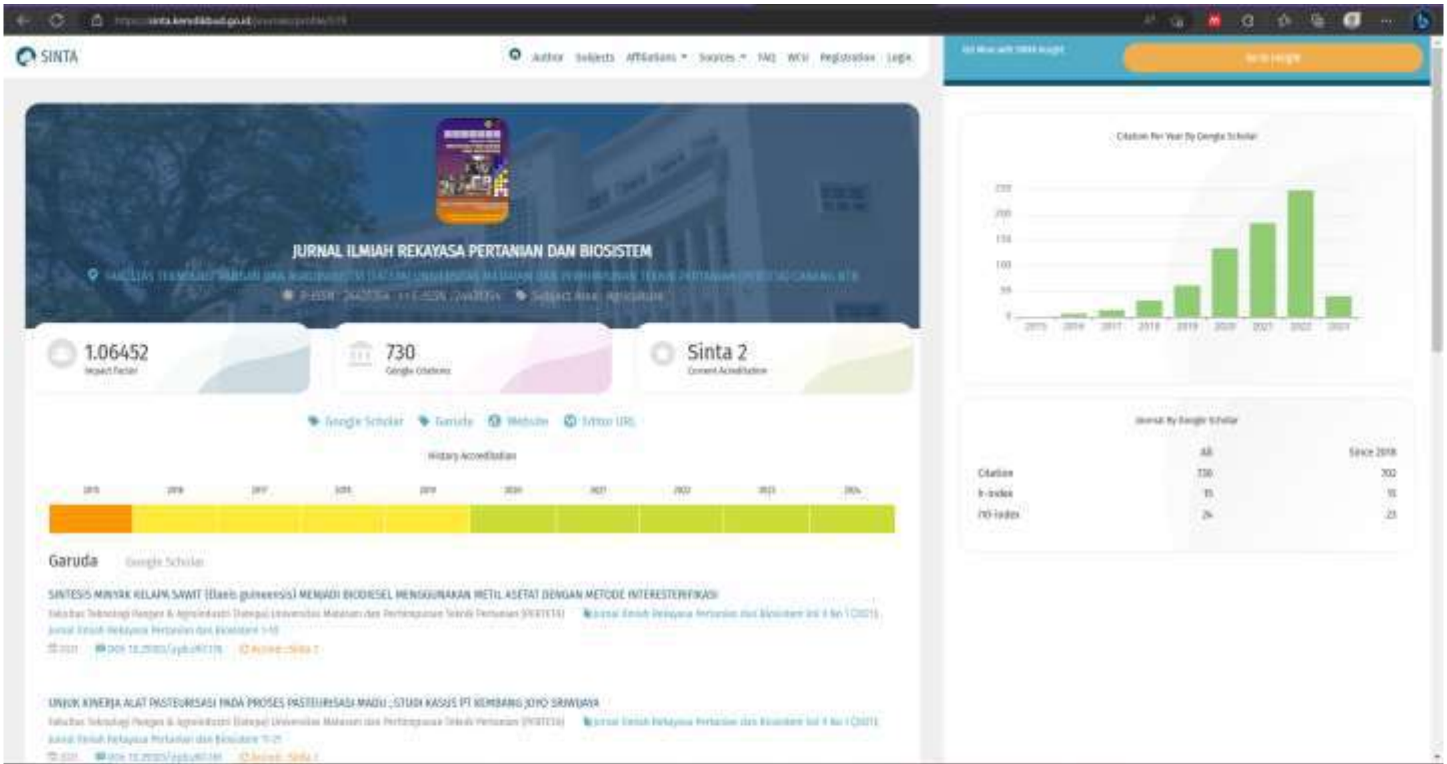
ISSN : 2301-8119
e-ISSN : 2443-1354

Jurnal Ilmiah REKAYASA PERTANIAN DAN BIOSISTEM

Volume 11 Nomor 1 Maret 2023

Diterbitkan Oleh
PROGRAM STUDI TEKNIK PERTANIAN
FAKULTAS TEKNOLOGI PANGAN DAN AGROINDUSTRI
UNIVERSITAS MATARAM
dan
PERHIMPUNAN TEKNIK PERTANIAN INDONESIA
(PERTETA) CABANG NUSA TENGGARA BARAT



Link Akreditasi Sinta : https://sinta.kemdikbud.go.id/journals/profile/519

EDITORIAL BOARD

REVIEWER

ARTICLES

DOI: 10.29303/jrpb.v11i1.465
ISSN 2301-8119, e-ISSN 2443-1354
Available online di http://jrpb.unram.ac.id/

CHARACTERISTICS OF *Albizia Chinensis* WOOD ORGANIC BRAKE PADS FRICTION COEFFICIENT, WEAR RATE AND WORKING TEMPERATURE BY VARIATY OF COMPOSITION

Azamataufiq Budiprasojo[1*], Bayu Rudiyanto[1]

[1]Politeknik Negeri Jember, Jember

Email[*]: azamataufiq@polije.ac.id

ABSTRACT

The use of organic materials as materials in the automotive industry is increasingly common. For example, the brake pads currently use organic materials. Organic brake pads have the advantage of being quiet, because they contain less metal which will rub against the brake rotor and provide a smoother braking experience because of its resin composition that makes their operation smoother. Although it has many advantages, this pad also has a disadvantage like its low hardness and less temperature resistances that make it is common to replace sooner than expected. This research investigates the wear and temperature of organic brake pads majority made from Albizia chinensis or in bahasa well known as kayu sengon, when used and these compositions are mixed with resin and aluminum and pressure to produce a long use of modern organic brake pads. 1st composition is Polyurethane 40 g, Wood 10 g, Aluminium 40 g, Carbon 10 g; 2nd composition is Polyurethane 40 g, Wood 15 g, Aluminium 30 g, Carbon 15 g; 3rd composition are Polyurethane 40 g, Wood 20 g, Aluminium 20 g, Carbon 20g. The minimum wear is $1.1.10^{-8}$ g/sec.mm^2 and the maksimum wear is $2.3.10^{-8}$ g/sec.mm^2 which is still 40% higher than the OEM standard brake pad. The minimum temperature of all organic brake is 129^{o}C and the maksimum temperature is 170^{o}C which is still reach 6% higher than the standard brake pad comparison. The minimum friction coefficient is 0.5 and the maksimum is 0.7 compared to its OEM standard 0.5. References to SNI, this value is in standard range, except the 1st composition.

Keywords: *Albizia Chinensis; brake pads natural fibre; wearness; friction coefficient*

INTRODUCTION

Backgrounds

The use of organic materials as materials in the automotive industry is increasingly common (Nandiyanto et al., 2022). For example, the brake pads currently use organic materials. Organic brake pads have the advantage of being quiet, because they contain less metal which will rub against the brake rotor and provide a smoother braking experience because of its resin composition that makes their operation smoother. Although it has many advantages, this pad also has a disadvantage like it has a low hardness and less temperature resistances that make it is common to replace sooner than expected.

Brake pads will get harder over time due to friction and pressure. This is because the object changes in temperature due to friction accompanied by pressure between the brake pads and the disc brake which causes heat followed by cooling by air (Wei et al., 2019). The heat will change the arrangement of the particles to become denser.

The solution to increase the mechanical ability of brake pads is to mix them with other materials known as composites. Composites are materials made of two or more separate and distinct materials to become a single form component. The existence of a combination of two or more different materials is to produce higher mechanical properties value (Lincoln et al., 2019).

Composites consist of a main material (matrix) and a type of reinforcement which is added to increase the strength and stiffness of the matrix. This reinforcement is usually in the form of resin (epoxy) (Qaidi et al., 2022). Composite materials consist of more than one type of material and are designed to get the best combination of characteristics from each of its constituent components. Composite materials have many advantages, including lighter weight, higher strength and durability.

The most commonly used composite material is aluminum. Aluminum is a light metal that is widely available in nature and occupies the second level of production after iron or steel (Chen et al., 2021). In addition, aluminum has good properties, such as being more corrosion resistant than iron.

The mixture of other ingredients, of course, comes from natural fibers because this brake pad is an organic brake pad. Natural fibers that are currently trying to be developed are those from trees because they are non-toxic when compared to those from asbestos. In this study, fiber from Albizia chinensis wood will be used. This wood is widely planted and support lots thing in fabrication production but unfortunately, when fabricating it produces powder which becomes waste.

The Albizia wood was chosen as the main ingredient material for organic brake pads because this wood has characteristics similar to asbestos material which is commonly used as the main raw material for synthetic brake pads, such as, having low density, high abrasive resistance, high shear strength (Dwiyati et al., 2017). The other reason because its cheap and easy to cultivation because this tree has adapted to the environment easily and also having a fast growth time under 5 years.

The main physical characteristic using in this research wood is that the wood has a 15% moisture content and straight grain. The color of the Albizia wood is glossy yellow to brown-red-ivory, its strength and durability are classified into strong class III–IV and durable class III–IV with a specific gravity of 0.33 kg/m3 (0.24-0.49 kg/m3). and a density of 320-640 kg/m3 (de Abreu Neto et al., 2020).

The last composition is activated carbon which is a material that has many pores in it. The pores owned by the carbon function as a medium for absorption of carbon. Carbon has several advantages, one of which is high absorption (Golondrino et al., 2018). This high absorption capacity can close the molecules to make it denser and to minimize air to enter the gap of the pads. Carbon is also useful as a heat retaining insulator to keep the pads at or below working temperature.

Targets

This research targets is to investigate the mechanical properties of natural brake pads composition and to understand the behaviors in purposes of simulation real condition. These all-material components are mixed in some variety to produce different organic brake pad prototypes. The prototype future investigates for its friction coefficient, its temperature gain, its wear in application.

Researchers compare several treatment variations with the variation test for comparison. Experiments carried out are the treatment effect of mixing the percentage composition of the composite Polyurethane glue, wood powder, aluminum powder, and last is carbon powder.

The aim of these composition comparisons is to find the right composition in order to get a strong brake pads structure that is resistant to friction but has a strong grip.

RESEARCH METHODS

Tools and materials

In this research, an infrared sensor temperature sensing device was used using to investigate the brake pad rising temperature during operation. This type of sensor is used because of it is benefit such become a popular contactless temperature sensing type (Labrador-Paez et al., 2018). A Arduino programming was used to write temperature sensing program language. The list of programming and its circuitry is shown as follows:

```
#include <Wire.h>
#include <Adafruit_MLX90614.h>
#include <LiquidCrystal_I2C.h>
float ambC = 0, objC = 0;
Adafruit_MLX90614 mlx =
Adafruit_MLX90614();
LiquidCrystal_I2C lcd(0x27, 16, 2);
void setup()
{
Serial.begin(9600);
lcd.init();
  lcd.backlight();
Serial.println("Adafruit MLX90614 test");
mlx.begin();
}
void loop()
{
  ambC = mlx.readAmbientTempC();
  objC = mlx.readObjectTempC();
Serial.print("Ambient = ");
Serial.print(ambC);
Serial.print("*C\tObject = ");
Serial.print(objC);
Serial.println("*C");
lcd.setCursor(0, 0);
lcd.print("Ambient : ");
lcd.setCursor(10, 0);
lcd.print(ambC, 1);
lcd.setCursor(14, 0);
lcd.print("*C");
lcd.setCursor(0, 1);
lcd.print("object  t: ");
lcd.setCursor(10, 1);
lcd.print(objC, 1);
lcd.setCursor(14, 1);
lcd.print("*C");
Serial.println();
  delay(500);
}
```

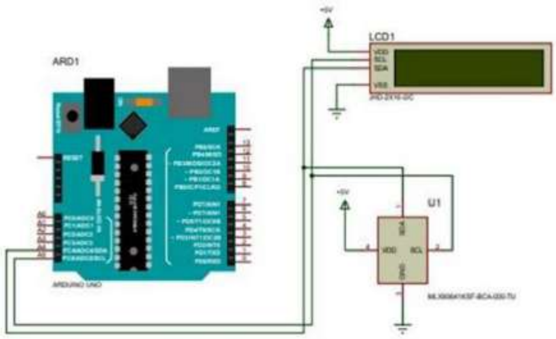


Figure 1. Temperature sensing wiring diagram

The manufacture of the brake pads begins with taking the used back brake pads, especially on the brake pad plate, cleaning the surface of the plate from the remnants of the composite that is still attached, making sure there is no oil or oil attached to the plate and preparing aluminum, Albizia chinensis wood, activated charcoal, and polyurethane glue. Making molds that are adapted to standard brake pads with a thickness that exceeds the thickness of the standard brake pad by 1 mm. It is assumed at the time of pressing as the value of the deformation tolerance.

In the manufacture of brake pads, mixing is carried out according to the composition in the 1st paragraph of methods. To ensure the homogeneity of the mixture, all mixtures will be filtered through a sieve with a mesh size of 40. After all the mixtures are ready, the mixture will be mixed with polyurethane resin and then poured on the brake pad mold provided.

Researcher use a pneumatic valve with 70 Psi of pressure to accommodate the pressure force to the brake pad caliper. The controller actuator is used to precisely control the push force in the system. The system shows in figure 2C and 2D. The brake pads are printed according to the size of the brake pads in the figure 2A.

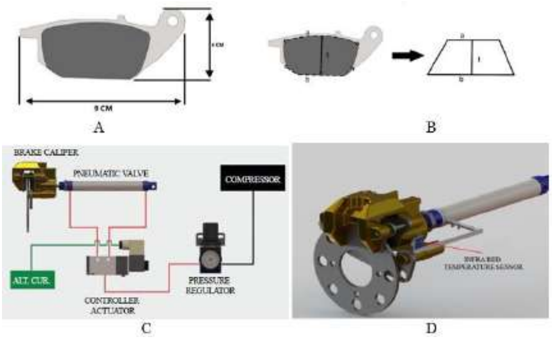


Figure 2. Brake Pads dimension and pneumatic wiring diagram

Methods

The research method used was an experimental method. Researchers compare several treatment variations with the variation test for comparison. Experiments carried out are the treatment effect of mixing the percentage composition of the composite Polyurethane glue, wood powder, aluminum powder, and last is carbon powder. All ingredients will be varied according to these ratios: 1st ratio is 40 g: 10 g: 40 g: 10 g; 2nd ratio is 40 g: 15 g: 30 g: 15 g; 3rd ratio is 40 g: 20 g: 20 g: 20 g.

The Albizia chinensis wood has to be prepared by being chopped into little pieces and then ground into extremely small particles. To remove any traces of oil, the fiber was continuously rinsed with clean water after being submerged in a mixed of 50% NaOH- 50% water solution for 24 hours. After 24h then the fiber rinsed using a flow clean water to eliminate the NaOH. Clean fiber then spread under the heat of the sun to dried the fiber from the water.

After the fiber was ground properly drying outside under the sun, the fiber must grinding into tiny particles using a manual grinder to become a homogenic small piece. After grinding, then fiber is being sieved into selected 150 μm sized particles by using 100 filter mesh of US size or 100 of Tyler size.

The aim of these composition comparisons research is to find the right composition in order to get a strong brake pads structure that is resistant to friction but has a strong grip. This experimental study was used to determine how the effect of variations in material composition on the coefficient of friction, wear rate and working temperature.

As a control references, researcher used a standard brake pad (Original Equipment Manufacturer-OEM) from a motorcycle with 6.8mm thickness (Li & Liu, 2019). The all processes as a flowchart diagram below.

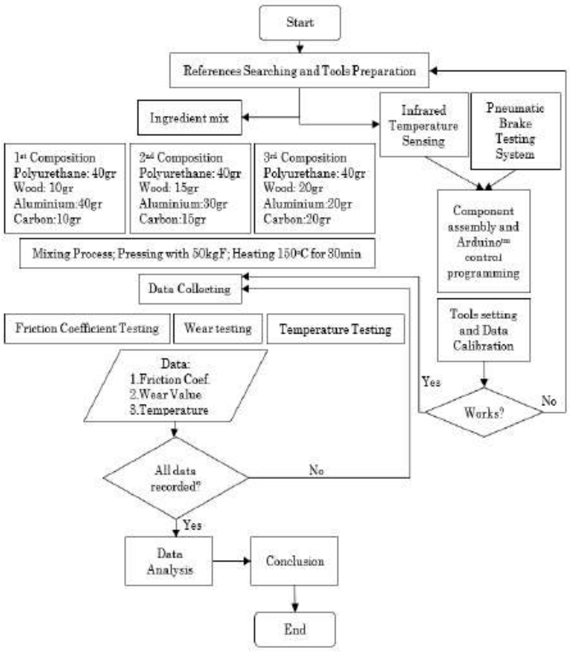


Figure 3. Research Flow Chart Diagram

To calculate the Brake pad wear, researchers use equation 1.

$$Friction\ Wear\ Rate\ (W) = \frac{Initial\ Weight - Final\ Weight}{Area\ of\ friction \times friction\ time} = \frac{W0\ (gr) - W1(gr)}{A\ (mm^2) \times T(sec.)} = \frac{W0\ (gr) - W1(gr)}{\frac{(a + b)(mm) \times t(mm)}{2} \times T(sec.)}$$

……(1) (CJ & Mohan, 2022)

To find the surface area of the plane because the profile of the brake lining does not form a perfect shape, the researcher assumes that the object is in the form of a trapezoid as seen in picture 3B. To reduce the deviation from the length of the side of the object, the author calculates the length of the top and bottom sides using a flexible ruler.

To calculate the friction of the brake pad researcher, use a static friction force formula. Static friction is the friction between two solid objects that are not moving relative to each other. For example, static friction can prevent an object from sliding down an inclined plane. The coefficient of static friction is generally denoted by, frictional force is denoted Static friction results from a force that is applied just before the object moves by fW (friction of weight) and normal force is denoted by fN (friction of normal).

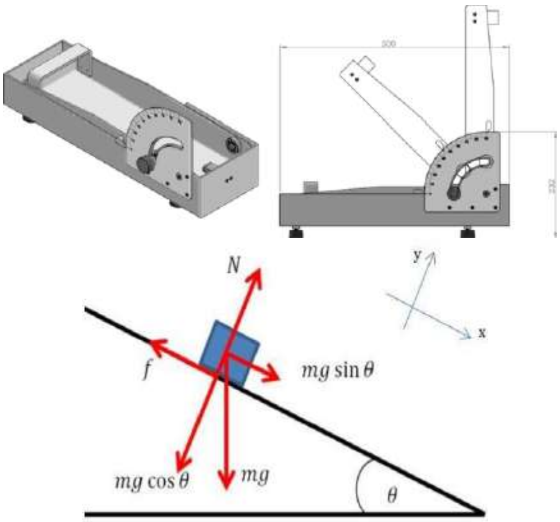


Figure 4. Friction Coefficient Tester

The maximum frictional force between two surfaces before motion occurs, is the product of the coefficient of static friction times the normal force. Thus, the friction coefficient calculates by following formula.

$$\mu s = \frac{fs}{fN} = \frac{\sin\theta}{\cos\theta} = \tan\theta \qquad \text{...... (2)}$$

(Yang et al., 2019)

RESULTS AND DISCUSSION

The following are the results of brake lining products made from a mixture of wood sawdust composites. The researcher used the original brake pad house as the holder of the all-brake pad variety.

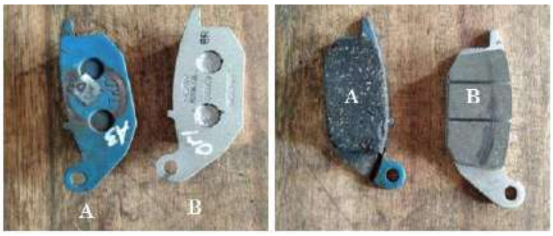


Figure 5. Brake pad Specimen, Organic (A) & OEM (B)

Researcher investigate the value of coefficient of brake pad friction, wear rate and working temperature and they're influence with the variety of mixture composition of the brake pad lining and compared it with SNI (Standar Nasional Indonesia – Indonesian National Standard). The results are presented in table 1 below.

Table 1. Natural brake pad characteristic

Brake Pads Type	Brake pad Friction Coefficient at 25°C	Brake Pad Wear Rate (gr/sec.mm²)			Max. Operation Temperature (°C)		
		40 km/h	60 km/h	80 km/h	40 km/h	60 km/h	80 km/h
SNI* 09-0143-1987	0.25-0.60	-	-	-	-	-	-
OEM	0.55	1.27×10^{-9}	2.23×10^{-9}	2.52×10^{-9}	123.8	152.3	160.8
1st Composition (Less Wood High Aluminum)	0.70	7.62×10^{-9}	1.10×10^{-8}	1.63×10^{-8}	129.7	158.4	165.3
2nd Composition (Moderate)	0.57	9.1×10^{-9}	1.52×10^{-8}	2.12×10^{-8}	135.7	160.1	170.1
3rd Composition (High Wood Less Alumunium)	0.55	1.07×10^{-8}	2.13×10^{-8}	2.62×10^{-8}	131.5	163.3	168.4

* SNI [12]

Based on the results of the friction coefficient test, it can be seen from the test diagram above, from several variations in the composition of materials 1st , 2nd and 3rd in the brake pad formula, the values obtained are from values 0.70 for material composition 1st , and 0.57 for composition 2nd and 0.55 for material composition 3rd.

Meanwhile, the comparison brake pad has the lowest coefficient of friction, which is 0.55. From the results of this test, it shows that there is an effect of several compositions of materials such as carbon powder, refere at the composition of high carbon powder materials, it shows a higher value in the composition of material 1 compared to the composition of ingredients 2nd and 3rd.

The higher wood ingredients will gain the friction coefficient. This is as predicted cause the size of wood grain size is bigger (Pramono et al., 2020). This phenomenon also indicates that the higher or greater the value of the composition of the filler material into the brake pad formula, the higher of the friction coefficient.

Researcher then compared friction data to the standard reference in Indonesia, known as SNI (Standard Nasional Indonesia) number 09-0143-1987 regarding brake linings for motorized vehicles, for class 1 type 1 b (light vehicles) for testing the coefficient of friction is 0.25 – 0.60.

It can be said that the test results for the coefficient of friction of the OEM brake pad and the material composition 2nd, and 3rd pass the SNI standard value requirement. But for material composition 1 the friction coefficient value is above from the SNI standard limit.

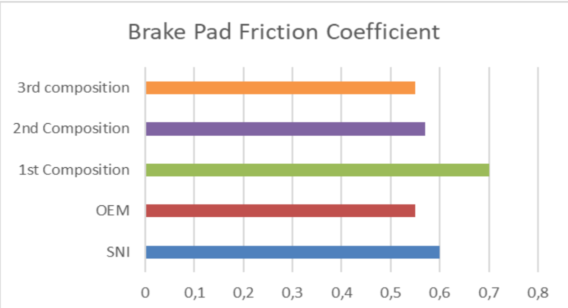


Figure 6. Brake Pad Friction Coefficient Comparison

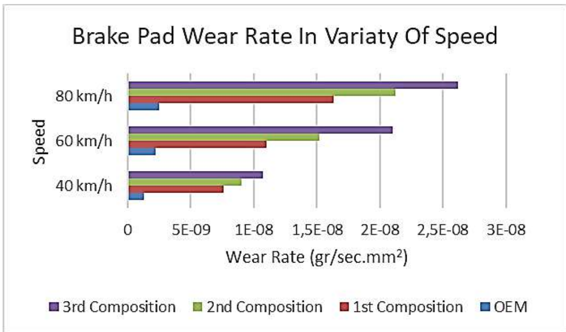


Figure 7. Brake Pad Wear Rate Comparison

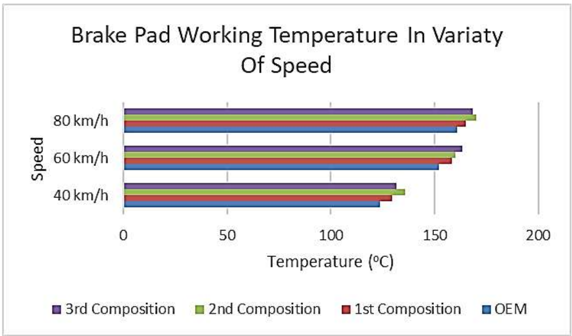


Figure 8. Brake Pad Working Temperature Comparison

The next test is the wear rate. The wear rate test is a test carried out to determine the wear rate on the test object or specimen. Wear is generally defined as the progressive loss of material or the removal of a certain amount of material from a given surface (Wei et al., 2019).

Based on the results of the wear rate test, it can be seen from the test diagram above, from several variations of material composition 1, 2 and 3 at 40 km/h, the highest wear rate is found in material composition 3rd with 1.07×10^{-8} g/sec.mm^2. While the wear rate on the composition of the material composition 2nd decreased to 9.1×10^{-8} g/sec.mm^2, and the material 1st is 7.62×10^{-9} g/sec.mm^2.

This wear rate is above the OEM as brake pad references which is has a value of 1.27×10^{-9} g/sec.mm^2. And for the working temperature of the brake pad can be seen to be almost the same as the OEM references value. As the main fact researcher found was the higher wear rate value, then also make working temperature of the brake pad increased.

It can be proven by looking at the test image above where the composition of material 1st has a temperature of 129.7 ºC, smaller than the two compositions 2nd and 3rd. While the comparison brake pad has a better working temperature of 123.8 ºC. The hot temperature on the disc brakes of vehicle can be bad for braking. High brake temperatures can make the brakes less grippy (Žuraulis et al., 2020).

According to this research the specimen temperature, all data is below 200 ^{o}C. This indicates that the composition of the ingredients has a better yield value than other compositions because it experiences the longest wear rate and lower temperature, but when compared to the OEM manufacturer's brake pad, it is the manufacturer's dregs still superior with differences below 7%.

Based on the results of the wear rate test, it can be seen from the test diagram above, from several variations in the composition of materials 1, 2 and 3 at 60 km/h and the 80 km/h, the wear rate value is almost the same as the previous test. Meanwhile, the comparison of working temperature can be seen to be almost the same as the wear rate value where, the higher the wear rate value, the greater the working temperature of the brake pad.

This indicates that each composition of the brake pad material has different characteristics with respect to the value of the wear rate and working temperature, but if try to look at the 60 km/h and 80 km/h tests, where there is consistency in the composition 2nd material, the results are higher wear rate values.

Can be concluded, this phenomenon proves that among the three variations of the composition of the brake pad, the composition of material 2nd is better than the composition of materials 1st and 3rd. However, when compared to the OEM manufacturer's brake pad, it is still far superior to the manufacturers. This proves that each composition material has a different function. And each added ingredient has a significant effect on the test.

CONCLUSION

It can be concluded that from all the compositions of the variations carried out, there is no a variety of organic brake pad can achieve or even been able to approach the wear rate of OEM brake pad. It still 40% lower than OEM brake pad wear rate. Even though the wear rate is below the OEM, but for the friction coefficient and rising operation temperature showed more equal between OEM and organic brake pad prototype. It can be concluded that from the brake pad comparison, the OEM is still better and superior than organic brake pad canvas with variety. The less of organic wood ingredients could increase the friction coefficient and brake pad wear rate. The added of Alumunium as one of brake ingredients known could increasing the brake pad wear rate, but not also significantly increasing the temperature heat resistances and friction coefficient. From all the friction coefficient tests that have been carried out, the results of the test formulas for ingredients 2nd and 3rd meet the quality standards of SNI 09-0143-1987 concerning motor vehicle brake pads linings. While the results for material 1st do not meet the standard coefficient of friction.

ACKNOWLEDGMENT

This paper and the research behind it would not have been possible without the exceptional support of Politeknik Negeri Jember especially Engineering Departemen Laboratories. Researcher thank to technicians for contribution and help of electrical, sensing and mechanism manufacturing.

REFERENCES

Chen, R., Cheng, X., Zhang, C., Wu, H., Zhu, H., & He, S. (2021). Sub-3 nm Aluminum Nanocrystals Exhibiting Cluster-Like Optical Properties. *Small, 17*(27), 2002524.

CJ, A., & Mohan, D. G. (2022). Predicting the ultimate tensile strength and wear rate of aluminium hybrid surface composites fabricated via friction stir processing using computational methods. *Journal of Adhesion Science and Technology*, *36*(16), 1707–1726.

de Abreu Neto, R., de Assis, A. A., Ballarin, A. W., & Hein, P. R. G. (2020). Effect of final temperature on charcoal stiffness and its correlation with wood density and hardness. *SN Applied Sciences*, *2*(6), 1020.

Dwiyati, S. T., Kholil, A., & Widyarma, F. (2017). Pengaruh penambahan karbon pada karakteristik kampas rem komposit serbuk kayu. *Jurnal Konversi Energi Dan Manufaktur*, *4*(2), 108–114.

Golondrino, J. C. C., MacRae, G. A., Chase, J. G., Rodgers, G. W., & Clifton, G. C. (2018). Hysteretic behaviour of asymmetrical friction connections using brake pads of d3923. *Structures*, *16*, 164–175.

Labrador-Paez, L., Pedroni, M., Speghini, A., Garcia-Sole, J., Haro-Gonzalez, P., & Jaque, D. (2018). Reliability of rare-earth-doped infrared luminescent nanothermometers. *Nanoscale*, *10*(47), 22319–22328.

Li, W., & Liu, T. (2019). Time varying and condition adaptive hidden Markov model for tool wear state estimation and remaining useful life prediction in micro-milling. *Mechanical Systems and Signal Processing*, *131*, 689–702.

Lincoln, R. L., Scarpa, F., Ting, V. P., & Trask, R. S. (2019). Multifunctional composites: A metamaterial perspective. *Multifunctional Materials*, *2*(4), 043001.

Nandiyanto, A. B. D., Hofifah, S. N., Ragadhita, R., Fiandini, M., Al Husaeni, D. N., & Maryanti, R. (2022). Resin-based brake pad with fleece fiber and its mechanical properties. *International Journal of Sustainable Transportation Technology*, *5*(2), 51–54.

Pramono, C., Salahudin, X., Taufik, I., Bagaskara, A., & Irawan, D. M. (2020). Study of mechanical properties of composite strengthened mango seed powder (mangifera indica cultivar manalagi), brass, and magnesium oxide for brake pads material. *Journal of Physics: Conference Series*, *1517*(1), 012012.

Qaidi, S. M. A., Mohammed, A. S., Ahmed, H. U., Faraj, R. H., Emad, W., Tayeh, B. A., Althoey, F., Zaid, O., & Sor, N. H. (2022). Rubberized geopolymer composites: A comprehensive review. *Ceramics International*.

Wei, L., Choy, Y. S., & Cheung, C. S. (2019). A study of brake contact pairs under different friction conditions with respect to characteristics of brake pad surfaces. *Tribology International*, *138,* 99–110.

Yang, M., Li, C., Zhang, Y., Jia, D., Li, R., Hou, Y., & Cao, H. (2019). Effect of friction coefficient on chip thickness models in ductile-regime grinding of zirconia ceramics. *The International Journal of Advanced Manufacturing Technology*, *102*, 2617–2632.

Žuraulis, V., Garbinčius, G., Skačkauskas, P., & Prentkovskis, O. (2020). Experimental study of winter tyre usage according to tread depth and temperature in vehicle braking performance. *Iranian Journal of Science and Technology, Transactions of Mechanical Engineering*, *44*, 83–91.