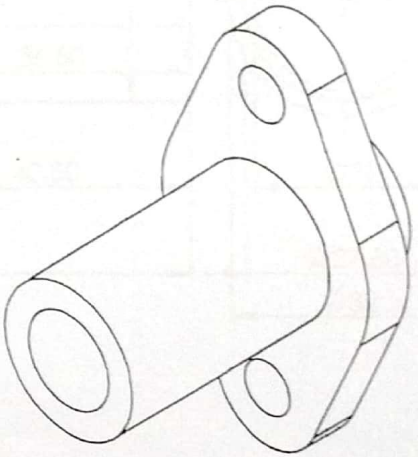

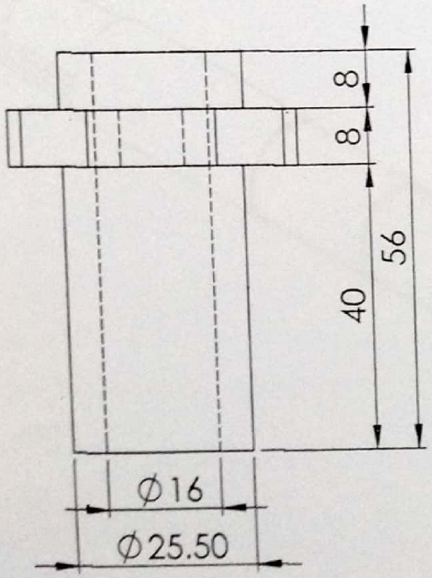


| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
|---|---|---|---|---|---|
| Skala : | Peru-bahan a | c | e | | Revisi : |
| Ukuran : | b | d | f | | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 12 | | | Digambar @rif s | |
| | | | | Diperiksa | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER Batur, Tegalrejo, Ceper, Klaten, Jawa Tengah 57465 Tlp. (0272-552968) Fax. (0272 - 552968) | | | Disetujui | |
| | | | | No. Gambar : | A4 |
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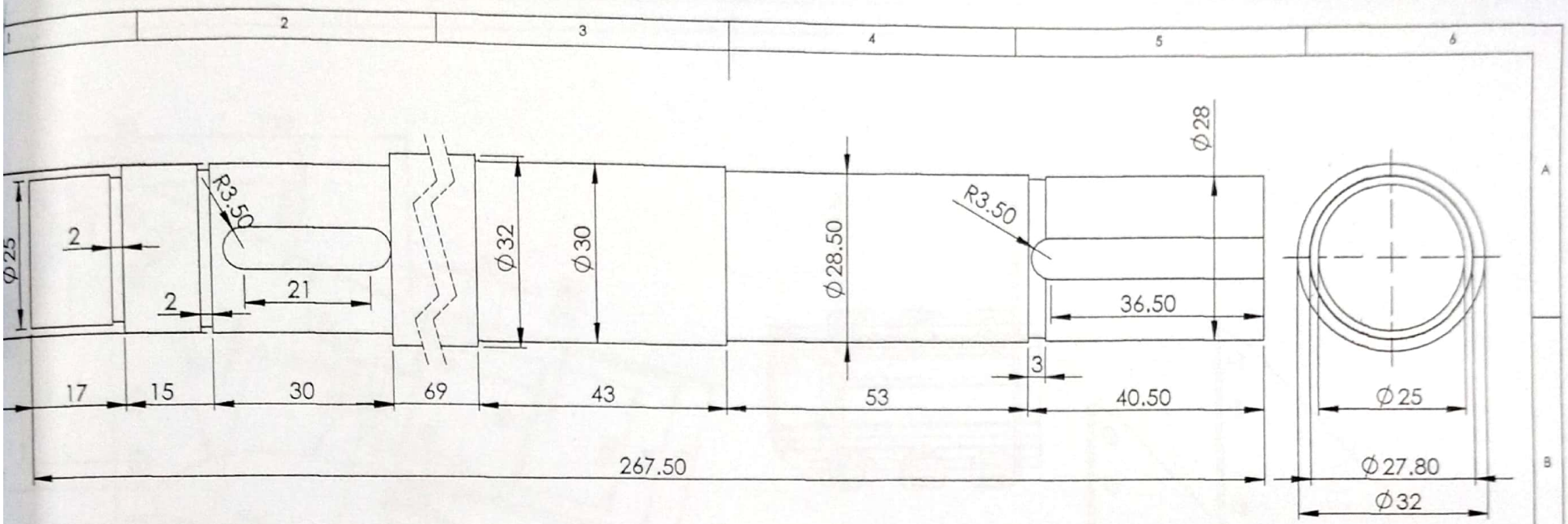


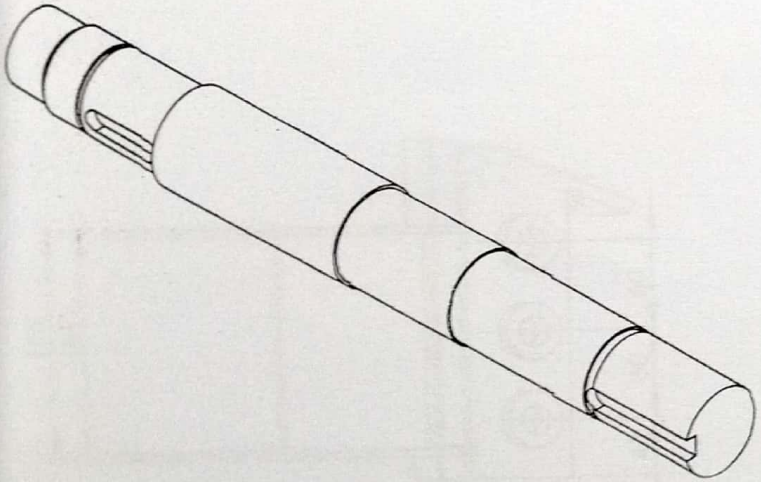

| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
|---|---|---|---|---|---|
| Skala : | Peru-bahan a | c | e | | Revisi : |
| Ukuran : | b | d | f | | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 13 | | | Digambar Grif s | |
| | | | | Diperiksa | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER | | | Disetujui | |
| | | | | No. Gambar : | A4 |
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| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan | | |
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| Ukuran : | | b | | | | | |
| | | c | | | | | |
| | | d | | | | | |
| | | e | | | | | |
| | | f | | | | | |

Toleransi:
Penyusutan:
Tamb. Pengerjaan:

Proyeksi

POLITEKNIK MANUFAKTUR CEPER
Batur, Tegalrejo, Ceper, Klaten, Jawa Tengah 57466
Telp. (0272-555960) Fax. (0272 - 555960)

PART 14

Digambar @rif s
Diperiksa
Disetujui
No. Gambar :
Revisi :
No. Bahan:

Berat :

A4

SHEET 1/1

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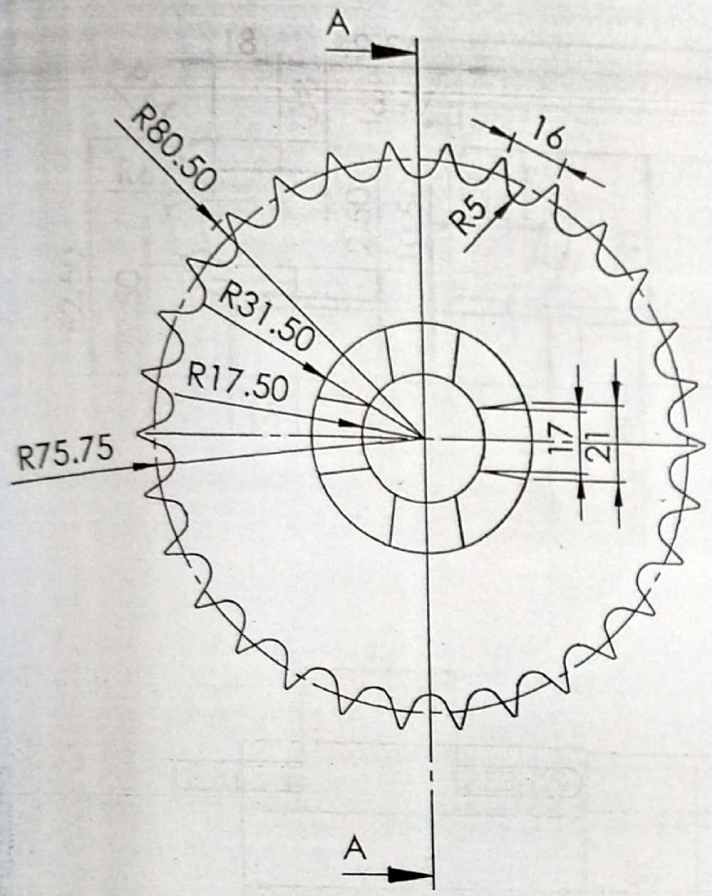
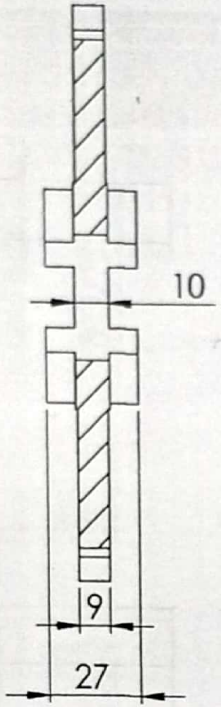
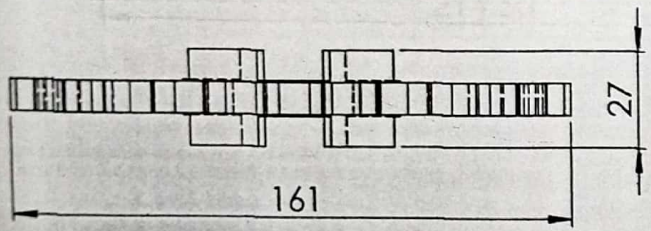
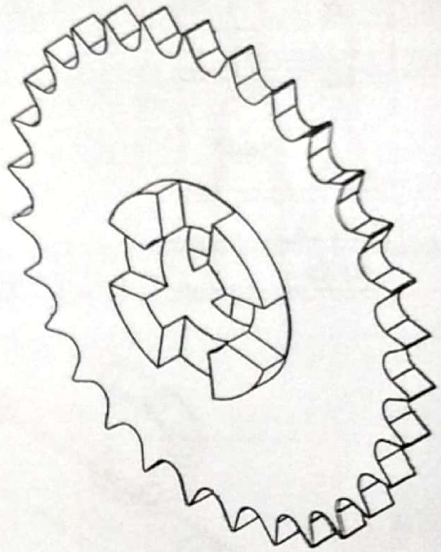



A-A



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|---|---|---|---|---|---|
| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
| Skala : | Perubahan a | c | e | | Revisi : |
| Ukuran : | b | d | f | | No. Bahan : |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 15 | | | Digambar Arif s | |
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| | | | | Berat : | SHEET 1/1 |

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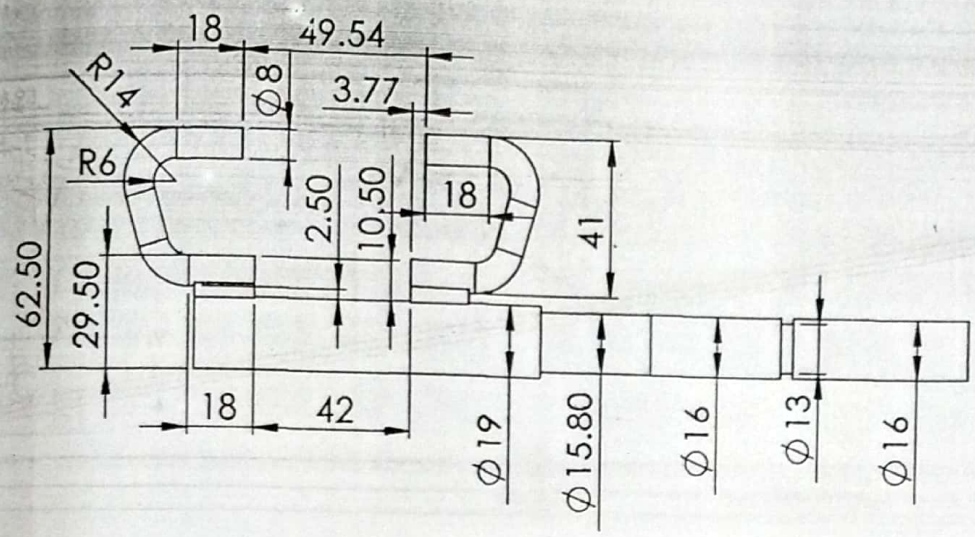


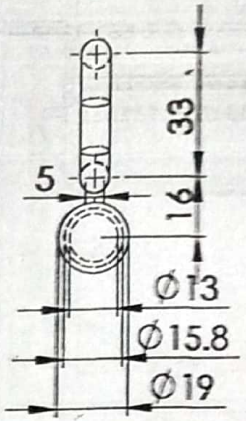


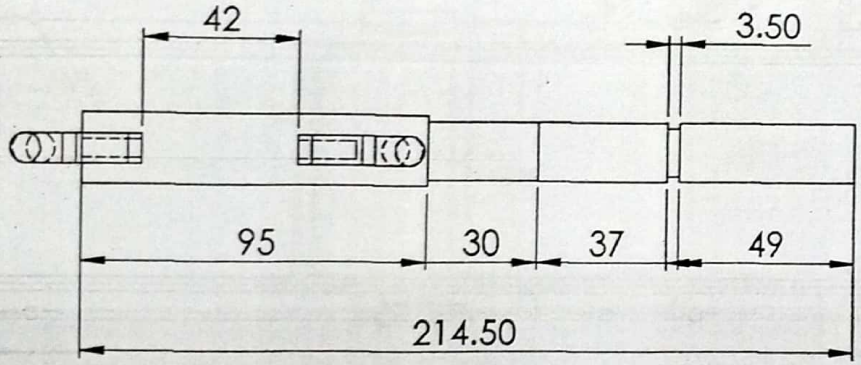


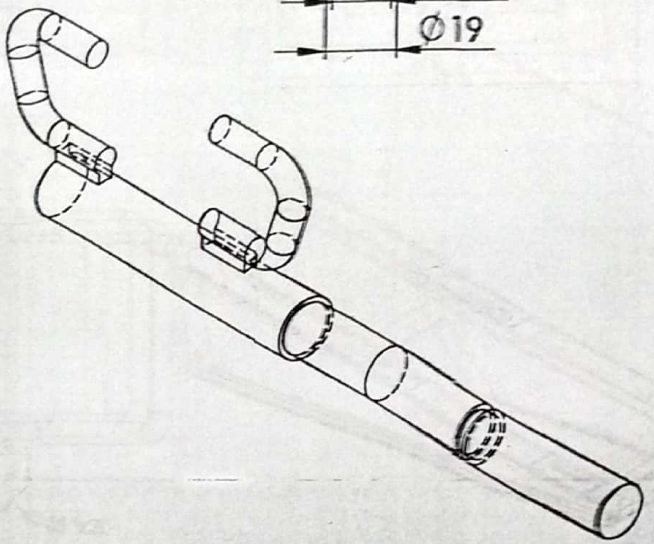

| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
|---|---|---|---|---|---|
| Skala : | Perubahan a | c | e | | Revisi : |
| Ukuran : | b | d | f | | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 16 | | | Digambar Gilis<br>Diperiksa<br>Disetujui<br>No. Gambar : | A4 |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER | | | | |

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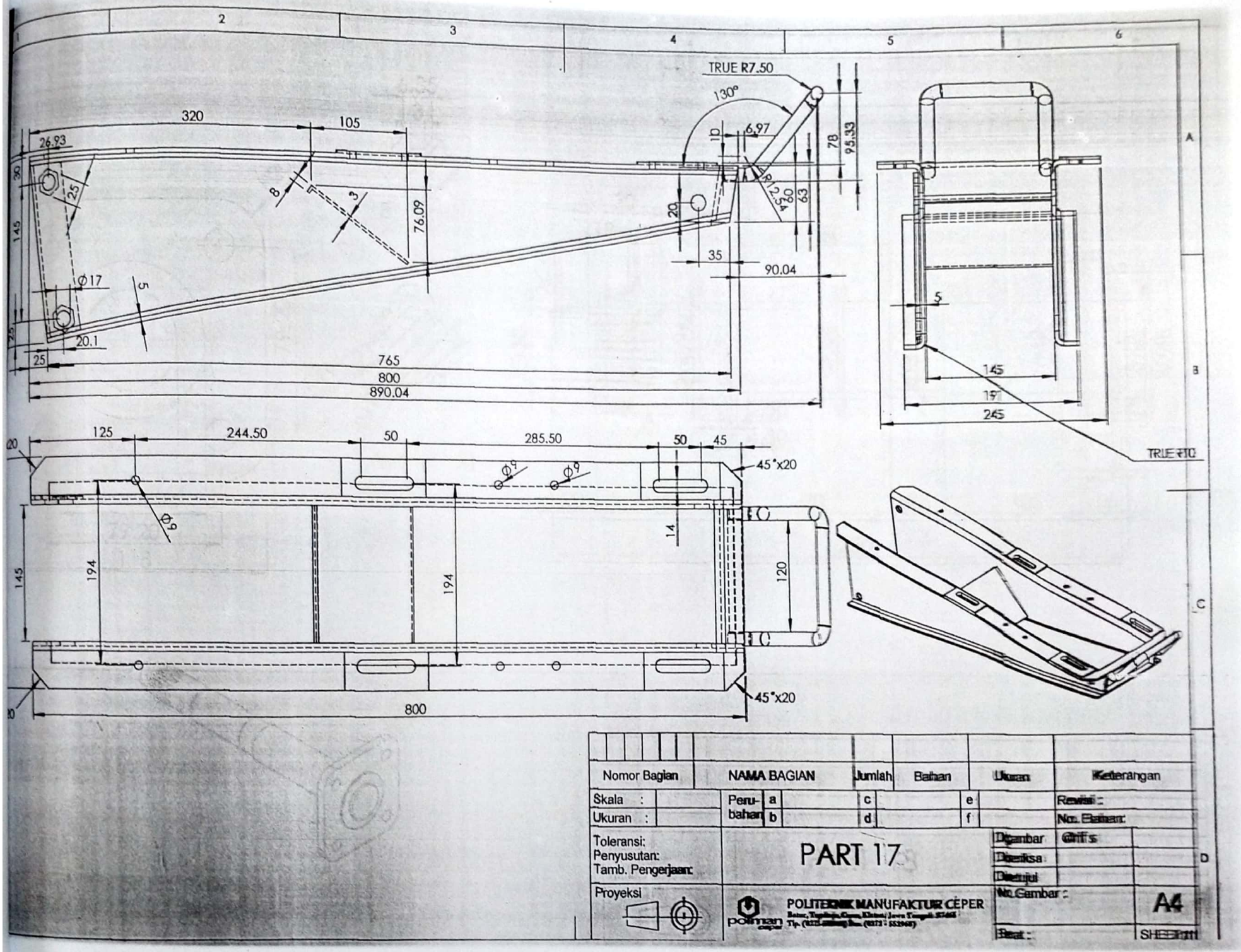


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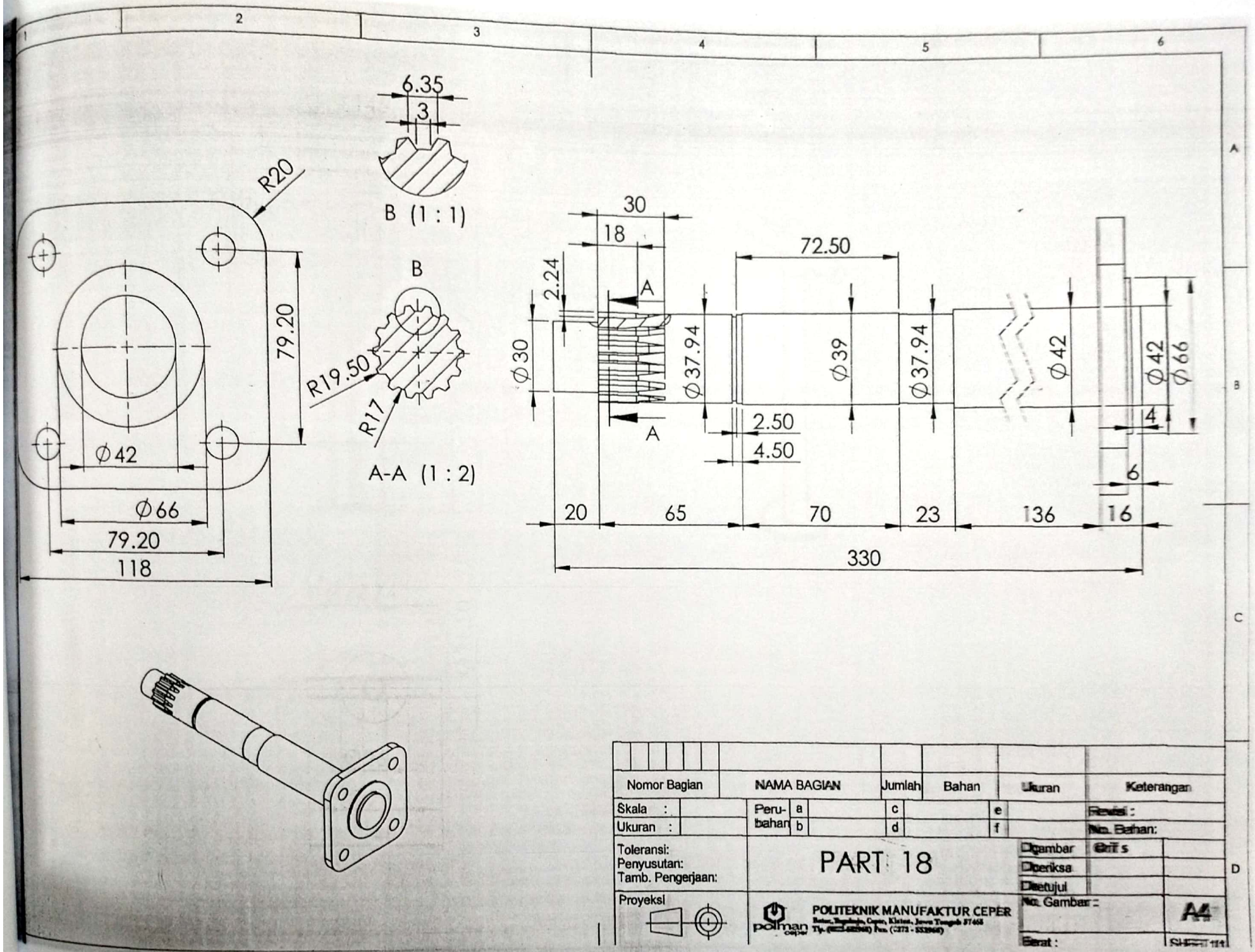


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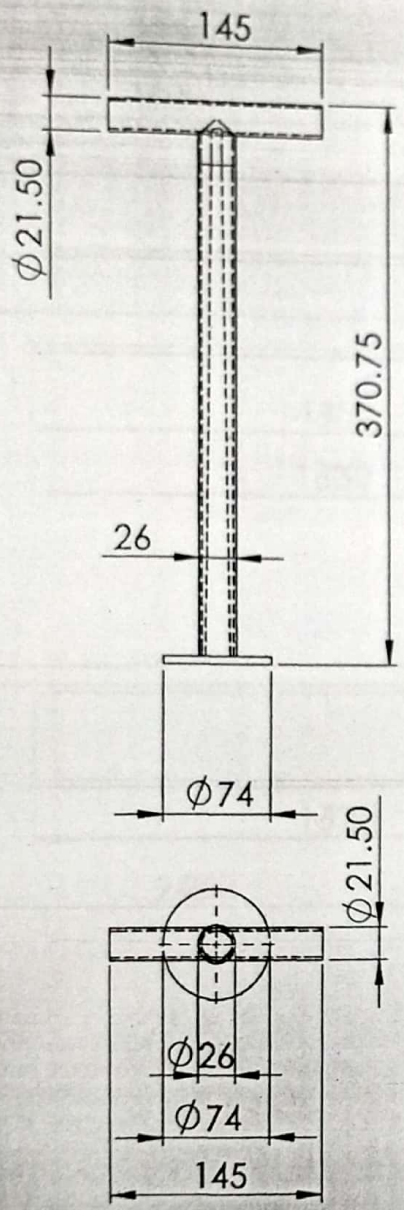


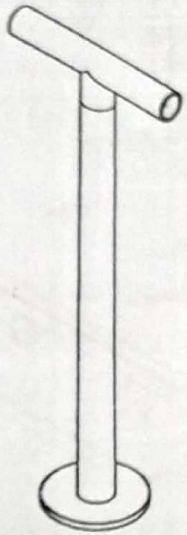

| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
|---|---|---|---|---|---|
| Skala : | Perubahan a | c | e | | Revisi : |
| Ukuran : | b | d | f | | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 19 | | | Digambar | GHT's |
| | | | | Diperiksa | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER | | | Disetujui | |
| | | | | No. Gambar : | A4 |
| | | | | Berat : | SHEET 01 |

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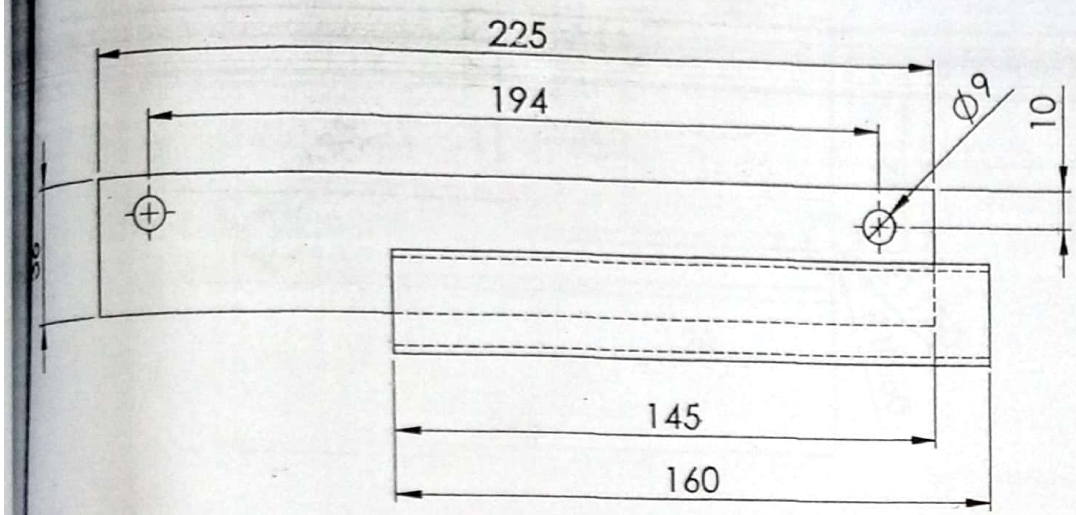


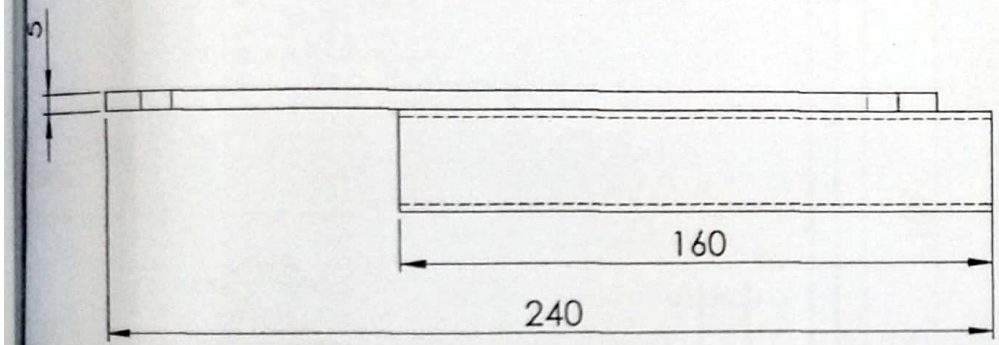


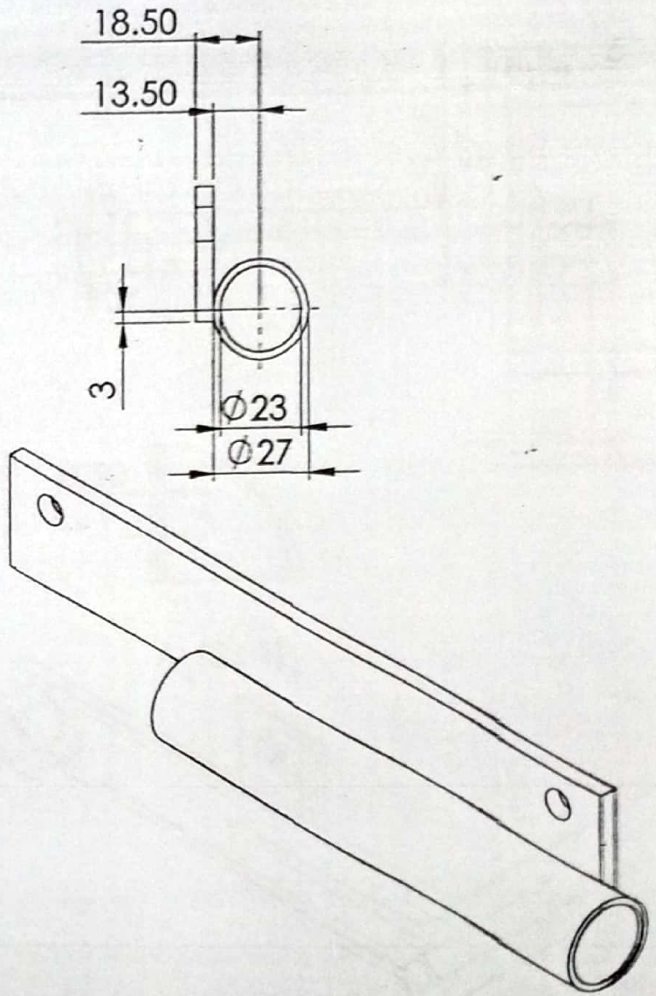


| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
|---|---|---|---|---|---|
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| Ukuran : | b | d | f | | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 20 | | | Digambar | Doni S. |
| | | | | Diperiksa | |
| | | | | Disetujui | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER | | | No. Gambar : | A4 |
| | | | | Berat : | SHEET 1/1 |

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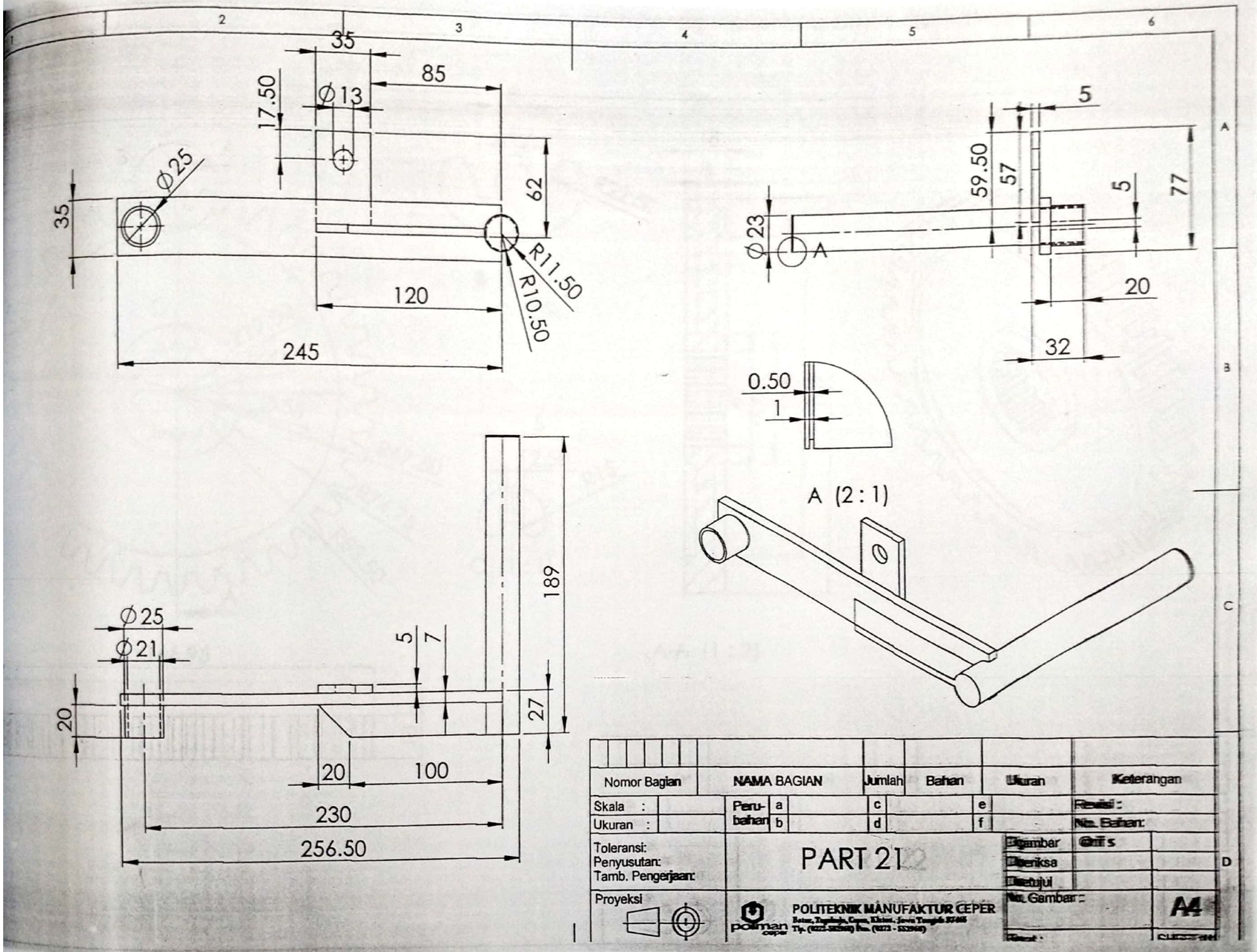


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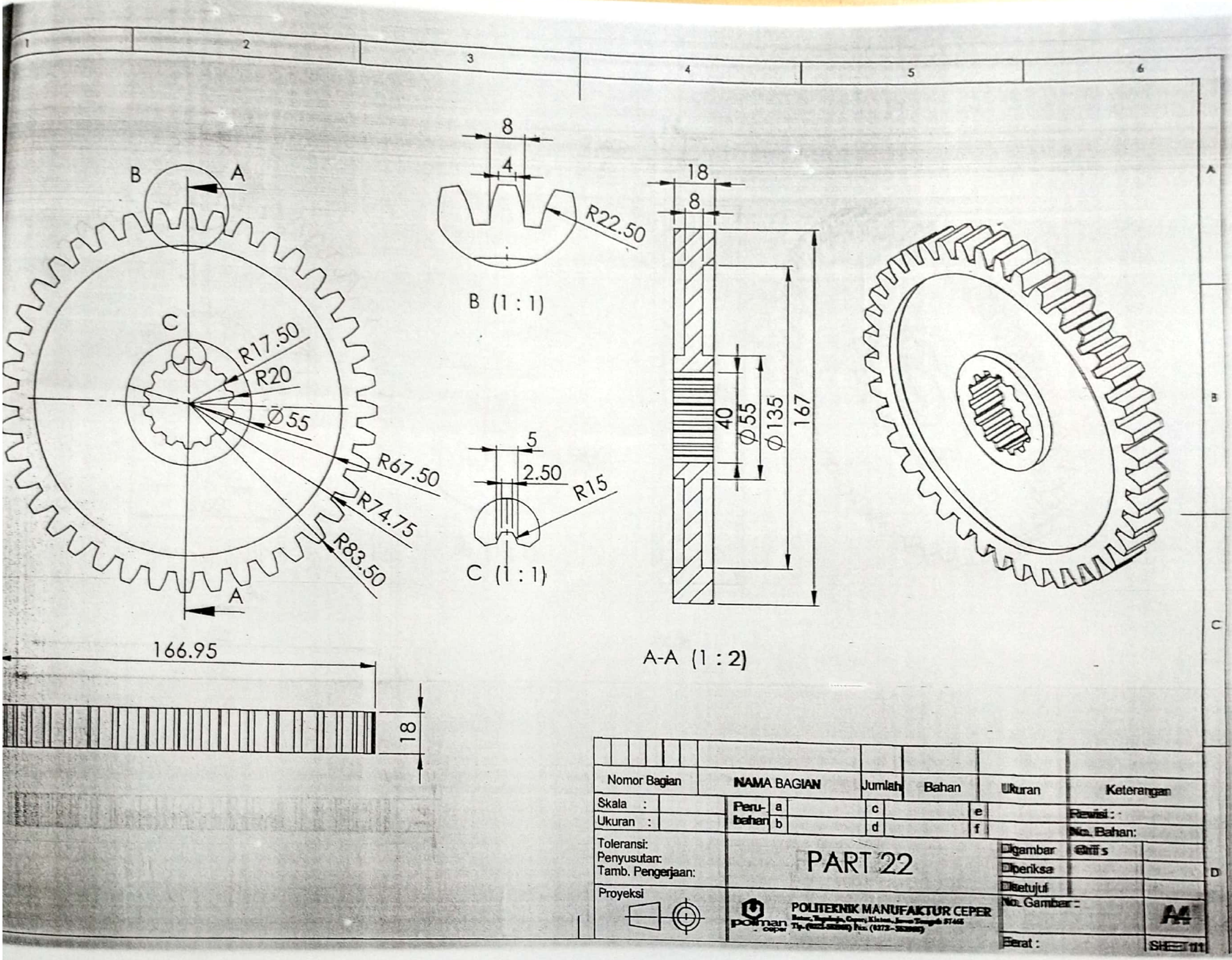


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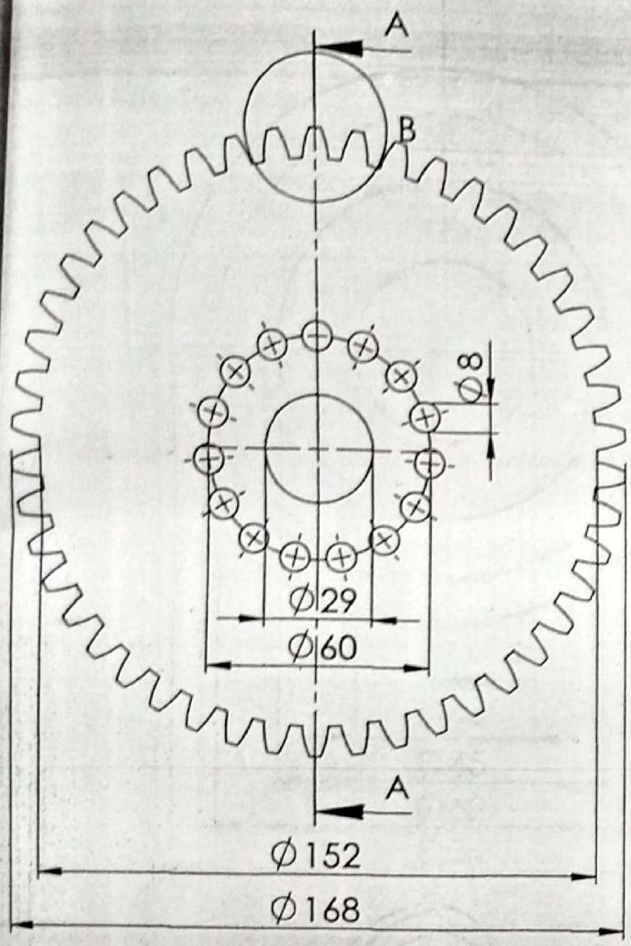
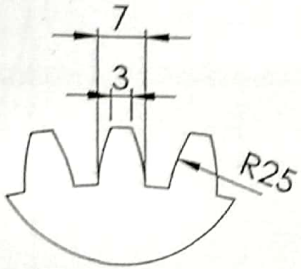
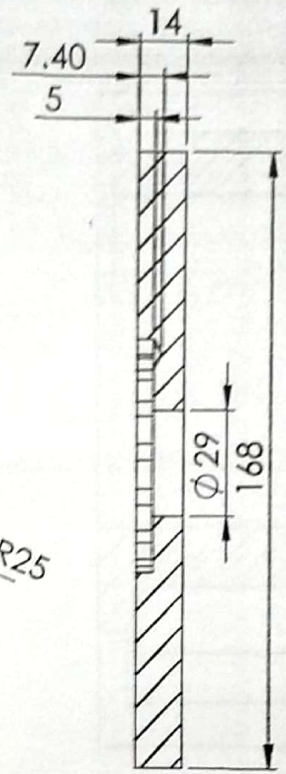
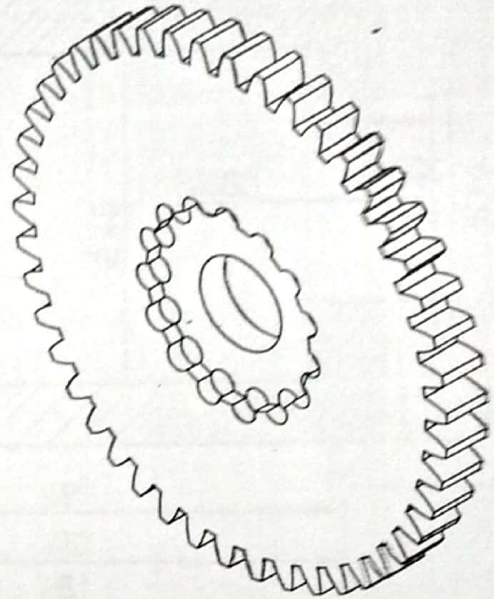


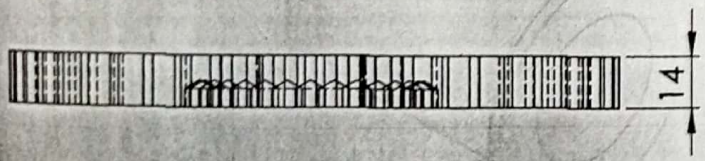




B (1 : 1)




A-A






| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
|---|---|---|---|---|---|
| Skala : | Perubahan a | c | | e | Revisi : |
| Ukuran : | b | d | | f | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 23 | | | Digambar | Oriis |
| | | | | Diperiksa | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER | | | Disetujui | |
| | | | | No. Gambar : | A4 |
| | | | | Berat : | SHEET 1/1 |

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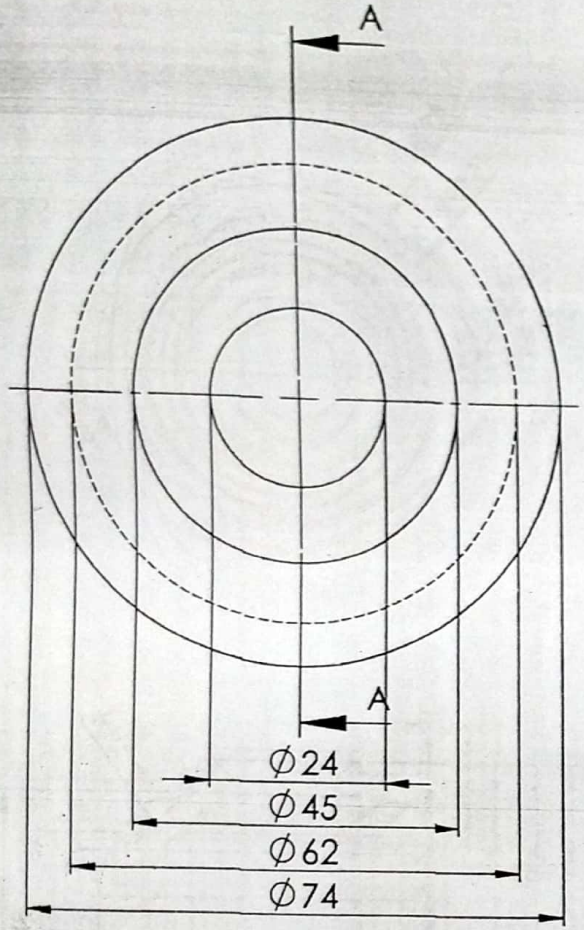
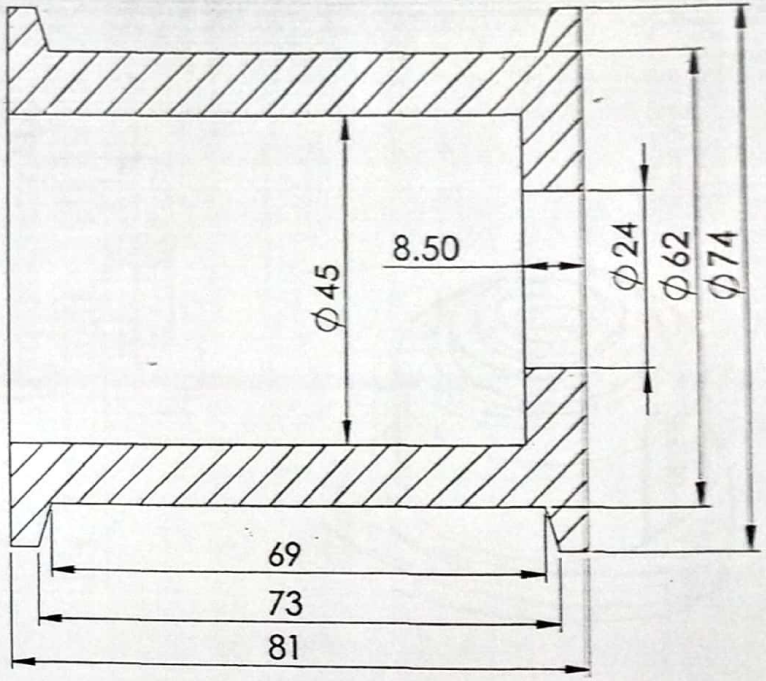
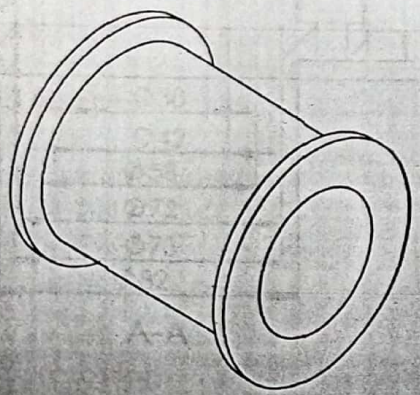



A-A (1 : 1)



| | | | | | | |
|---|---|---|---|---|---|---|
| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan | |
| Skala : | Perubahan a | c | e | | Revisi : | |
| Ukuran : | b | d | f | | No. Bahan: | |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 24 | | | Digambar | Griffs | |
| | | | | Diperiksa | | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER | | | Disetujui | | |
| | | | | No. Gambar : | A4 | |
| | | | | Berat : | Skala 1:1 | |

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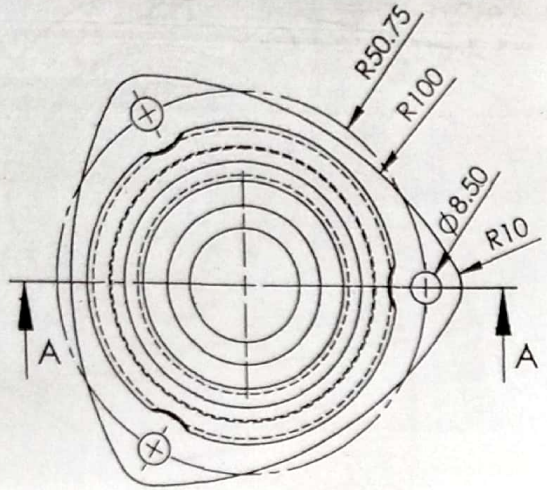


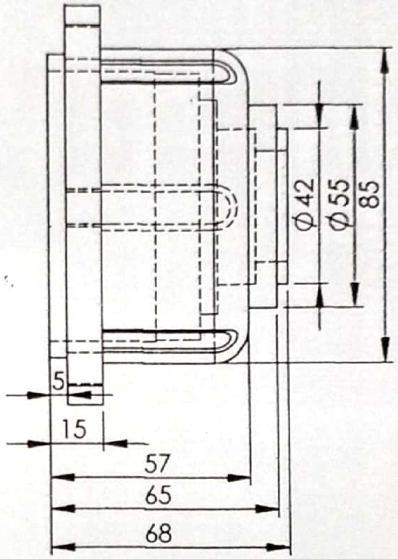


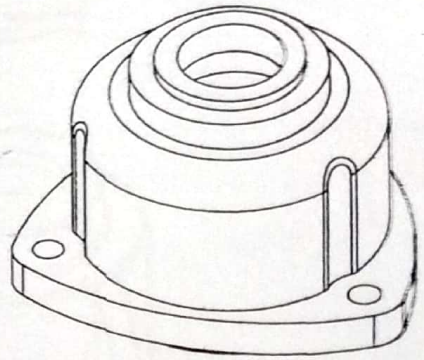

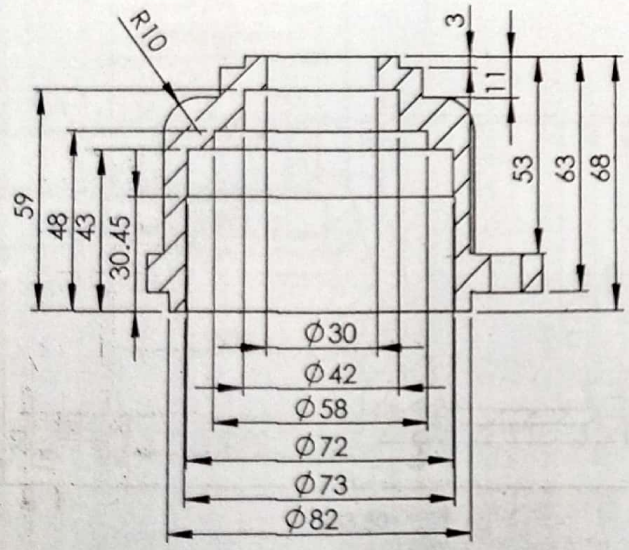


A-A

| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
|---|---|---|---|---|---|
| Skala : | Perubahan a | c | e | | Revisi : |
| Ukuran : | b | d | f | | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 25 | | | Digambar Grif s<br>Diperiksa<br>Disetujui | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER | | | No. Gambar : | |
| | | | | Berat : | SHEET 11 |

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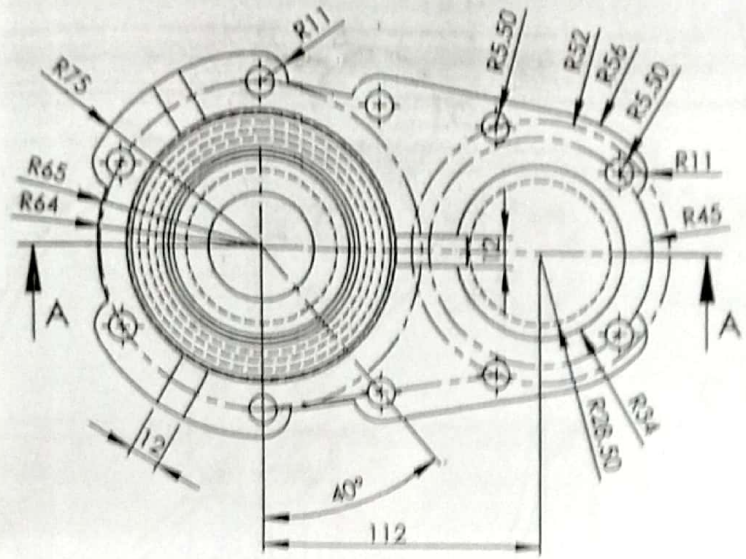


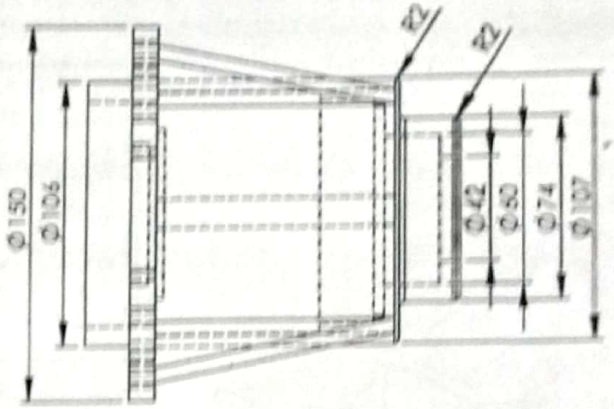


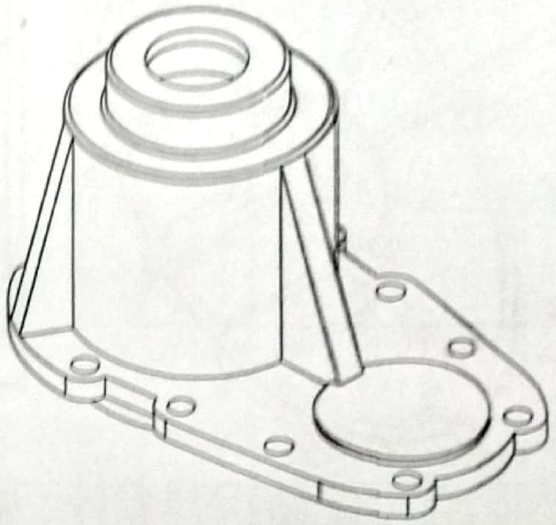

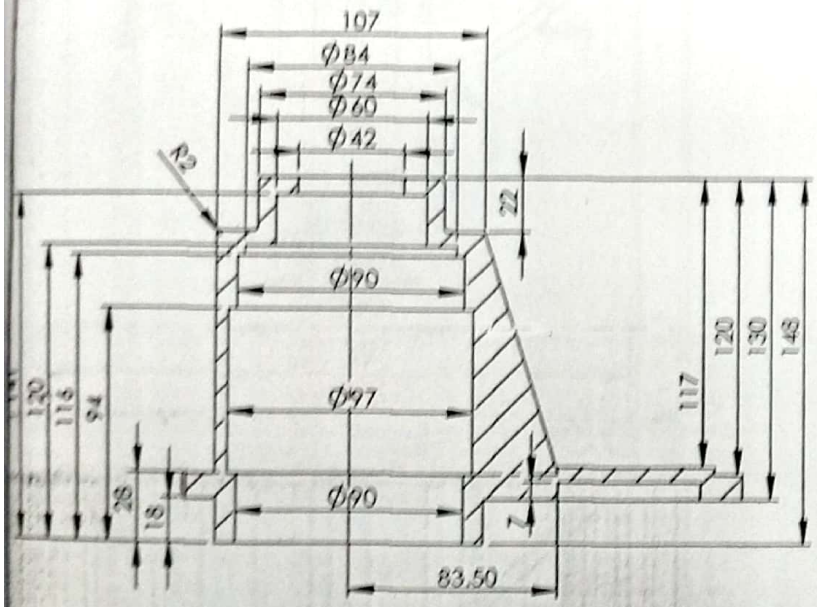


A-A (1 : 3)

| | | | | | | |
|---|---|---|---|---|---|---|
| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan | |
| Skala : | Perubahan a | c | e | | Revisi : | |
| Ukuran : | b | d | f | | No. Bahan: | |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 26 | | | | Digambar | Grid: s |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER | | | | Diperiksa | |
| | | | | | No. Gambar : | A4 |
| | | | | | Berat : | SHEET 1/1 |

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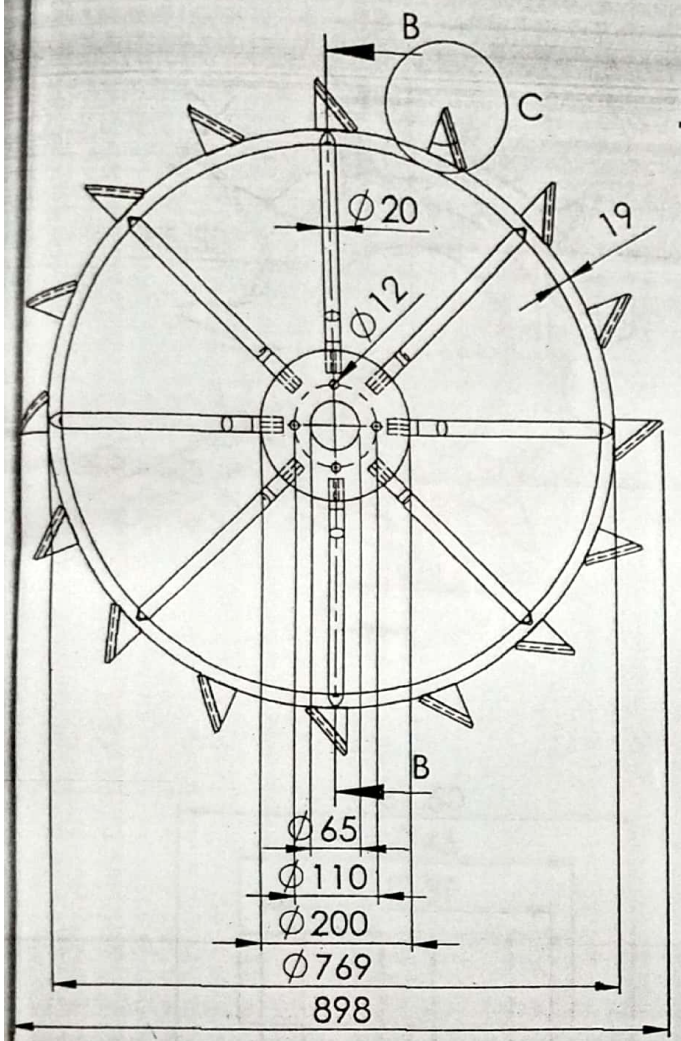
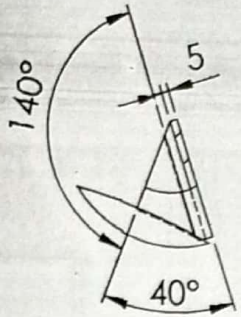
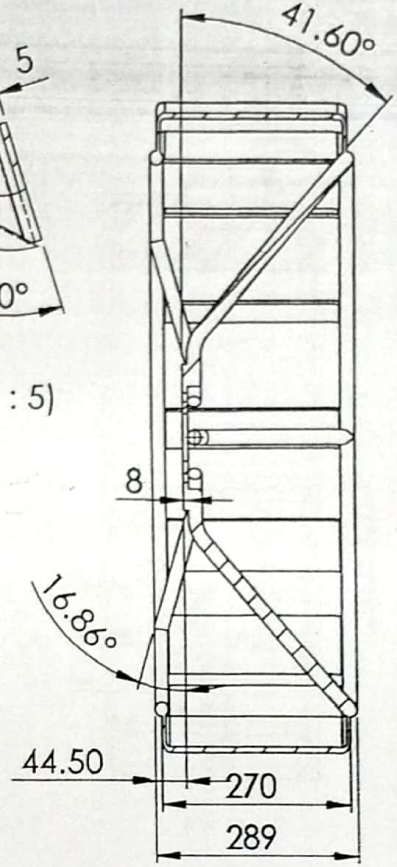
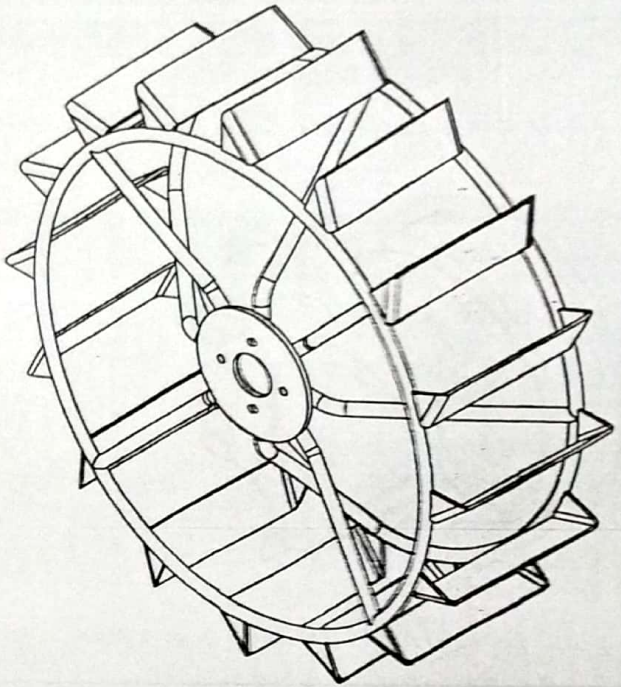


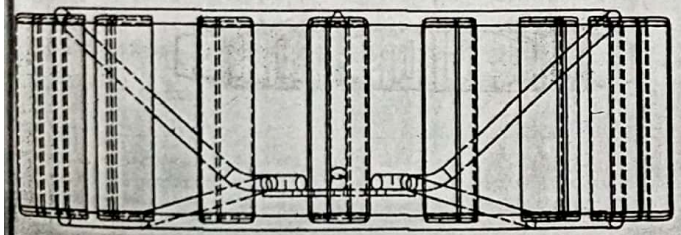




C (1 : 5)




B-B (1 : 10)





| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
|---|---|---|---|---|---|
| Skala : | Perubahan a | c | e | | Revisi : |
| Ukuran : | b | d | f | | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 27 | | | Digambar Grifs<br>Diperiksa<br>Disetujui<br>No. Gambar : | A4 |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER | | | Berat : | SHEET 1/1 |

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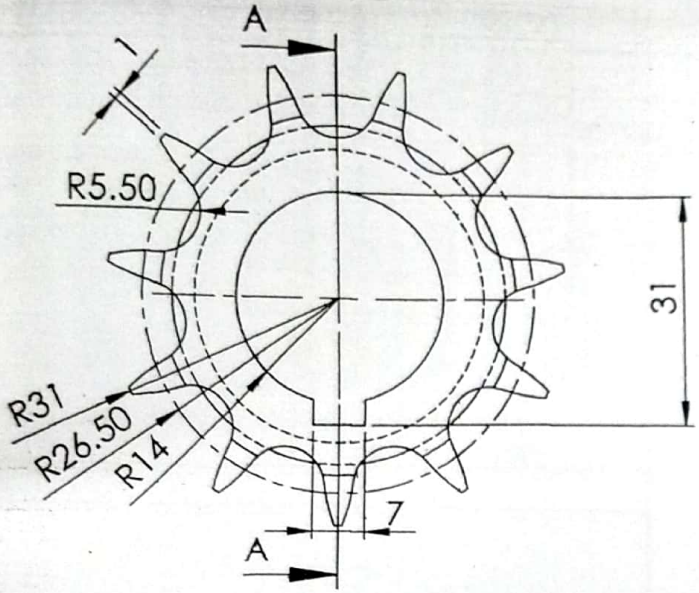
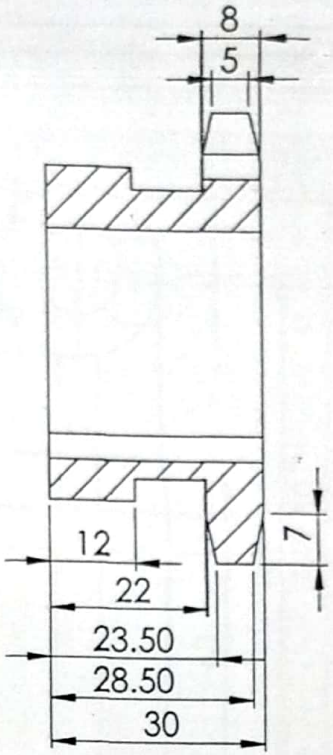
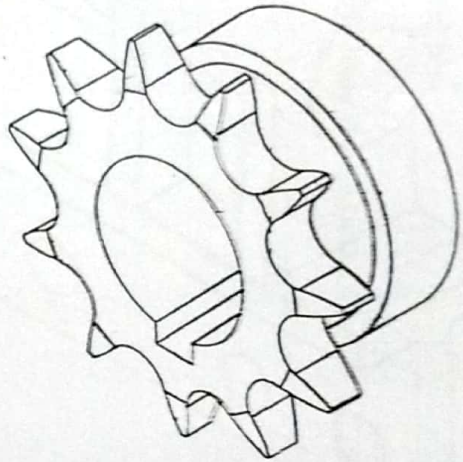
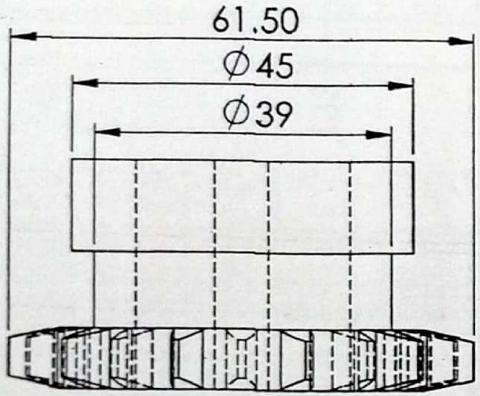



A-A






| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
|---|---|---|---|---|---|
| Skala : | Perubahan a | c | e | | Revisi : |
| Ukuran : | b | d | f | | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 28 | | | Digambar: Arif s | |
| | | | | Diperiksa | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER | | | Disetujui | |
| | | | | No. Gambar : | A4 |

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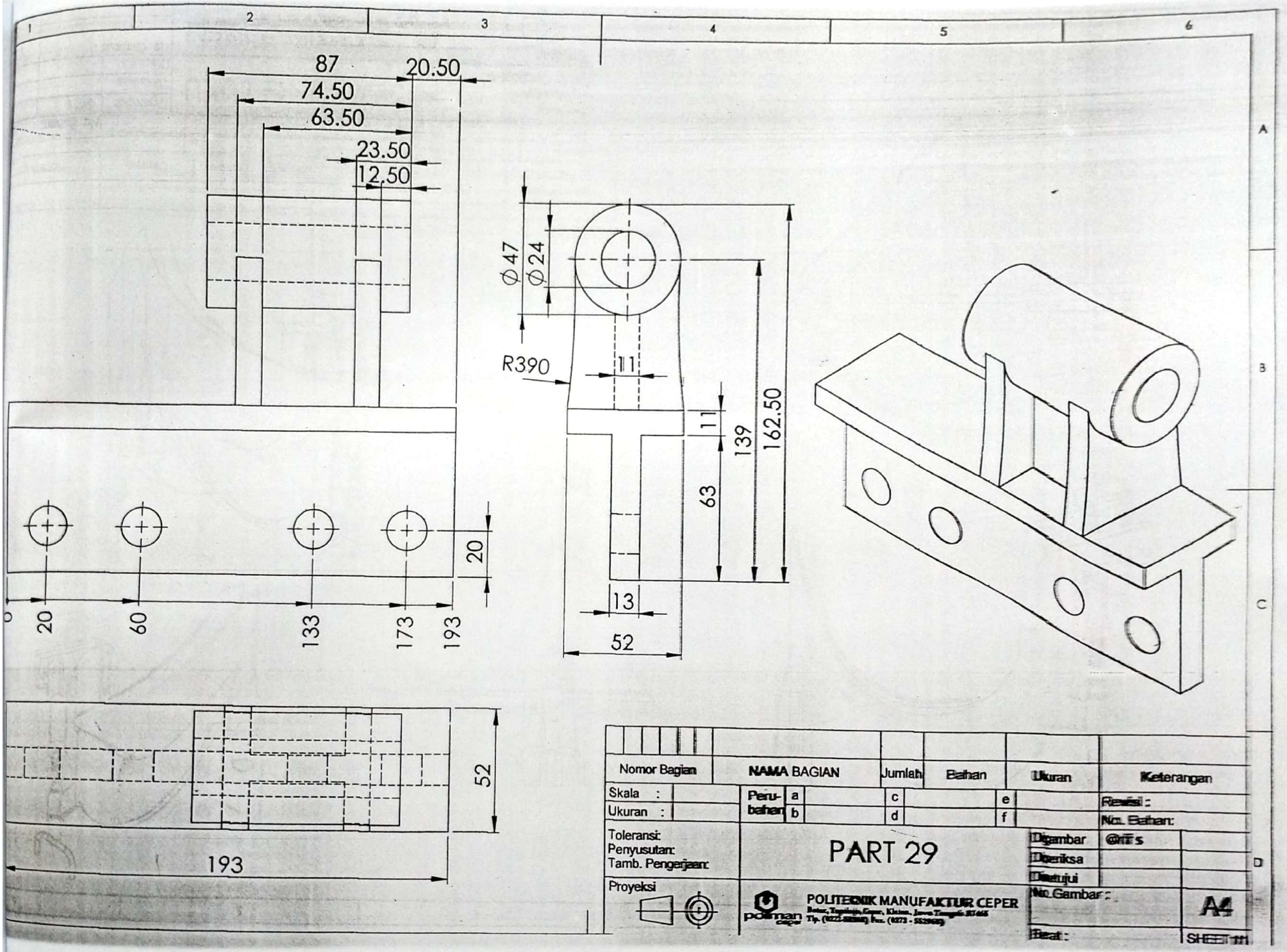


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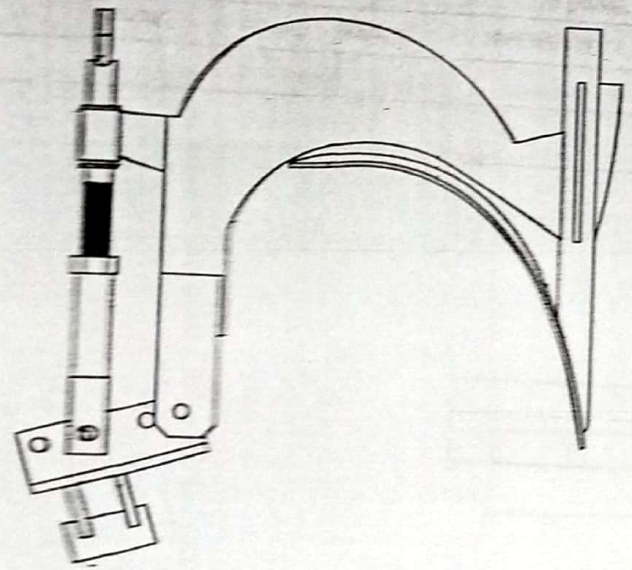

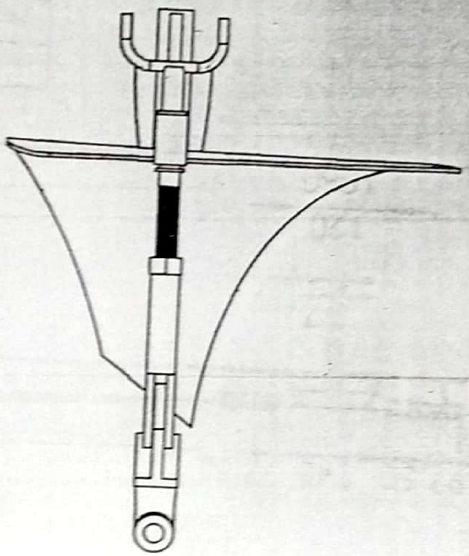

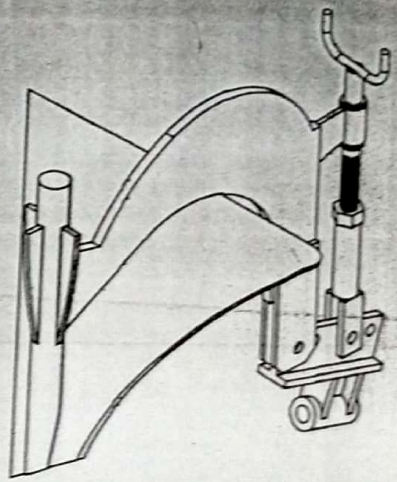

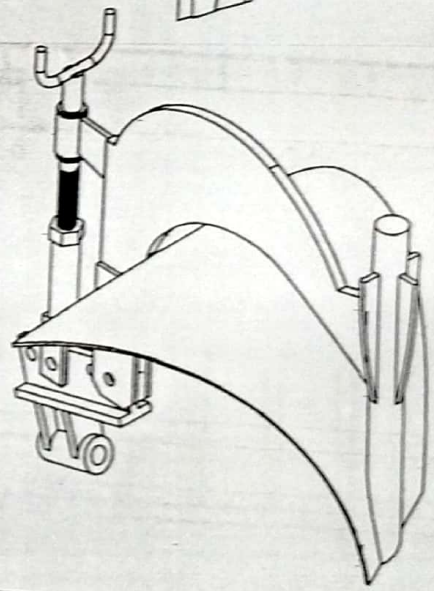

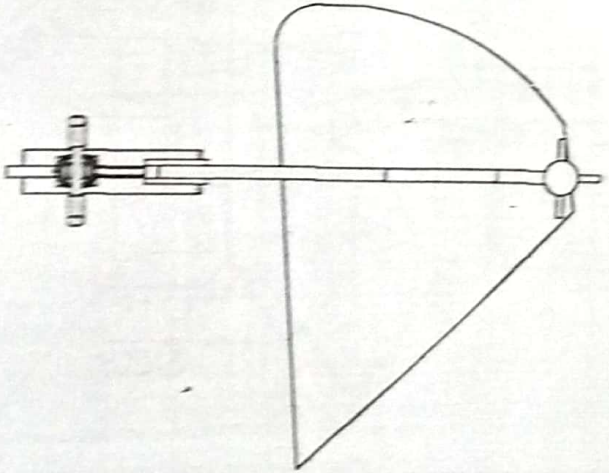

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Nomor Bagian | NAMA BAGIAN | | Jumlah | Bahan | Ukuran | | Keterangan |
| Skala : | Perubahan | a | c | e | | Revisi : | |
| Ukuran : | | b | d | f | | No. Bahan: | |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | ASSEMBLING LUKU | | | | Digambar | @rif s | |
| | | | | | Diperiksa | | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER Batur, Tegalrejo, Ceper, Klaten, Jawa Tengah 57466 Tlp. (0272-582968) Fax. (0272 - 582968) | | | | Disetujui | | |
| | | | | | No. Gambar : | | |
| | | | | | Berat : | | SH |

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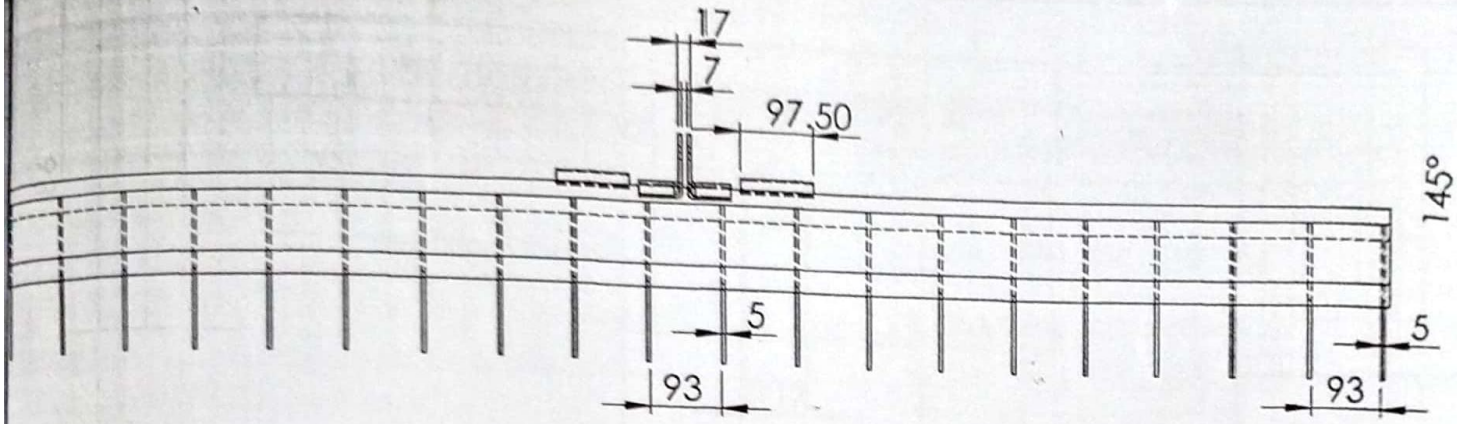


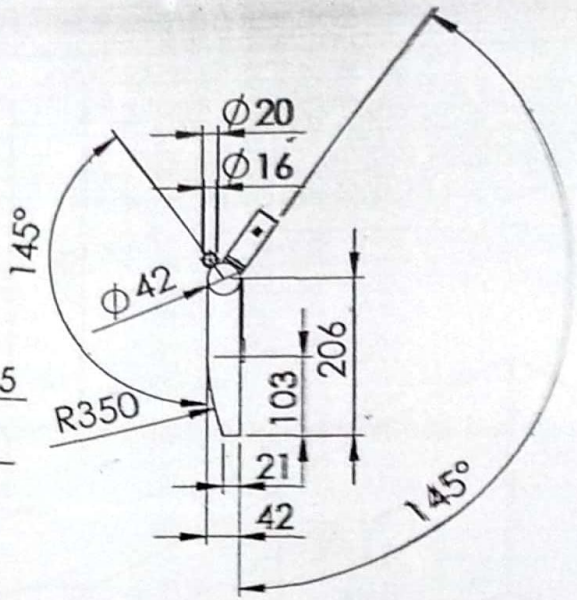


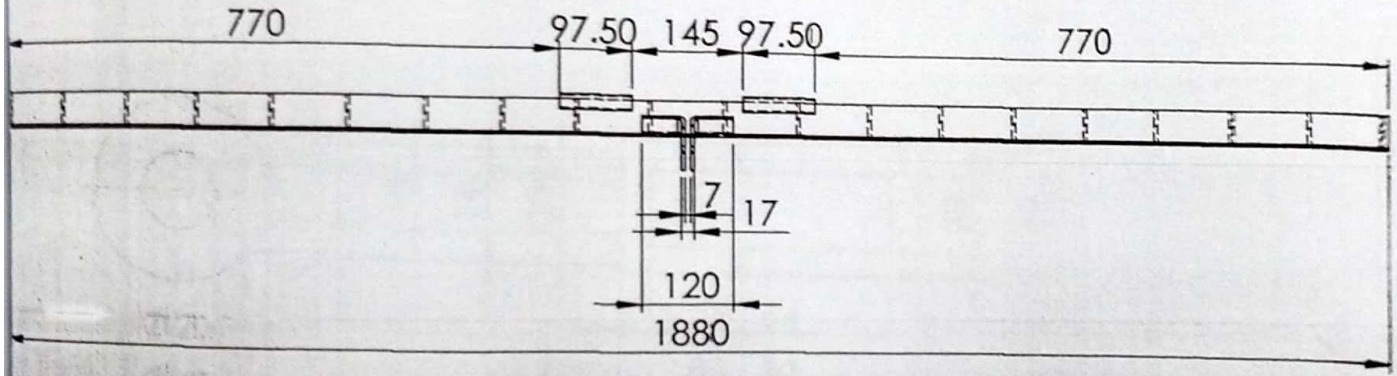


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| Skala : | Perubahan a | c | e | | Revisi : |
| Ukuran : | b | d | f | | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 31 | | | Digambar Griffs | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER | | | Diperiksa | |
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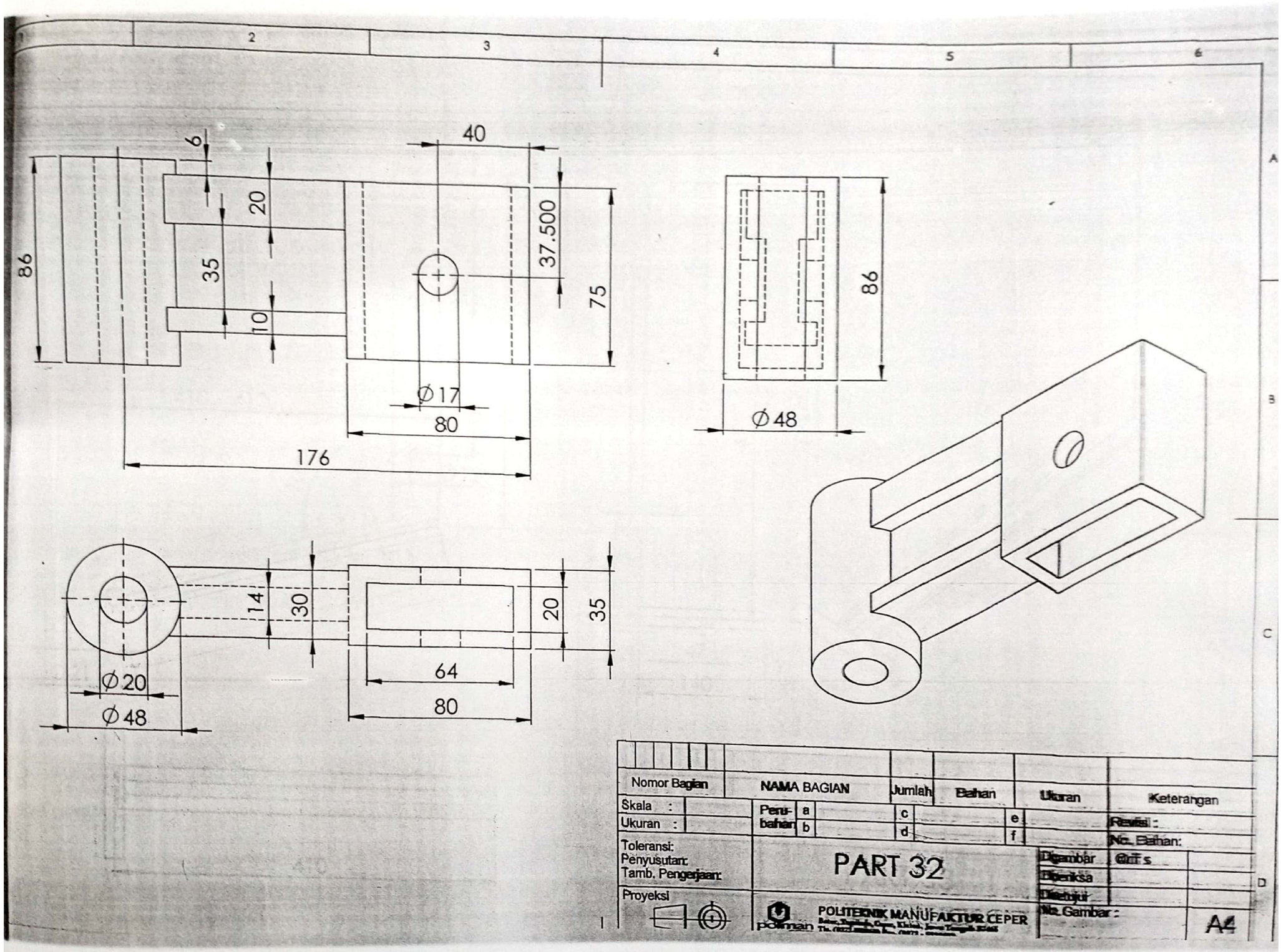


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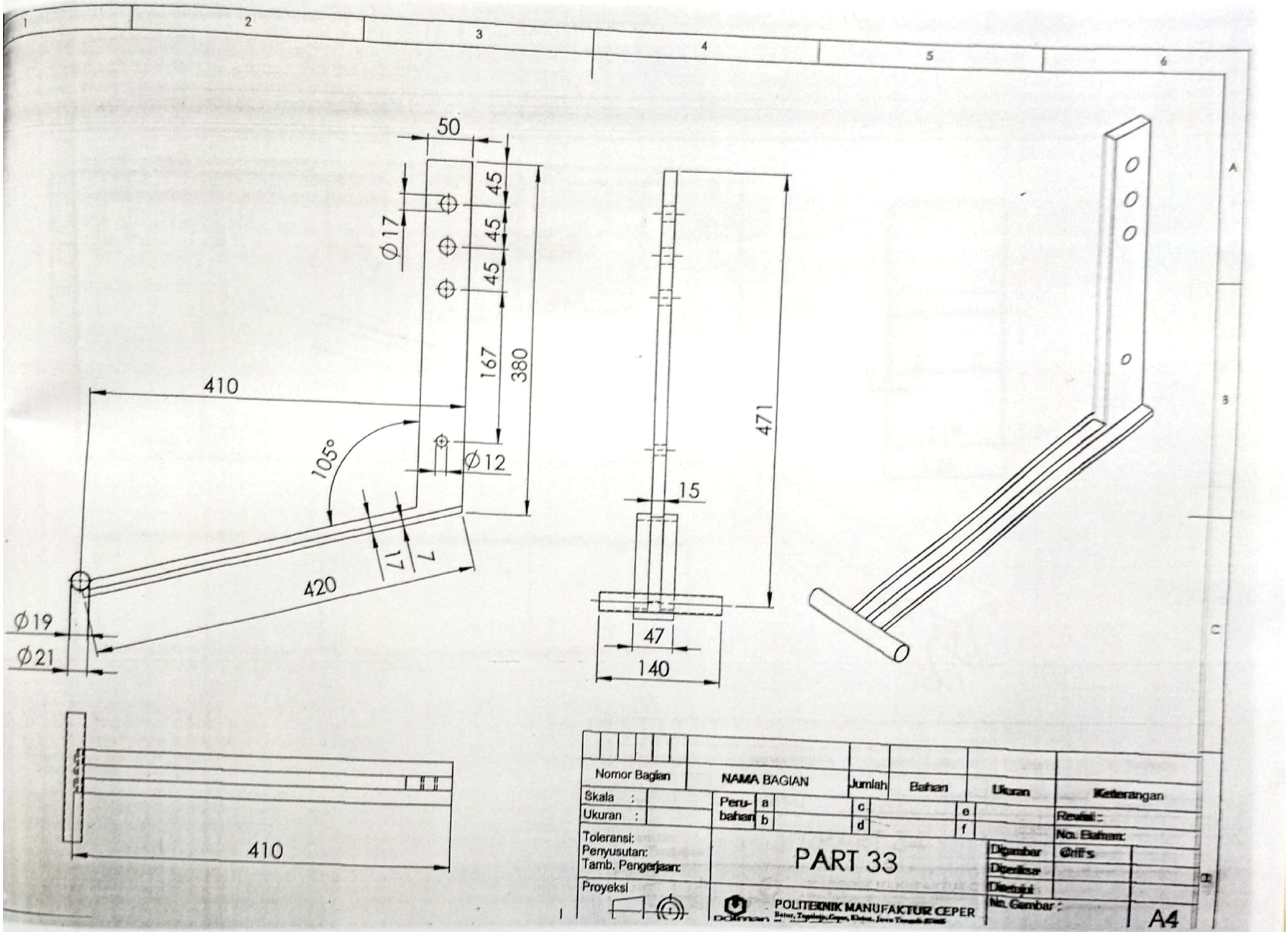


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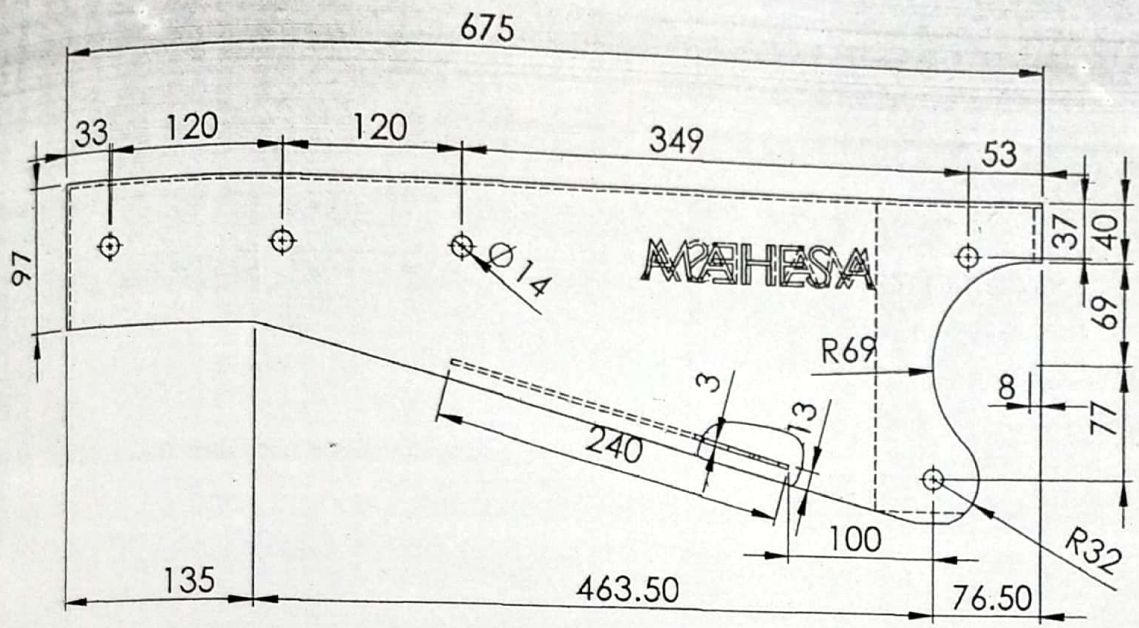


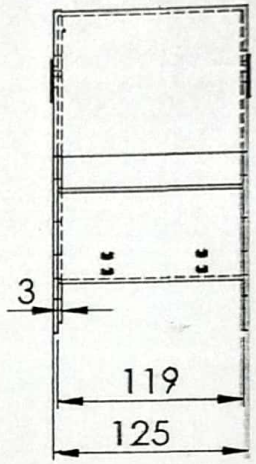


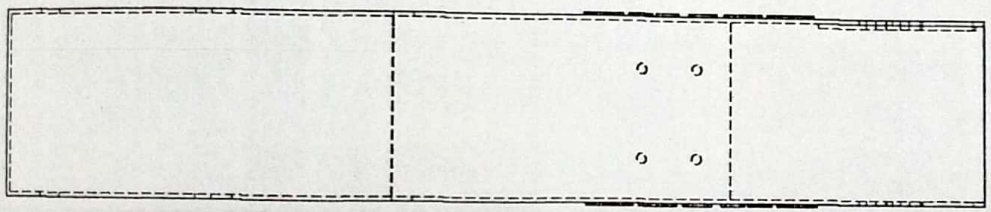

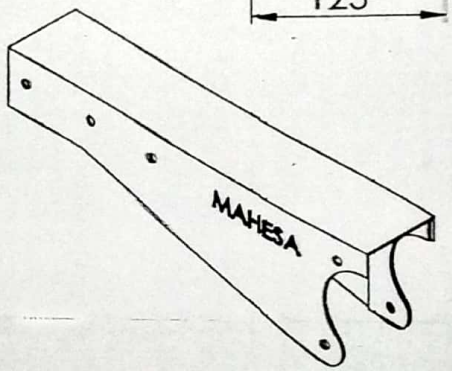


| Nomor Bagian | NAMA BAGIAN | Jumlah | Bahan | Ukuran | Keterangan |
|---|---|---|---|---|---|
| Skala : | Perubahan a | c | e | | Revisi : |
| Ukuran : | b | d | f | | No. Bahan: |
| Toleransi: Penyusutan: Tamb. Pengerjaan: | PART 34 | | | Digambar | Diff s |
| | | | | Diperiksa | |
| Proyeksi | POLITEKNIK MANUFAKTUR CEPER Batur, Tegalrejo, Ceper, Klaten, Jawa Tengah 57466 Telp. (0272-552948) Fax. (0272 - 553966) | | | Disetujui | |
| | | | | No. Gambar : | A4 |

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# LAMPIRAN C DAFTAR SUPPLIER BAHAN BAKU DI CEPER

| NO | NO AGT | NAMA ANGGOTA | NAMA PERUSAHAAN | ALAMAT |
|---|---|---|---|---|
| 1 | 5 | H. Margono | COKRO | BATUR, TEGAL, CEPER |
| 2 | 16 | Ali Afandi | RAJA TERANG | BATUR, TEGAL, CEPER |
| 3 | 23 | Padyo Hartono | SUMBER HIDUP | BANGKALAN, CEPER, KLATEN |
| 4 | 24 | H. Agus Salim | CV. INDRA DATA SAKTI | BANGKALAN, CEPER, KLATEN |
| 5 | 30 | H. Dawan Ashari | KARYA MAKMUR | BANGKALAN BARU, CEPER |
| 6 | 32 | H. Wachid Hasyim | BAJA JAYA | NGAWONGGO |
| 7 | 47 | H. Suarto | SINAR INDUSTRI | TAMPIRAN |
| 8 | 52 | Ishar Abadi | SINAR ABADI | BANGKALAN, CEPER, KLATEN |
| 9 | 55 | H. Asmawi | SINAR SUPER JAYA | BATUR, TEGAL, CEPER |
| 10 | 56 | H. Sholikah | JAYA MAKMUR | JEMBLOGAN |
| 11 | 58 | Dr. H. Musa Ashari | RAJA KURNIA | JEMBLOGAN |
| 12 | 60 | H. Hartanto Samsi | DARU KENCANA | TAMPIRAN |
| 13 | 68 | Hadi Mulyono | | NGAWONGGO |
| 14 | 72 | Thoyibi | | BATUR, TEGAL, CEPER |
| 15 | 73 | Nurudin | NURUDIN | BATUR, TEGAL, CEPER |
| 16 | 77 | H. Zartamli | SARI LOGAM | BATUR, TEGAL, CEPER |
| 17 | 79 | HA. Samingun M. | BAJA MULYA | BATUR, TEGAL, CEPER |
| 18 | 84 | Chumaizah | | KRENEKAN |
| 19 | 86 | Munawir Kamil | MAHKOTA | BATUR, TEGAL, CEPER |
| 20 | 87 | H. Ahmad Darwin | KARYA UTAMA | KRENEKAN |
| 21 | 88 | H. Ali Suyanto | INDAH KARYA | BATUR, TEGAL, CEPER |
| 22 | 92 | H. Purwono Atmojo | ATMAJA JAYA | BATUR, TEGAL, CEPER |
| 23 | 94 | Sumarjo | BAROKAH | NGAWONGGO |
| 24 | 95 | Suhandoyono | SANTOSO | KERON, TROESNO, PEDAN |
| 25 | 96 | Suharmono | SEMERU PUTRA | TEGALSARI |
| 26 | 97 | Bahrudin | RAFINA MARGA | BATUR, TEGAL, CEPER |
| 27 | 99 | Nurhadi | KLINDRA JAYA | SENTONO, NGAWONGGO, CEPER |
| 28 | 105 | H. Didik Dwiyanto | RAJA KARYA | KRENEKAN, KLEPU, CEPER |
| 29 | 106 | H. Makmuri | MAKMUR | BENDO, NGAWONGGO, CEPER |
| 30 | 107 | H. Santoso | SENTOSA | KLATEN |
| 31 | 109 | Hartanto Mulyono | | BANGKALAN |
| 32 | 112 | M. Rochimi | | BENDO, NGAWONGGO, CEPER |
| 33 | 114 | Muhyidin | PENGECORAN LOGAM SAR | KRENEKAN, KLEPU, CEPER |
| 34 | 116 | Drs. H. Syamsudin A. | SETYA KARYA | BANGKALAN, CEPER, KLATEN |
| 35 | 117 | H. Muhida Hudaf | ANGLING ABADI | KRENEKAN, KLEPU, CEPER |
| 36 | 118 | Drs. H. Anas Yusuf M. | NIRWASA PERWARA | BATUR, TEGAL, CEPER |
| 37 | 119 | Ahsin Fatoni | LOGAM KUSUMA | JL. SELATAN MASJID BATUR |
| 38 | 120 | m. Muasir | UD DWI TUNGGAL | BATUR, TEGALREJO, CEPER |
| 39 | 121 | H. Prayono Hadi | PRIMA LOGAM | NGAWONGGO |
| 40 | 125 | Anwar Sanusi | MUTIARA | NOTOMULYO, JAMBUKULON, CEPER |
| 41 | 126 | H. Badrul Munir, BSc | BAHARI | BATUR, TEGALREJO, CEPER |
| 42 | 128 | H. Setyo Gunawan | MULTI GUNA | BATUR, TEGALREJO, CEPER |
| 43 | 129 | Tunjung Suprapto | BUDILAKSANA | TEGALREJO |
| 44 | 131 | Agus Prasetyanto | EMPU SUPO | BATUR, CEPER |
| 45 | 132 | Endang Werdiningsih | | KARANGWUNI KULON, DLIMAS, CEPER |
| 46 | 133 | Ahmaddi Ds. | | KARANGWUNI KULON, DLIMAS, CEPER |
| 47 | 134 | Hartiningsih | | BATUR RT. 01/02, CEPER, KLATEN |
| 48 | 135 | Alfiyah Salamun | | TAMPIRAN |
| 49 | 136 | Sri Murtii Sofyan | | BATUR TIMUR NO. 06 |
| 50 | 137 | Hanafi | ALFIHAN | BATUR |
| 51 | 138 | Muqorobin | | BATUR, TEGALREJO, CEPER |
| 52 | 139 | Darmawan | | NGAWONGGO |
| 53 | 141 | Kusumasto | BUANA INDAH | BATUR, TEGALREJO, CEPER |
| 54 | 142 | Krisdiyanto | LOGAM JAYA | BATUR CEPER |
| 55 | 146 | H. Hussein Syifa'. SE | PT. BAHAMA LASAKKA | BATUR, TEGALREJO, CEPER |
| 56 | 148 | Drs. H. Nurqoni Iskd | PT. IKADA II | TEGALSARI, NGAWONGGO, CEPER |
| 57 | 150 | H. Safrudin | INDO METAL PERSADA | JEBLOGAN, CEPER |
| 58 | 151 | Umardani NH | NINDYA KARYA PUTRA | BATUR, TEGALREJO, CEPER |
| 59 | 152 | H. Susanto TP | SOLO CASTING | BANGKALAN |

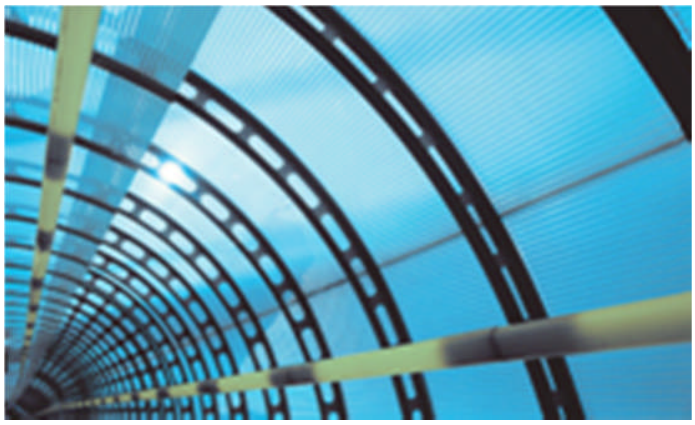
| | | | | |
|---|---|---|---|---|
| 60 | 153 | Ali Wiyasa | | BATU |
| 61 | 155 | HM. Ramell | TEHNIK UTAMA | BATUR, TEGALREJO, CEPER |
| 62 | 156 | Rochani Mashudi | | KLATEN |
| 63 | 158 | Istiana | UD. MULTI KARYA LOGAM | SOLO |
| 64 | 159 | M. Zainal | | BATUR, TEGALREJO, CEPER |
| 65 | 161 | Abdul Haris | | BATUR, TEGALREJO, CEPER |
| 66 | 162 | Bambang Yusuf W | JAYA WARSA | SOLO |
| 67 | 163 | Hj. Siti Thoyibah | | BATUR, TEGALREJO, CEPER |
| 68 | 164 | MN. Budianto | INDUKSI COR LOGAM PUTRI | NGAWONGGO |
| 69 | 165 | Bandiyah Iskandar | BAROKAH ADI | JETIS RT. O2/O4, KLEPU, CEPER |
| 70 | 166 | Asngadi | ABADI INDAH | BATUR, TEGALREJO, CEPER |
| 71 | 167 | Ir. Jamaludi | | KURUNG BARU, KURUNG, CEPER |
| 72 | 170 | Mudriq | | SENTONO, NGAWONGGO |
| 73 | 171 | Aspari | BONJOR JAYA | SENTONO, NGAWONGGO |
| 74 | 172 | Istanto | | KURUNG BARU, KURUNG, CEPER |
| 75 | 173 | Shodiq Kamal | JULU BHAKTI UTAMA | SOLO |
| 76 | 174 | Tri Murtini Syoko | CIPTA KARYA LOGAM | BATUR, TEGALREJO, CEPER |
| 77 | 175 | Anwar Suraji | | NOTOMULYO, JAMBUKULON, CEPER |
| 78 | 178 | Aries | CV DEWANTARA PERMATA | KURUNG BARU, KURUNG, CEPER |
| 79 | 179 | H. Purnomo | | BATUR, TEGALREJO, CEPER |
| 80 | 182 | H. Djoko Widodo | SINGER | BATUR, TEGALREJO, CEPER |
| 81 | 183 | Agus Mustofa | CITRA MANDIRI | BATUR, TEGALREJO, CEPER |
| 82 | 185 | Rustami | | BATUR, TEGALREJO, CEPER |
| 83 | 186 | Sudirman | CV SUDIRMAN | KURUNG BARU, KURUNG, CEPER |
| 84 | 187 | H. Sahudin Ganny | AKBAR MATARAM | BATUR, TEGALREJO, CEPER |
| 85 | 188 | H. Ainur | INDO KARYA PERDANA | TULUNG |
| 86 | 190 | H. SohibQoirudin | FATMA KARYA INDAH | TEGALREJO, CEPER |
| 87 | 191 | Suhadiq | CV ANGARA MAS | BATUR, TEGALREJO, CEPER |
| 88 | 192 | Sri Muryati | BATUR LOGAM MATA | BANGKALAN |
| 89 | 193 | Ahmad Zaini | SALMA | BANGKALAN |
| 90 | 194 | H Hanif Wahidi | CV MARINDO UTAMA | NGARAN RT. O1/02, KLENCENG, CEPER |
| 91 | 196 | H. Agus Yulianto | REKSA CIPTA TERINDO | KURUNG BARU, KURUNG, CEPER |
| 92 | 197 | Erwin MK | ANEKA META INDUSTRI | BANGKALAN, CEPER |
| 93 | 200 | Turoso | UD. LANCAR JAYA | BATUR, TEGALREJO, CEPER |
| 94 | 201 | H. Anwar Khoirul R | RODA MAS | KURUNG BARU, KURUNG, CEPER |
| 95 | 203 | Martu Zuhri | | BANGKALAN CEPER |
| 96 | 204 | Kadir Suroso | | BATUR , TEGALREJO, CEPER |
| 97 | 205 | Anwar Leo | MUSTIKA JAYA | BATUR, TEGALREJO, CEPER |
| 98 | 207 | Arif Rahmawan | | SOLO CASTING |
| 99 | 208 | M. Sutaqin | | BANGKALAN CEPER |
| 100 | 209 | Abdul Muis | | TEGALREJO, CEPER |
| 101 | 213 | Daryoni Abdullah | | BANGKALAN, CEPER |
| 102 | 214 | Eni Setyamuhti | SAHABAT TEKNIK | BATUR BARU |
| 103 | 215 | Muhammad | | BATUR, TEGALREJO, CEPER |
| 104 | 216 | Bari | | BANGKALAN, CEPER |
| 105 | 218 | Surya Eni | UD PASGAR JAYA | KEBONGAN, CEPER |
| 106 | 219 | Raden Ratna Sari | UD SEMBADA | TEGALREJO, CEPER |
| 107 | 222 | M. Wahidin | TERINDO NAFIA | KURUNG BARU, KURUNG, CEPER |
| 108 | 223 | Umar Sumali | | TRGALSARI |
| 109 | 225 | Mutaqin | CV MUKTI LOGAM PERSADA | BATUR, CEPER |
| 110 | 226 | Arif Setyawan | | KEBONGAN, CEPER |
| 111 | 227 | Taufiq Andri M | | BANGKALAN |
| 112 | 228 | Anis Yulianto M | | BATUR, TEGALREJO, CEPER |
| 113 | 229 | Mufitrohman H | | BATUR, TEGALREJO, CEPER |
| 114 | 230 | Fany Irwanto M | | BATUR, TEGALREJO, CEPER |
| 115 | 231 | Ery Santoso | | KEBONGAN, CEPER |
| 116 | 232 | Yusuf Darmawan | | BATUR, TEGALREJO, CEPER |
| 117 | 233 | Irfan Aldi | GELORA MARINDO | TEGALREJO, CEPER |
| 118 | 234 | Ihwani | | BANGKALAN, CEPER |
| 119 | 235 | Budi Hartanto | KARYA RINI | BANGKALAN RT.02/02, CEPER |

| | | | | |
|---|---|---|---|---|
| 120 | 236 | Sri Handayani | | BATUR, TEGALREJO, CEPER |
| 121 | 237 | Muh. Sngidu | ADIMULYA | BATUR, TEGALREJO, CEPER |
| 122 | 238 | H. Wiyono Atmojo | CV. TUNGGAL PERKASA | TAPIRAN, RT.37/15, NGAWONGSO |
| 123 | 239 | H. Ngadiyono | CV. MULYA JAYA | BANGKALAN RT.04/02, CEPER |
| 124 | 240 | Triawan Budi S | | BENDO, NGAWONGSO |
| 125 | 242 | Ir. HM Tolkah | | SENTONO, NGAWONGSO |
| 126 | 243 | Bayu Prasetya, S. Th. I | | BATUR BARU,TEGALREJO, CEPER |
| 127 | 244 | Nur Sefudin, ST | TEKNIK UTAMA JAYA | BATUR, CEPER |
| 128 | 245 | H. Lukman Herawan | PT. ANEKA ADHILOGAM KA | BATUR, CEPER |
| 129 | 246 | Hj. Puji Astuti | WIJAYA MAKMUR | TEGALSARI, NGAWONGGO, CEPER |
| 130 | 247 | Sugeng Widodo | PUTRA BAJA SAKTI | TEGALREJO, CEPER |
| 131 | 249 | Eddy Sudarwono | | JL. PENDEAN II/69,CENDONGCATUR |
| 132 | 250 | Hada Amrullah | | JEBLOGAN, CEPER |
| 133 | 251 | Danang Setiyawan | | TEGALSARI,NGAWONGGO,CEPER |
| 134 | 252 | Susilowati Hj. | | BANGKALAN |
| 135 | 253 | Rina Kuswandari | | GATAK,NGAWONGGO, RT. 17/40, CEPER |
| 136 | 254 | Lutfa Rakhmawati | | BATUR, RT 003/001, TEGALREJO,CEPER |
| 137 | 255 | Budiyanto Cahyono | | TEGALREJO |
| 138 | 256 | Niyala Farihati,M.Si | TEKNIKA JAYA | KURUNG BARU, KURUNG, CEPER |
| 139 | 257 | Erni Dwi Aswati | | KLATEN |
| 140 | 258 | Hammam Baihaqi, S.H., M.S | NUFFINDO NAJANAS | KADIREJO RT.09/04, KARANGNOM |
| 141 | 259 | Ajlev Rozzak Auzyair | CV. LAKSANA AJI | JETIS RT.003/004, KLEPU, CEPER |
| 142 | 260 | Hj. Siti Aminah | | NGAWONGGO |
| 143 | 261 | Hairul Umam | | SOLO |
| 144 | 262 | Hj. Istiqomah | | BANGKALAN |
| 145 | 263 | Sri Winaryanti | UD. LANGGENG | BATUR, TEGALREJO, CEPER |
| 146 | 264 | Ika Ayu Fajarwai | LANCAR ABADI | JEBLOGAN, CEPER |
| 147 | 265 | Siti Zulali | | BENDO NGAWONGGO, CEPER |
| 148 | 266 | Eko Wahyono | | BANGKALAN, RT. 002/002, CEPER, CEPER |
| 149 | 267 | Herjuno Ariwibowo Arifin | | JL. JAWA NO. 27 RT. 007/004, KEL TIMUR |
| 150 | 268 | Siti Hartuti | TUNAS LOGAM JAYA | BATUR, TEGALREJO, CEPER |
| 151 | 269 | Osep Teja Sulamunajat | CV. MARIA IFIFIFERRO | NGAWONGGO, RT.19/09, CEPER, KLATEN |
| 152 | 270 | Edward Iwan Tirta | NASIONAL IRON CASTING | BATUR, RT 003/001, TEGALREJO,CEPER |

# LAMPIRAN D DATA DICTIONARY

# SAP PowerDesigner
## Physical Data Model Report

***Model: Disertasi***
***Report: Hybrid computational intelligence for the Selection of Manufacturing Industry Suppliers***



Author: Denny Trias Utomo
Version:
Date: 08/04/2020
Summary:

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# I Introduction

## I.1 Description

## I.2 Card of model Disertasi

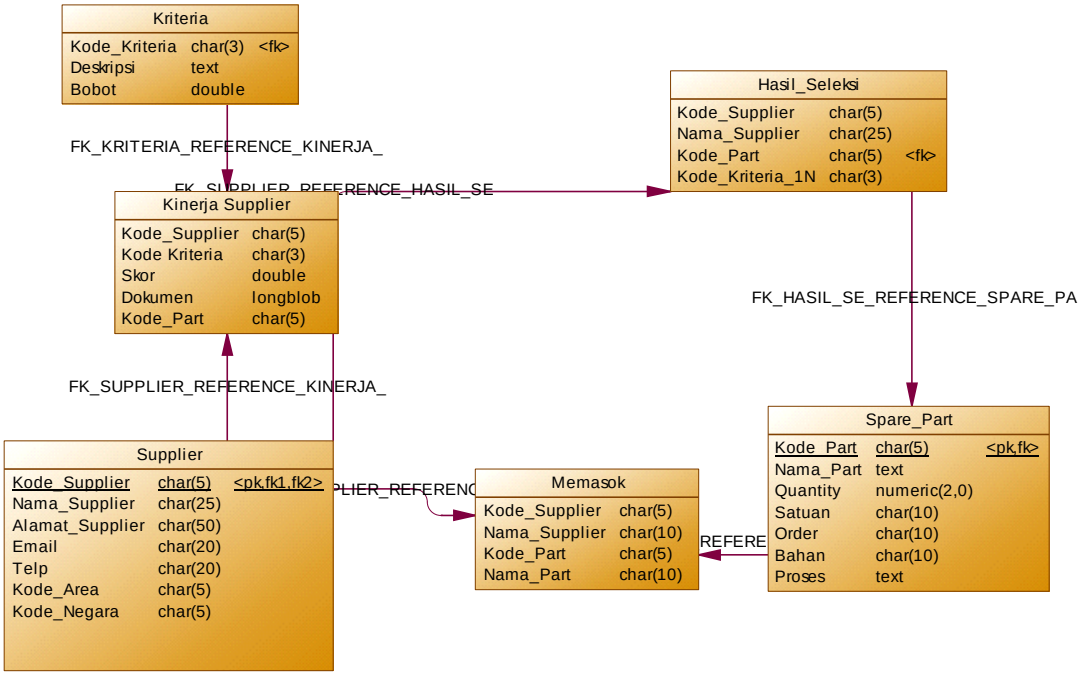
| | |
|---|---|
| Name | Disertasi |
| Code | DISERTASI |
| DBMS | MySQL 5.0 |
| Comment | |
| Database | <None> |

# II Short model description

## II.1 List of diagrams

| Name | Code |
|---|---|
| Disertasi | DISERTASI |

## II.2 Diagram Disertasi




### *II.2.1 List of tables in diagram*

| Name | Code |
|---|---|
| Hasil_Seleksi | HASIL_SELEKSI |
| Kinerja Supplier | KINERJA_SUPPLIER |
| Kriteria | KRITERIA |
| Memasok | MEMASOK |
| Spare_Part | SPARE_PART |
| Supplier | SUPPLIER |

### *II.2.2 List of references in diagram*

| Name | Code | Parent Table | Child Table | Foreign Key Columns | Parent Role | Child Role |
|---|---|---|---|---|---|---|
| Reference | REFEREN | Memasok | Supplier | Kode_Supp | | |

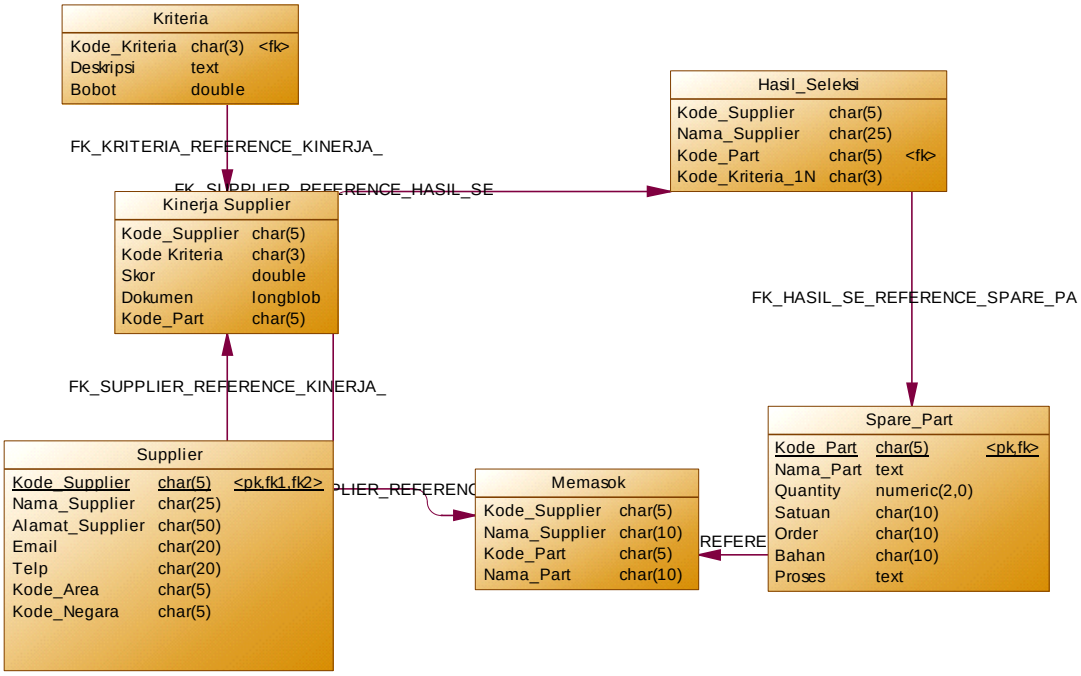
| | | | | | | |
|---|---|---|---|---|---|---|
| _1 | CE_1 | | | lier | | |
| Reference_2 | REFERENCE_2 | Memasok | Spare_Part | Kode_Part | | |
| Reference_3 | REFERENCE_3 | Kinerja Supplier | Kriteria | Kode_Kriteria | | |
| Reference_4 | REFERENCE_4 | Kinerja Supplier | Supplier | Kode_Supplier | | |
| Reference_5 | REFERENCE_5 | Hasil_Seleksi | Supplier | | | |
| Reference_6 | REFERENCE_6 | Spare_Part | Hasil_Seleksi | Kode_Part | | |

# III Full model description

## III.1 List of diagrams

| Name | Code |
|---|---|
| Disertasi | DISERTASI |

## III.2 Diagram Disertasi




### *III.2.1 List of tables in diagram*

| *Name* | *Code* |
|---|---|
| Hasil_Seleksi | HASIL_SELEKSI |
| Kinerja Supplier | KINERJA_SUPPLIER |
| Kriteria | KRITERIA |
| Memasok | MEMASOK |
| Spare_Part | SPARE_PART |
| Supplier | SUPPLIER |

#### III.2.1.1 Table Hasil_Seleksi

##### *III.2.1.1.1 Card of table Hasil_Seleksi*

| | |
|---|---|
| Name | Hasil_Seleksi |
| Code | HASIL_SELEKSI |

#### *III.2.1.1.2 Server validation rule of the table Hasil_Seleksi*

%RULES%

#### *III.2.1.1.3 Check constraint name of the table Hasil_Seleksi*

TK_HASIL_SELEKSI

#### *III.2.1.1.4 List of incoming references of the table Hasil_Seleksi*

| Name | Code | Child Table | Foreign Key Columns | Parent Role | Child Role |
|---|---|---|---|---|---|
| Reference_5 | REFERENCE_5 | Supplier | | | |

#### *III.2.1.1.5 List of outgoing references of the table Hasil_Seleksi*

| Name | Code | Parent Table | Foreign Key Columns | Parent Role | Child Role |
|---|---|---|---|---|---|
| Reference_6 | REFERENCE_6 | Spare_Part | Kode_Part | | |

#### *III.2.1.1.6 List of diagrams containing the table Hasil_Seleksi*

| Name | Code |
|---|---|
| Disertasi | DISERTASI |

#### *III.2.1.1.7 List of columns of the table Hasil_Seleksi*

| Name | Code |
|---|---|
| Kode_Supplier | KODE_SUPPLIER |
| Nama_Supplier | NAMA_SUPPLIER |
| Kode_Part | KODE_PART |
| Kode_Kriteria_1N | KODE_KRITERIA_1N |

### III.2.1.2 Table Kinerja Supplier

#### *III.2.1.2.1 Card of table Kinerja Supplier*

| | |
|---|---|
| Name | Kinerja Supplier |
| Code | KINERJA_SUPPLIER |

#### *III.2.1.2.2 Description of the table Kinerja Supplier*

Tabel Kinerja Supplier
Tabel ini berisi relasi kinerja tiap supplier terhadap masing-masing kriteria

#### *III.2.1.2.3 Server validation rule of the table Kinerja Supplier*

%RULES%

#### *III.2.1.2.4 Check constraint name of the table Kinerja Supplier*

TK_KINERJA_SUPPLIER

#### *III.2.1.2.5 List of incoming references of the table Kinerja Supplier*

| Name | Code | Child Table | Foreign Key Columns | Parent Role | Child Role |
|---|---|---|---|---|---|
| Reference_3 | REFERENCE_3 | Kriteria | Kode_Kriteria | | |
| Reference_4 | REFERENCE_4 | Supplier | Kode_Supplier | | |

#### *III.2.1.2.6 List of diagrams containing the table Kinerja Supplier*

| Name | Code |
|---|---|
| Disertasi | DISERTASI |

#### *III.2.1.2.7 List of columns of the table Kinerja Supplier*

| Name | Code |
|---|---|
| Kode_Supplier | KODE_SUPPLIER |
| Kode Kriteria | KODE_KRITERIA |
| Skor | SKOR |
| Dokumen | DOKUMEN |
| Kode_Part | KODE_PART |

### III.2.1.3 Table Kriteria

#### *III.2.1.3.1 Card of table Kriteria*

| | |
|---|---|
| Name | Kriteria |
| Code | KRITERIA |

#### *III.2.1.3.2 Description of the table Kriteria*

Tabel Kriteria
Berisi daftar kriteria beserta bobot tiap kriteria yang digunakan untuk memilih supplier

#### *III.2.1.3.3 Server validation rule of the table Kriteria*

%RULES%

#### *III.2.1.3.4 Check constraint name of the table Kriteria*

TK_KRITERIA

#### *III.2.1.3.5 List of outgoing references of the table Kriteria*

| Name | Code | Parent Table | Foreign Key Columns | Parent Role | Child Role |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Reference_3 | REFERENCE_3 | Kinerja Supplier | Kode_Kriteria | | |

#### *III.2.1.3.6 List of diagrams containing the table Kriteria*

| Name | Code |
|---|---|
| Disertasi | DISERTASI |

#### *III.2.1.3.7 List of columns of the table Kriteria*

| Name | Code |
|---|---|
| Kode_Kriteria | KODE_KRITERIA |
| Deskripsi | DESKRIPSI |
| Bobot | BOBOT |

### III.2.1.4 Table Memasok

#### *III.2.1.4.1 Card of table Memasok*

| | |
|---|---|
| Name | Memasok |
| Code | MEMASOK |

#### *III.2.1.4.2 Server validation rule of the table Memasok*

%RULES%

#### *III.2.1.4.3 Check constraint name of the table Memasok*

TK_MEMASOK

#### *III.2.1.4.4 List of incoming references of the table Memasok*

| Name | Code | Child Table | Foreign Key Columns | Parent Role | Child Role |
|---|---|---|---|---|---|
| Reference_1 | REFERENCE_1 | Supplier | Kode_Supplier | | |
| Reference_2 | REFERENCE_2 | Spare_Part | Kode_Part | | |

#### *III.2.1.4.5 List of diagrams containing the table Memasok*

| Name | Code |
|---|---|
| Disertasi | DISERTASI |

#### *III.2.1.4.6 List of columns of the table Memasok*

| Name | Code |
|---|---|

| | |
|---|---|
| Kode_Supplier | KODE_SUPPLIER |
| Nama_Supplier | NAMA_SUPPLIER |
| Kode_Part | KODE_PART |
| Nama_Part | NAMA_PART |

## III.2.1.5 Table Spare_Part

### *III.2.1.5.1 Card of table Spare_Part*

| | |
|---|---|
| Name | Spare_Part |
| Code | SPARE_PART |

### *III.2.1.5.2 Description of the table Spare_Part*

Tabel Spare_Part
Tabel ini berisi data master spare part untuk merakit traktor tangan

### *III.2.1.5.3 Server validation rule of the table Spare_Part*

%RULES%

### *III.2.1.5.4 Check constraint name of the table Spare_Part*

TK_SPARE_PART

### *III.2.1.5.5 List of incoming references of the table Spare_Part*

| Name | Code | Child Table | Foreign Key Columns | Parent Role | Child Role |
|---|---|---|---|---|---|
| Reference_6 | REFERENCE_6 | Hasil_Seleksi | Kode_Part | | |

### *III.2.1.5.6 List of outgoing references of the table Spare_Part*

| Name | Code | Parent Table | Foreign Key Columns | Parent Role | Child Role |
|---|---|---|---|---|---|
| Reference_2 | REFERENCE_2 | Memasok | Kode_Part | | |

### *III.2.1.5.7 List of diagrams containing the table Spare_Part*

| Name | Code |
|---|---|
| Disertasi | DISERTASI |

### *III.2.1.5.8 List of columns of the table Spare_Part*

| Name | Code |
|---|---|
| Kode_Part | KODE_PART |
| Nama_Part | NAMA_PART |

| | |
|---|---|
| Quantity | QUANTITY |
| Satuan | SATUAN |
| Order | ORDER |
| Bahan | BAHAN |
| Proses | PROSES |

#### *III.2.1.5.9 List of keys of the table Spare_Part*

| Name | Code | Primary |
|---|---|---|
| Key_1 | KEY_1 | X |

### III.2.1.6 Table Supplier

#### *III.2.1.6.1 Card of table Supplier*

| | |
|---|---|
| Name | Supplier |
| Code | SUPPLIER |

#### *III.2.1.6.2 Description of the table Supplier*

Tabel Supplier
Tabel ini berisi data master Supplier yang akan mensuplay bahan baku pembuatan taraktor tangan

#### *III.2.1.6.3 Server validation rule of the table Supplier*

%RULES%

#### *III.2.1.6.4 Check constraint name of the table Supplier*

TK_SUPPLIER

#### *III.2.1.6.5 List of outgoing references of the table Supplier*

| Name | Code | Parent Table | Foreign Key Columns | Parent Role | Child Role |
|---|---|---|---|---|---|
| Reference_1 | REFERENCE_1 | Memasok | Kode_Supplier | | |
| Reference_4 | REFERENCE_4 | Kinerja Supplier | Kode_Supplier | | |
| Reference_5 | REFERENCE_5 | Hasil_Seleksi | | | |

#### *III.2.1.6.6 List of diagrams containing the table Supplier*

| Name | Code |
|---|---|
| Disertasi | DISERTASI |

#### *III.2.1.6.7 List of columns of the table Supplier*

| Name | Code |
|---|---|
| Kode_Supplier | KODE_SUPPLIER |
| Nama_Supplier | NAMA_SUPPLIER |
| Alamat_Supplier | ALAMAT_SUPPLIER |
| Email | EMAIL |
| Telp | TELP |
| Kode_Area | KODE_AREA |
| Kode_Negara | KODE_NEGARA |

#### *III.2.1.6.8 List of keys of the table Supplier*

| Name | Code | Primary |
|---|---|---|
| KEY_1 | KEY_1 | X |

## *III.2.2 List of references in diagram*

| *Name* | *Code* | *Parent Table* | *Child Table* | *Foreign Key Columns* | *Parent Role* | *Child Role* |
|---|---|---|---|---|---|---|
| Reference_1 | REFERENCE_1 | Memasok | Supplier | Kode_Supplier | | |
| Reference_2 | REFERENCE_2 | Memasok | Spare_Part | Kode_Part | | |
| Reference_3 | REFERENCE_3 | Kinerja Supplier | Kriteria | Kode_Kriteria | | |
| Reference_4 | REFERENCE_4 | Kinerja Supplier | Supplier | Kode_Supplier | | |
| Reference_5 | REFERENCE_5 | Hasil_Seleksi | Supplier | | | |
| Reference_6 | REFERENCE_6 | Spare_Part | Hasil_Seleksi | Kode_Part | | |

### III.2.2.1 Reference Reference_1

#### *III.2.2.1.1 Card of reference Reference_1*

| | |
|---|---|
| Name | Reference_1 |
| Code | REFERENCE_1 |
| Child Table | Supplier |
| Parent Table | Memasok |
| Foreign Key Columns | Kode_Supplier |
| Parent Role | |
| Child Role | |

#### *III.2.2.1.2 List of diagrams containing the reference Reference_1*

| Name | Code |
|---|---|
| Disertasi | DISERTASI |

#### *III.2.2.1.3 List of reference joins of the reference Reference_1*

| Display Name | Parent Table Column | Child Table Column |
|---|---|---|
| Kode_Supplier = Kode_Supplier | Kode_Supplier | Kode_Supplier |

### III.2.2.2 Reference Reference_2

#### *III.2.2.2.1 Card of reference Reference_2*

| | |
|---|---|
| Name | Reference_2 |
| Code | REFERENCE_2 |
| Child Table | Spare_Part |
| Parent Table | Memasok |
| Foreign Key Columns | Kode_Part |
| Parent Role | |
| Child Role | |

#### *III.2.2.2.2 List of diagrams containing the reference Reference_2*

| Name | Code |
|---|---|
| Disertasi | DISERTASI |

#### *III.2.2.2.3 List of reference joins of the reference Reference_2*

| Display Name | Parent Table Column | Child Table Column |
|---|---|---|
| Kode_Part = Kode_Part | Kode_Part | Kode_Part |

### III.2.2.3 Reference Reference_3

#### *III.2.2.3.1 Card of reference Reference_3*

| | |
|---|---|
| Name | Reference_3 |
| Code | REFERENCE_3 |
| Child Table | Kriteria |
| Parent Table | Kinerja Supplier |
| Foreign Key Columns | Kode_Kriteria |
| Parent Role | |
| Child Role | |

#### *III.2.2.3.2 List of diagrams containing the reference Reference_3*

| Name | Code |
|---|---|
| Disertasi | DISERTASI |

#### *III.2.2.3.3 List of reference joins of the reference Reference_3*

| Display Name | Parent Table Column | Child Table Column |
|---|---|---|
| Kode Kriteria = Kode_Kriteria | Kode Kriteria | Kode_Kriteria |

### III.2.2.4 Reference Reference_4

#### *III.2.2.4.1 Card of reference Reference_4*

| | |
|---|---|
| Name | Reference_4 |
| Code | REFERENCE_4 |
| Child Table | Supplier |
| Parent Table | Kinerja Supplier |
| Foreign Key Columns | Kode_Supplier |
| Parent Role | |
| Child Role | |

#### *III.2.2.4.2 List of diagrams containing the reference Reference_4*

| Name | Code |
|---|---|
| Disertasi | DISERTASI |

#### *III.2.2.4.3 List of reference joins of the reference Reference_4*

| Display Name | Parent Table Column | Child Table Column |
|---|---|---|
| Kode_Supplier = Kode_Supplier | Kode_Supplier | Kode_Supplier |

### III.2.2.5 Reference Reference_5

#### *III.2.2.5.1 Card of reference Reference_5*

| | |
|---|---|
| Name | Reference_5 |
| Code | REFERENCE_5 |
| Child Table | Supplier |
| Parent Table | Hasil_Seleksi |
| Foreign Key Columns | |
| Parent Role | |
| Child Role | |

#### *III.2.2.5.2 List of diagrams containing the reference Reference_5*

| Name | Code |
|---|---|
| Disertasi | DISERTASI |

## III.2.2.6 Reference Reference_6

### *III.2.2.6.1 Card of reference Reference_6*

| | |
|---|---|
| Name | Reference_6 |
| Code | REFERENCE_6 |
| Child Table | Hasil_Seleksi |
| Parent Table | Spare_Part |
| Foreign Key Columns | Kode_Part |
| Parent Role | |
| Child Role | |

### *III.2.2.6.2 List of diagrams containing the reference Reference_6*

| Name | Code |
|---|---|
| Disertasi | DISERTASI |

### *III.2.2.6.3 List of reference joins of the reference Reference_6*

| Display Name | Parent Table Column | Child Table Column |
|---|---|---|
| Kode_Part = Kode_Part | Kode_Part | Kode_Part |

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Research Article

Computer and Information Science

# PRELIMINARY STUDY OF WEB BASED DECISION SUPPORT SYSTEM TO SELECT MANUFACTURING INDUSTRY SUPPLIERS IN INDUSTRY 4.0 ERA IN INDONESIA

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**Abstract**

Industry 4.0 is an integration between automation and manufacturing industry which requires the use of information technology to implement it. In the operational management framework, there is a supply chain management function that is strongly influenced by quality suppliers. Because choosing a quality new supplier is not an easy thing, we need a reliable application tool and utilizing web-based artificial intelligence technology for the selection of suppliers in the manufacturing industry. The selection of new suppliers is a complex problem because it involves multiple criteria, therefore it is necessary to make a decision support system that is able to complete supplier selection properly. Although the selection of suppliers in the manufacturing industry is not new, in the era of Industry 4.0, a decision support system that is used to choose an absolute supplier based online that must be accessible via the web or mobile application. Therefore the writer's idea in this paper is very relevant to be implemented in the manufacturing industry in all fields in the industrial era 4.0.

**Keywords:** Industry 4.0, supply chain management, decision support system

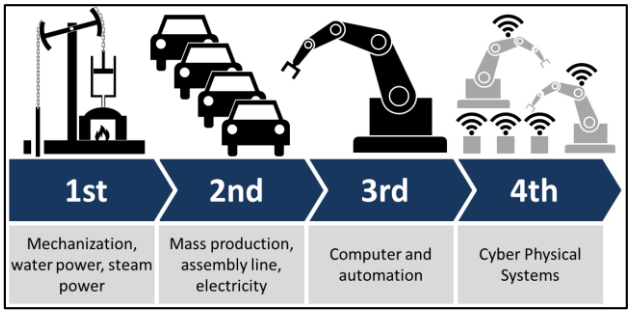
**摘要**

**关键词:**

参考文:

# I. INTRODUCTION

In Industry 4.0 industry players integrate computer networks and communicate with each other through internet networks which, finally, with certain intelligence methods embedded in applications in the form of intelligent knowledge bases, can finally make decisions without human involvement. The combination of physical-cyber systems, the Internet of Things (IoT), and the Internet of Systems makes Industry 4.0 possible and makes smart factories a reality. ("What Is Hannover Messe Fair and How Does It Play a Role in the U.S.?" 2016)




Gambar 1 : Timeline Revolusi Industri
Source : *("What Is Hannover Messe Fair and How Does It Play a Role in the U.S.?," 2016)*

In Indonesia, the development of Industry 4.0 was strongly encouraged by the Ministry of Industry. Industry Minister Airlangga Hartarto said that for Indonesia to compete with other countries in the industry, Indonesia must also follow the trend. [2]

Transformation of the Industrial Revolution 4.0 in the manufacturing industry logistics, starting with the integration of production and logistics processes with the appropriate information technology system. This includes exchanging product and production data within the company as well as with customers and suppliers. According to the Cambridge dictionary, the definition of a supplier is a company, person, etc. providing things that people want or need, especially during the production process over a long period of time [3]

Suppliers in Industry 4.0, in particular, will benefit from the exchange of design and supply chain data. Communication throughout the production process will be (close to) realtime among humans, machines, parts and products. The system that is currently owned will develop into a hierarchical and tiered network with an open and standard interface. Data will be stored in the cloud to increase availability accurately. This will allow more flexibility when reacting to changes (both expected and unexpected) in the production process [4]

In the 4.0 industrial revolution, inventory management is demanded to be more global because Industry 4.0 is an integration of the economy with information technology, it will create a process of flow of goods, services, investment, and capital, entering from one region to another with a very high competitive level. Thus, it requires a policy of truly competitive local products that are valuable and highly competitive in order to be able to compete with similar products from other countries. (Anindhitya, n.d.) In relation to inventory management, the industrial world in the Industrial 4.0 era, the most influential things were suppliers.

Still related to the industrial revolution 4.0, choosing suppliers who can fulfill raw material orders that are in line with company industry standards in the long term is absolutely necessary. These activities are categorized as strategic activities, because the role of suppliers will also be instrumental in determining the success of the company. If the raw material provided by the supplier is of poor quality, this will also affect the quality of the product produced, so productivity decreases [5]–[12]. The accuracy of supplier selection greatly affects the cost-efficiency [5], [9]. The right supply of raw materials guarantees a good quality product. With a good supply of raw materials, resulting in an increase in process efficiency so that the company's operating costs can be reduced. And affect the increase in marketing, which results in increasing company profits. If the supplier cannot provide the raw materials according to the company's requirements, then it is certain that the production schedule will be disrupted. [13]

Supplier selection, in general, is a multi-criteria issue where each criterion used has different interests and information about it is not precisely known. In this case, the selection of suppliers based on low price offers is no longer efficient. To get maximum supply chain performance, it must combine other criteria that are relevant to the company's objectives.[14]

The selection of new suppliers who have never been partners with companies, is a more complex problem, because data is not yet available, and supplier performance is unknown. To choose a new supplier, you cannot use assumptions but must be based on empirical data that can be accounted for, because it greatly affects production performance. (Pujawan et al., 2015). Unlike the case with the selection of old suppliers who had been collaborating with the company. Business capability data, track records and other performances are already in the company's database, making it easier to choose and

evaluate suppliers who will become partners with the company. Table 1.1 shows a comparison of the selection of new suppliers and old suppliers.[15]

Table 1.1 Comparison of Selection of Old Suppliers with New Suppliers

| Item | Old Supplier | New Supplier |
|---|---|---|
| Supplier track record | Is known | Unknown |
| Management Capability | Is known | Unknown |
| Price | Is known | Unknown |
| Delivery Performance | Is known | Unknown |
| Environmental Awareness | Is known | Unknown |
| Service | Is known | Unknown |
| Flexibility | Is known | Unknown |
| Technical Ability | Is known | Unknown |
| Innovative | Is known | Unknown |
| Management Approach | Is known | Unknown |
| Geographical location | Is known | Unknown |

Supplier selection is classified as a semi-structured problem, where some of these problems are sufficiently structured to be solved by computers (calculation of criteria, calculation of efficiency, etc.) and some require a decision from the manager (selection of evaluation methods, selection of criteria, inputting values).[16]. The process of selecting suppliers with various criteria can be completed by a computer system that is able to interact with decision-makers. The system is a decision support system (DSS) for supplier selection [17].

Based on research that has been done, no one has implemented a Decision Support System on web-based online media called Online DSS.

DSS Online is a Decision Support System which is an application of computer software programs using web-based internet media. Users access certain pages on the site on the internet then enter their company data to be analyzed by the company using the online application. Evaluation results are immediately updated interactively using the web media. Table 1.2 illustrates the comparison of Conventional DSS and Online DSS.

Table 1.2. Comparison of Conventional DSS with DSS Online

| Item | Conventional DSS | Online DSS |
|---|---|---|
| Speed of decision making | The results are only known after the data recapitulation by the company | Instantly the results are known after the data is filled out completely by the supplier |
| The accuracy of decision making | Depending on the supplier that fills in supporting data and recapitulation of data contained by the company in the Decision Support System | It depends on the accuracy of the data that is filled in by the supplier only |
| Working hours of decision making activities | Active according to company working hours | Active for 24 hours non-stop |

Based on the description above, then in this paper a new method is designed to select new suppliers online based on web that aims to improve the performance of decision making that already exists.

## II. LITERATURE REVIEW

Several papers on supplier selection using a decision support system have been written by researchers, but no one has written about a decision support system for choosing an online supplier, even though online supplier selection is indispensable in Industry 4.0.

Among these papers explain the following matters : The selection of suppliers involves very complicated multi-criteria [14] therefore it is necessary to first record all data contained in a supplier database in accordance with the requirements required by the company. The supplier database according to Krusiak in 2013 wrote that supplier selection was based on 1) customer performance quality rating 2) delivery performance quality rating, 3) total lead time 4) last sales price 5) engineering/design service support. [18]

The supplier database is used to compile a decision support system that has been used by the business world for many years in relation to making strategic corporate decisions which in this paper will be applied in choosing the right supplier. The decision support system is "filled" with an artificial intelligence algorithm to increase the sophistication of the system itself. Artificial intelligence is a study of problem-solving [19].

Currently being developed by the author is a web-based online supplier selection model that can be accessed 24 hours a day in order to welcome the industrial era 4.0.

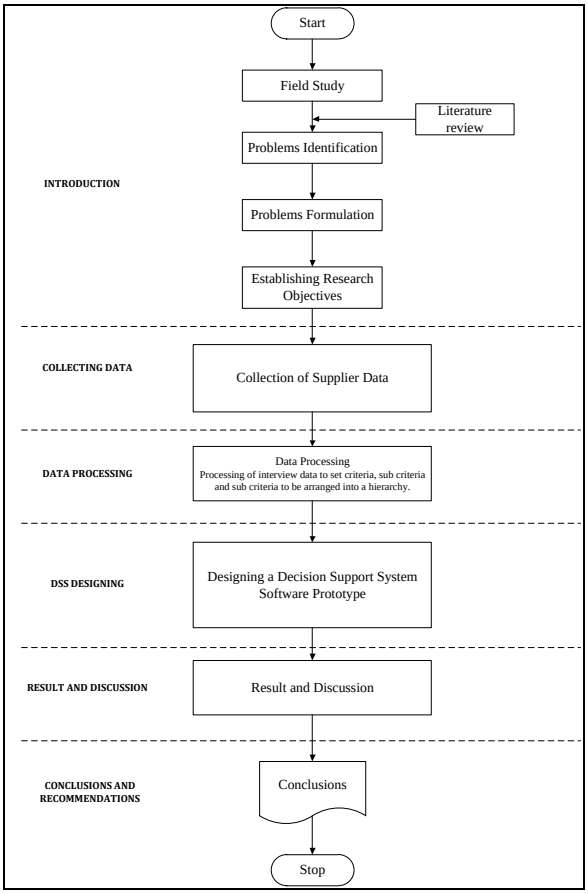



Figure 3.1. Research methods

# III. METHODS

## A. Time and place

The time of writing this paper was held in December 2018 until August 2019 which is located in the Mechanical Engineering Study Program, Faculty of Engineering, Universitas Brawijaya and the Computing and Information Systems Laboratory of the Department of Information Technology, State Polytechnic, Jember.

## B. Materials and Tools

The tools used in this research are:

1. Web Server Apache
2. Lenovo Thinkpad L440 laptop
3. EPSON L-210 printer, HP Deskjet 2130
4. External hard drive: 1TB, 500GB, 250GB
5. 100 MBps internet connection

## C. Research Methods

Figure 3.1 below is a flow chart of the stages of the research conducted :

The following is an explanation of Figure 3.1 starting from the preliminary stages, data collection, system design, and drawing conclusions made by the author in conducting this research are as follows:

**The Preliminary Stage**

The preliminary stages carried out in this research are field studies, literature studies, problem identification, problem formulation, and determination of research objectives. The following is an explanation of each activity in the preliminary stage:

Field Study

Field studies conducted in this research are observation activities, to identify and reveal the facts that exist in more depth. In this research, a field study was conducted by observing the supplier selection decision-making system

Literature review

A literature study aims to find information to support the research conducted. Literature study used to support this research comes from journals, textbooks, research reports, the internet, and other literature relating to supplier selection and also the FAHP method.

Identification of problems

To know and understand the problem, the initial step that must be done is to identify

variables that affect the supplier selection system in the company

Formulation of the problem

After identification of the problem then the problem formulation is then carried out. In the formulation of the problem, researchers must formulate what problems will be examined so that it can simplify the research process.

Determination of Research Objectives

Goal setting is intended so that researchers can focus on the problem to be studied, so that research can be done systematically and not deviate from the problem to be studied. In addition, the purpose of the research is intended to measure the success of the research conducted by researchers.

**Data Collection Stage**

Data collection is the recording of things / information / characteristics of some or all elements of the population that support and support research. Data collected in this study are as follows:

Supplier data

Data collection is done through observation, interviews, and documentation to meet all the data

needed to solve problems that arise. Data collection methods used are as follows:

Interview

That is a method used in obtaining data by asking questions directly when the company conducts an activity.

Observation

That is a method of obtaining data by making direct observations of the actual situation in the company.

Questionnaire

Namely a method of giving questions to other people who made respondents be answered by distributing questionnaires or questionnaires

Archive / documentation

Namely by studying company documents in the form of project activity reports.

**Data Processing Stage**

After collecting the data, the next step is data processing. The data from the results of interviews and discussions relating to any supplier selection criteria to establish criteria, sub-criteria, and sub-criteria then do the preparation of the hierarchy.

**Prototype Design of Software Decision Support System (DSS) Supplier Selection**

This stage is the design of components of the DSS using the prototyping method. Details of these components will be explained in the following:

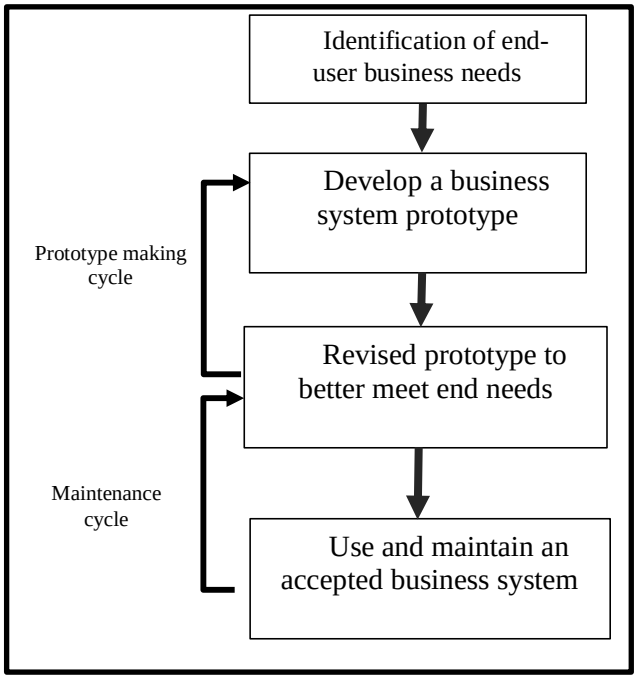



Figure 3.2 Figure Prototyping Cycle

System Requirements Analysis

The development of information systems requires investigation and analysis of the reasons for ideas or ideas to build and develop information systems. The analysis was carried out to see the various components used by the current system including hardware, software, networks, and human resources.

The analysis also documents the activities of the information system including input, processing, output, storage, and control.

Next, conduct a feasibility study to formulate information needed by the end-user, resource requirements, costs, benefits and feasibility of the proposed project.

System requirements analysis as part of the initial study aims to identify the problems and specific needs of the system. System-specific requirements are specifications of the things the system will do when implemented

System requirements analysis must define specific system requirements including:

System input required (input)

Output generated (output)

Operations performed (process)

Data source handled

Control (control)

The system requirements analysis phase requires an evaluation to find out the system's ability by defining what the system should be able to do then determining the criteria that the system must meet. Some criteria that must be met are the achievement of objectives, speed, cost, quality of information produced, efficiency and productivity, accuracy and validity and reliability or reliability.

System Design

System analysis (system analysis) describes what the system must do to meet user information needs. The system design (system design) determines how the system meets these objectives. The system design consists of design activities that produce functional specifications. System design can be seen as interface, data and process design with the aim of producing specifications that match the product and user interface method, database structure and processing and control procedures. The system design will produce a prototype software package, a good product should include seven parts:

Quick and easy menu features.

Easy-to-print report.

A data dictionary that stores information in each field including the length of the field, editing in each report and the format of the field used.

Database with the optimal format and key record.

Displays online query precisely to data stored in databases.

A simple structure with a programming language that allows users to do special processing, time events, automated procedures, and others.

System Testing

The prototype software package is tested, implemented, evaluated and modified repeatedly until it is acceptable to the user. System testing aims to find errors that occur in the system and make system revisions. This stage is important to ensure that the system is error-free

According to Sommerville (2001) system testing consists of:

Unit testing to test individual components independently without other system components to guarantee the correct operating system. Module testing consisting of interconnected components. Testing sub-system consisting of several modules that have been integrated. Testing the system to find errors resulting from interactions between subsystems with their interfaces and validating functional and non-functional requirements. Acceptance testing with data entered by the user and not simulation data test.

Documentation in the form of recording of each step of the work from the beginning to the end of making the program.

Testing web-based information systems can use traditional software testing techniques and methods. Web application testing includes link testing, browser testing, usability testing, load, voltage and malar testing

One measurement model that has been translated into several different languages and does not show significant differences in measurement results is End User Computing (EUC) Satisfaction. This model emphasizes user satisfaction with technological aspects including aspects of content, accuracy, format, time and ease of use of the system

Implementation

After the prototype is received, at this stage it is the implementation of a system that is ready to operate and the learning process of the new system then occurs and compares it with the old system, technical and operational evaluation as well as user interaction, systems, and information technology.

**Result and Discussion**

Conduct a discussion of the results of making an application, then an analysis of applications that have been completed.

**Conclusion and Suggestion**

Conclusions and suggestions are the final steps of the research process. Conclusions can be used as a basis for answering the objectives of the study. While suggestions are input for the object under study.

## IV. DISCUSSION

In this part of the discussion, problem analysis is explained, problem identification, explaining the concept of problem solution explaining the method used in solving the dissertation problem. With the explanation of this framework, it is expected to clarify the position of the research to be conducted

In the supplier selection system as written by Kusiak, determined by the criteria (Kusiak, 2000):

1) Management ability
2) Price
3) Environmental awareness
4) Shipping performance
5) Service
6) Flexibility
7) Technical ability
8) Innovative
9) Management approach
10) Geographical location

This criterion is an indicator of supplier selection, based on that criterion is assessed to obtain supplier scores.

### A. Problem analysis

A company in the manufacturing industry has a material supplier in the purchasing department. Suppliers of these materials are numerous and vary in quality, as well as in their track records. For suppliers who have been old suppliers, it is very easy to find out the supplier's track record using the database in the existing Management Information System, while for suppliers who have never been suppliers of raw materials to the company, then do not have a supplier's track record in the Management Information System database.

The Management Company has the desire to be able to evaluate the entire quality of these suppliers to maintain regularity in the supply of raw materials in production so that the production flow runs smoothly. The problem that must be resolved is how to select

suppliers who have capabilities according to the standards set by the company.

**B. New Supplier Selection Concept**

Industry 4.0 is the 4th generation in the development of Industrial technology. The first industrial revolution began with the discovery of the principle of steam power by Heron of Alexandria in 100 AD, which was later refined by James Watt, in 1769 whose technology is still in use today. In 1866, Werner von Siemens transferred the principle of a steam engine to an electric generator. This breakthrough made energy transportable and paved the way for the types of machines that run on electric motors during the second industrial revolution.

The second industrial revolution, marked by perfecting the production process. In 1870 in Cincinnati inspired Henry Ford, Jr. introduced the principle of producing assembly lines into the world of cars - which were then still made by hand. The first Ford was launched from the assembly line in 1913 and this new form of organization finally took effect throughout the world. It was during this period that an assembly line was found in mass production.

The third Industrial Revolution, the field of computer use and robotics automation. The first flip-flop circuit in 1958 laid the foundation for a big electronic leap forward. Only three years later, the first numerical control device appeared on the market. In 1973 Kuka Robotics launched the first robot with six axes, a step that helped move forward automation in Germany and around the world. The third industrial revolution is marked by the development use of the computer world and robotics automation.

When entering Industry 4.0, there is a fundamental problem if the era of digitalization is carried out specifically in relation to the selection of suppliers from other countries that enter Indonesia, bearing in mind that technical data that are not yet available besides that the cultures of other countries are different from the Indonesian people. Most of the new suppliers that enter Indonesia, certainly do not have a track record recorded in the company database, for that it is not easy to choose suppliers that fit the company criteria.

The selection of suppliers, can not be separated from the initial data availability. For new suppliers who have never been suppliers to companies, registration is required via the web. In the initial stages, the company disseminates information about announcements being suppliers. In the second stage, the company receives the registration requirements document, while the supplier registers online by sending data via email. In the third stage, the company accepts registration and provides a link address for the supplier criteria filling the form. In the fourth stage, the company checks the completeness of the supporting data, and store data in the database. In the fifth stage, the data stored in the database is processed by the Decision Support System to obtain a proper supplier order.

Decision Support System that is built, is a measuring tool used to select new suppliers based on technical criteria and cultural criteria. This system works by entering score data based on technical criteria. The score data is managed using the Fuzzy AHP method to rank suppliers. In brief, this concept is illustrated in Figure 4.1 below.

# V. CONCLUSION

The selection of new suppliers in the manufacturing industry is a complex problem because it involves multiple criteria, therefore the DSS needs to be made that is able to complete supplier selection well.

Although the selection of suppliers in the manufacturing industry is not new, in the era of Industry 4.0, DSS used to choose an absolute supplier based online that must be accessible via the web or android. Therefore the writer's idea in this paper is very relevant to be implemented in the manufacturing industry in all fields in the industrial era 4.0

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# COVER LETTER

Title of the manuscript

## PRELIMINARY STUDY OF WEB BASED DECISION SUPPORT SYSTEM TO SELECT MANUFACTURING INDUSTRY SUPPLIERS IN INDUSTRY 4.0 ERA IN INDONESIA

Abstract

Industry 4.0 is an integration between automation and manufacturing industry which requires the use of information technology to implement it. In the operational management framework, there is a supply chain management function that is strongly influenced by quality suppliers. Because choosing a quality new supplier is not an easy thing, we need a reliable application tool and utilizing web-based artificial intelligence technology for the selection of new suppliers in the manufacturing industry. The selection of suppliers is a complex problem because it involves multiple criteria, therefore it is necessary to make a decision support system that is able to complete supplier selection properly. Although the selection of suppliers in the manufacturing industry is not new, in the era of Industry 4.0, a decision support system that is used to choose an absolute supplier based online that must be accessible via the web or mobile app. Therefore the writer's idea in this paper is very relevant to be implemented in the manufacturing industry in all fields in the industrial era 4.0.

Keywords

Industry 4.0, supply chain management, decision support system

**Type of manuscript (please specify):**

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# Performance Improvement Operations Management Industry Uses Supplier Selection Online

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## Abstract

Operational management is the management of a business to the fullest use of all factors of production that is both labor (SDM), machinery, equipment, raw materials and other production factors in the process of transformation to become a wide variety of products or services. What can be done by the management of the operation is to carry out all the functions of the management process: planning (planning), organizing (organizing), the establishment of staff, leadership and control.

Supply chain management is a system in which business process is used to set a mature plan obtained from raw materials to finished goods produced until the final consumer. In a series of supply chain management, the role of the good supplier.

Supplier is one part of the supply chain is very important and affect the viability of a production process. Improper supplier selection may disrupt the operational activities of the company, while the selection of the right supplier will minimize the cost of purchasing, improve the competitiveness of the market and end-user satisfaction.

In the era of information and technology as it is today, with the AEC, suppliers not only from one country, existing suppliers may consist of suppliers from foreign countries. To improve the performance and efficiency of supplier selection in order to obtain a quality supplier with low cost and efficient process necessary suppliers Elections online. In this paper put forward the basic idea of performance improvement operations management by selecting suppliers online. The method used to create an online supplier selection is prototyping. The result is a framework concept online supplier selection methods.

**Keyword:** Operational Management, Supply Chain Management, Supplier, Supplier Selection Online

**Background of study**

Within the framework of the supply chain, including the activities of selecting suppliers of complex problems in multi-criteria decision making due to factors involved have different interests. To select a good supplier is not only based on a consideration of the issue price of cheap, but many other criteria that must be involved. (Yu and Tsai, 2008)

On the other hand, selecting new suppliers in particular have a higher degree of difficulty because the data has not been saved partner's track record in the company's database. To select a new supplier is not allowed to use assumptions as the basis for the selection of new suppliers. All must be based on empirical data that owned by the client itself.

To solve the problems of the new supplier selection put forward the basic idea of choosing a new supplier uses a web-based online media.

## Literature Review

In a previous study written, supply chain management system is a business process that is used to set a mature plan obtained from raw materials to finished goods produced by the final consumer. (Koster and Delfmann, 2005). Within the framework Supply chain management is related to the selection of the right supplier. (Blecker and Hamburg International Conference of Logistics, 2014) Selection of appropriate suppliers will affect operations and production management as it affects the availability of raw materials (Dima and Grabara, 2013). Selection of suppliers is a strategic decision in the supply chain that improve competitive advantage. (Cooper et al., 1997). Therefore, it is necessary to use a device supplier selection decision support system. (Scott et al., 2015a) Selection of suppliers involves a combination of variables (multi-criteria) complex when used for decision making. (Scott et al., 2015b) Therefore, all the data needed to be managed into useful information for decision-making through a database system (Talarico and Maya Duque, 2015)

Across the studies that have been written are not currently applied online through the Internet media to choose suppliers. Therefore, this study aims to create a prototype decision support system supplier selection is accessible online.

## Methodology

The design phase is a decisive stage of implementation can be done well. To implement the prototype used prototyping method as shown in Figure 1.

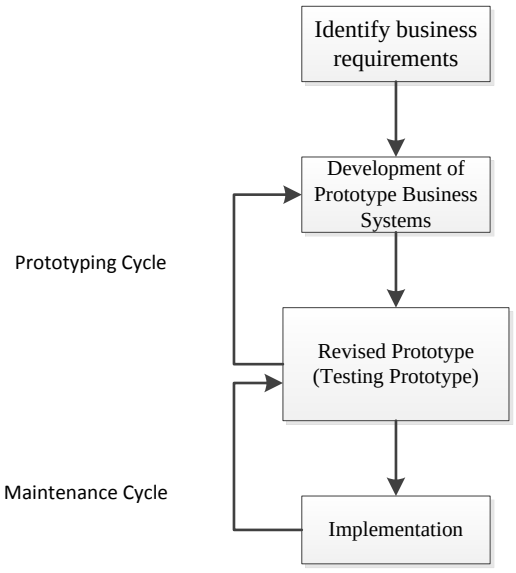


**Figure 1.** Prototyping Methods

A. **Identify business requirements**

Building information systems began with identifying the needs of the information related to the company's business needs. This identification to analyze all the components used in the system include hardware, software, network including brain ware. At this stage also noted the activities of input, process and control the storage out.

Furthermore, conduct a feasibility study (feasibility study) to formulate the required information the end user, resource requirements, costs, benefits and feasibility of the proposed project. Analysis of system requirements as part of the initial study aims to identify the problems and specific needs of the system. The specific needs of the system are the specification of the things that will be done when the system is implemented.

Needs analysis phase requires evaluation system to determine the ability of the system to define what should be done by the system then determines the criteria to be met system. Several criteria must be met are achieving goals, speed, cost, quality of information produced, efficiency and productivity, accuracy and validity and reliability or reliability.

**B. Development of Prototype Business Systems**

Prototype development begins with a series of System Design. This activity, determines how the system will meet these objectives. The system design consists of design activities that produce functional specifications. Comprised of interface design, data and processes with the aim of producing specifications for the product and the user interface method, the database structure as well as the processing and control procedures.

The system design will generate prototype software package, a good product should include seven parts:

1) The menu features quick and easy.

2) The display input and output.

3) The report is printed.

4) The data dictionary that stores information on every field, including the length field, editing in any format reports and field use.

5) Database with key formats and record optimal.

6) Displays the online query appropriately to the data store

7) The structure of a simple programming language that allows users to perform special processing, time of occurrence, automated procedures and others.

**C. Revised Prototype (Prototype Testing)**

Prototyping software packages tested, implemented, evaluated and modified repeatedly until acceptable wearer. Testing the system aims to find mistakes that occur in the system and revise the system. This stage is important to ensure that the system is free of errors. (Pressman, 2005)

Testing of web-based information systems can use the techniques and methods of traditional software testing. Web application testing includes testing the links, browser testing, usability testing, load testing. One model measurements that have been translated into several different languages and did not show significant differences in measurement results is the End User Computing (EUC) Satisfaction. This model emphasizes user satisfaction towards the technological aspects include aspects of the content, accuracy, format, timing and ease of use of the system.

**D. Implementation**

Once the prototype is accepted, then at this stage is the implementation of the system are ready for operation and further the learning process of the new system and compare it with the old system, technical and operational evaluation and user interactions, systems and information technology. (Mc Leod, Jr. and P. Schell , nd)

## Results and discussion

Selection of new suppliers cannot be separated from the availability of preliminary data. A new supplier who has never been a supplier for the company registration is required through the web. At the initial stage, the company disseminates information on the announcement of a supplier. The second stage of the company receiving the document while the registration requirements of the supplier to register online by sending data via email. The third stage of the company received the registration and provide the link address for the form filling criteria for suppliers. The fourth stage companies to check the completeness of data capacity, and of saving the data in the database. The fifth stage, the data stored in the database is processed by the system Pedukung Decision in order to obtain proper sequence selected supplier.

**Conclusion**.

Based on the description above, it can be concluded that the difficulty of Choosing a new supplier in the era of AEC, can be Overcome using online decision making tools. In making the design tools decision making is done using a prototyping method. There are Several stages for prototyping the method, namely: identification of business needs, the development of a business system prototype, the prototype revision in order to meet the final requirement, implementation.

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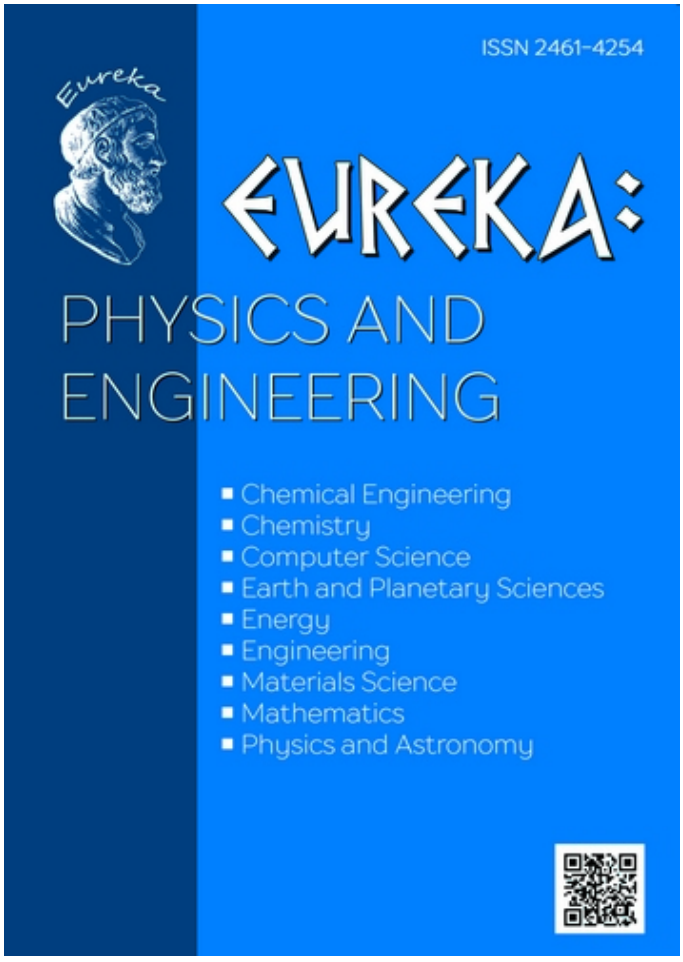


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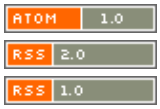

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# from journal «EUREKA: Physics and Engineering» _№1.2022_Denny Trias Utomo (please acknowledge receipt of the letter)

2 messages

**Journal Eureka** <jr@scijr.info> 13 June 2021 at 14:33
To: "S.SI" <denny_trias@polije.ac.id>

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The article was accepted for consideration of the possibility of publication in the journal **«EUREKA: Physics and Engineering»** for №1. 2022 (release until 30.01.2022).

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To: Journal Eureka <jr@scijr.info>

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Denny Trias Utomo, S.Si, M.Eng
NIP. 197110092003121001
Penata Tk-1 / Lektor

Lecturer of Dept. Information Technology
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**Masuma Mammadova**
Editor-in-Chief
**EUREKA: Physics and Engineering**

*[20 June 2021]*

**Dear Dr Mammadova**,
Please find enclosed our manuscript entitled "*IMPLEMENTATION OF A FUZZY DECISION SUPPORT SYSTEM FOR SELECTION OF HAND TRACTOR ASSEMBLY SUPPLIERS*", which we would like to submit for publication as an paper in **EUREKA: Physics and Engineering**.
*[Insert a sentence on the broad topic of the study and its importance. Then, insert 1–2 sentences explaining what is known on your subject and the relevant knowledge gap you are filling. In the final sentence, explain the objectives of the study and its novel aspect]*

*A supplier is a company or individual that provides the raw materials needed by the company and its competitors to produce certain goods In this study, a decision support system for supplier selection at the company has been developed using the AHP fuzzy method. The results of this study are expected to help companies in selecting suppliers that match the predetermined criteria. In building a decision support system that provides supplier recommendations, the authors apply the AHP fuzzy method in the process.*

*[Insert about 3 sentences briefly describing the methods of the study and the main findings]*

*The application of the AHP fuzzy method to the system and manual calculations gives the same ranking results. With the Supplier Selection Decision Support System Using the AHP Fuzzy Method, it can help companies in selecting suppliers. Based on the research that has been done, suggestions can be made for a Decision Support System for Supplier Selection Using the Fuzzy AHP Method so that in the future it can facilitate the use of a more dynamic system.*

*[State the implications or potential applications of the findings. Explain who will be interested in the findings and why they should care about them. Explain how this is appropriate for the readership of the journal]*

*Supplier selection is a complex problem in the current Industry 4.0 era. The large number of suppliers with different performance qualities makes it difficult for the company's internal parties to choose the appropriate supplier. On the other hand, the kinds of raw materials needed to make finished products are very diverse. The suitability of quality suppliers needed to supply raw materials needed by the industry is an important matter to be resolved. Likewise with the hand tractor assembly industry, this small and medium industry is also very dependent on the availability of supply materials, and of course it also depends on the selection of the supplier itself.*
*This paper describes the selection of suppliers in the manufacturing industry with a case study on the assembly of a small hand tractor industry. This dissertation research begins with literature study activities through FGDs, and literature studies, then followed by making an application prototype design.*

We confirm that this manuscript has not been published elsewhere and is not under consideration by another journal. All authors have approved the manuscript and agree with submission to **EUREKA: Physics and Engineering**.

The study was supported by a grant from the *[insert funding body here]*. [CAN BE DELETED IF NOT RELEVANT]

The authors have no conflicts of interest to declare. [OR DESCRIBE DETAILSE OF CONFLICTS OF INTEREST FOR EACH AUTHOR]

We would like to recommend the following researchers as potential reviewers for this paper:

1. *Syed Taueef Mohyud-Din, HITEC University, Pakistan*
   *[Reviewer 1 name plus contact information]*
2. *Volodymyr Mosorov, Institute of Applied Computer Science Lodz University of Technology, Poland*
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3. *Anna Brzozowska, Institute of Logistics and International Management Czestochowa University of Technology, Poland*
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We ask that the following researchers are excluded as reviewers because of potential conflict of interest:

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Please address all correspondence to:
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*Telp. +62-331-333531*
*Mobile +62 81336608000*
*Email : denny_trias@polije.ac.id*

We look forward to hearing from you at your earliest convenience.

Yours sincerely,

*Denny Trias Utomo, S.Si, MT*

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Denny Trias Utomo,
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Number : 74/VIII/ICOMERA2020/LoA
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First Author : Denny Trias Utomo
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Affiliation : Department of Information Technology, Politeknik Negeri Jember, Jalan Mastrip no. 165, Jember, Indonesia
Co-authors : Mukhamad Angga Gumilang, Purnomo Budi Santoso
Paper Title : Database Design Using Product Structure, Bill of Material and Group Technology for Supplier Decision Support Systems (Case Study: Hand Tractor Manufacturing)
Paper ID : iCOMERA-Paper 074

Dear Denny Trias Utomo
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# Database design with product structure, Bill of Material and group technology for supplier decision support systems (*Case study: hand tractor manufacturing*)

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# Database design with product structure, Bill of Material and Group Technology for supplier decision support systems (*Case study: hand tractor manufacturing*)

**Denny Trias Utomo[1*], Mukhamad Angga Gumilang[1], Purnomo Budi Santoso[2]**
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Abstract.Supplier selection is a common problem for manufacturing industries because there are so many supplier options. The decision support system is one solution that can help industries in which one is the best supplier with specific criteria. In the case of manufacturing industries, to give decisions supports system input data, we need to identify the bill of materials. Furthermore, group technology also can be used to optimize the bill of materials. In this paper, we present the database design process from the bill of materials combined with group technology in tractor manufacturing industries. Product structure diagram, bill of materials table, database design diagram are created as results. From this result, we can develop a decision support system with some computing algorithmsfor the next study.

Keywords: Supplierselection, database design, product structure,bill of material, group technology, decision support systems.

## 1.Introduction

Industrial Revolution 4.0, inventory management is demanded to be more global because Industry 4.0 is an integration of the economy with information technology, it will create a process of flow of goods, services, investment, and capital, from one area to another with very high competitive rates. Thus, it requires a truly competitive local product policy that is valuable and highly competitive to be able to compete with similar products from other countries [1]. About industrial inventory management in the Industrial 4.0 era, the most influential factors were suppliers.

In industry 4.0 selecting suppliers who can fulfill raw material orders that are in line with company industry standards in the long term is necessary. These activities are categorized as strategic activities because the role of suppliers will also be instrumental in determining the success of the company. If the raw material provided by the supplier is of poor quality, then this will also affect the quality of the product produced, so that productivity decreases [2] [3][4] [5] [6] [7] [8]. The accuracy of supplier selection greatly affects the cost-efficiency [2] [5]. The right supply of raw materials guarantees a good quality product. With a good supply of raw materials, increasing process efficiency so that the company's operating costs can be reduced. And affect the increase in

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marketing, which results in increasing company profits. If the supplier cannot provide the raw materials according to the company's requirements, then it is certain that the production schedule will be disrupted [9].

The selection of new suppliers who have never been partners with the company, is a more complex problem, because data is not yet available, and supplier performance is unknown. To choose a new supplier, you cannot use assumptions but must be based on empirical data that can be accounted for, because it greatly affects production performance [10]. Unlike the case with the selection of old suppliers who have been collaborating with the company. Data on business capability, track record, and other performance already exists in the company's database, making it easier to select and evaluate suppliers who will become partners with the company.

Supplier selection is classified as a semi-structured problem, where some of these problems are sufficiently structured to be solved by computers (calculation of criteria, calculation of efficiency, etc.) and some require a decision from the manager (selection of evaluation methods, selection of criteria, inputting values) [11] The process of selecting suppliers with various criteria can be completed by a computer system that can interact with decision-makers. The system is a decision support system (DSS) for supplier selection [12].

Online-Decision Support System which is an application of computer software programs using web-based internet media. Users access certain pages on the site on the internet then enter their company data to be analyzed by the company using the online application. Evaluation results are immediately updated interactively using the web media.

Decision Support System also hasa requirement, such as a database and an algorithm to fulfill supplier selection task. In this research, we try to make a database design in the case of tractor manufacturing industries. Before we make a database design, we implement a product structure and a group of technology.

## 2. Methods and Materials

Supplier selection is a complex issue in the current Industrial 4.0 era. A large number of suppliers with varying quality of performance makes it difficult for the internal company to choose the right supplier to supply raw materials. On the other hand, various kinds of raw materials needed to make finished products, are very diverse. The suitability of the quality suppliers needed to supply the raw materials needed by the industry is important to be resolved. Likewise, with the hand tractor assembly industry, this small and medium industry is also very dependent on the availability of supply materials, and certainly also depends on the selection of the supplier itself.

In this research case study supplier data 153, raw material data 70 raw materials with variable supplier selection criteria as many as 10 variables.The location of this research is in the Center for the Flat Metal Industry Klaten Solo, namely in the Flat Manufacturing Polytechnic. While the implementation of his research in the Computational and Information Systems Lab and Jember State Polytechnic Information Systems Engineering Laboratory. Methods for designing a database for Decisions Support System (DSS) in the case of tractors manufacturing are four steps: (1) Product Structure, (2) Bill of Materials, (3) Group Technology, and (4) Database diagrams. These steps are described in Figure 1.

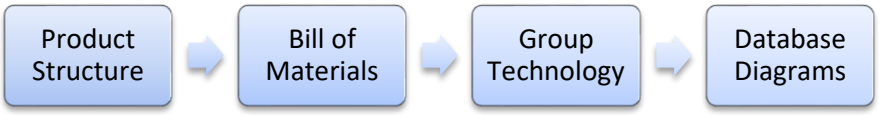


**Figure 1** Steps for Designing Database Diagrams

## 3. Result and Discussions

### *3.1 Product Structure*

In the initial stage of this database design series drawings of hand tractors obtained in the field. Technical drawings of hand tractors can be seenin Figure 2.Product Structure Pictures are shown in Figure 3, where the images show the product structure consisting of 3 levels. In the picture also explained how to get each spare part, some are obtained by purchasing, and some are obtained by making their own., the structure of the hand tractor product is made. To compile a database of raw materials the structure of this product was compiled from technical

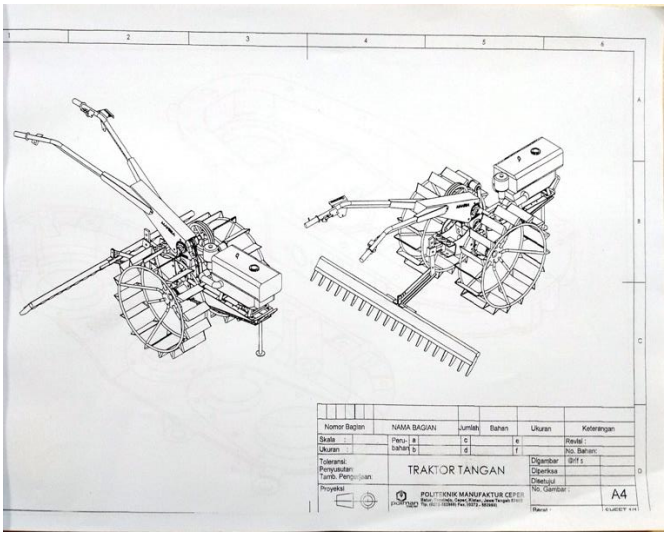


**Figure 2** Technical Drawings of Hand Tractor

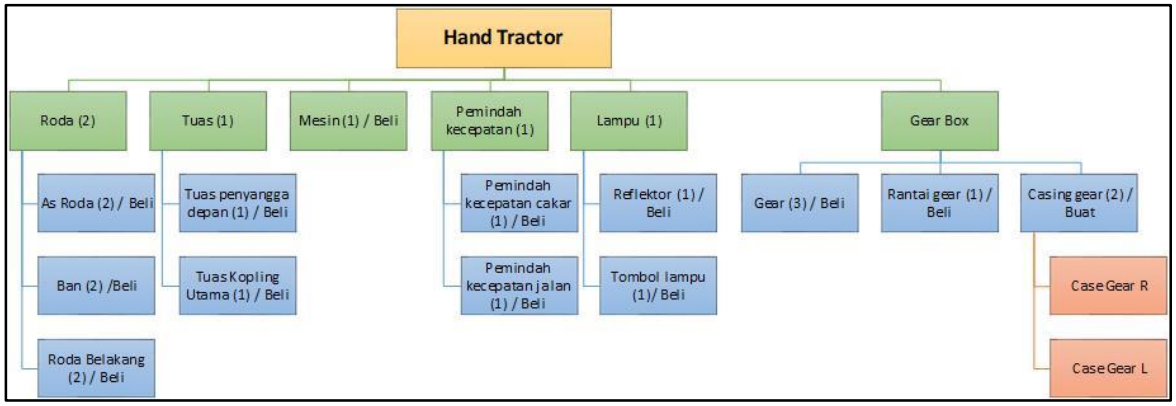


**Figure 3** Product Structure of Hand Tractor

### 3.2 *Bill of Materials (BOM)*

Bill of material or product structure (sometimes called BOM or product structure list) is a list of raw materials, sub-assemblies, intermediate assemblies, sub-components, parts, and the amount of each needed to produce the final product. BOM can be used for communication between manufacturing partners or limited to a single factory. Bills of material are often associated with production orders whose issuance can produce orders for components in the bill of materials that are in stock and demand for components that are not in stock ("Bill of Materials," 2020).

Based on the Product Structure that was created in the previous step, a Bill of Material table is prepared as shown in Table 1 below.

**Table 1.** Bill of Materials

| Code | Description | Qty | Metrics | Order | Materials | Process |
|---|---|---|---|---|---|---|
| 1000 | Wheel | 2 | pcs | Purchase | | |
| 1100 | Axle | 1 | pcs | Purchase | | |
| 1200 | Tire | 2 | pcs | Purchase | rubber | printed out |
| 1300 | Rear Tire | 2 | pcs | Purchase | | |
| 2000 | Lever | 1 | pcs | Purchase | | |
| 2100 | Buffer lever | 1 | pcs | Purchase | | |
| 2200 | Main Clutch Lever | 1 | pcs | Purchase | | |
| 3000 | Machine | 1 | pcs | Purchase | | |
| 4000 | Speed shifting | 1 | pcs | Purchase | | |
| 4100 | Claw speed shifter | 1 | pcs | Purchase | | |
| 4200 | Road speed mover | 1 | pcs | Purchase | | |
| 5000 | Lamp | 1 | pcs | Purchase | | |
| 5100 | Light switch | 1 | pcs | Purchase | | |
| 5200 | Reflector | 1 | pcs | Purchase | | |
| 6000 | Gear Box | 1 | pcs | Develop | | |
| 6100 | Gear Chain | 1 | pcs | Purchase | iron | printed out |
| 6200 | Gear casing | 1 | pcs | Purchase | steel | printed out |
| 6300 | Gear | 3 | pcs | Purchase | iron | printed out |

Based on the Bill of Materials, most of the spare parts are obtained by way of scanning, while the ones making themselves are gearbox components. The gearbox is manufactured by UKM in Ceper Klaten Solo, Central Java.

*3.3 Group of Technology (GT)*

Group technology or GT is a production technique where parts that have similarities in geometry, manufacturing processes, and/or functions are produced in one location using a small number of machines or processes. Group technology is based on the general principle that many problems are the same and by grouping the same problems, one solution can be found for a set of problems, thus saving time and effort. ("Technology Group," 2019).

Technology Group or GT at this stage is needed to compile the Code Part Number that will be used in the compilation of the database. This Code Part Number is a grouping of spare parts according to their function. The code consists of 4 digits, the 1st digit shows the Spare Parts, 1 means the Wheel parts, 2 means the Lever parts etc. The 2nd digit shows the Parts Subdivision, 11 means Axle, 12 means Tires, etc. Digits 3 and 4 show the Parts Sub Variant.

3. 4 *Database Diagrams*

The final step of making this database design is to make a database diagram that will be implemented in the Information System. Database diagrams arranged based on BoM and GT are shown in Figure 4 Database Diagrams.

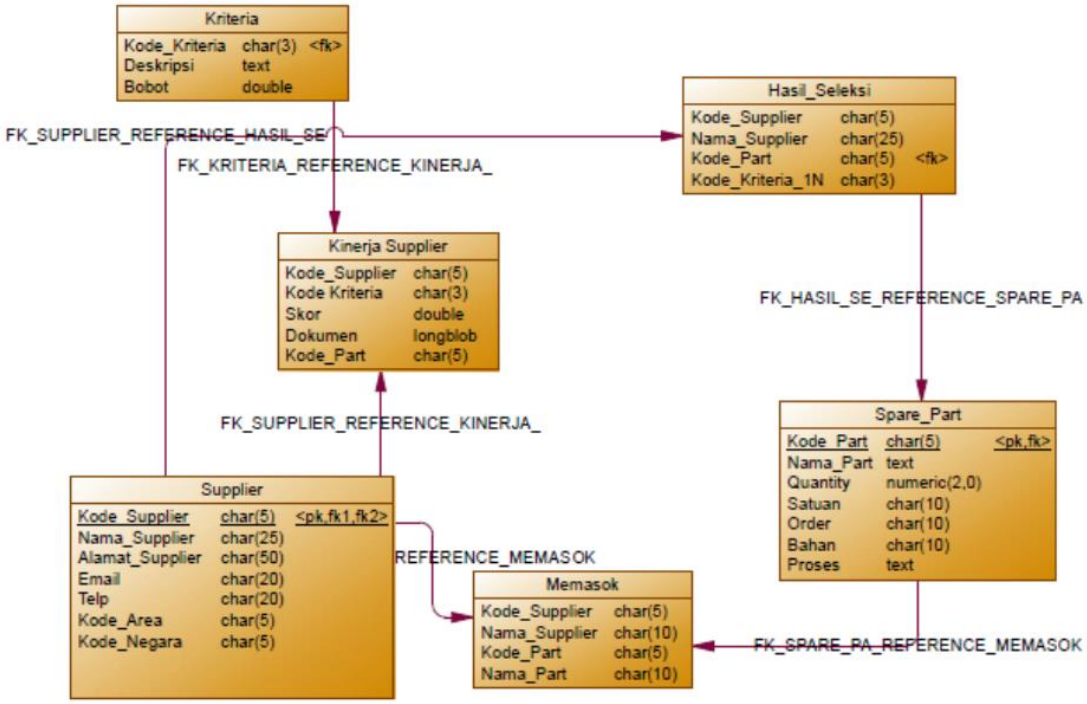


**Figure 4.** Database Diagram

The Database Diagram illustrates that 6 main database tables are used to process Supplier Management Information Systems. Namely Supplier Tables, Supplier Performance Tables, Criteria Tables, Supplying Tables, Spart Part Tables, Selection Results Tables. Each table forms relations between tables as described in Figure 4. In the database diagram also illustrates the existence of data items/fields columns that are used to manage information in the database management system.

## 4.Conclusion and Future Works

This paper presents an alternative solution to solving problems in a long series of activities selecting suppliers of manufacturing industries by compiling a database design using the Bill of Materials and Group Technology.After compiling this scientific publication, further research should be conducted to create a database design using manufactured products other than hand tractors. Besides, further research is needed to compile a more detailed knowledge base and product structure database.

## 5.Acknowledgment

Prof. Dr. Ir Pratikto, MMT Lecturer in the Department of Mechanical Engineering, Faculty of Engineering, Universitas Brawijaya. Sugiono, ST, MT, Ph.D.Lecturer in the Department of Industrial Engineering, Faculty of Engineering, Universitas Brawijaya. Hendra Yufit Riskiawan, ST. M.Sc Head of the Information Technology Department, Jember State of Polytechnic**.**

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# #114 Summary

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| Authors | Denny Trias Utomo, Mukhamad Angga Gumilang, Purnomo Budi Santoso |
| Title | Database Design Using Product Structure, Bill of Material and Group Technology for Supplier Decision Support Systems (Case Study: Hand Tractor Manufacturing) |
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| Date submitted | July 30, 2020 - 01:02 PM |
| Track | Industrial Engineering |
| Director | None assigned |
| Author comments | Dear ICOMERA 2020 Committee In the following, we send our paper to take part in the international seminar ICOMERA 2020. We hope that our paper will fit the scope and be accepted as a paper at the seminar. Thank you for all your attention |

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Abstract

Supplier selection is a common problem for manufacturing industries because there are so many supplier options. The decision support system is one solution that can help industries in which one is the best supplier with specific criteria. In the case of manufacturing industries, to give decisions supports system input data, we need to identify the bill of materials. Furthermore, group technology also can be used to optimize the bill of materials. In this paper, we present the database design process from the bill of materials combined with group technology in tractor manufacturing industries. Product structure diagram, bill of materials table, database design diagram are created as results. From this result, we can develop a decision support system with some computing algorithms for the next study.

**Indexing**

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Keywords: Supplier selection, database design, product structure, bill of material, group technology, decision support systems

Type, method or approach: Group Technology; Bill of Material

Language: en

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Dear Mr Denny Trias Utomo,

We are pleased to inform you that your paper titled "Database Design Using Product Structure, Bill of Material and Group Technology for Supplier Decision Support Systems (Case Study: Hand Tractor Manufacturing)" is accepted with revision to be presented and published in The 2nd International Conference on Mechanical Engineering Research and Application (iCOMERA) 2020. The review result, Turnitin check result for the paper and other guidelines can be found in the attachment.

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Research Article

Computer and Information Science

# PRELIMINARY STUDY OF WEB BASED DECISION SUPPORT SYSTEM TO SELECT MANUFACTURING INDUSTRY SUPPLIERS IN INDUSTRY 4.0 ERA IN INDONESIA

**Denny Trias Utomo[ab]*, Pratikto[b], Parnomo Budi Santoso[c], Sugiono[c]**
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**Abstract**

Industry 4.0 is an integration between automation and manufacturing industry which requires the use of information technology to implement it. In the operational management framework, there is a supply chain management function that is strongly influenced by quality suppliers. Because choosing a quality new supplier is not an easy thing, we need a reliable application tool and utilizing web-based artificial intelligence technology for the selection of suppliers in the manufacturing industry. The selection of new suppliers is a complex problem because it involves multiple criteria, therefore it is necessary to make a decision support system that is able to complete supplier selection properly. Although the selection of suppliers in the manufacturing industry is not new, in the era of Industry 4.0, a decision support system that is used to choose an absolute supplier based online that must be accessible via the web or mobile application. Therefore the writer's idea in this paper is very relevant to be implemented in the manufacturing industry in all fields in the industrial era 4.0.

**Keywords:** Industry 4.0, supply chain management, decision support system

**摘要**

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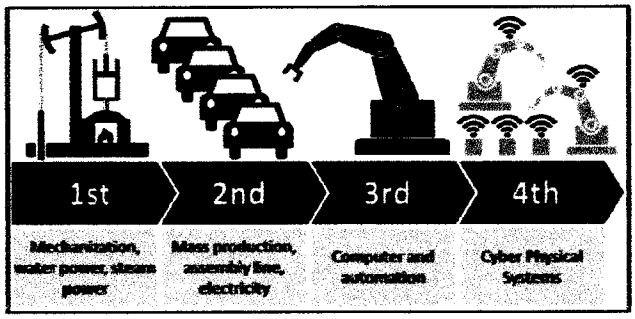
# I. INTRODUCTION

In Industry 4.0 industry players integrate computer networks and communicate with each other through internet networks which, finally, with certain intelligence methods embedded in applications in the form of intelligent knowledge bases, can finally make decisions without human involvement. The combination of physical-cyber systems, the Internet of




Gambar 1 : Timeline Revolusi Industri
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Things (IoT), and the Internet of Systems makes Industry 4.0 possible and makes smart factories a reality. ("What Is Hannover Messe Fair and How Does It Play a Role in the U.S.?" 2016)

In Indonesia, the development of Industry 4.0 was strongly encouraged by the Ministry of Industry. Industry Minister Airlangga Hartarto said that for Indonesia to compete with other countries in the industry, Indonesia must also follow the trend. [2]

Transformation of the Industrial Revolution 4.0 in the manufacturing industry logistics, starting with the integration of production and logistics processes with the appropriate information technology system. This includes exchanging product and production data within the company as well as with customers and suppliers. According to the Cambridge dictionary, the definition of a supplier is a company, person, etc. providing things that people want or need, especially during the production process over a long period of time [3]

Suppliers in Industry 4.0, in particular, will benefit from the exchange of design and supply chain data. Communication throughout the production process will be (close to) realtime among humans, machines, parts and products. The system that is currently owned will develop into a hierarchical and tiered network with an open and standard interface. Data will be stored in the cloud to increase availability accurately. This will allow more flexibility when reacting to changes (both expected and unexpected) in the production process [4]

In the 4.0 industrial revolution, inventory management is demanded to be more global because Industry 4.0 is an integration of the economy with information technology, it will create a process of flow of goods, services, investment, and capital, entering from one region to another with a very high competitive level. Thus, it requires a policy of truly competitive local products that are valuable and highly competitive in order to be able to compete with similar products from other countries. (Anindhitya, n.d.) In relation to inventory management, the industrial world in the Industrial 4.0 era, the most influential things were suppliers.

Still related to the industrial revolution 4.0, choosing suppliers who can fulfill raw material orders that are in line with company industry standards in the long term is absolutely necessary. These activities are categorized as strategic activities, because the role of suppliers will also be instrumental in determining the success of the company. If the raw material provided by the supplier is of poor quality, this will also affect the quality of the product produced, so productivity decreases [5]–[12]. The accuracy of supplier selection greatly affects the cost-efficiency [5], [9]. The right supply of raw materials guarantees a good quality product. With a good supply of raw materials, resulting in an increase in process efficiency so that the company's operating costs can be reduced. And affect the increase in marketing, which results in increasing company profits. If the supplier cannot provide the raw materials according to the company's requirements, then it is certain that the production schedule will be disrupted. [13]

Supplier selection, in general, is a multi-criteria issue where each criterion used has different interests and information about it is not precisely known. In this case, the selection of suppliers based on low price offers is no longer efficient. To get maximum supply chain performance, it must combine other criteria that are relevant to the company's objectives.[14]

The selection of new suppliers who have never been partners with companies, is a more complex problem, because data is not yet available, and supplier performance is unknown. To choose a new supplier, you cannot use assumptions but must be based on empirical data that can be accounted for, because it greatly affects production performance. (Pujawan et al., 2015). Unlike the case with the selection of old suppliers who had been collaborating with the company. Business capability data, track records and other performances are already in the company's database, making it easier to choose and

evaluate suppliers who will become partners with the company. Table 1.1 shows a comparison of the selection of new suppliers and old suppliers.[15]

Table 1.1 Comparison of Selection of Old Suppliers with New Suppliers

| Item | Old Supplier | New Supplier |
|---|---|---|
| Supplier track record | Is known | Unknown |
| Management Capability | Is known | Unknown |
| Price | Is known | Unknown |
| Delivery Performance | Is known | Unknown |
| Environmental Awareness | Is known | Unknown |
| Service | Is known | Unknown |
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| Geographical location | Is known | Unknown |

Supplier selection is classified as a semi-structured problem, where some of these problems are sufficiently structured to be solved by computers (calculation of criteria, calculation of efficiency, etc.) and some require a decision from the manager (selection of evaluation methods, selection of criteria, inputting values).[16]. The process of selecting suppliers with various criteria can be completed by a computer system that is able to interact with decision-makers. The system is a decision support system (DSS) for supplier selection [17].

Based on research that has been done, no one has implemented a Decision Support System on web-based online media called Online DSS.

DSS Online is a Decision Support System which is an application of computer software programs using web-based internet media. Users access certain pages on the site on the internet then enter their company data to be analyzed by the company using the online application. Evaluation results are immediately updated interactively using the web media. Table 1.2 illustrates the comparison of Conventional DSS and Online DSS.

Table 1.2. Comparison of Conventional DSS with DSS Online

| Item | Conventional DSS | Online DSS |
|---|---|---|
| Speed of decision making | The results are only known after the data recapitulation by the company | Instantly the results are known after the data is filled out completely by the supplier |
| The accuracy of decision making | Depending on the supplier that fills in supporting data and recapitulation of data contained by the company in the Decision Support System | It depends on the accuracy of the data that is filled in by the supplier only |
| Working hours of decision making activities | Active according to company working hours | Active for 24 hours non-stop |

Based on the description above, then in this paper a new method is designed to select new suppliers online based on web that aims to improve the performance of decision making that already exists.

## II. LITERATURE REVIEW

Several papers on supplier selection using a decision support system have been written by researchers, but no one has written about a decision support system for choosing an online supplier, even though online supplier selection is indispensable in Industry 4.0.

Among these papers explain the following matters : The selection of suppliers involves very complicated multi-criteria [14] therefore it is necessary to first record all data contained in a supplier database in accordance with the requirements required by the company. The supplier database according to Krusiak in 2013 wrote that supplier selection was based on 1) customer performance quality rating 2) delivery performance quality rating, 3) total lead time 4) last sales price 5) engineering/design service support. [18]

The supplier database is used to compile a decision support system that has been used by the business world for many years in relation to making strategic corporate decisions which in this paper will be applied in choosing the right supplier. The decision support system is "filled" with an artificial intelligence algorithm to increase the sophistication of the system itself. Artificial intelligence is a study of problem-solving [19].

Currently being developed by the author is a web-based online supplier selection model that can be accessed 24 hours a day in order to welcome the industrial era 4.0.

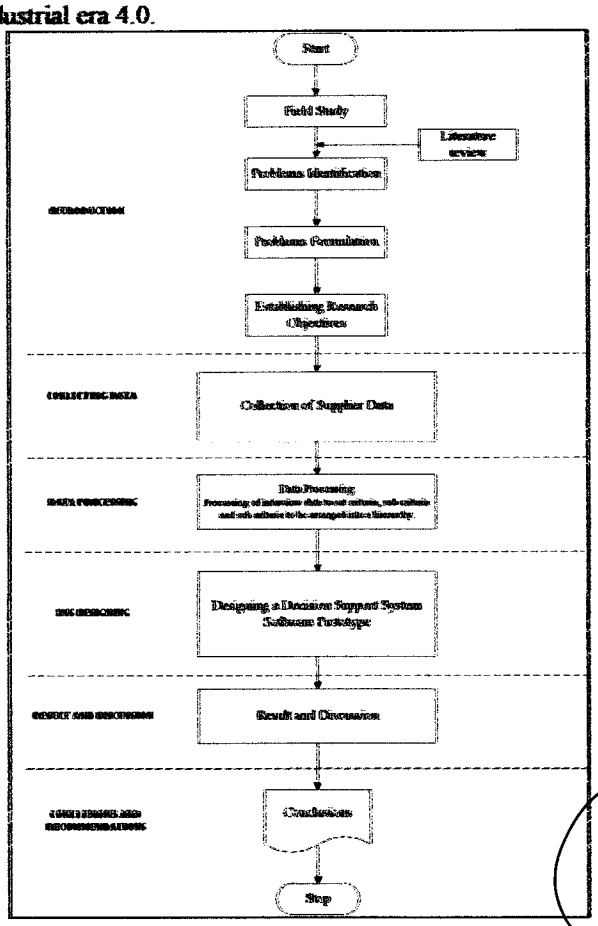


Figure 3.1. Research methods

## III. METHODS

### A. Time and place

The time of writing this paper was held in December 2018 until August 2019 which is located in the Mechanical Engineering Study Program, Faculty of Engineering, Universitas Brawijaya and the Computing and Information Systems Laboratory of the Department of Information Technology, State Polytechnic, Jember.

### B. Materials and Tools

The tools used in this research are:

1. Web Server Apache
2. Lenovo Thinkpad L440 laptop
3. EPSON L-210 printer, HP Deskjet 2130
4. External hard drive: 1TB, 500GB, 250GB
5. 100 MBps internet connection

### C. Research Methods

Figure 3.1 below is a flow chart of the stages of the research conducted :

The following is an explanation of Figure 3.1 starting from the preliminary stages, data collection, system design, and drawing conclusions made by the author in conducting this research are as follows:

**The Preliminary Stage**

The preliminary stages carried out in this research are field studies, literature studies, problem identification, problem formulation, and determination of research objectives. The following is an explanation of each activity in the preliminary stage:

Field Study

Field studies conducted in this research are observation activities, to identify and reveal the facts that exist in more depth. In this research, a field study was conducted by observing the supplier selection decision-making system

Literature review

A literature study aims to find information to support the research conducted. Literature study used to support this research comes from journals, textbooks, research reports, the internet, and other literature relating to supplier selection and also the EAHP method.

Identification of problems

To know and understand the problem, the initial step that must be done is to identify

variables that affect the supplier selection system in the company

Formulation of the problem

After identification of the problem then the problem formulation is then carried out. In the formulation of the problem, researchers must formulate what problems will be examined so that it can simplify the research process.

Determination of Research Objectives

Goal setting is intended so that researchers can focus on the problem to be studied, so that research can be done systematically and not deviate from the problem to be studied. In addition, the purpose of the research is intended to measure the success of the research conducted by researchers.

**Data Collection Stage**

Data collection is the recording of things / information / characteristics of some or all elements of the population that support and support research. Data collected in this study are as follows:

Supplier data

Data collection is done through observation, interviews, and documentation to meet all the data

needed to solve problems that arise. Data collection methods used are as follows:

Interview

That is a method used in obtaining data by asking questions directly when the company conducts an activity.

Observation

That is a method of obtaining data by making direct observations of the actual situation in the company.

Questionnaire

Namely a method of giving questions to other people who made respondents be answered by distributing questionnaires or questionnaires

Archive / documentation

Namely by studying company documents in the form of project activity reports.

**Data Processing Stage**

After collecting the data, the next step is data processing. The data from the results of interviews and discussions relating to any supplier selection criteria to establish criteria, sub-criteria, and sub-criteria then do the preparation of the hierarchy.

**Prototype Design of Software Decision Support System (DSS) Supplier Selection**

This stage is the design of components of the DSS using the prototyping method. Details of these components will be explained in the following:

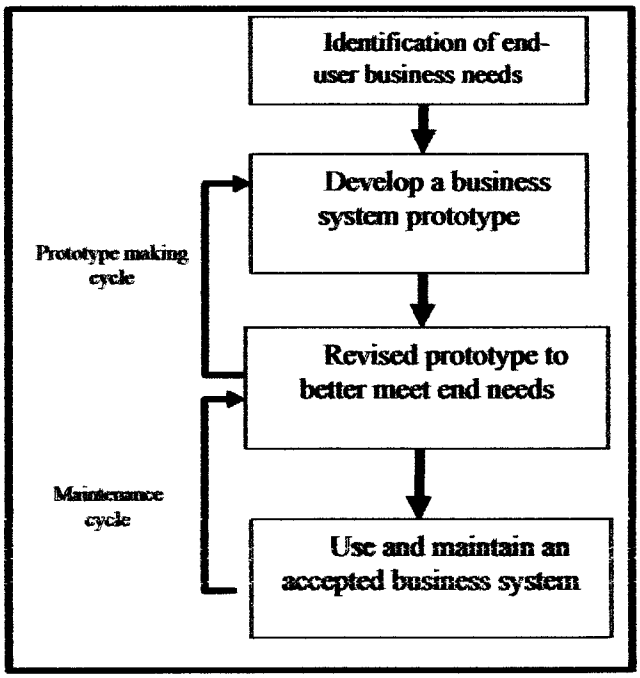


Figure 3.2 Figure Prototyping Cycle

System Requirements Analysis

The development of information systems requires investigation and analysis of the reasons for ideas or ideas to build and develop information systems. The analysis was carried out to see the various components used by the current system including hardware, software, networks, and human resources.

The analysis also documents the activities of the information system including input, processing, output, storage, and control.

Next, conduct a feasibility study to formulate information needed by the end-user, resource requirements, costs, benefits and feasibility of the proposed project.

System requirements analysis as part of the initial study aims to identify the problems and specific needs of the system. System-specific requirements are specifications of the things the system will do when implemented

System requirements analysis must define specific system requirements including:

System input required (input)

Output generated (output)

Operations performed (process)

Data source handled

Control (control)

The system requirements analysis phase requires an evaluation to find out the system's ability by defining what the system should be able to do then determining the criteria that the system must meet. Some criteria that must be met are the achievement of objectives, speed, cost, quality of information produced, efficiency and productivity, accuracy and validity and reliability or reliability.

System Design

System analysis (system analysis) describes what the system must do to meet user information needs. The system design (system design) determines how the system meets these objectives. The system design consists of design activities that produce functional specifications. System design can be seen as interface, data and process design with the aim of producing specifications that match the product and user interface method, database structure and processing and control procedures. The system design will produce a prototype software package, a good product should include seven parts:

Quick and easy menu features.

Easy-to-print report.

A data dictionary that stores information in each field including the length of the field, editing in each report and the format of the field used.

Database with the optimal format and key record.

Displays online query precisely to data stored in databases.

A simple structure with a programming language that allows users to do special processing, time events, automated procedures, and others.

System Testing

The prototype software package is tested, implemented, evaluated and modified repeatedly until it is acceptable to the user. System testing aims to find errors that occur in the system and make system revisions. This stage is important to ensure that the system is error-free

According to Sommerville (2001) system testing consists of:

Unit testing to test individual components independently without other system components to guarantee the correct operating system. Module testing consisting of interconnected components. Testing sub-system consisting of several modules that have been integrated. Testing the system to find errors resulting from interactions between subsystems with their interfaces and validating functional and non-functional requirements. Acceptance testing with data entered by the user and not simulation data test.

Documentation in the form of recording of each step of the work from the beginning to the end of making the program.

Testing web-based information systems can use traditional software testing techniques and methods. Web application testing includes link testing, browser testing, usability testing, load, voltage and malar testing

One measurement model that has been translated into several different languages and does not show significant differences in measurement results is End User Computing (EUC) Satisfaction. This model emphasizes user satisfaction with technological aspects including aspects of content, accuracy, format, time and ease of use of the system

Implementation

After the prototype is received, at this stage it is the implementation of a system that is ready to operate and the learning process of the new system then occurs and compares it with the old system, technical and operational evaluation as well as user interaction, systems, and information technology.

**Result and Discussion**

Conduct a discussion of the results of making an application, then an analysis of applications that have been completed.

**Conclusion and Suggestion**

Conclusions and suggestions are the final steps of the research process. Conclusions can be used as a basis for answering the objectives of the study. While suggestions are input for the object under study.

## IV. DISCUSSION

In this part of the discussion, problem analysis is explained, problem identification, explaining the concept of problem solution explaining the method used in solving the dissertation problem. With the explanation of this framework, it is expected to clarify the position of the research to be conducted

In the supplier selection system as written by Kusiak, determined by the criteria (Kusiak, 2000):

1) Management ability
2) Price
3) Environmental awareness
4) Shipping performance
5) Service
6) Flexibility
7) Technical ability
8) Innovative
9) Management approach
10) Geographical location

This criterion is an indicator of supplier selection, based on that criterion is assessed to obtain supplier scores.

### A. Problem analysis

A company in the manufacturing industry has a material supplier in the purchasing department. Suppliers of these materials are numerous and vary in quality, as well as in their track records. For suppliers who have been old suppliers, it is very easy to find out the supplier's track record using the database in the existing Management Information System, while for suppliers who have never been suppliers of raw materials to the company, then do not have a supplier's track record in the Management Information System database.

The Management Company has the desire to be able to evaluate the entire quality of these suppliers to maintain regularity in the supply of raw materials in production so that the production flow runs smoothly. The problem that must be resolved is how to select

suppliers who have capabilities according to the standards set by the company.

**B. New Supplier Selection Concept**

Industry 4.0 is the 4th generation in the development of Industrial technology. The first industrial revolution began with the discovery of the principle of steam power by Heron of Alexandria in 100 AD, which was later refined by James Watt, in 1769 whose technology is still in use today. In 1866, Werner von Siemens transferred the principle of a steam engine to an electric generator. This breakthrough made energy transportable and paved the way for the types of machines that run on electric motors during the second industrial revolution.

The second industrial revolution, marked by perfecting the production process. In 1870 in Cincinnati inspired Henry Ford, Jr. introduced the principle of producing assembly lines into the world of cars - which were then still made by hand. The first Ford was launched from the assembly line in 1913 and this new form of organization finally took effect throughout the world. It was during this period that an assembly line was found in mass production.

The third Industrial Revolution, the field of computer use and robotics automation. The first flip-flop circuit in 1958 laid the foundation for a big electronic leap forward. Only three years later, the first numerical control device appeared on the market. In 1973 Kuka Robotics launched the first robot with six axes, a step that helped move forward automation in Germany and around the world. The third industrial revolution is marked by the development use of the computer world and robotics automation.

When entering Industry 4.0, there is a fundamental problem if the era of digitalization is carried out specifically in relation to the selection of suppliers from other countries that enter Indonesia, bearing in mind that technical data that are not yet available besides that the cultures of other countries are different from the Indonesian people. Most of the new suppliers that enter Indonesia, certainly do not have a track record recorded in the company database, for that it is not easy to choose suppliers that fit the company criteria.

The selection of suppliers, can not be separated from the initial data availability. For new suppliers who have never been suppliers to companies, registration is required via the web. In the initial stages, the company disseminates information about announcements being suppliers. In the second stage, the company receives the registration requirements document, while the supplier registers online by sending data via email. In the third stage, the company accepts registration and provides a link address for the supplier criteria filling the form. In the fourth stage, the company checks the completeness of the supporting data, and store data in the database. In the fifth stage, the data stored in the database is processed by the Decision Support System to obtain a proper supplier order.

Decision Support System that is built, is a measuring tool used to select new suppliers based on technical criteria and cultural criteria. This system works by entering score data based on technical criteria. The score data is managed using the Fuzzy AHP method to rank suppliers. In brief, this concept is illustrated in Figure 4.1 below.

## V. CONCLUSION

The selection of new suppliers in the manufacturing industry is a complex problem because it involves multiple criteria, therefore the DSS needs to be made that is able to complete supplier selection well.

Although the selection of suppliers in the manufacturing industry is not new, in the era of Industry 4.0, DSS used to choose an absolute supplier based online that must be accessible via the web or android. Therefore the writer's idea in this paper is very relevant to be implemented in the manufacturing industry in all fields in the industrial era 4.0

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## PRELIMINARY STUDY OF WEB BASED DECISION SUPPORT SYSTEM TO SELECT MANUFACTURING INDUSTRY SUPPLIERS IN INDUSTRY 4.0 ERA IN INDONESIA

Abstract

Industry 4.0 is an integration between automation and manufacturing industry which requires the use of information technology to implement it. In the operational management framework, there is a supply chain management function that is strongly influenced by quality suppliers. Because choosing a quality new supplier is not an easy thing, we need a reliable application tool and utilizing web-based artificial intelligence technology for the selection of new suppliers in the manufacturing industry. The selection of suppliers is a complex problem because it involves multiple criteria, therefore it is necessary to make a decision support system that is able to complete supplier selection properly. Although the selection of suppliers in the manufacturing industry is not new, in the era of Industry 4.0, a decision support system that is used to choose an absolute supplier based online that must be accessible via the web or mobile app. Therefore the writer's idea in this paper is very relevant to be implemented in the manufacturing industry in all fields in the industrial era 4.0.

Keywords

Industry 4.0, supply chain management, decision support system

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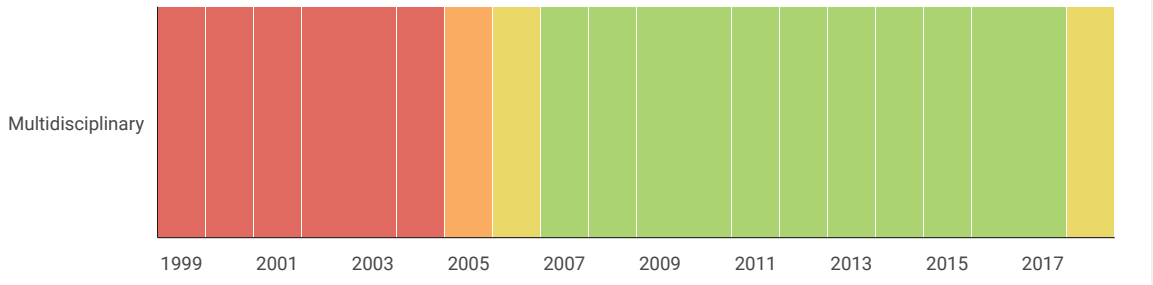


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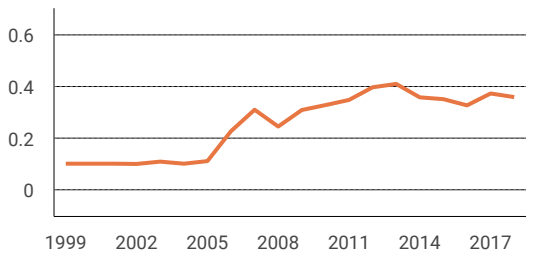


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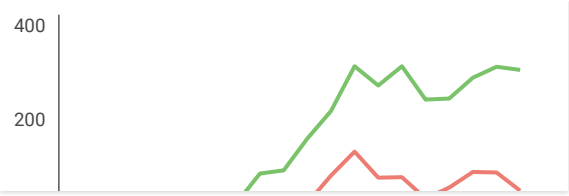


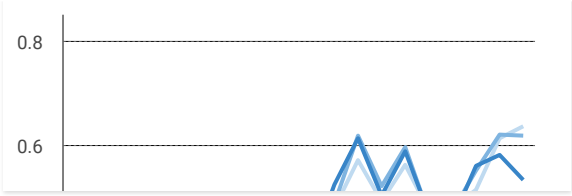


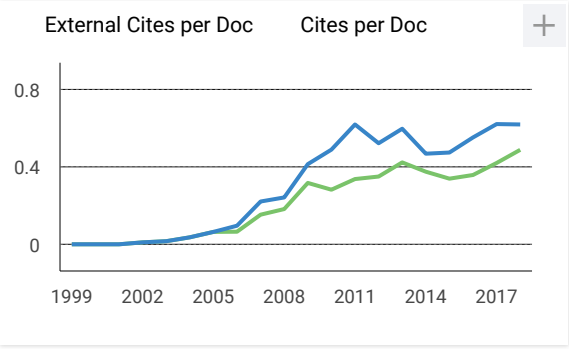


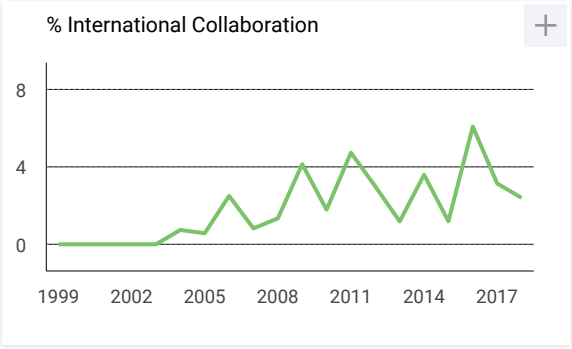


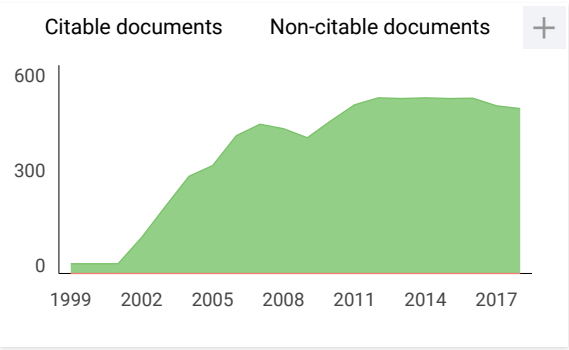


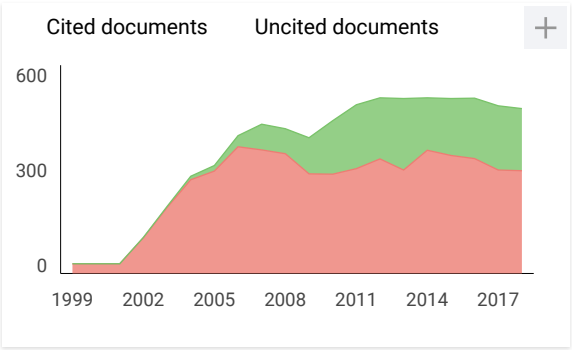

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Kepada: Mr Denny Trias Utomo <denny_trias@polije.ac.id>

Mr Denny Trias Utomo

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Thank you,
Editor-in-Chief

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# Invoice Payment of Journal Vol 55 (2) 2020

3 pesan

**DENNY TRIAS UTOMO, S.SI** <denny_trias@polije.ac.id> 25 Februari 2020 09.40
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Dear editor
In the following, we send a journal payment transfer letter for Vol 55 (2) 2020.
Payment will be received within 3 days from today

We thank you for all the cooperation and support

Best regards
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Denny Trias Utomo, S.Si, M.Eng
NIP. 197110092003121001
Penata Tk-1 / Lektor

Lecturer of Dept. Information Technology
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Dear Sir
We got the payment. The article is being prepared for publication.
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Lecturer of Dept. Information Technology
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Title should be brief and informative, specific and amenable to indexing. The title should contain less than 15 words, each starting with a capital letter, and be centered, typeset the title in bold, Times New Roman (TNR) 16pt, single line spacing.

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Keywords: Not more than five keywords should be indicated separately; these should be chosen carefully and must not be phrases of several words. Typeset your keywords in TNR 10 pt, alignment: justify; line spacing: single. These keywords will be used for indexing.

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> Title of your paper: Preliminary Study of Web Based Decision Support System to Select Manufacturing Industry Suppliers in Industry 4.0 Era in Indonesia
> Corresponding Author's Email Address: denny_trias@polije.ac.id
> Author(s): Denny Trias Utomo, Pratikto, Purnomo Budi Santoso, Sugiyono
> Keywords: Industry 4.0, supply chain management, decision support system
> Abstract: Industry 4.0 is an integration between automation and manufacturing industry which requires the use of information technology to implement it. In the operational management framework, there is a supply chain management function that is strongly influenced by quality suppliers. Because choosing a quality new supplier is not an easy thing, we need a reliable application tool and utilizing web-based artificial intelligence technology for the selection of new suppliers in the manufacturing industry. The selection of new suppliers is a complex problem because it involves multiple criteria, therefore it is necessary to make a decision support system that is able to complete supplier selection properly. Although the selection of suppliers in the manufacturing industry is not new, in the era of Industry 4.0, a decision support system that is used to choose an absolute supplier based online that must be accessible via the web or android. Therefore the writer's idea in

> this paper is very relevant to be implemented in the manufacturing industry in all fields in the industrial era 4.0.

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**DENNY TRIAS UTOMO, S.SI** <denny_trias@polije.ac.id> 6 Februari 2020 17.30
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Dear Editor
Thank you for the response, we will continue to revise the paper manuscript as requested

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NIP. 197110092003121001
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> Title of your paper: Preliminary Study of Web Based Decision Support System to Select Manufacturing Industry Suppliers in Industry 4.0 Era in Indonesia
> Corresponding Author's Email Address: denny_trias@polije.ac.id
> Author(s): Denny Trias Utomo, Pratikto, Purnomo Budi Santoso, Sugiyono
> Keywords: Industry 4.0, supply chain management, decision support system
> Abstract: Industry 4.0 is an integration between automation and manufacturing industry which requires the use of information technology to implement it. In the operational management framework, there is a supply chain management function that is strongly influenced by quality suppliers. Because choosing a quality new supplier is not an easy thing, we need a reliable application tool and utilizing web-based artificial intelligence technology for the selection of new suppliers in the manufacturing industry. The selection of new suppliers is a complex problem because it involves multiple criteria, therefore it is necessary to make a decision support system that is able to complete supplier selection properly. Although the selection of suppliers in the manufacturing industry is not new, in the era of Industry 4.0, a decision support system that is used to choose an absolute supplier based online that must be accessible via the web or android. Therefore the writer's idea in this paper is very relevant to be implemented in the manufacturing industry in all fields in the industrial era 4.0.

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**DENNY TRIAS UTOMO, S.SI** <denny_trias@polije.ac.id> 6 Februari 2020 17.30
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Thank you for the response, we will continue to revise the paper manuscript as requested

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[Kutipan teks disembunyikan]

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Denny Trias Utomo, S.Si, M.Eng
NIP. 197110092003121001
Penata Tk-1 / Lektor

Lecturer of Dept. Information Technology
Jember State of Polytechnic - Indonesia

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Research Article

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# PRELIMINARY STUDY OF WEB BASED DECISION SUPPORT SYSTEM TO SELECT MANUFACTURING INDUSTRY SUPPLIERS IN INDUSTRY 4.0 ERA IN INDONESIA

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**Abstract**

Industry 4.0 is an integration between automation and manufacturing industry which requires the use of information technology to implement it. In the operational management framework, there is a supply chain management function that is strongly influenced by quality suppliers. Because choosing a quality new supplier is not an easy thing, we need a reliable application tool and utilizing web-based artificial intelligence technology for the selection of suppliers in the manufacturing industry. The selection of new suppliers is a complex problem because it involves multiple criteria, therefore it is necessary to make a decision support system that is able to complete supplier selection properly. Although the selection of suppliers in the manufacturing industry is not new, in the era of Industry 4.0, a decision support system that is used to choose an absolute supplier based online that must be accessible via the web or mobile application. Therefore the writer's idea in this paper is very relevant to be implemented in the manufacturing industry in all fields in the industrial era 4.0.

**Keywords:** Industry 4.0, supply chain management, decision support system

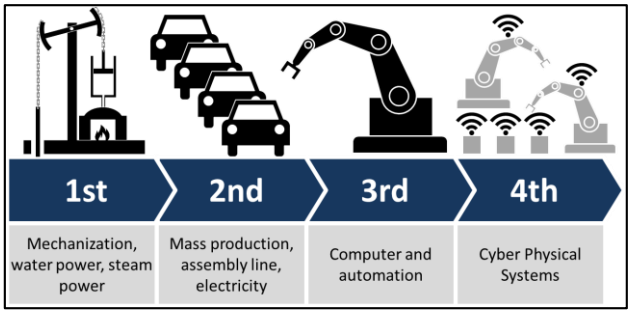
**摘要**

**关键词:**

参考文:

# I. INTRODUCTION

In Industry 4.0 industry players integrate computer networks and communicate with each other through internet networks which, finally, with certain intelligence methods embedded in applications in the form of intelligent knowledge bases, can finally make decisions without human involvement. The combination of physical-cyber systems, the Internet of Things (IoT), and the Internet of Systems makes Industry 4.0 possible and makes smart factories a reality. ("What Is Hannover Messe Fair and How Does It Play a Role in the U.S.?" 2016)




Gambar 1 : Timeline Revolusi Industri
Source : *("What Is Hannover Messe Fair and How Does It Play a Role in the U.S.?," 2016)*

In Indonesia, the development of Industry 4.0 was strongly encouraged by the Ministry of Industry. Industry Minister Airlangga Hartarto said that for Indonesia to compete with other countries in the industry, Indonesia must also follow the trend. [2]

Transformation of the Industrial Revolution 4.0 in the manufacturing industry logistics, starting with the integration of production and logistics processes with the appropriate information technology system. This includes exchanging product and production data within the company as well as with customers and suppliers. According to the Cambridge dictionary, the definition of a supplier is a company, person, etc. providing things that people want or need, especially during the production process over a long period of time [3]

Suppliers in Industry 4.0, in particular, will benefit from the exchange of design and supply chain data. Communication throughout the production process will be (close to) realtime among humans, machines, parts and products. The system that is currently owned will develop into a hierarchical and tiered network with an open and standard interface. Data will be stored in the cloud to increase availability accurately. This will allow more flexibility when reacting to changes (both expected and unexpected) in the production process [4]

In the 4.0 industrial revolution, inventory management is demanded to be more global because Industry 4.0 is an integration of the economy with information technology, it will create a process of flow of goods, services, investment, and capital, entering from one region to another with a very high competitive level. Thus, it requires a policy of truly competitive local products that are valuable and highly competitive in order to be able to compete with similar products from other countries. (Anindhitya, n.d.) In relation to inventory management, the industrial world in the Industrial 4.0 era, the most influential things were suppliers.

Still related to the industrial revolution 4.0, choosing suppliers who can fulfill raw material orders that are in line with company industry standards in the long term is absolutely necessary. These activities are categorized as strategic activities, because the role of suppliers will also be instrumental in determining the success of the company. If the raw material provided by the supplier is of poor quality, this will also affect the quality of the product produced, so productivity decreases [5]–[12]. The accuracy of supplier selection greatly affects the cost-efficiency [5], [9]. The right supply of raw materials guarantees a good quality product. With a good supply of raw materials, resulting in an increase in process efficiency so that the company's operating costs can be reduced. And affect the increase in marketing, which results in increasing company profits. If the supplier cannot provide the raw materials according to the company's requirements, then it is certain that the production schedule will be disrupted. [13]

Supplier selection, in general, is a multi-criteria issue where each criterion used has different interests and information about it is not precisely known. In this case, the selection of suppliers based on low price offers is no longer efficient. To get maximum supply chain performance, it must combine other criteria that are relevant to the company's objectives.[14]

The selection of new suppliers who have never been partners with companies, is a more complex problem, because data is not yet available, and supplier performance is unknown. To choose a new supplier, you cannot use assumptions but must be based on empirical data that can be accounted for, because it greatly affects production performance. (Pujawan et al., 2015). Unlike the case with the selection of old suppliers who had been collaborating with the company. Business capability data, track records and other performances are already in the company's database, making it easier to choose and

evaluate suppliers who will become partners with the company. Table 1.1 shows a comparison of the selection of new suppliers and old suppliers.[15]

Table 1.1 Comparison of Selection of Old Suppliers with New Suppliers

| Item | Old Supplier | New Supplier |
|---|---|---|
| Supplier track record | Is known | Unknown |
| Management Capability | Is known | Unknown |
| Price | Is known | Unknown |
| Delivery Performance | Is known | Unknown |
| Environmental Awareness | Is known | Unknown |
| Service | Is known | Unknown |
| Flexibility | Is known | Unknown |
| Technical Ability | Is known | Unknown |
| Innovative | Is known | Unknown |
| Management Approach | Is known | Unknown |
| Geographical location | Is known | Unknown |

Supplier selection is classified as a semi-structured problem, where some of these problems are sufficiently structured to be solved by computers (calculation of criteria, calculation of efficiency, etc.) and some require a decision from the manager (selection of evaluation methods, selection of criteria, inputting values).[16]. The process of selecting suppliers with various criteria can be completed by a computer system that is able to interact with decision-makers. The system is a decision support system (DSS) for supplier selection [17].

Based on research that has been done, no one has implemented a Decision Support System on web-based online media called Online DSS.

DSS Online is a Decision Support System which is an application of computer software programs using web-based internet media. Users access certain pages on the site on the internet then enter their company data to be analyzed by the company using the online application. Evaluation results are immediately updated interactively using the web media. Table 1.2 illustrates the comparison of Conventional DSS and Online DSS.

Table 1.2. Comparison of Conventional DSS with DSS Online

| Item | Conventional DSS | Online DSS |
|---|---|---|
| Speed of decision making | The results are only known after the data recapitulation by the company | Instantly the results are known after the data is filled out completely by the supplier |
| The accuracy of decision making | Depending on the supplier that fills in supporting data and recapitulation of data contained by the company in the Decision Support System | It depends on the accuracy of the data that is filled in by the supplier only |
| Working hours of decision making activities | Active according to company working hours | Active for 24 hours non-stop |

Based on the description above, then in this paper a new method is designed to select new suppliers online based on web that aims to improve the performance of decision making that already exists.

## II. LITERATURE REVIEW

Several papers on supplier selection using a decision support system have been written by researchers, but no one has written about a decision support system for choosing an online supplier, even though online supplier selection is indispensable in Industry 4.0.

Among these papers explain the following matters : The selection of suppliers involves very complicated multi-criteria [14] therefore it is necessary to first record all data contained in a supplier database in accordance with the requirements required by the company. The supplier database according to Krusiak in 2013 wrote that supplier selection was based on 1) customer performance quality rating 2) delivery performance quality rating, 3) total lead time 4) last sales price 5) engineering/design service support. [18]

The supplier database is used to compile a decision support system that has been used by the business world for many years in relation to making strategic corporate decisions which in this paper will be applied in choosing the right supplier. The decision support system is "filled" with an artificial intelligence algorithm to increase the sophistication of the system itself. Artificial intelligence is a study of problem-solving [19].

Currently being developed by the author is a web-based online supplier selection model that can be accessed 24 hours a day in order to welcome the industrial era 4.0.

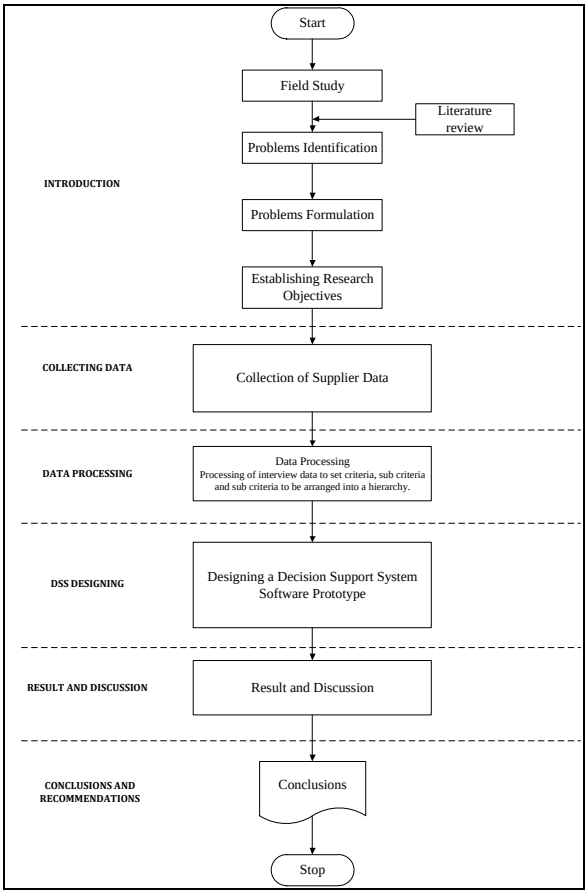



Figure 3.1. Research methods

# III. METHODS

## A. Time and place

The time of writing this paper was held in December 2018 until August 2019 which is located in the Mechanical Engineering Study Program, Faculty of Engineering, Universitas Brawijaya and the Computing and Information Systems Laboratory of the Department of Information Technology, State Polytechnic, Jember.

## B. Materials and Tools

The tools used in this research are:

1. Web Server Apache
2. Lenovo Thinkpad L440 laptop
3. EPSON L-210 printer, HP Deskjet 2130
4. External hard drive: 1TB, 500GB, 250GB
5. 100 MBps internet connection

## C. Research Methods

Figure 3.1 below is a flow chart of the stages of the research conducted :

The following is an explanation of Figure 3.1 starting from the preliminary stages, data collection, system design, and drawing conclusions made by the author in conducting this research are as follows:

**The Preliminary Stage**

The preliminary stages carried out in this research are field studies, literature studies, problem identification, problem formulation, and determination of research objectives. The following is an explanation of each activity in the preliminary stage:

Field Study

Field studies conducted in this research are observation activities, to identify and reveal the facts that exist in more depth. In this research, a field study was conducted by observing the supplier selection decision-making system

Literature review

A literature study aims to find information to support the research conducted. Literature study used to support this research comes from journals, textbooks, research reports, the internet, and other literature relating to supplier selection and also the FAHP method.

Identification of problems

To know and understand the problem, the initial step that must be done is to identify

variables that affect the supplier selection system in the company

Formulation of the problem

After identification of the problem then the problem formulation is then carried out. In the formulation of the problem, researchers must formulate what problems will be examined so that it can simplify the research process.

Determination of Research Objectives

Goal setting is intended so that researchers can focus on the problem to be studied, so that research can be done systematically and not deviate from the problem to be studied. In addition, the purpose of the research is intended to measure the success of the research conducted by researchers.

**Data Collection Stage**

Data collection is the recording of things / information / characteristics of some or all elements of the population that support and support research. Data collected in this study are as follows:

Supplier data

Data collection is done through observation, interviews, and documentation to meet all the data

needed to solve problems that arise. Data collection methods used are as follows:

Interview

That is a method used in obtaining data by asking questions directly when the company conducts an activity.

Observation

That is a method of obtaining data by making direct observations of the actual situation in the company.

Questionnaire

Namely a method of giving questions to other people who made respondents be answered by distributing questionnaires or questionnaires

Archive / documentation

Namely by studying company documents in the form of project activity reports.

**Data Processing Stage**

After collecting the data, the next step is data processing. The data from the results of interviews and discussions relating to any supplier selection criteria to establish criteria, sub-criteria, and sub-criteria then do the preparation of the hierarchy.

**Prototype Design of Software Decision Support System (DSS) Supplier Selection**

This stage is the design of components of the DSS using the prototyping method. Details of these components will be explained in the following:

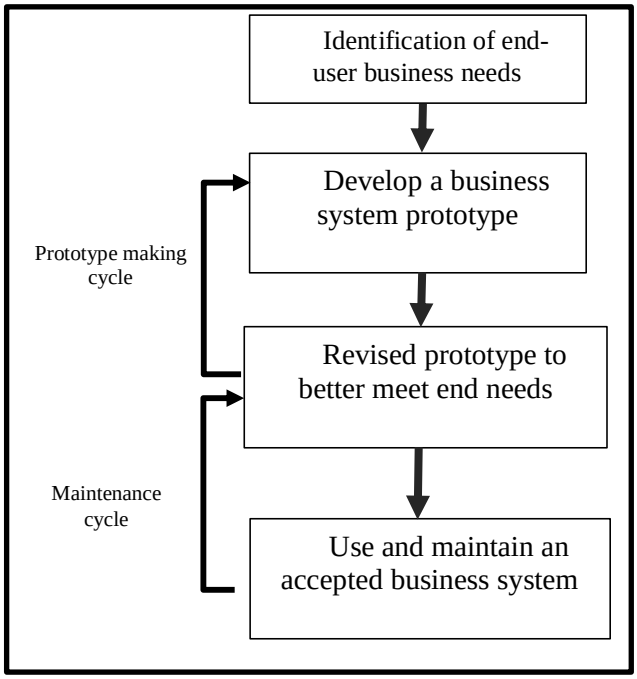



Figure 3.2 Figure Prototyping Cycle

System Requirements Analysis

The development of information systems requires investigation and analysis of the reasons for ideas or ideas to build and develop information systems. The analysis was carried out to see the various components used by the current system including hardware, software, networks, and human resources.

The analysis also documents the activities of the information system including input, processing, output, storage, and control.

Next, conduct a feasibility study to formulate information needed by the end-user, resource requirements, costs, benefits and feasibility of the proposed project.

System requirements analysis as part of the initial study aims to identify the problems and specific needs of the system. System-specific requirements are specifications of the things the system will do when implemented

System requirements analysis must define specific system requirements including:

System input required (input)

Output generated (output)

Operations performed (process)

Data source handled

Control (control)

The system requirements analysis phase requires an evaluation to find out the system's ability by defining what the system should be able to do then determining the criteria that the system must meet. Some criteria that must be met are the achievement of objectives, speed, cost, quality of information produced, efficiency and productivity, accuracy and validity and reliability or reliability.

System Design

System analysis (system analysis) describes what the system must do to meet user information needs. The system design (system design) determines how the system meets these objectives. The system design consists of design activities that produce functional specifications. System design can be seen as interface, data and process design with the aim of producing specifications that match the product and user interface method, database structure and processing and control procedures. The system design will produce a prototype software package, a good product should include seven parts:

Quick and easy menu features.

Easy-to-print report.

A data dictionary that stores information in each field including the length of the field, editing in each report and the format of the field used.

Database with the optimal format and key record.

Displays online query precisely to data stored in databases.

A simple structure with a programming language that allows users to do special processing, time events, automated procedures, and others.

System Testing

The prototype software package is tested, implemented, evaluated and modified repeatedly until it is acceptable to the user. System testing aims to find errors that occur in the system and make system revisions. This stage is important to ensure that the system is error-free

According to Sommerville (2001) system testing consists of:

Unit testing to test individual components independently without other system components to guarantee the correct operating system. Module testing consisting of interconnected components. Testing sub-system consisting of several modules that have been integrated. Testing the system to find errors resulting from interactions between subsystems with their interfaces and validating functional and non-functional requirements. Acceptance testing with data entered by the user and not simulation data test.

Documentation in the form of recording of each step of the work from the beginning to the end of making the program.

Testing web-based information systems can use traditional software testing techniques and methods. Web application testing includes link testing, browser testing, usability testing, load, voltage and malar testing

One measurement model that has been translated into several different languages and does not show significant differences in measurement results is End User Computing (EUC) Satisfaction. This model emphasizes user satisfaction with technological aspects including aspects of content, accuracy, format, time and ease of use of the system

Implementation

After the prototype is received, at this stage it is the implementation of a system that is ready to operate and the learning process of the new system then occurs and compares it with the old system, technical and operational evaluation as well as user interaction, systems, and information technology.

**Result and Discussion**

Conduct a discussion of the results of making an application, then an analysis of applications that have been completed.

**Conclusion and Suggestion**

Conclusions and suggestions are the final steps of the research process. Conclusions can be used as a basis for answering the objectives of the study. While suggestions are input for the object under study.

## IV. DISCUSSION

In this part of the discussion, problem analysis is explained, problem identification, explaining the concept of problem solution explaining the method used in solving the dissertation problem. With the explanation of this framework, it is expected to clarify the position of the research to be conducted

In the supplier selection system as written by Kusiak, determined by the criteria (Kusiak, 2000):

1) Management ability
2) Price
3) Environmental awareness
4) Shipping performance
5) Service
6) Flexibility
7) Technical ability
8) Innovative
9) Management approach
10) Geographical location

This criterion is an indicator of supplier selection, based on that criterion is assessed to obtain supplier scores.

### A. Problem analysis

A company in the manufacturing industry has a material supplier in the purchasing department. Suppliers of these materials are numerous and vary in quality, as well as in their track records. For suppliers who have been old suppliers, it is very easy to find out the supplier's track record using the database in the existing Management Information System, while for suppliers who have never been suppliers of raw materials to the company, then do not have a supplier's track record in the Management Information System database.

The Management Company has the desire to be able to evaluate the entire quality of these suppliers to maintain regularity in the supply of raw materials in production so that the production flow runs smoothly. The problem that must be resolved is how to select

suppliers who have capabilities according to the standards set by the company.

**B. New Supplier Selection Concept**

Industry 4.0 is the 4th generation in the development of Industrial technology. The first industrial revolution began with the discovery of the principle of steam power by Heron of Alexandria in 100 AD, which was later refined by James Watt, in 1769 whose technology is still in use today. In 1866, Werner von Siemens transferred the principle of a steam engine to an electric generator. This breakthrough made energy transportable and paved the way for the types of machines that run on electric motors during the second industrial revolution.

The second industrial revolution, marked by perfecting the production process. In 1870 in Cincinnati inspired Henry Ford, Jr. introduced the principle of producing assembly lines into the world of cars - which were then still made by hand. The first Ford was launched from the assembly line in 1913 and this new form of organization finally took effect throughout the world. It was during this period that an assembly line was found in mass production.

The third Industrial Revolution, the field of computer use and robotics automation. The first flip-flop circuit in 1958 laid the foundation for a big electronic leap forward. Only three years later, the first numerical control device appeared on the market. In 1973 Kuka Robotics launched the first robot with six axes, a step that helped move forward automation in Germany and around the world. The third industrial revolution is marked by the development use of the computer world and robotics automation.

When entering Industry 4.0, there is a fundamental problem if the era of digitalization is carried out specifically in relation to the selection of suppliers from other countries that enter Indonesia, bearing in mind that technical data that are not yet available besides that the cultures of other countries are different from the Indonesian people. Most of the new suppliers that enter Indonesia, certainly do not have a track record recorded in the company database, for that it is not easy to choose suppliers that fit the company criteria.

The selection of suppliers, can not be separated from the initial data availability. For new suppliers who have never been suppliers to companies, registration is required via the web. In the initial stages, the company disseminates information about announcements being suppliers. In the second stage, the company receives the registration requirements document, while the supplier registers online by sending data via email. In the third stage, the company accepts registration and provides a link address for the supplier criteria filling the form. In the fourth stage, the company checks the completeness of the supporting data, and store data in the database. In the fifth stage, the data stored in the database is processed by the Decision Support System to obtain a proper supplier order.

Decision Support System that is built, is a measuring tool used to select new suppliers based on technical criteria and cultural criteria. This system works by entering score data based on technical criteria. The score data is managed using the Fuzzy AHP method to rank suppliers. In brief, this concept is illustrated in Figure 4.1 below.

# V. CONCLUSION

The selection of new suppliers in the manufacturing industry is a complex problem because it involves multiple criteria, therefore the DSS needs to be made that is able to complete supplier selection well.

Although the selection of suppliers in the manufacturing industry is not new, in the era of Industry 4.0, DSS used to choose an absolute supplier based online that must be accessible via the web or android. Therefore the writer's idea in this paper is very relevant to be implemented in the manufacturing industry in all fields in the industrial era 4.0

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# COVER LETTER

Title of the manuscript

## PRELIMINARY STUDY OF WEB BASED DECISION SUPPORT SYSTEM TO SELECT MANUFACTURING INDUSTRY SUPPLIERS IN INDUSTRY 4.0 ERA IN INDONESIA

Abstract

Industry 4.0 is an integration between automation and manufacturing industry which requires the use of information technology to implement it. In the operational management framework, there is a supply chain management function that is strongly influenced by quality suppliers. Because choosing a quality new supplier is not an easy thing, we need a reliable application tool and utilizing web-based artificial intelligence technology for the selection of new suppliers in the manufacturing industry. The selection of suppliers is a complex problem because it involves multiple criteria, therefore it is necessary to make a decision support system that is able to complete supplier selection properly. Although the selection of suppliers in the manufacturing industry is not new, in the era of Industry 4.0, a decision support system that is used to choose an absolute supplier based online that must be accessible via the web or mobile app. Therefore the writer's idea in this paper is very relevant to be implemented in the manufacturing industry in all fields in the industrial era 4.0.

Keywords

Industry 4.0, supply chain management, decision support system

**Type of manuscript (please specify):**

- [X] Regular article
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Denny Trias Utomo — 7 February 2020

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