DESIGN INNVOVATION OF MOTORCYCLE MUFFLER BY APPLYING CATALYTIC CONVERTER BASED ON NON-NOBLE MATERIAL TO REDUCE EXHAUST EMISSION

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Abstract- Exhaust emissions from vehicles is one of the main sources of air pollution. The most effective technology to reduce emissions of Carbon Monoxide (CO) and Hydrocarbon (HC) is the application of the catalytic converter in the exhaust system of the motorcycle muffler. The commonly used catalysts are noble materials such as Palladium, Platinum, and Rhodium. In this study, Copper-Zinc (CuZn) and Copper (Cu) material has been selected as catalyst because it has high activity in the exhaust system, low cost production, the availability is abundant, and operated at a lower temperature than the noble material. Measurements of exhaust emission were carried out at 2000 and 2500 rpm using gas analyzer. Design innovation of CuZn and Cu catalyst were a cylindrical shape with 6.6 cm of length; 2.4 cm of diameter and 10 tubes in the inner of the cylinder. The purpose of this research was to compare the performance of two different types of catalyst. The research results showed that CuZn catalyst was effective to decrease CO emission up to 47.71% in 2000 rpm, while HC emission decreased up to 55.34% in 2500 rpm. Cu catalyst was effective to decrease of CO emission up to 46.61% in 2000 rpm, while HC emission decreased up to 47.13% in 2500. Copper-Zinc catalyst can reduce of CO and HC emission higher than Cu catalyst. Overall, CuZn and Cu catalyst has given a good performance due in accordance with regulation from Ministry of Environment in Indonesia No. 5 Th. 2006 about exhaust emission standard of old motor vehicle. Therefore, CuZn and Cu catalyst based on non-noble material has been considered as a prospective catalyst to reduce emission of CO and HC.

Keywords- catalytic converter, exhaust emissions, non-noble material

I. INTRODUCTION

Exhaust emissions from vehicles is one of the main sources of air pollution. Data from the Ministry of Environment says that air pollution from motor vehicles, especially premium fuel (spark ignition engines) is 70% of carbon monoxide (CO) and 60% of hydrocarbon (HC). Gas emissions of carbon monoxide and hydrocarbon are toxic and harmful to the environment and human health.

The most effective technology to reduce emissions of Carbon Monoxide (CO) and Hydrocarbon (HC) is the application of the catalytic converter in the exhaust system of the motorcycle muffler. The catalytic converter is one of the alternative technologies to reduce the emission of pollutants from motor vehicles, especially gasoline-fueled engine [1]. The function of a catalytic converter is oxidizing of carbon monoxide and hydrocarbon emissions quickly. The aim of catalytic converter installation in the exhaust system of motorcycle muffler is to convert harmful pollutants such as carbon monoxide and hydrocarbon into harmless gases such as carbon dioxide (CO_2) and water vapor (H_2O) through a chemical reaction as shown in equation 1 for carbon monoxide and equation 2 for hydrocarbon [2].

$2CO + O_2 \rightarrow 2\ CO_2$ ..... (1)

$HC + O_2 \rightarrow CO_2 + H_2O$ ..... (2)

The commonly used catalysts are noble materials such as Palladium, Platinum, and Rhodium in the form of a honeycomb monolith support frame which has a large specific surface area [3]. But, the price of the noble material is relatively expensive, the availability is scarce, and operated at high temperature, so it is necessary to study non-noble materials to overcome such limitations.

Transition metal with a high abundance and relatively inexpensive price can be one of the alternatives as the catalytic converter [4]. Copper-Zinc (CuZn) and Copper (Cu) material has been selected as catalyst because it has high activity in the exhaust system, low cost production, the availability is abundant, and operated at a lower temperature than the noble material.

II. DETAILS EXPERIMENTAL

Measurements of exhaust emission were carried out at 2000 and 2500 rpm using gas analyzer. The conversion efficiency of CO and HC emission was decreased in accordance with distance position of catalytic converter from exhaust manifold [5]. Therefore, the catalytic converter was located about 45 cm from exhaust manifold of motorcycle.
The purpose of this research was to compare the performance of two different types of catalyst.

1. Preparation of Catalyst

Design innovation of Copper-Zinc (CuZn) metal as a catalyst was a cylindrical shape with 6.6 cm of length; 2.4 cm of diameter and 10 tubes in the inner of the cylinder (Fig 1), while design innovation of Copper (Cu) metal as a catalyst was a cylindrical

shape with 6.6 cm of length; 2.2 cm of diameter and 8 tubes in the inner of the cylinder (Fig 2).



Fig 1. Design of CuZn catalyst



Fig 2. Design of Cu catalyst

2. Preparation of Motorcycle Muffler

In this study, motorcycle muffler of Honda Supra Fit 2004 was an controlled object which its muffler has been modified by adding copper-zinc and copper metal as a catalyst. The scheme of standard motorcycle muffler shown in figure 3.

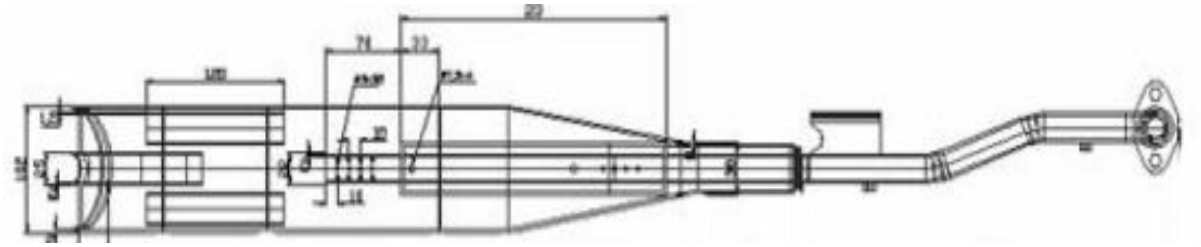


Fig 3. Scheme of standard motorcycle muffler

3. Calibration of Gas Analyzer

Calibration of gas analyzer was done when the engine on the working condition. The calibration was automatically done by the gas analyzer. The gas analyzer shown in figure 4.



Fig 4. Gas analyzer

4. Emission Test

Emission test was conducted to determine the amount of exhaust emission from motorcycle muffler. Measurements of exhaust emission were carried out at 2000 and 2500 rpm using gas analyzer. According to test procedure as shown in figure 5.

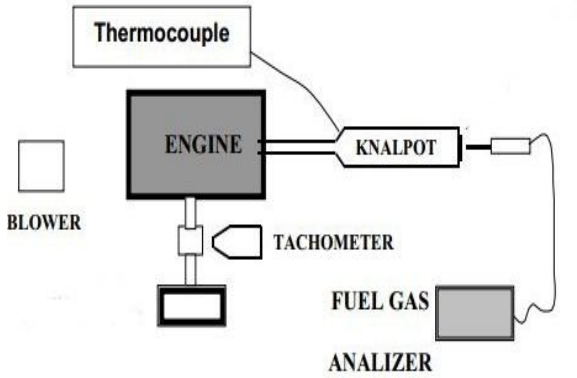


Fig 5. Scheme of emission test process

III. RESULTS AND DISCUSSION

The research results showed that CuZn catalyst was effective to decrease CO emission up to 47.71% in 2000 rpm, while HC emission decreased up to 55.34% in 2500 rpm. Cu catalyst was effective to decrease of CO emission up to 46.61% in 2000, while HC emission decreased up to 47.13% in 2500 rpm as shown in table 1.

Table 1. Result of percentage reduction CO and HC emissions

Type of catalyst	Speed of machine 2000 rpm		Speed of machine 2500 rpm	
	CO (%vol)	HC (ppm vol)	CO (%vol)	HC (ppm vol)
Without catalyst	6.495	1564.11	7.679	1241.78
Copper-Zinc catalyst	2.296	925.78	4.695	554.56
Percentage (%)	**47.71**	**40.81**	**38.86**	**55.34**
Without catalyst	6.495	1564.11	7.679	1241.78
Copper catalyst	3.468	836.11	4.72	656.56
Percentage (%)	**46.61**	**46.54**	**38.53**	**47.13**

Based on the regulation from Ministry of Environmen about exhaust emission standard of old motor vehicle, the levels of CO and HC were allowed on 5,5% and 2400 rpm at idle condition, respectively.

3.1. Effect of Catalyst toward CO Concentration

The speed of machine on the engine rotation depends on fuel combustion processes. Figure 6 shows that speed of vehicle is slow at low engine speed (2000 rpm), hence the CO content in the ambient air has a low concentration. The concentration of CO from the exhaust system used catalyst is lower than without the catalyst. Therefore, applying CuZn and Cu catalyst as a catalytic converter can reduce the emission of CO from the exhaust gas, so the levels of CO are below the quality standard of national regulation from Ministry of Environment.

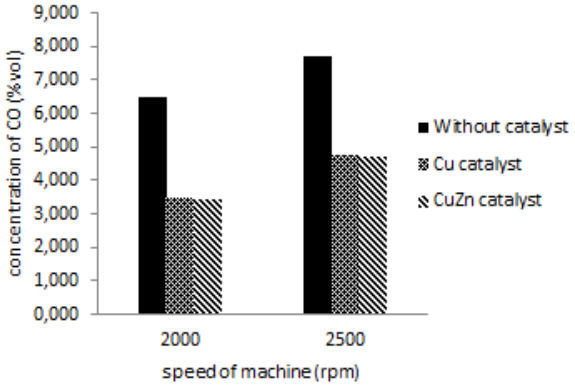


Fig 6. The effect of catalyst toward CO concentration

3.2. Effect of Catalyst toward HC Concentration

Fig 7 shows a decrease of emissions in line with the increase in engine rotation. This happens because the temperature of exhaust system rising, therefore the rate of oxidation reaction of hydrocarbon on the catalytic converter become faster.

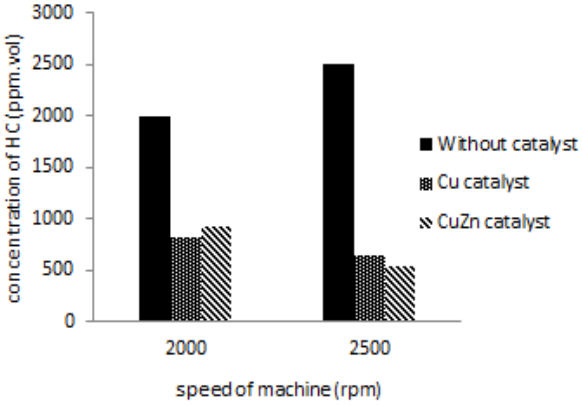


Fig 7. The effect of catalyst toward HC concentration

3.3. Effect of Catalyst toward CO_2 Concentration

The lowest speed of machine (2000 rpm) produces exhaust gas with the lowest CO_2 level. On the reaction of complete combustion, the CO_2 will be formed along with water vapor. While the incomplete combustion of CO gas will be formed thus reducing the concentration of CO_2. The addition of the catalyst will increase the concentration of CO_2 as shown in figure 8.

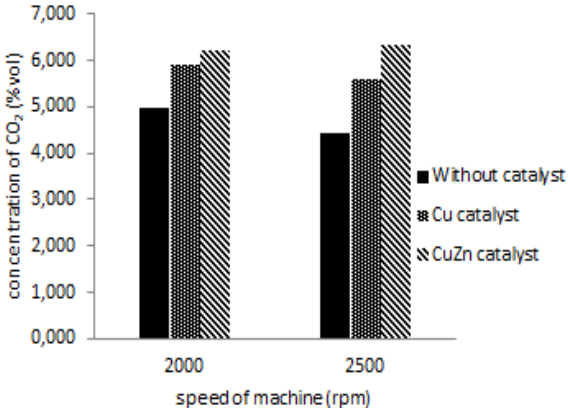


Fig 8. The effect of catalyst toward CO_2 concentration

3.4. Effect of Catalyst toward O_2 Concentration

O_2 gas in the combustion process is not toxic emissions. The amount of O_2 formed show presentation of combustion air, which useless in the combustion process. Figure 9 shows a comparison between the presentation of the O_2 concentration in the exhaust standard (without catalyst) toward exhaust using CuZn and Cu catalyst. The concentration of oxygen (O_2) in the exhaust gases of vehicle is inversely proportional to the concentration of carbon dioxide (CO_2). The combustion process said to be perfect if the amount of oxygen into the combustion chamber is sufficient for any hydrocarbon molecules.

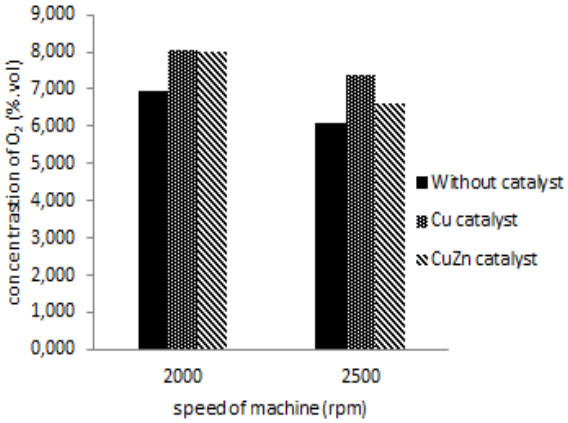


Fig 9. The effect of catalyst toward O_2 concentration

CONCLUSIONS

In this study, applying catalytic converter based on non-noble material was tested for minimization of engine emission. CuZn catalyst can reduce of CO and HC emission higher than Cu catalyst. The emission test that we have conducted clearly demonstrates the effectiveness of CuZn and Cu as a catalyst for the reduction of CO and HC emission. Therefore, CuZn and Cu catalyst based on non-noble material has been considered as a prospective catalyst to reduce emission of CO and HC.

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