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# The Effect of adding aluminum scrap to motor vehicle mufflers to reduce the danger of exhaust emissions

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**Abstract**
Air pollution due to motor vehicle exhaust emissions is increased. Polluted air harms human health dan the environment. Consequently, it is essential to make a sustained effort to reduce air pollution. The purpose of this research is to investigate the effect of adding aluminum scrap to the exhaust system of a motor vehicle on gas emissions composition. The motor vehicle exhaust system was modified to accommodate aluminum scrap placement. A gas analyzer was utilized to observe exhaust gas composition, such as carbon dioxide, hydrocarbon, and carbon monoxide. Aluminum scrap with different masses was wrapped around the exhaust's inner tube in 50 gr, 70 gr and 90 gr. The engine speed was maintained at 500 rpm throughout the testing process. It was found that the temperature of the outer exhaust tube is in a range of 40 degrees Celsius to 50 degrees Celsius. The results revealed that the most appropriate amount of aluminum scrap was 90 gr n to reduce carbon monoxide, hydrocarbon, and carbon dioxide in an exhausts gas. The surprising outcome was 76.78 % of carbon monoxide content declined, and furthermore hydrocarbon, and carbon dioxide content were deteriorated by 61.63% and 78.37%, respectively.

**Keywords:**
Air Pollution, Motor Vehicles, Gas Analyzer, Aluminum, Exhaust

## 1 Introduction

Fossil fuel is still the main energy resource in most modes of transportation. The growing use of vehicles like cars and motorcycles is a key role in increasing air pollution caused by exhaust emission gas. Some of the emission components such as carbon monoxide (CO), hydrocarbon (HC), and carbon dioxide (CO2) give a negative effect on human health and are responsible for ozone depletion in the atmosphere. High air pollution is one of the most environmental issues in the world. Consequently, environmentally friendly transportation become more attractive for example electric vehicles. Unfortunately, electric vehicle has not reached a mass production stage in Indonesia at the moment and this air pollution problem still remains [1][2].

Air pollution caused by exhaust gas is considered a serious crime. This crime is an environmental crime that has a huge, long term and continuous impact. People do not aware of the effect of vehicle pollutant directly as the result, vehicle user does not realize the loss suffered. They are the victim. The victim and suspect are the same people. This is called a crime without a victim [3].

Considering the dangers of exhaust gas emission, some serious effort is needed to control and reduce air pollution to minimize its negative effect on a human. According to Environment Sustainable Transportation (EST) program well known as environment-friendly transportation has twelve programs or approaches that can be performed to decrease air pollution caused by the transportation sector. One of the programs is vehicle emissions control which becomes the focus of this research. Exhaust gas tube modification is a part of vehicle emission control [4][5].

Exhaust gas emission tests were carried out using stainless steel scrap. The engine speed was set up to 500 rpm resulting in 40 degrees Celsius to 50 degrees Celsius on the outside tube surface. Stainless steel scrap in the amount of 50 gr, and 79 gr results revealed that the best amount of stainless-steel scrap was 70 g in reducing exhaust gas pollutant number. Compared to the original tailpipe, there were 71.09%, 48.26%, and 66.35% of CO, HC, and CO2 amount loss, respectively [6][7].

The application of a copper catalytic converter with a honeycomb surface shape is able to reduce exhaust gas emission levels on motorcycles. The highest decrease in CO value was at 4000 rpm with a difference of 1.76%, for the highest decrease in HC value occurred at 4000 rpm with 73 ppm. While the decline for the highest CO2 value occurred at a 2000 rpm engine speed of 3.3%. The decline in the value of exhaust gases will help and reduce air pollution from motorcycle exhaust gases [8].

This study emphasizes on creating alternative equipment to reduce exhaust gas pollutants on a 100cc motorcycle. A modified tailpipe is applied and wrapped with aluminum scrap around the inside tube and normal tailpipe is also tested for benchmarking the results.

The aim of this research is to investigate the effect of aluminum scrap wrapped around inside tailpipe on exhaust gas pollutant *content* level of 100c motor cycle. It is expected this research can be valuable in providing an alternative equipment which can be attached to tailpipe to reduce exhaust gas pollutant. Expectantly, the outcome of this research contributes in supporting government to achieve a satisfactory Air Quality Index (AQI).

## 2 Methodology

Here are four pollution resource from vehicle i.e.

1. Tailpipe is the main resource of pollutant (65-85%) and emit burnt or unburnt hydro carbon, variety of nitrogen oxide (NOx), carbon monoxide dan alcohol mixture such as aldehyde, ketone, phenol, ester, ether, epoxide, peroxide and oxygen.
2. Engine oil pan is the second resource (20%) and produce burnt and unburnt hydrocarbon
3. Fuel tank become resource of pollutant due to exposed to hot weather that lead to evaporate raw hydrocarbon (5%).
4. Carburetor is also resource of pollutant due to evaporation of fuel during traffic jam in hot weather (5-10%)

### 2.1 Effect of Air Pollution

The major pollutant in exhaust gas emission is carbon monoxide, variety of hydrocarbon compounds, nitrogen oxides (NOx), Sulphur (SOx), dust particulate including plumbum (Pb). Air pollution can be explained into three process i.e. attrition, vaporization and combustion [9][10][11][12].

Table 1. The effect exhaust gas emission to human health [13]

| Pollutant | Effect |
|---|---|
| CO | Disturbing concentration and body reflex, sleep disorder, deteriorate cardiovascular disease due to lack of oxygen. CO bind hemoglobin hence number of oxygen in the blood is reduced. |
| CO2 | Increase lung disease risk and trigger cough |
| HC | Initiate eye irritation, cough, sleep disorder, skin spots and genetic code alteration. Improving total in mortality, cardiovascular disease, asthma and chronic lung disease |

## 2.2 Tailpipe

Tailpipe is not only for discharging combustion residue but as a part of exhaust stroke. Turbulence effect is maintained in tailpipe continuously. Exhaust gas turbulence flow is utilized to push back piston. Another function of tailpipe is to absorb vibration as a result of reciprocating motion of piston and the vibration is transferred to chassis hence engine vibration is diminished.

## 2.3 Tailpipe part

Tailpipe of vehicle, in general, consist of [14];

1. Header
   Header is beginning part of tailpipe attached to engine. Number of a header is depend on the number of engine cylinder. Main purpose of header is to connect all tailpipe system to exhaust system of a vehicle.
2. Resonator
   Resonator is also known as tailpipe filter. The use of resonator is to reduce noise emission from engine combustion process.
3. Silencer
   Silencer has similar function with resonator to decrease noise produced by combustion process in the cylinder.

## 2.4 Exhaust gas emission calculation

The following equation is applied throughout this work [6] and Mean value, percentage emission and percentage of emission degrade exhaust gas emission eq. (1)-(3):

$$Mean\ Value = \frac{Value}{Number\ of\ data\ value} \quad (1)$$

$$Percentage\ emission = \frac{Mean\ emission\ with\ catalyst}{Mean\ emission\ without\ catalyst} \quad (2)$$

$$\text{Percentage of emission degradation} = 100\% - Percentage\ emission \quad (3)$$

## 2.5 Pertalite fuel

Pertalite is utilized in this work. Official specification of pertalite is published by Pertamina Ltd according to decision letter of General Directorate of Oil and Gas number: 313.K/10/DJM.T/2013 about fuel standard and quality of Bensin 90 for domestic market (Table 2).

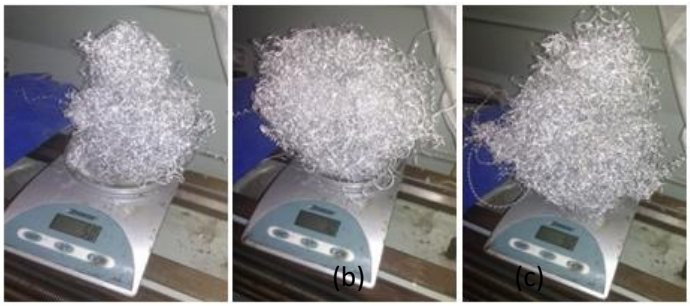
Table 2. Pertalite fuel specification [15]

| No, | Content | Description |
|---|---|---|
| 1. | Octane number | 90 - 91 |
| 2. | Maximum Sulphur | 0.05% m/m (equals to 500 ppm) |
| 3. | Lead | none |
| 4. | Metal | none |
| 5. | Maximum residue | 2,0% |
| 6. | Density | 715 kg/m$^3$- 770 kg/m$^3$ (at 15 ˚C) |
| 7. | Visual appearance | Clear dan bright |

The work was start with designing and drawing the modified tailpipe and produced it, accordingly. Emission test was then carried on original and modified tailpipe. All the necessary data was taken to be analyzed and conclusion was generated at the end. Tailpipe design is depicted on Fig 1 and Fig 2.

## 2.6 Method

This work based on experimental with mass of aluminum scrap as variable parameter. Aluminum scrap was taken from lathe work waste. Testing was performed at speed of motor cycle engine of 500 rpm. The measured temperature on the outside outer tube was 40 to 50 degrees Celsius.




(a) (b) (c)

Fig 3. Aluminum scrap was weighing to a.50gr, b.70gr and c.90g

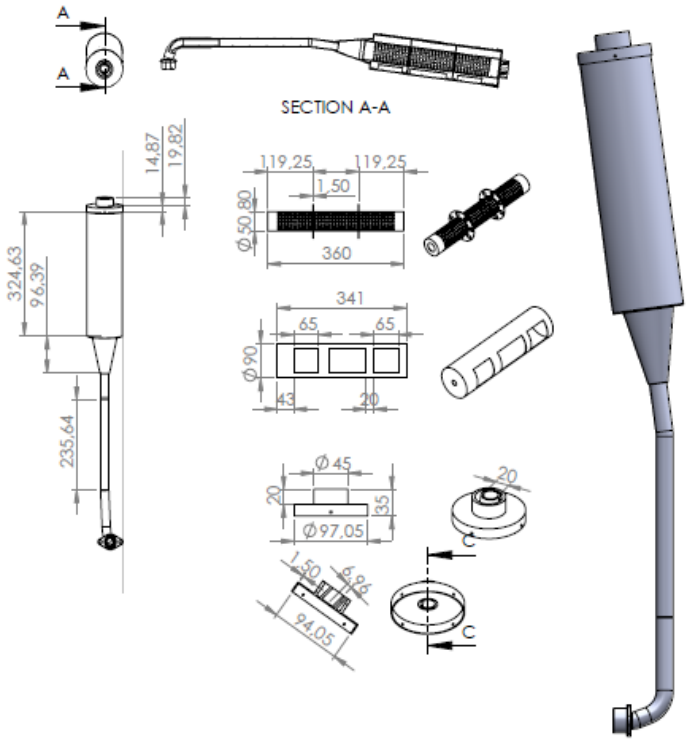



Fig 1. Modified tailpipe

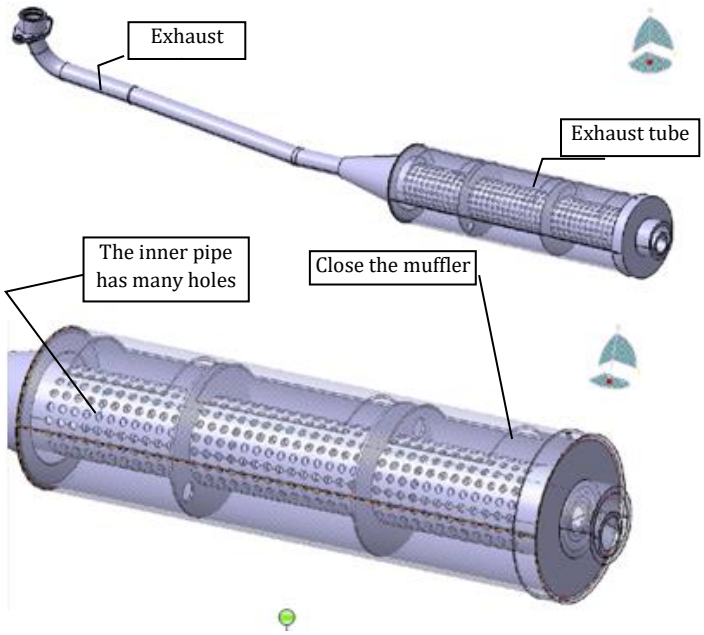



Fig 2. Modified tailpipe in 3D

Fig 4. Testing tailpipe using gas analyzer

## 3 Results And discussion

Experiment data results is presented on Table.3 for standard (original) tailpipe without any aluminium scrap added and modified tailpipe wrapped around with variation mass of aluminium scrap.Results n percentage were determined using eq.(1,) (2) and (3).

1. CO pollutant content measured from standard tailpipe was 6.33 %. It was found that there 70.77% CO content reduction when the modified tailpipe wrapped around with 50 g of aluminum scrap.

Table 3. Experiment data results of exhaust gas emission flowed through standard

| Number | Tailpipe | Engine speed | Exhaust gas flow rate | Pollutant Content | | | Tailpipe Outer tube temperature |
|---|---|---|---|---|---|---|---|
| | | | | CO | HC | $CO_2$ | |
| | | rpm | m/s | % | ppm | % | $^0C$ |
| 1 | Standard | 500 | 28 | 6.33 | 513.3 | 4.16 | 42.6 |
| 2 | Modified and 50 g Al added | 506 | 21.1 | 1.85 | 185 | 1.1 | 43.6 |
| 3 | Modified and 70 g Al added | 504 | 20.7 | 1.61 | 185 | 0.96 | 45 |
| 4 | Modified and 90 g Al added | 504 | 20.6 | 1.47 | 197 | 0.9 | 45.7 |

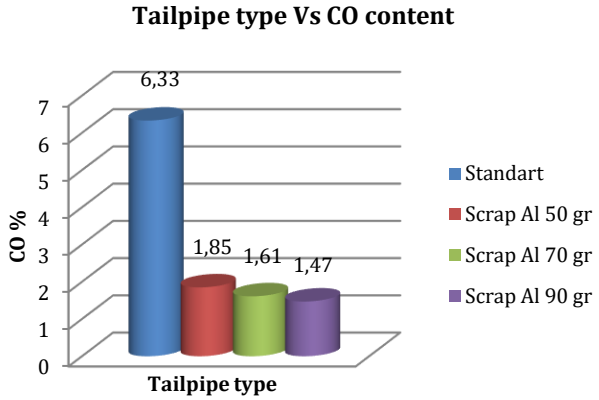



Fig 5. Tailpipe type vs CO

Whereas 70% CO reduction detected with addition of 70 g of aluminum and about 76.76% reduction with 90 g aluminum added to the tailpipe.Fig 5 described content percentage of CO according to testing results, CO pollutant can be declined because it reduced due to oxidation by aluminum scrap inside the tailpipe.

2. The decrease of HC in exhaust gas emission is 63.96% as a result of 50 g aluminum addition and identical result also showed for 70 g of aluminum addition. Initial content of HC was 513.3 ppm and because of the addition of 90 g aluminum scrap equipped with 50 g and 70 g of aluminum scrap. Fig 6 illustrate tailpipe type vs HC content graph. the number is plunged to 197 ppm. Interestingly, with 90 g aluminum, HC content is a slightly higher than tailpipe equipped with 50 g and 70 g of aluminum scrap. Fig. 6 illustrate Tailpipe type vs HC content graph

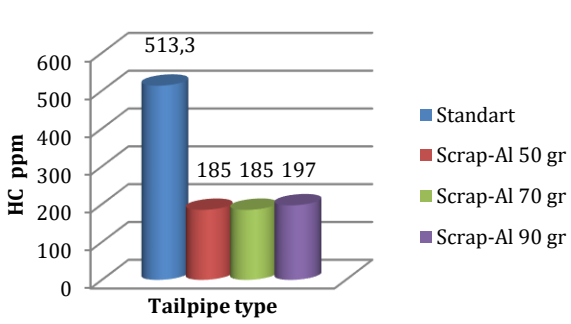



Fig 6. Tailpipe type vs HC content graph

It is also found that HC content could be reduced because of oxidation process inside of tailpipe assisted by aluminum scrap.

3. Similar trend of results exposed in this section in term of $CO_2$ content. There was 73.56% decline of $CO_2$ content caused by the presence of 50 g aluminum scrap. Furthermore, 76.93% and 78.37% reduction occurred by means of the existence of 70 g and 90 g of aluminum scrap, accordingly. The correlation between the aluminum scrap (tailpipe type) vs $CO_2$ content is depicted in Fig 7.

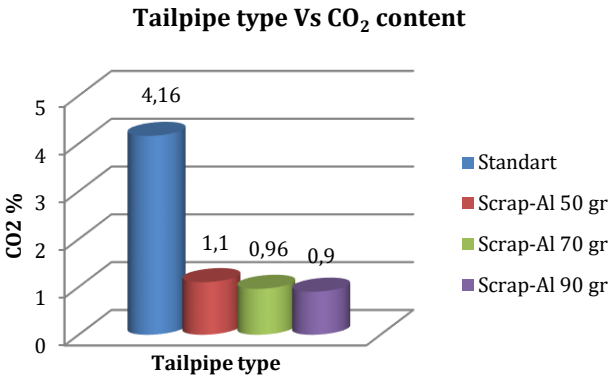



Fig 7. Tailpipe type vs $CO_2$

It is not surprise that $CO_2$ content was taken to lower number thanks to aluminum scrap that promote oxidation process inside of tailpipe.

## 4 Conclusions

The results discovered that addition of 90 g aluminium scrap is the best amount to be introduced into tailpipe system to decline the content of pollutant in exhaust gas emission of motorcycle. Comparison can be provided between pollutant content in exhaust gas emission from standard and modified tailpipe with the presence of 90 g aluminium scrap around inner tube. CO compound reduction was attained at 76.78% and final content was only 1.47. Similarly, it was 61.63% for HC component with 197 ppm still remain. Finally, in case of $CO_2$, there was reduction in 78.73% which made 0.9% of $CO_2$ compound persist in the exhaust gas.

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