Engineering of motorcycle exhaust gases to reduce air pollution

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Abstract. Air pollution from motor vehicle exhaust emissions is increasing, so it is necessary to attempt to control its exhaust emissions. Given the dangers of exhaust emissions, efforts need to be made to control and reduce air pollution so that negative impacts on people and the environment can be reduced. One engineering technology as a manifestation of vehicle emission control is engineering and modification of the exhaust gas channel. Engineering and modification are expected to be able to make a tool that will be able and function to reduce the danger of exhaust gases. The researcher will conduct experiments and manufacture of tools and initial testing on one motorized vehicle to see and observe the composition of the exhaust gas produced from the exhaust. The elements to be observed are CO values, HC values, and CO₂ values as comparative data. The tool that will be used to observe and see these elements is the Gas Analyzer tool. This tool is one instrument that is useful for measuring the portion and composition of a combined gas. From the results of testing and analysis obtained data on the exhaust emission test with an average engine speed of 500 rpm, and with the temperature of the exhaust tube 40 °C to 45 °C. After testing the standard exhaust model, then testing the engineering exhaust model which added 50 gr, 70 gr, and 90 gr scrap of stainless steel obtained the best conclusion to reduce and reduce the danger of exhaust emissions is engineered exhaust which added 70 g scrap of stainless steel and when compared to a standard exhaust, CO elements dropped to 71.09% and HC elements dropped to 48.26% and CO₂ elements dropped to 66.35%.

1. Introduction

Transportation today still uses fossil fuels as the main fuel, and the increasing use of oil-fueled vehicles, such as cars and motorbikes, results in increased levels of air pollution caused by exhaust emissions. Some types of emissions include Carbon Monoxide (CO), Hydrocarbon (HC), and Carbon Dioxide (CO₂) which has a bad impact on the health of the human body and erodes the ozone layer in the atmosphere [1]. High air pollution makes people and the world concerned, this makes people want alternative friendly and environmentally friendly transportation such as electric-powered motorized vehicles, but electric-powered vehicles in Indonesia are still not mass-produced, so the problem of air pollution caused by this exhaust gas is still not finished.

Given the dangers of exhaust emissions, efforts need to be made to control and reduce air pollution so that negative impacts on human beings can be reduced and minimized. In accordance with the Environment Sustainable Transportation (EST) program or better known as environmentally friendly transportation, there are 12 programs or approaches that can be carried out to reduce air pollution...
problems originating from the transportation sector, one of which is Vehicle Emissions Control which will be the focus of research studies. One engineering technology as a manifestation of Vehicle Emission Control is the modification of the exhaust gas channel [2].

This research will discuss the problems related to the manufacture of alternative tools for reducing exhaust gas in 100cc motorcycle vehicles. Tests were conducted to find the results of 100cc motor vehicle exhaust emissions with standard exhaust as comparable data. Testing is done to find the results of exhaust emissions of 100 cc motorized bicycle vehicles with an exhaust that has been added in the tool which is the result of engineering and modification.

Based on the orientation of the rotor rotation, the wind turbine is divided into two types namely horizontal and vertical axis. The horizontal axis of rotation is parallel to the direction of the wind, while the vertical axis is opposite to the direction of the wind. Horizontal axis-based axis lift, slim blade, and high rotational speed. The rotor-based vertical axis drag force, wide blade and low rotational speed. There are many technologies developed to reduce the number of air pollution sourced from vehicle exhaust gases. So far the use of Catalytic Converter is the best way to control vehicle exhaust emissions [3].

2. Theory
Exhaust gas emissions resulting from the combustion process in a vehicle engine is one source of air pollution. The resulting exhaust gas emissions are in the form of carbon monoxide (CO), carbon dioxide (CO$_2$), hydrocarbons (HC), and nitrogen oxides (NOx). Fuels generally contain elements of carbon, hydrogen, oxygen, nitrogen, and sulfur. In perfect combustion, exhaust gas from combustion results in the form of carbon dioxide (CO$_2$) and water (H$_2$O) and air that is not involved in combustion. But perfect combustion is difficult to achieve so that there are exhaust gases from other combustion products such as CO, HC, and also NOx because 79% of air for combustion consists of nitrogen. This allows the reduction of CO, HC, NOx and SO$_2$ levels. Catalytic converters are believed to be able to meet future emissions requirements and emissions regulations [4, 5].

2.1. Motor vehicle pollution sources
There are four sources of pollution originating from motorized vehicles, namely:
1. Exhaust pipe (exhaust) is the most important source (65-85%) and emits burning or unburned hydrocarbon (HC), various nitrogen oxide (NOx), carbon monoxide (CO) and alcoholic mixtures, aldehydes, ketones, phenols, acids, esters, ethers, epoxides, peroxides and other oxygen.
2. The oil bath is the second source (20%) and releases hydrocarbon (HC) that burns or not.
3. The fuel tank is a factor caused by hot weather with crude hydrocarbon evaporation losses (5%).
4. Carburetors are another factor, especially when driving in a position of congestion with hot weather, with evaporation losses and raw fuel (5-10%).

2.2. Calculating exhaust emissions
The formula below will be used for;

a. Average value when testing exhaust emissions;
   \[
   \text{Average value} = \frac{\text{Amount of Value}}{\text{Number of Data}} \quad (1)
   \]

b. Emission percentage;
   \[
   \text{Percentage of exhaust emissions} = \frac{\text{average emissions with scrap}}{\text{average emissions without a scrap}} \times 100 \% \quad (2)
   \]
c. Emission reduction percentage;
   \[
   \text{Emission reduction percentage} = 100\% - \text{emission percentage} \quad (3)
   \]

2.3. Impact of air pollution
Pollutants that are mainly found in the exhaust gases of motorized vehicles are carbon monoxide (CO), various hydrocarbon compounds, various oxides of nitrogen (NO$_x$) and sulfur (SO$_x$), and dust
particulates including lead (PB). Air pollution can be explained by 3 processes, namely (attrition, vaporization, and combustion) [6].

2.4. Exhaust line
The exhaust gas channel is not merely a function of delivering residual combustion. The exhaust gas channel is still one unit of the exhaust process. In this exhaust gas channel, the effects of turbulence are constantly maintained. With the exhaust line, the exhaust gas turbulence flow is changed to the piston driving force. Another function is the exhaust gas channel as a vibration damper. Vibration due to rising and falling of the piston from the cylinder head is forwarded to the exhaust body, frame, and chassis, so that engine vibration is not too much.

2.5. Exhaust parts
The following are parts of the exhaust on motorized vehicles:

1. Header: The header is the exhaust tip installed on the engine. The number of headers on the exhaust depends on how many cylinders the engine has. The main function of the header is to connect the entire exhaust system with the exhaust system owned by a motor vehicle.
2. Resonator: The second part of the exhaust is a resonator or commonly known as the exhaust filter. Many resonators are owned by motorized vehicles that function to process the noise produced by the results of engine firing.
3. Silencer: Silencer also has a function similar to a resonator, to help minimize the noise produced by the combustion of a motor vehicle.

2.6. Pertalite fuel oil
The fuel that will be used in this research is PERTALITE. The specifications owned by Peralite, the official PT. Pertamina is based on the decision of the Director General of Oil and Gas No.313.K/ 10/ DJM.T/ 2013 concerning the Standards and Quality of Gasoline Fuel 90 which is marketed domestically (Table 1).

| No. | Content                  | Information                  |
|-----|--------------------------|-------------------------------|
| 1.  | Octane levels            | 90 - 91                       |
| 2.  | Maximum sulfur content of| 0,05% m/m (equivalent to 500 ppm) |
| 3.  | Lead content             | There is no                  |
| 4.  | Metal content            | There is no                  |
| 5.  | Maximum residue          | 2.0%                         |
| 6.  | Specific gravity         | Maximum 770 kg/m³            |
|     |                          | Maximum 715 kg/m³ (at 15 °C) |
| 7.  | Visual appearance        | Clear and bright             |

3. Methods
The method begins with designing and drawing engineering techniques (Figure 1), then make modifications to the standard pot according to the design. Continued to test the exhaust emissions on the standard pot and on the engine pot, and make analysis and conclusions from experiments and research.
4. Research procedure
The study was conducted using experimental research methods with different treatment of gram or scrap weight variables (utilization of residual turning called gram or scrap to reduce exhaust emissions).

Tests and analysis of data on the exhaust emission test will be regulated by the dependent variable with an engine speed of ± 500 rpm, and with the temperature of the outer tube with 40 °C to 45 °C. After testing the standard model, then the engineering model that is added 50 gr, 70 gr, and 90 gr scrap of stainless steel (Figure 2 and 3) [8].

![Figure 1. Image of exhaust engineering (a), engineered exhaust and 3D modification (b).](image)

**Figure 1.** Image of exhaust engineering (a), engineered exhaust and 3D modification (b).

![Figure 2. Stainless steel scrap added to the engineering exhaust is weighed 50 gr, 70 gr, and 90 gr.](image)

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![Figure 3. Testing with a gas analyzer on the engineered exhaust is added to scrap stainless steel weighing 50 gr, 70 gr, and 90 gr.](image)

**Figure 3.** Testing with a gas analyzer on the engineered exhaust is added to scrap stainless steel weighing 50 gr, 70 gr, and 90 gr.
5. Results and discussion

The average value of the exhaust gas data obtained from standard exhaust testing, exhaust testing with 50 gr of added scraps, 70 gr of added scraps, and 90 gr of added scraps tabulated and put together, as can be seen in Table 2;

Table 2. Comparison data of waste gas emissions testing on the standard exhaust and on modified exhaust with additional stainless steel scrap.

| No. | Exhaust          | Engine rotation | Wind Speed | Exhaust gas | Exhaust tube temperature | CO  | HC  | CO₂  |
|-----|------------------|-----------------|------------|-------------|----------------------------|-----|-----|------|
| 1   | Standard         | 500             | 28         | 42.6        | 6.33                       | 513.3| 4.16|      |
| 2   | With scrap 50 gr | 500             | 23.8       | 40.7        | 3.66                       | 282 | 2.4 |      |
| 3   | With scrap 70 gr | 500             | 23.3       | 44.3        | 1.83                       | 265.6| 1.4 |      |
| 4   | With scrap 90 gr | 500             | 21.5       | 44          | 3.57                       | 335 | 2.7 |      |

By using Equation 1, Equations 2 and 3, the percentage of emissions is calculated as well as the percentage of emissions reductions that occur:

a. The decrease in the element of Carbon monoxide (CO) in exhaust emissions with a 50 gr and 70 gr scrap added exhaust decreased 42.18% to 71.09% but for the added scrap 90 gr of CO elements in exhaust emissions only dropped 43.60 %, as shown in Figure 4;

b. Decreasing the element of Hydro Carbon (HC) on exhaust gas emissions with 50 gr and 70 gr scrap added exhaust has decreased by 45.06% to 48.26% but for the added scrap 90 gr of HC element in exhaust emissions only decreased by 34.74 %, as shown in Figure 5;

c. The decrease in the element of carbon dioxide (CO₂) in exhaust gas emissions with scrap added 50 gr and 70 gr occurred a decrease of 42.31% to 66.35%, but for those who added scrap 90 grams of CO₂ elements in exhaust emissions only dropped 35, 10%, as shown in Figure 6;
6. Conclusion

From the results of testing and analysis of data on the exhaust emission test with an average engine speed of 500 rpm, and with the temperature of the outer tube, the 40 °C to 45 °C. After testing the standard exhaust model, then the engineering exhaust model which was added 50 gr, 70 gr, and 90 gr scrap of stainless steel was concluded; the best way to reduce and reduce the danger of exhaust emissions is engineered exhaust which added 70 gr of stainless steel scrap. And when compared to a standard exhaust, CO elements dropped to 71.09% and HC elements dropped to 48.26% and CO₂ elements dropped to 66.35%.

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