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DESIGN OF PORTABLE CATALYTIC CONVERTER WITH TEMPERATURE CONTROL BASED ON ARDUINO FOR WASTE GAS DIESEL ENGINE

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Abstract

Catalityc converter is device that using of catalyst media.The media of catalyst is expected to accelerate the reaction rate at a certain temperature. In the process of combustion of fuel and air in addition to enthalpy, residual combustion products are emissions or pollutants of CO, CO_2, NOx, HC, soot or smoke and other elements that can pollute the environment and can endanger human health. Diesel engines produce more soot and NOx gas pollutants than gasoline motors, but produce lower CO_2. With the regulation of the temperature of the catalytic converter installed in the exhaust manifold system or diesel engine exhaust can reduce exhaust emissions in the form of black smoke or soot. The testing of this study used a quasi experimental method by comparing the exhaust gas data produced by diesel motors in the exhaust manifold system both those using and without catalytic converters. Data retrieval is carried out conditioned at room temperature during testing. The test starts at the rotation of the diesel engine 1500 RPM to 4000 RPM with an increase in rotation every 500 RPM. The overall results of using catalytic converters are very effective in reducing the density of the smoke or opacity of the diesel engine its was average of 18.69%.

Keywords— ***Catalytic Converter*, Exhaust Emission, Diesel Engine**

1. INTRODUCTION

Motor vehicle exhaust gas emissions are one of the biggest contributors to air pollution. Data from the Ministry of Environment (2004) shows that the biggest causes of air pollution are 70% of transportation equipment, 20% of industrial processes, and the remainder comes from household waste. This is caused by an increase in motorized vehicles, especially in the big cities in Indonesia. The highest air pollution is produced by diesel vehicles. This can be seen from the amount of diesel fuel used as diesel fuel by 40% of the total fuel (Nasikindkk, 2004).

Catalytic Converter was first applied in the USA in 1975. The principle of converter catalyst describes and converts pollutant levels in a chemical reaction to oxidized compounds. Development of catalytic converters for Selective Catalytic Reduction (SCR) diesel engine emissions and Selective Non Catalytic Reduction (SNCR). Mokhtar (2014) analyzed catalytic converters made from copper plate catalyst in the form of honeycomb can oxidize and reduce CO emission levels by 41.85%, while HC emissions decreased by 29.16%, and CO2 emissions fell by 12.88%. In this research, the catalytic converter will develop the SCR method with a type of aluminum-coated catalyst with a humidified glaswool fiber, which is expected to reduce gas emission levels and reduce diesel motor smoke smoke.

2. LITERATURE REVIEW

2.1 Exhaust Emissions of 4 Stroke Diesel Engine

Exhaust gas emissions are residual products from fuel combustion in the combustion chamber of an internal combustion engine, an outdoor combustion engine, a jet engine which is released through the engine exhaust system. Motor vehicle emissions contain various chemical compounds. Stoichiometric combustion process for diesel fuel with molecular bonds $C_{16}H_{34}$:

$$C_{16}H_{34} + 24,5O_2 + 92,12N_2 \rightarrow 16CO_2 + 17H_2O + 92,12N_2$$

In actual circumstances the combustion process in a diesel motor is not in an ideal and very complex condition, which will produce pollutants and emissions. According to Ministry of Environment standards, exhaust emissions in diesel motors:

1. Threshold for CO (Carbon Monoxide) was 1 gram/km;
2. Threshold for HC + NOx (Hydro Carbon + Nitrogen Oxide), 0,7 gram/km and 0,9 gram/km;
3. The Opacity was (k) 2,261/m^{-2}.

Based on the Republic of Indonesia Minister of Environment Regulation Number 05 in 2006, it was explained that the exhaust emissions threshold of diesel and gasoline vehicles as follows :

Table 1. Threshold Value of Vehicle Emission

Category	Production Year	Parameter			Testing Method
		CO (%)	HC (ppm)	Opacity (% HSU)	
Spark Ignition Engine (Gasoline 4 stroke)	<2007	4,5	1200		Idle
	≥2007	1,5	200		
Compression Ignition Engine (Diesel 4 stroke) :					Trial speed engine /
GVW ≤ 3,5 ton	<2010			70	Independe
	≥2010			40	nt speed
GVW > 3,5 ton	<2010			70	engine
	≥2010			50	(RPM)

Diesel motors have high thermal efficiency, are weather resistant, and are flexible to fuel types. That's why diesel engines, very much and very wide use, especially, which requires large power capacity. Diesel motors produce CO2 that is relatively small compared to a gasoline fuel motor because of the greater heat efficiency, but combustion in this engine system produces nitrogen oxides (NOx) and smoke that are worse than other combustion engines, as in the graph below:

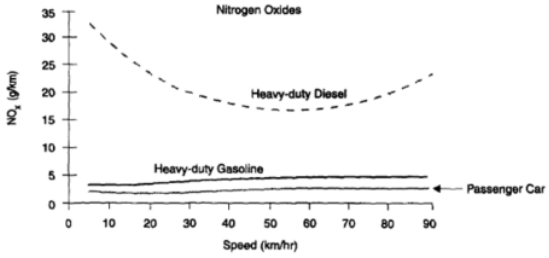

Figure 1. Diesel Motor NOx Graph (Faiz, 1996)

2.2 *Catalytic Converter (CAT)*

Device attached to the exhaust system of an auto or other engine to eliminate or substantially reduce polluting emissions. It converts three harmful substances into harmless ones: carbon monoxide (a poisonous gas) into carbon dioxide, nitrogen oxides (cause acid rain and smog) into nitrogen and oxygen, and hydrocarbons (cause smog and respiratory problems) into carbon dioxide and water.

3. RESEARCH OBJECTIVES AND BENEFITS

3.1 Research Objectives

In this study, the objectives to be achieved are as follows:

a. Determine the type of catalytic converter for diesel motors.
b. Determine the parameters of diesel motor exhaust emissions.
c. Analyzing the pattern of diesel gas exhaust emissions data produced between standard exhaust and catalytic converter temperature settings.

3.2 Benefits of Research

Exhaust gas emissions are one of the contributions in air pollution. Because the causes of vehicle exhaust emissions vary greatly from fuel factors, fuel and air mixing processes, engine leakage factors, ineffective combustion process factors. One of the treatments for controlling exhaust emissions of vehicles is equipped with catalytic converters. In diesel motorcycles, exhaust emissions that become the benchmark in the measurement are the opacity or density of smoke, so the benefits of research are expected to be:

1. Reducing the level of Opacity or smoke density of diesel motor exhaust emissions.
2. Utilization and use of types of materials for catalysts for diesel motor converters.
3. As an enrichment of diesel motor teaching materials and vehicle pollution control.
4. Contributing in realizing the institution's vision and mission.
5. Can be applied directly by the community.

4. RESEARCH METHODS

This research was carried out based on the stages that emphasized the use of catalytic converters with aluminum catalysts to reduce exhaust gas generated from the combustion process of diesel motors. To be able to reach this indicator, the stages of this research are illustrated in Figure 2, with the stages as follows:

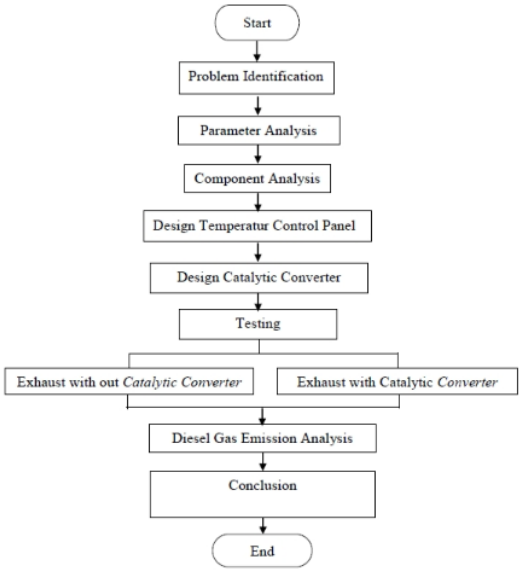

Figure 2. Research Flow Chart

4.1. Time and Location of Research

This research will be conducted at the Jember Polytechnic Automotive Machinery Laboratory in the Automotive Engine Study Program. This research takes 6 months from the beginning of the proposal to be accepted until the making of the final report and journal.

4.2. Variation of Observation

This research is a development and innovation on catalytic converter systems with motorized aluminum catalysts to reduce diesel motor exhaust emissions. Test parameters in the form of percentage Smoke Smoke Opacity is a dependent variable in this study. The independent variables in this study are engine speed from 1500 to 4000 RPM with an increase interval of 500 RPM.

4.3. Research Model

The research model uses pseudo experimental test data. The design of the catalytic converter temperature regulation system by giving a 2 mm diameter perforated perforation, which is placed parallel to the distance or insulated (according to the image) and there is a digunakan copper pipe used to drain cooling water in the catalytic tube of the converter. The object of research is using a 4-stroke diesel engine (engine stand), by utilizing muffler installed as catalytic converter.

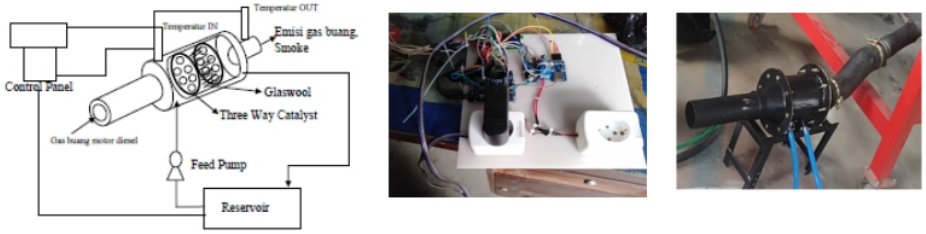

Figure 3. Catalytic Conveter (CAT) Diesel Design

4.4. Testing Procedure

For retrieval of data using observations with Portable Gas Analyzer for Diesel devices empirically at the condition of the vehicle reaches the optimal engine temperature of 80^0C. temperature testing is adjusted to room temperature / environment. The diesel motor stand engine has computerized data recording that is equipped with measuring instruments, Tachometers, Water and Air Temperature Sensors, Exhaust Temperature.

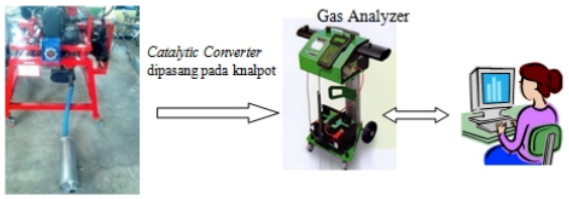

Figure 4. Testing Procedure

5. RESULTS AND DISCUSSION

Before testing, first a warm start on a diesel engine is carried out and inspection is possible for 10 minutes to reach a temperature of 80^0C. Following are the test results as in table 2.

Table 2. Value Test Experiment

No	Engine Speed (rpm)	Opacity Smoke with out CAT		Opacity Smoke with CAT	
		(%)	(m^{-1})	(%)	(m^{-1})
1	1500	4	0,16	3	0,12
2	2000	4	0,21	3	0,18
3	2500	5	0,22	4	0,19
4	3000	5	0,26	4	0,19
5	3500	4	0,23	2	0,17
6	4000	3	0,16	2	0,15

Table 2 describe, at 1500 rpm engine speed produces 4% Opacity Smoke for no catalytic converter, while using a catalytic converter 3% or a 25% decrease. Due to the Smoke Opacity meter working principle based on light optical sensors, if it reads 4%, the light capable of being blown out by an optical sensor is 96% and if 3% of the light can be blown out it is forwarded to the counter signal by 97%. Here is a table of 3 percent decreases in each increase in rpm by comparing data using or without a catalytic converter (CAT):

Table 3. Percentage of decreasing opacity each engine speed

No	Engine Speed (rpm)	Decreas in Opacity Percentage (%)	
		(%)	(m^{-1})
1	1500	25	25
2	2000	25	14,29
3	2500	20	13,64
4	3000	20	26,92
5	3500	50	26,09
6	4000	33,33	6,25

Figure 5 shows a graph of the difference in the results of smoke concentration tests with or witha out catalytic converters (CAT), for each change and increase in engine speed with a percentage (%).

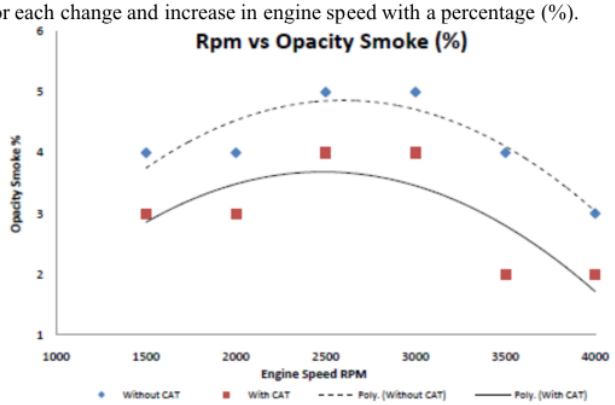

Figure 5. Graph of Opacity (%) at various engine speed (Rpm)

Figure 5 shows a graph of the difference in smoke concentration or opacity test results with or with out catalytic converters (CAT), for each change and increase in engine speed in units per meter (1 / m).

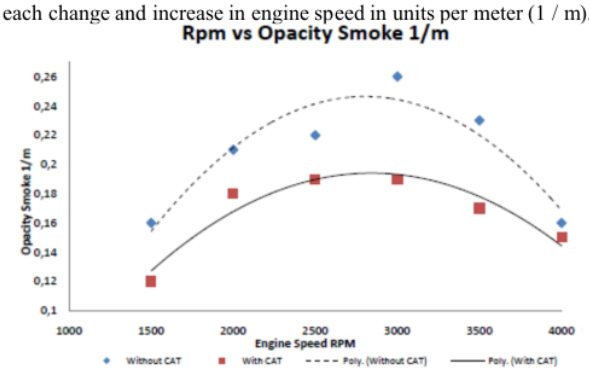

Figure 6. Graph of Opacity (1 / m) at various engine speed (Rpm)

Figure 6 it can be explained that the use of catalytic converters can reduce the overall concentration level by an average of 18.69%, at 3500 rpm significant 50% reduction value. This is due to the effect of cooling water flowing in the copper pipe coil that is fitted on the inside catalytic tube converter which temperature arround to 60^0C - 70^0C, so it will cool the room as a result the diesel exhaust particulate (PM particulate Matter) will be affected by a temperature drop of 80^0C which was then captured by an aluminum porcelain plate filter for the smoke concentration screening process. This aluminum porcelain plate (small holes) inside the muffler can break down and capture the soot of diesel motor exhaust gas. For opacity smoke with a unit of 1 / m, it can be explained for example for 1500 rpm engine speed, has opacity smoke 0.12, meaning that the sensor reads and converts smoke density by 0.12 meters from the total distance of 1 (one) meter measured. Figures 4 and 5 have the same trend or pattern, which is openly parabolic down where there is an increase in smoke concentration until the peak will then decrease with increasing engine speed (rpm).

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From the results of the research conducted, conclusions can be drawn as follows:

1. By regulating the temperature of the catalytic converter which has an aluminum-coated porphorous filter it is very effective in reducing the smoke density or opacity of the diesel engine as a whole by an average of 18.69%.
2. At 3500 rpm, the density of diesel engine smoke is 4% and 0.23 1 / m without using a catalytic converter, while the density of smoke using catalytic converters is 2% and 0.17 1 / m or a 50% decrease.

6.2 Suggestions

Further research is still needed on the position of placement of variations in catalyst distance, variations in the number of catalysts, variations in fuel on exhaust emissions, and to test the ability or performance of 4 stroke diesel engine.

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