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TORQUE (PERFORMANCE) ANALYSIS, EXHAUST GAS EMISSIONS, AND EXHAUST FLOW MODELING VARIATION OF CATALYTIC CONVERTER FILTER NUMBER

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Abstract. In a combustion engine, to generate torque, a combustion and compression process is required. Apart from obtaining mechanical energy, the combustion results also produce exhaust emissions, which can result in a polluted environment. This research aims to determine the influence of torque and exhaust gas emission modeling by using variations in the number of filters using simulation software. This research is descriptive and quantitative research with an experimental method. This research uses a Dyno test tool and a Gas Analyzer from this research to find out data from the exhaust that has been varied. The addition of a filter reduces the torque value by 1.7%. The presence of a filter on the catalytic converter has been proven to reduce levels of exhaust emissions that are harmful to the environment (CO, HC). Of the variations in the number of catalytic converters, filter number 2 is the best, producing 9.71 hp with CO emission levels of 1.7% and HC 553 PPM.

Keywords : catalytic converter, emission, torque, filters

1. INTRODUCTION

Most of the pollution and air pollution is caused by exhaust gases from vehicles which are currently expanding at an alarming rate. From the activities of motorized vehicles using petroleum fuel, CO, HC, and NOx exhaust gases are produced. Exhaust gas from combustion can produce air pollution. This study has been devoted to the investigation of the use of an exhaust gas energy recovery system in a test bench of a single-cylinder diesel engine in four different modes of operation, in search of the potential for recovery energy in these classes of devices, the influence of fuel on their efficiency and the influence of the device in the reduction of polluting emissions. For this reason, a thermoelectric generator is constructed, which is mainly made up of an internal rectangular duct-type heat exchanger and twenty thermoelectric modules installed on the upper and the lower side of the heat exchanger in a 5×2 arrangement. A data acquisition system is connected to the thermoelectric generator and it allows monitoring of the electrical power generated by the thermoelectric modules, the temperatures of the exhaust gases at the inlet and outlet of the heat exchanger, and the polluting emissions. The maximum net electrical power recovered was 65.28 W and 57.8 W for the B5 and the B10, respectively. The maximum value of energy recovery obtained leads to a decrease in fuel and a reduction in CO2, CO, HC, NOx, and NO emissions of 2.43% and 2.65% for B10 and B5. [1]

This investigation experimentally examines the influence of hydroxy gas fumigation in a diesel engine fueled with a biodiesel blend derived from waste palm cooking oil (B10). For the experimental tests, a fixed rotation speed of 2000 rpm and a load condition of 50%, 75%, and 100% have been established. Hydroxy gas (HHO) has been added through the engine's air intake system at a flow of 0.5 lpm, 0.75 lpm, and 1 lpm. Results have demonstrated the positive effect of HHO fumigation on the combustion performance of the B10 blend. Moreover, a reduction of 4.3% in the BSFC and a 2.64% increase in peak pressure in B10 due to the presence of HHO have been observed. On the other hand, a decrease of 8.7%, 9.9%, and 22.8% in CO2, HC, and smoke opacity emissions has been evidenced with the addition of HHO in B10. B10 implementation has promoted NOx emission escalation. However, this increase has been only 1.23% compared to pure diesel. In conclusion, HHO enrichment favors combustion performance and emissions minimization, which represents a significant opportunity to mitigate the negative effect of the lower calorific power of these types of fuels. [2]

This study investigates the influence of biodiesel blends produced from agro-industrial residues of palm oil (Elaeis guineensis), on the performance and emission characteristics of a small-diameter single-cylinder diesel engine. The engine tests have been performed at three different loads with a constant speed of 3600 rpm. Experimental results have shown that the blends of biodiesel PB5 and PB10 cause a consumption of 1.12% and 2.45% higher than diesel. The addition of biodiesel from palm oil residues has allowed the reduction of CO, CO2, and HC emissions by 28.6%;12.6%, and 14.3%. However, biodiesel has caused an increase in Nox emissions and smoke density. The evaluation of the thermal efficiency of the brake has shown a difference of 2.4% and 3.7% for PB5 and PB10 compared to conventional diesel. Similar efficiency compared to diesel and significant reductions in CO, CO2, and HC emissions, show that biodiesel blends produced from palm oil agro-industrial wastes have the potential to partially replace the diesel content in the fuel, thus contributing to the reduction of engine emissions and reduce the environmental pollution caused by this type of waste. [3]

The high cost of extending national grid to the highly dispersed Fiji Islands has made many locations to be without electricity. Therefore, a techno-economic assessment of standalone (solar PV, diesel generator) and hybrid solar PV-diesel generator systems in four different regions of Fiji Islands has been carried out. The potential reduction in greenhouse emissions of a standalone diesel generator has been estimated and compared with that of the hybrid system. Solar radiation data for the four selected locations (Ba, Suva, Labasa, and Rakiraki) have been fed into the Homer software for analysis. This study is a comparative study of the four selected locations. Only the current price of diesel of $0.8 and the mean radiation of 5.64; 5.13; 4.79 and 5.22 kWh/m^2-day for the four selected locations, respectively, have been used thus there has been no variation in the value of these factors. It has been shown that Ba is the best location with the least levelized cost of energy of $0.4976/kW, while the highest levelized cost of energy of $0.5734/kW has been obtained for Rakiraki for a standalone PV solar energy system. The obtained findings can be a useful guide to stakeholders in Fiji and the world at large for effective energy planning. [4] Many developing countries are opting to rely on coal-fired power mainly due to the abundance of the resource and its economic viability since the capital needed to build a new coal-fired power plant is not as large as a nuclear power plant. Compared to nuclear power, coal-fired power does not bear the risk of major catastrophe and therefore it will be relevant in the power industry for many years to come. However, the major drawback of coal-fired power plants is the fact that it is not a clean energy prospect and it is considered one of the main contributors to the world's greenhouse gases. Coal combustion is usually associated with the emission of greenhouse gases such as CO, CO2, NOx, and SO2. One of the main objectives of coal combustion research is to develop techniques that will help power plant operators to utilize coal cleanly and efficiently by adopting coal blending practices. Currently, emission mitigation and boiler cleanliness issues through the coal blending process are focusing more on laboratory scale tests and not utilizing actual plant data and behavior. This study evaluates the effectiveness of the implementation of the Coal Combustion Prediction Analysis Tool (CPAT) as a tool to facilitate power plant operators in predicting the impact of individual or blended coal quality. It will provide early predictions on boiler combustion performance related to the coal quality and it will assist the power plant operators preparing for boiler process control optimization. This study will also discuss slagging and fouling factors of different coal type, which are used in one coal-fired power plant in Southeast Asia. [5]

Fuel quality is an important indicator for the efficient operation of SI engine. Gasoline fuel is produced in many countries under specifications that did not meet the standard specifications that negatively affect engine operation efficiency. Hence, in this study, the impact of Methyl tertiary butyl ether addition to local low octane gasoline on the performance of spark ignition engines and exhaust emission characteristics has been investigated. The fuel samples prepared with additive ratio selected by 5%, 10% and 15% in addition to local gasoline as a comparison threshold. Engine test has been performed and the resulted data collected at constant engine load and increasing speed. Study results reveal noticeable improvement in engine brake power and BSFC at medium and high engine speed with MTBE additive and the maximum improvement obtained with the addition of 10% MTBE to local gasoline at 3000 rpm engine speed. Increasing MTBE additive with local gasoline results in reducing HC and CO emission for all ratios and the minimum value of these emissions obtained with 15% MTBE over the whole engine speed with an increase in CO2 emission. Based on the obtained results, introducing MTBE at 10% additive ratio is suitable to improve the engine performance and mitigate the engine emissions compared to local low octane gasoline. 6]. The addition of a catalytic converter in motor vehicles has been proven to reduce exhaust emissions. The addition of a catalytic converter in motor vehicles has been proven to reduce exhaust emissions. However, the addition of filters to the catalytic converter that is excessive can reduce engine performance[7][8][9][10].

Research on catalytic converters using experimental tests can determine the content of CO2, CO, HC, and O2, as well as determine engine performance. Visual modeling using engineering software can explain the phenomenon of exhaust gas flow in the catalytic converter [11] [12]. Catalytic converters on standard motorbikes do not use plate filters, plate filters that use metal can attract CO and HC emissions. From here the researchers raised the issue of how much influence the number of plate filters has on exhaust gas emission levels and their performance values [13].

This study discusses the effect of the number of catalytic converter filters on a 150cc motorcycle on torque values and modeling exhaust gas analyzers using Ansys software. For further research, it is possible to develop catalytic analysis on automobiles and heavy equipment, and variables will also be added that affect exhaust quality and improve performance, of course with the addition of data and variables a statistical analysis is needed to get the best composition [12][11][14][15]. The purpose of this research is to obtain minimum exhaust emissions and maximum engine performance.

2. METHODS

2.1 Tools & Materials

A. Tools

- dyno test

Figure 2 Diyno test for performance tester

Tool specifications:
Maximum power 200 HP
Drum Diameter 305 mm
Total weight 350 kg
Year of use 2020

Dyno test is a test that is used to determine the performance of a vehicle's motor.

- Motorcycle 150 cc


Figure 3 motor cycle 150 cc

-Gas Analyzer

Figure 4 gas emissinon Analyzer

Gas analyzer is an instrument or device used to measure the proportion and composition of combined gases. The function of the gas analyzer is to monitor exhaust emissions of CO, CO2, HC, and O2 by continuously measuring emissions.

-Catalytic converter

Figure 5 catalytic converter

2.2 Dimension catalytic converter

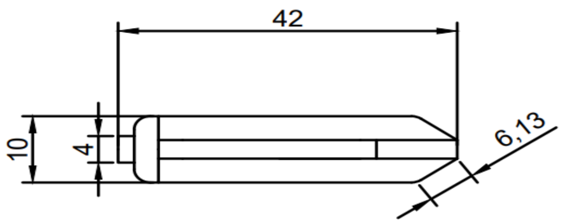


Figure 6 catatalic converter using one filter

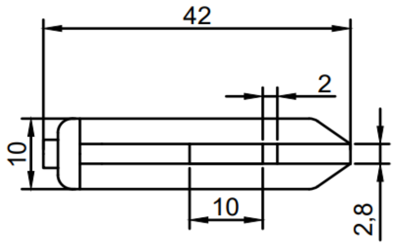


Figure 7 catalytic converter using two filters

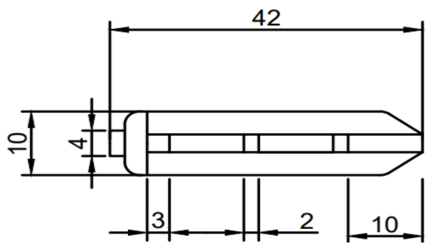


Figure 8 Catalytic converter using three filters

Units: millimeter

2.3 Boundary Condition

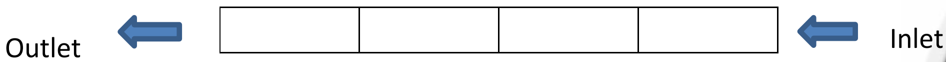


Figure 9 Boundary Condition Catalytic converter

2.4 Research Diagram

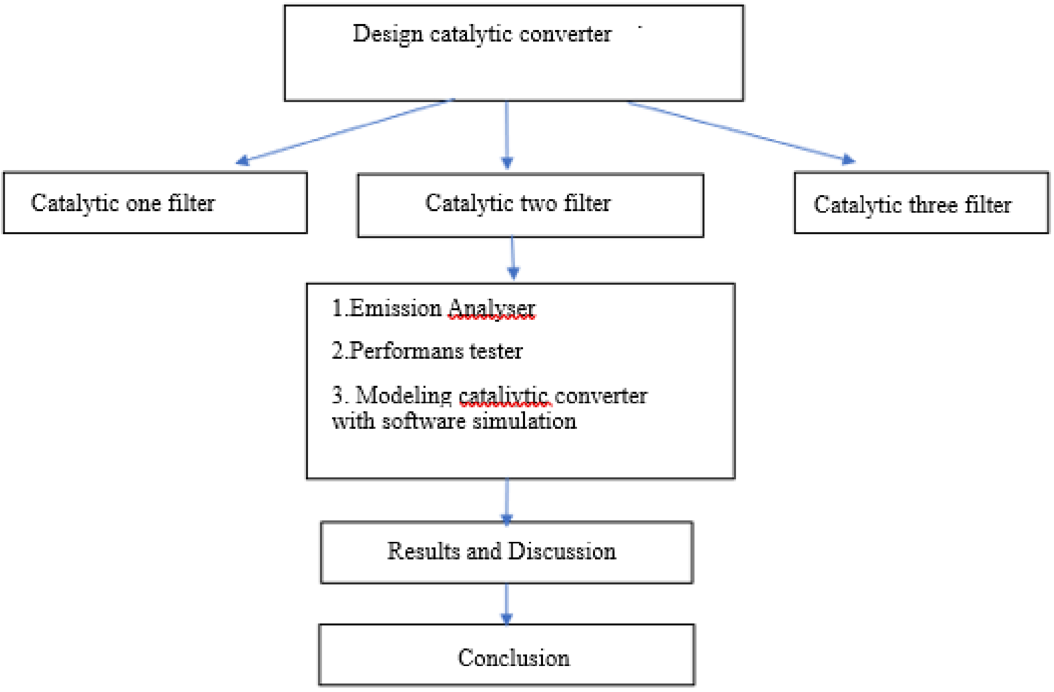


Figure 10 Research Diagram

3. RESULTS AND DISCUSSION

3.1 Performance Data Result

In the torque experiment, it was obtained using data obtained from the dynotest test.

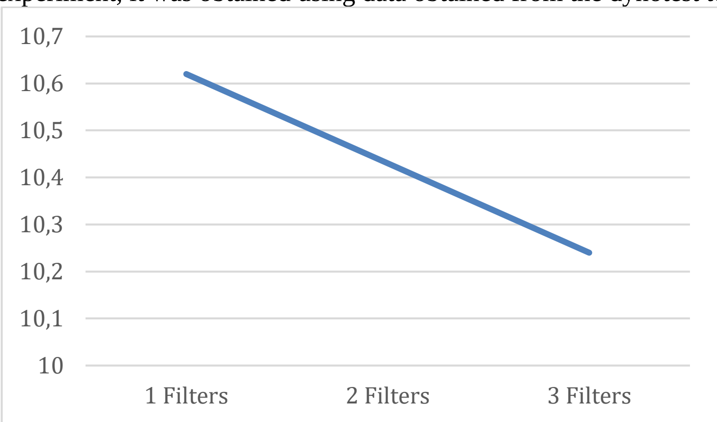


Figure 11 Number of filters vs Torque Value

The data above is, the results of taking the Dyno test where the data shows that for the results of the catalytic converter using 1 filter, the torque value was 10.30 N.m, and the catalytic converter using 2 filters obtained a torque value of 9.60 N.m. Meanwhile for 3 filters obtained a torque of 9.37 N.m. For 3 filters, the minimum torque produced is due to the large number of filters installed. The air coming out of the engine is not free to come out, so the resulting torque value is small.

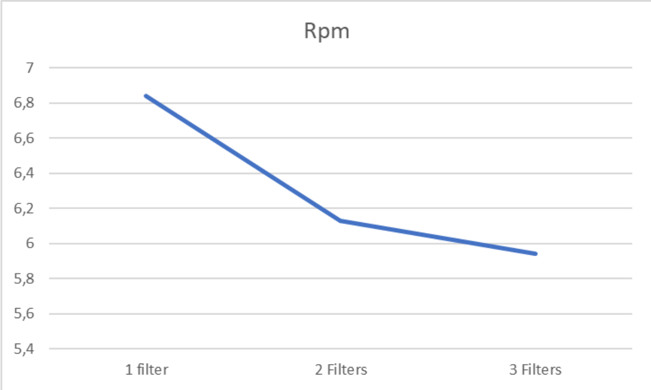


Figure 12 the Relationship between Number of Filters-Engine Revolutions

The data above is, the results of taking the Dyno test where the data shows that for the results of the catalytic converter using 1 filter, the rotation value was 6.84 rpm. The catalytic converter using 2 filters obtained a rotation value of 6.13 rpm. Meanwhile, the 3 filters obtained a rotation of 5.94 rpm. For 3 filters, the minimum torque produced is due to the large number of filters installed. The air coming out of the engine is not free to come out, so the resulting rotation value is small.

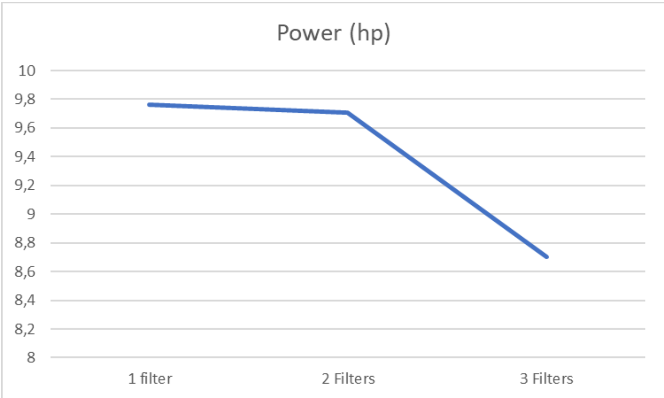


Figure 13 of the relationship between the number of filters and machine power

The following is a graph from the Dyno test where the data shows the highest results, namely 1 filter where the data produced power was 9.76 hp and filter 2 was 9.71 hp, for the lowest data, namely on 3 filters which only produced 8, 7 hp.

3.2 Emission Test Data Results

In the process of taking Emission Data obtained from the Analyzer.

Content of CO exhaust emissions

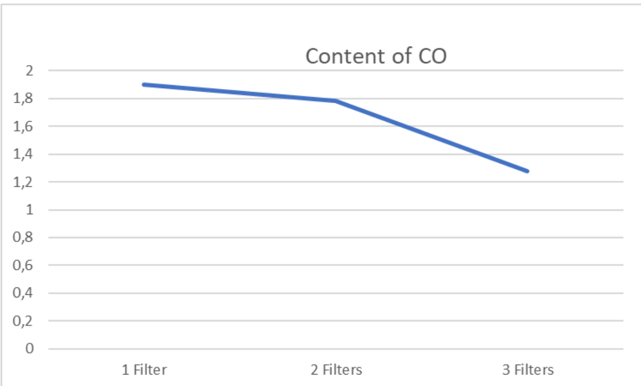


Figure 14 Number of filters-Content of CO (%)

From the graph above, it shows that the highest CO exhaust gas emission content was obtained in 1 filter, with a content of 1.9% and for 2 filters the data produced was 1.78% and for the lowest CO content, namely in 3 filters, it was 1.28%. The greater the number of filters, the lower the CO levels produced, meaning that the increase in the number of filters has an effect on the CO2 levels.

Content of CO2 exhaust emissions

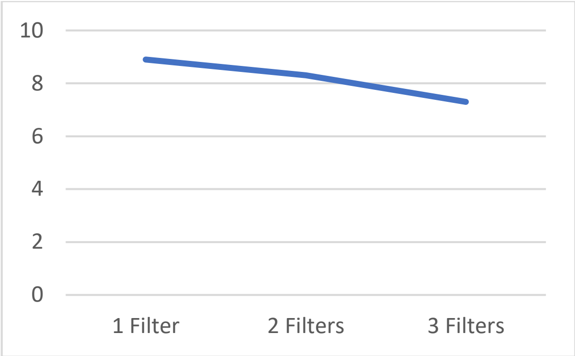


Figure 15 Number of filters-Content of CO_2 (%)

This graph shows that the CO2 content from exhaust gas emissions has the highest content in 3 filters at 8.90%, while for 2 filters it is 8.30% and the lowest content is in 1 filter at 7.30%. This graph shows that the best data is for 3 filter because CO2 can be filtered perfectly.

Content of HC exhaust emissions

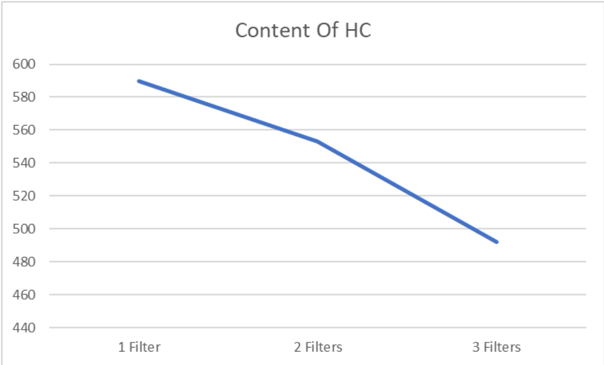


Figure 16 Number of filters-Content of HC (ppm)

Graph 4 shows the highest data obtained on 1 filter of 590 ppm, on 2 filters of 553 ppm, and on 3 filters of 492 ppm. Increasing the number of filters can reduce HC levels.

Content of O_2 exhaust emissions

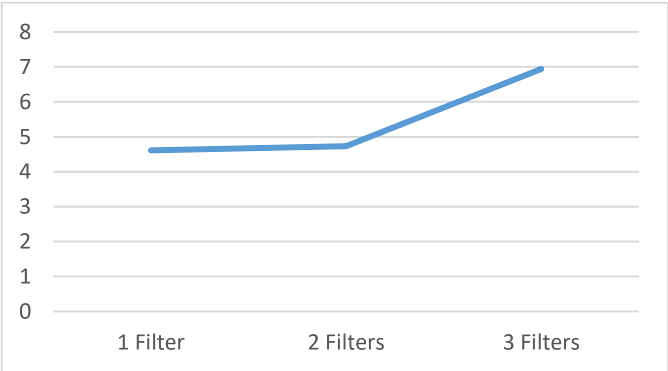
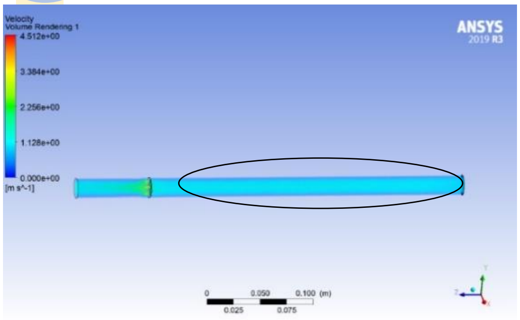
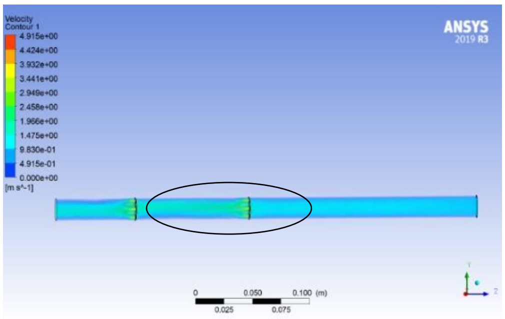


Figure 17 Number of filters-Content of O_2 (%)

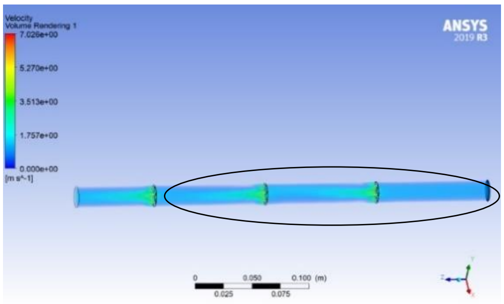
Graph 17 shows that 1 filter is 4.61% and 2 filters is 4.73% and 3 filters is 6.94%. Increasing the number of filters can increase O2 levels.



(a) Velocity 1 filter



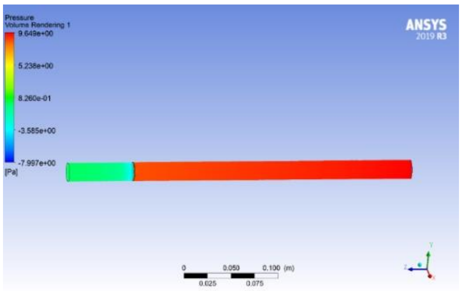
(b) Velocity 2 filters



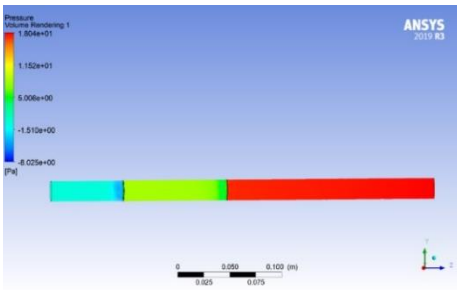
(c) Velocity 3 filters

Figure 18 Simulation results Velocity 1Filter, 2 Filters and 3 filters

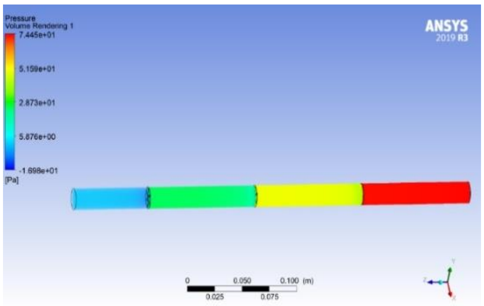
Simulation analysis of exhaust gas velocity for filter 1, filter 2, and filter 3. As seen in Figure 18 (a) the speed of the inlet side is 3.384 m/s, then in Figure 18 (b) the speed of the inlet side is 1.966 m/s, and in Figure 18 (c) the speed of the inlet side is 1.757 m/s. From the inlet speed data, it can be concluded that the more the number of filters, the lower the catalytic converter inlet speed.



a) 1 Filter



b) 2 Filters



c) 3 Filters

Figure 19 Simulation results Pressure 1Filter, 2 Filters and 3 filters

You can see in picture (a) the pressure on the inlet side is 9.64 Pascal and on the outlet side the value is -7.997 Pascal, then Figure 19 (b) the pressure on the inlet side is 18.04 and the pressure on the outlet side is -8.025 and in Figure 19 (c) the pressure on the inlet side is 7.445 and on the outlet side it is -16.98 Pascal. The use of filter number 3 is not recommended because on the outlet side, there is excessive back pressure, the value increases by 112.3% of the pressure of filter number 1. Excessive back pressure can reduce engine performance (see performance test results in Table 3).

Tabel 3 Velocity-Pressure

Catalytic	Velocity (m/s)	Pressure (Pascal)
1 Filter	4.51	9.65
2 Filters	4.91	18.04
3 Filters	7.02	74.45

4. CONCLUSION

a) The more filters there are in the exhaust, the lower the power produced
b) The presence of a filter on the catalytic converter has been proven to reduce levels of exhaust emissions that are harmful to the environment (CO, HC).
(c) Of the variations in the number of catalytic converters, filter number 2 is the best, the power produced is 9.71 hp with a CO emission level of 1.7% and HC 553 PPM

Based on the results of the Acceleration and Emission tests that have been carried out, the authors suggest several things, including;

a) Before performance testing, make sure the vehicle to be used is in good condition
b) When testing, don't forget to calibrate the tool before use.

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