UTILIZATION AND EXPERIMENTAL USE OF STAINLESS STEEL METAL SCRAP MACHINERY WASTE, ST-40 IRON, COPPER AND ALUMINUM TO REDUCE CO, HC, CO2 ELEMENTS IN VEHICLE EXHAUST

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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*

Abstrak

Pencemaran udara dari emisi gas buang kendaraan bermotor semakin meningkat, sehingga perlu upaya pengendalian emisi gas buang yang dihasilkan kendaraan bermotor. Mengingat bahaya emisi gas buang, maka perlu usaha-usaha untuk mengendalikan dan mengurangi pencemaran udara agar dampak negatif bagi manuisa dan lingkungan dapat dikurangi. Salah satu teknologi rekayasa sebagai wujud dari kontrol emisi kendaraan adalah merekayasa dan modifikasi saluran gas buang. Tujuan penelitian ini adalah merekayasa dan melakukan modifikasi alat yang akan mampu dan berfungsi untuk mereduksi bahaya gas buang. Peneliti akan melakukan eksperimen dan pembuatan alat serta pengujian awal pada satu kendaraan bermotor untuk melihat dan mengamati komposisi gas buang yang dihasilkan dari knalpot standart. Unsur yang akan diamati adalah nilai CO, nilai HC, dan nilai CO2 sebagai data pembanding yang di uji pada knalpot modifikasi. Alat yang akan digunakan untuk mengamati dan melihat unsur-unsur tersebut adalah alat Gas Analyzer. Dari hasil pengujian dan analisa didapat data pada uji emisi gas buang dengan putaran mesin rata-rata 500 rpm, dan dengan suhu tabung luar knalpot 40 ^{0}C hingga 50 ^{0}C. Setelah pengujian model knalpot standart, kemudian pengujian model knalpot modifikasi yang ditambahkan 50 gr, 70 gr, dan 90 gr skrap dari stainlis steel, scrap besi ST 40, skrap tembaga, dan scrap aluminium hasil limbah dan diperoleh kesimpulan yang paling baik untuk menurunkan dan mengurangi bahaya emisi gas buang adalah knalpot inovasi yang ditambahkan 90 gr skrap Aluminium. Dan jika dibandingkan dengan knalpot standar, unsur CO turun hingga 76,78% dan unsur HC turun hingga 61,63% serta unsur CO2 turun hingga 78,37%.

Kata kunci: Polusi Udara, Kendaraan Bermotor, Gas Analyzer, Aluminium, Knalpot

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 (Tampubolon, Purwanto, and Setyoko 2020)(Sulistyono 2012).

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 (Gusnita 2016).

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 (Irawan 2012)(Umar et al. 2021).

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 (A. M. Siregar and Siregar 2019)(A. M. Siregar, Siregar, and Yani 2020).

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 (M. A. Siregar et al. 2019).

This study emphasizes on creating alternative equipment to reduce exhaust gas pollutants on a 100 cc 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).

There 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%)

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 (Alimsardjono et al. 1997)(Mokhtar 2014)(Abidin and Hasibuan 2019)(Sengkey, Jansen, and Wallah 2011).

Table 1. The effect exhaust gas emission to human health (Gunawan and Budi 2017)

Pollutant	Effect
CO (Carbon Monoxide)	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 (Carbon Dioxide)	Increase lung disease risk and trigger cough

Pollutant	Effect
HC (Hydrocarbon)	Initiate eye irritation, cough, sleep disorder, skin spots and genetic code alteration. Improving total in mortality, cardiovascular disease, asthma and chronic lung disease

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.

Tailpipe part

Tailpipe of vehicle, in general, consist of (Sanata 2011);

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.

Exhaust gas emission calculation

The following equation is applied throughout this work (A. M. Siregar and Siregar 2019);

Mean value exhaust gas emission ;

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

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

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

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 Figure 1 and Figure 2.

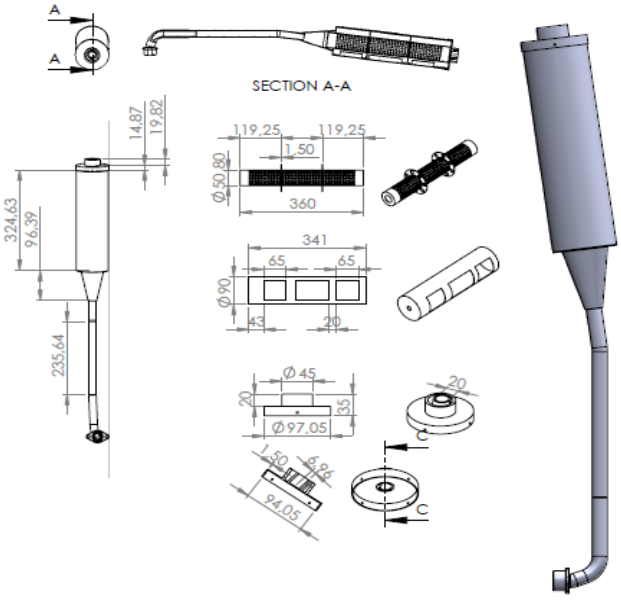

Figure 1. Modified tailpipe

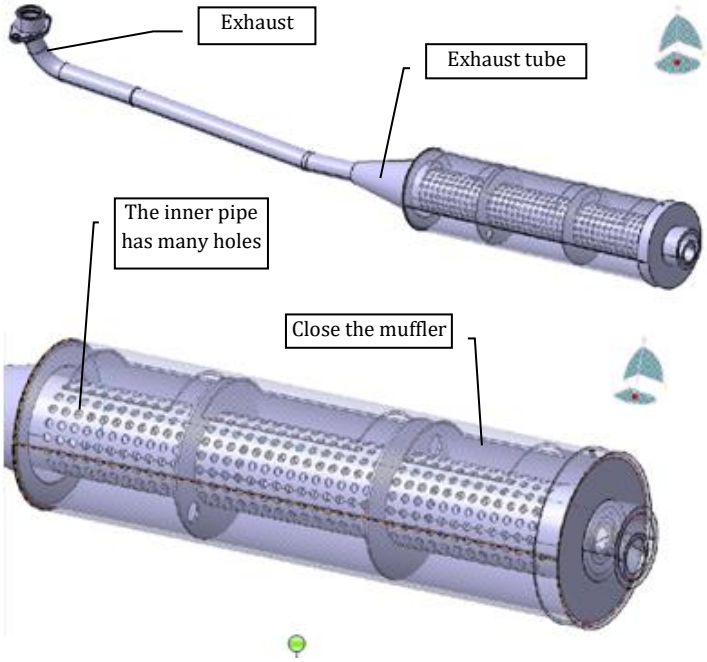

Figure 2. Modified tailpipe in 3D

METHODOLOGY

This research is based on experiments with the mass of aluminum pieces as a variable parameter. Stainless Steel Scrap, St-40 Iron, Copper and Aluminum are taken from lathe work waste. The test was carried out at a motorbike engine speed of 500 rpm. The measured temperature on the outer outer tube is 40 to 50 degrees Celsius. The original exhaust was tested to obtain baseline data. Next, the modified exhaust was tested with pieces of Stainless Steel, St-40 Iron, Copper and Aluminum installed on the inside with masses of 50 g, 70 g and 90 g.

Figure 3. Stainless steel scrap was weighing to 50 g, 70 g and 90 g.

Figure 4. St-40 Iron scrap was weighing to 50 g, 70 g and 90 g

Figure 5. Copper scrap was weighing to 50 g, 70 g and 90 g

Figure 6. Aluminum scrap was weighing to 50 g, 70 g and 90 g.

Figure 7. Testing tailpipe using gas analyzer

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. Pertalite fuel specification (Silvia, Munthe, and Diniaty n.d.)

Number	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	Max 770 kg/m^3 Min 715 kg/m^3 (at 15 $^{\circ}$C)
7.	Visual appearance	Clear dan bright

RESULTS AND DISCUSSION

The experimental data are presented in the following four tables for standard (original) exhaust pipes without the addition of scrap and modified exhaust pipes which were added with variations in the mass of scrap pieces of Stainless Steel, St-40 Iron, Copper and aluminum.

Table 3. Exhaust gas emission experiment data is channeled through standard and modified exhausts with stainless steel scrap

Nu	Tailpipe	Engine speed	Pollutant Content		
			CO	HC	CO_2
		rpm	%	ppm	%
1	Standard	500	6.33	513.3	4.16
2	Modified and 50 g Stailess steel added	500	3.66	282	2.4
3	Modified and 70 g Stailess steel added	500	1.83	265.6	1.4
4	Modified and 90 g Stailess steel added	500	3.57	335	2.7

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 40^0C to 45^0C. 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 element decreases by 71.09% and the HC element decreases by 48.26% and the CO2 element decreases by 66.35%.

Table 4. Exhaust gas emission experiment data is channeled through standard and modified exhausts with ST-40 iron scrap

Nu	Tailpipe	Engine speed	Pollutant Content		
			CO	HC	CO_2
		rpm	%	ppm	%
1	Standard	500	6.33	513.3	4.16
2	Modified and 50 g ST-40 iron added	506	1.86	216.3	1.13
3	Modified and 70 g ST-40 iron added	504	1.99	207.3	1.20
4	Modified and 90 g ST-40 iron added	504	1.75	212	1.07

From the test and analysis results obtained data on the exhaust emission test with an average engine speed of 500 rpm, and with an exhaust outer tube temperature of 40 0C to 45 0C. After testing the standard exhaust model, then testing the engineered exhaust model which added 50 gr, 70 gr, and 90 gr scrap from ST-40 iron, it was obtained that the best conclusion to reduce and the danger of exhaust gas emissions was engineering exhaust added 90 gr scrap from iron ST-40. And when compared to a standard exhaust, the CO element drops to 72.35% and the HC element drops to 58.70%, and the CO2 element drops to 74.28%.

Table 5. Exhaust gas emission experiment data is channeled through standard and modified exhausts with copper scrap

Nu	Tailpipe	Engine speed	Pollutant Content		
			CO	HC	CO_2
		rpm	%	ppm	%
1	Standard	500	6.33	513.3	4.16
2	Modified and 50 g copper added	506	2.52	258	1.7
3	Modified and 70 g copper added	504	2.34	315.6	1.53
4	Modified and 90 g copper added	504	1.79	198.6	1.06

From the test results and data analysis on exhaust emission tests with an average engine speed of 500 rpm, and with an exhaust tube temperature of 40 ^{0}C to 45 ^{0}C. After testing the standard exhaust model, then the innovative exhaust model which added 50 gr, 70 gr, and 90 gr of copper scrap was concluded. The best way to reduce and reduce the danger of exhaust emissions is the exhaust innovation which added 90 grams of copper scrap. And when compared to standard exhaust, CO elements are reduced by 71.72% and HC elements are reduced to 61.31% and CO2 elements are reduced to 74.52%.

Table 6. Exhaust gas emission experiment data is channeled through standard and modified exhausts with aluminum scrap

Nu	Tailpipe	Engine speed	Pollutant Content		
			CO	HC	CO_2
		rpm	%	ppm	%
1	Standard	500	6.33	513.3	4.16
2	Modified and 50 g Al added	506	1.85	185	1.1

Nu	Tailpipe	Engine speed	Pollutant Content		
			CO	HC	CO_2
		rpm	%	ppm	%
3	Modified and 70 g Al added	504	1.61	185	0.96
4	Modified and 90 g Al added	504	1.47	197	0.9

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 CO2, there was reduction in 78.73% which made 0.9% of CO2 compound persist in the exhaust gas.

The content of dangerous exhaust gases with this experiment can be reduced by modifying the exhaust and adding 4 types of iron scrap. In these four experiments the exhaust gas underwent a good reduction and oxidation process so that exhaust gas emissions could be reduced. In the future, air pollution caused by exhaust gas will also be reduced.

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 CO2, there was reduction in 78.73% which made 0.9% of CO2 compound persist in the exhaust gas. Because the best is 90gram aluminum scrap, it is recommended that the inner exhaust tube be modified from aluminum.

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