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Optimum Design of Manganese-Coated Copper Catalytic Converter to Reduce Carbon Monoxide Emissions on Gasoline Motor

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Abstract

One of the engineering technologies that can be used to reduce air pollution is the use of catalytic converter mounted on vehicle gas exhaust duct. Unfortunately, these tools are very expensive in the market and not all motor vehicles use these technologis, because the catalyst was made from exoensive metals and rarely available in the market, such as: Palladium, Platinum and Rhodium. Besides, the catalyst is susceptible to premium fuel with low levels of lead (Pb) which results in the damage of the function of the catalyst due to blockage in the honeycomb Catalytic Converter. Therefore research needs to be done in the laboratory to test the other substrate materials as a catalyst, to study the ability of the catalyst in a catalytic converter to reduce exhaust emissions of Carbon Monoxide. This research will also study the performance capabilities and assess the effectiveness of Manganese-coated Copper catalysts which are designed in such a way to obtain the appropriate shape and type of Catalytic Converter catalyst and suitable for premium fuel motor vehicles. The result showed that (1) Catalytic Converter design and modification of catalytic materials can be an alternative to overcome the high air pollution problem from the transportation sector, esspecially particular Carbon Monoxide exhaust emissions from gasoline motors. (2) The use of Manganese-Coated Copper as a catalyst in the catalytic converter was significantly able to increase the reduction of Carbon Monoxide exhaust emissions. (3) The increase of catalyst cells amount decreased the concentration of Carbon Monoxide exhaust emissions. (4) Optimum Design of Model 2 Catalytic Converter was able to reduce exhaust emissions of Carbon Monoxide.

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Keywords: catalytic converter, copper catalyst, manganese, exhaust emissions, carbon monoxide

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1. Introduction

The use of catalytic converter to reduce emission from vehicle exhaust has been recently. Mostly the cataytic converter used for motor vehicles (on the market) is in a type of pellet and monolithic catalysts and the materials made from nobel metals, such as palladium (Pd), Platinum (Pt) and Rhodium (Rh) [1]. Those metals have a high specific activity, a large degree of volatility, easily oxidized and easily broken at temperature of 500-900 ^{o}C, which result in reducing activity of the catalyst. Besides these metals have a low availability and quite expensive [2]

The installation of the catalytic converter on exhaust channel with catalysts of Pd, Pt and Rh with alumina, silica and ceramic buffer, are quite expensive in facrication, difficult to find and less suitable used in Indonesia, because most of fuel still contains high Pb. However, this type of catalytic converter can convert exhaust emissions (CO, HC and NOx) with quite high conversion (80-90 %) [3]. These information lead us to search new alternative for new materials and lower price. For this alternative, the transition metal oxides are the promising options to oxidize CO emission such as CuO, NiO and Cr_2O_3. The materials known as oxidation catalyst are Platinum, Plutonium, Nickel, Manganese, Chromium and other metals oxides forms, while some metals are known as a reduction catalyst, i.e. iron, copper, nickel alloys and these materials oxides [4]. Besides, some metals known to be effective as an oxidized and reduction catalyst materials, ranging from large to small are Pt, Pd, Ru > Mn, Cu >> Ni > Fe > Cr > Zn and oxides of these metals [5]. Thoese types of catalytic converter can reduce exhaust emissions (CO, HC, NOx) between 16 % to 80 % [6]. The other alternatives are modification of the exhaust duct in motor vehicle[7]. Therefore, how is the ability of an catalytic converter to reduce exhaust emissions need to be conducted.

This study aims to design or to create a tool to reduce exhaust emissions of motor vehicles often called as catalytic converter in variation of Manganese-Coated Copper Catalyst. This tool is particularly to reduce exhaust emissions of carbon monoxide and to find optimum design.

2. Methodology

This research is based on the ideas and stages that are systematically arranged. The initial phase of the research is conducted by library research to deepen the fobject to be researched, both the problems of air pollution and emission control technologies, especially in the design of Catalytic Converter. This library research on the previous research is used as the basis in comparing the results of the research with the previous research, so the originality of the research is maintained and there is no duplication of the research.

2.1. Research Material

The research material consists of two main parts: the inside and outside construction of Catalytic Converter. The inside construction consists of a substrate and washcoat material made of copper metal as the catalyst, whereas the outer form of the catalyst (Chasing) is made of Stainless Steel and support / sustainer. [8]

The inside substrate material is made of Manganese-Coated Copper with the size of 160 mm x 100 mm in oval shaped adjusted with the shape of chasing and half of the area is given 2 mm holes with 3 mm space between holes.

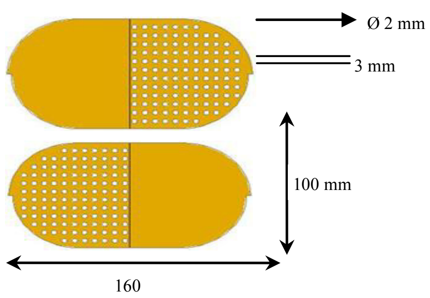

Fig. 1. Catalyst Dimension

While the number of Catalysts material models consist of 4 models as shown below:

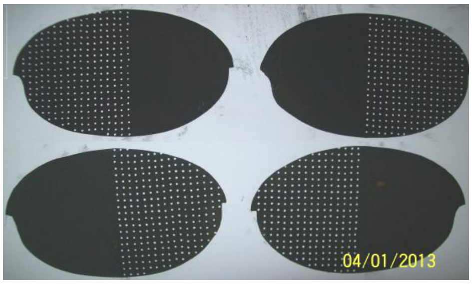

Fig. 2. Model 1: Catalys Plate of Manganese-Coated Copper

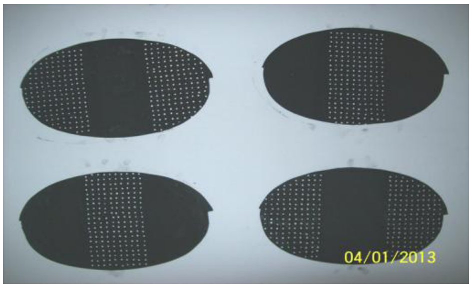

Fig. 3. Model 2: Catalys Plate of Manganese-Coated Copper

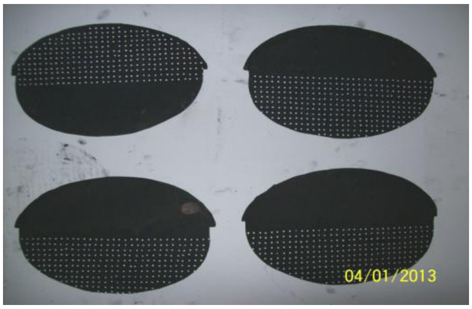

Fig. 4. Model 3: Catalys Plate of Manganese-Coated Copper

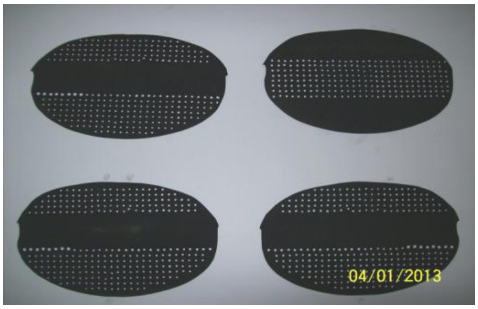

Fig. 5. Model 4: Catalys Plate of Manganese-Coated Copper

2.2. Chasing

Chasing is the outside part of a Catalytic Converter that is chose based on the general shape, mostly use which is made of Stainless Steel plate [9]. It has a cover that can be opened and closed with bolts like a drawer, during the turn of cells number variations in the inisede frame. It is installed asbestos to protect the inside with the outer construction, vibration damper, thermal insulator and to avoid leaks of the exhaust gases. The edge of Chasing is installed with flange (cantilever) and exhaust packing, so that the conditions of Catalytic Converter is really tight and toned at the time of installation and no leak of gas emissions when tested.

Chasing construction figure is shown in the following picture :

Fig 6. Catalytic Converter Chasing

2.3.Test Preparation

Before conducting the research and collecting the data, the researcher prepares the following tools to be used in the research consisting of :

2.3.1.Testing Machine

The researcher uses Stand Toyota 1500 CC machine as the testing machine.

2.3.2.Gas Analyzer

While, the instrument used to test the exhaust emissions of Carbon Monoxide in this study is Gas Analyzer Qrotech of type QRO-402 belonging to the researcher, it is a more accurate tool rather than the type 401 which is commonly used in auto repair shops.

Fig. 7. Testing Machine

Fig. 8. Qrotech Type 402

2.3.3. Thacometer

This tool is used to find out and see the changes of vehicle engine revs when the researchers do the variation of engine rev on the tested vehicle.

Fig. 9. Thacometer

2.4. Data Collection Stage

Before collecting the test data, the first thing that needs to do is preparing the standard conditions of the machine with Tune Up, so that the machine is ready to work. At the stage of data collection, the researcher warms the engine to prepare the machine to be ready at the test conditions. The first stage is the measurement without Catalytic Converter. This measurement is aimed to determine the concentration of exhaust emissions of the tested machine released without any additional tools. The measurement is performed three times and each data obtained is recorded, and its results is analyzed next

The steps are as follows: firstly, the machine is turned on, idle rotation, measuring plug is inserted into the mouth of the exhaust, and then step on the gas pedal and read the motor rpm display, after that read the display on the gas analyzer test tools take note the measurement numeral results on the display, repeat the step two for different rpm variations; 1000, 1500, 2000, 2500, 3000, back to 2500, 2000, 1500, 1000 and until the idle rotation returns and at each different rpm measurement the gauge plug is pulled from the exhaust vent. Once the measurement without Catalytic Converter is completed, it is followed with the measurement of Catalytic, with the same steps [10].

3. Research Result and Discussion

Based on the research conducted by the researcher, the results of the measurements show that the use of substrate material of Manganese Coated Copper (CuMn) is able to reduce exhaust emissions output of Carbon Monoxide. The reducion of Carbon Monoxide is varied in accordance with the variations of engine rotation changes and variations of catalyst increase in cell numbers done by the researcher.

Base on the results of the exhaust emissions testing conducted by the researcher without both Catalytic Converter and Catalytic Converter of Manganese coated Copper it is shown with graphic method as in the following drawing graphs. The catalytic converter model 1 proven ability Manganese Coated Copper catalyst in reducing CO emissions. Figure 10-13 show that by increasing cell numbers of 10 and 15, the CO reduction could be achieved significantly. It also occurs in the catalytic converter model 2, model 3 and model 4.

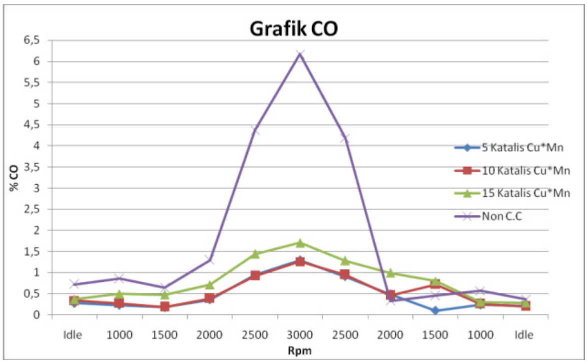

Fig. 10. CO Emission Reduction With Manganese-Coated Copper Model 1

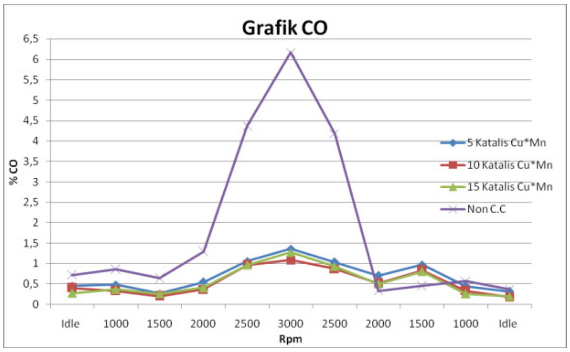

Fig. 11. Graph of CO Emission Reduction With Manganese Coated Copper Model 2

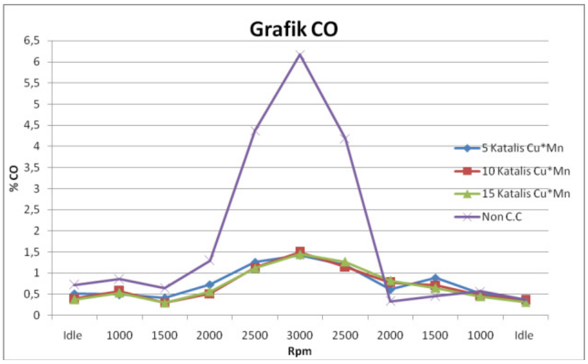

Fig. 12. Graph of CO Emission Reduction With Manganese-Coated Copper Model 3

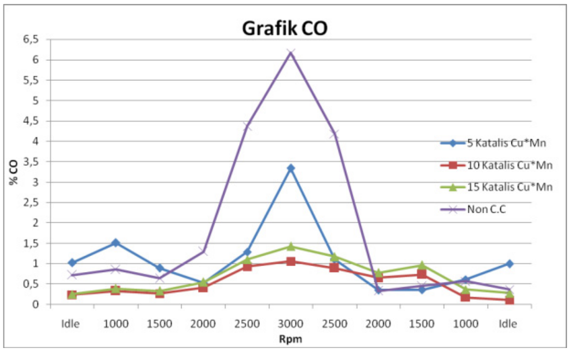

Fig. 13. Graph of CO Emission Reduction With Manganese-Coated Copper Model 4

Of the above figures, it can be analyzed that the installation of catalytic converter with Manganese-coated Copper catalyst is able to reduce the concentration of Carbon Monoxide emissions. Each variation of engine rotation decreases Carbon Monoxide gas emissions significantly. The use of catalytic converter can directly decrease the concentration of CO emissions and is still appropriate with the eligibility standards in international quality standards of Euro 3 standard [11].

The above figures show that the decrease in the concentration of carbon monoxide exhaust emissions increases with the addition of layer/catalyst cell amount installed on Catalytic Converter. The decrease of exhaust emission is different at each rpm changes variation. It is fluctuated as shown in the images. These fluctuations are due to changes in the different fuel and air mixtures when entering the combustion chamber. This up and down trends is normal, considering the testing machine still uses a carburetor system (fuel cannot be optimal, not yet uses electronic fuel injection system/EFI systems). In the EFI system the amount of fuel entering the combustion chamber can be optimized for each variation of engine rotation/rpm [12], [13], [14], [15].

Of exhaust emissions test results, the highest decrease of CO emission concentrations levels occurs at the highest rotation of 3000 rpm. While Optimum Design of Model 2 Catalytic Converter was able to reduce exhaust emissioans of Carbon Monoxide. An average reduction emissions of carbon monoxide for each model can be show in table :

Table 1. Optimum Design of Catalytic Converter

Model	5 Cells	10 Cells	15 Cells	Average
1	79,0 %	79,6 %	72,4 %	77,0 %
2	**78,0 %**	**81,5 %**	**79,3 %**	**79,6 %**
3	76,9 %	75,5 %	76,6%	76,2%
4	45,8 %	82,9 %	76,9 %	68,5 %

4. Conclusions

1. Catalytic converter design and modification of catalytic materials can be an alternative to overcome the high air pollution problem from the transportation sector, esspecially particular Carbon Monoxide exhaust emissions from gasoline motors.
2. The use of Manganese-Coated Copper as a catalyst in the catalytic converter was significantly able to increase the reduction of Carbon Monoxide exhaust emissions.
3. The increase of catalyst cells amount decreased the concentration of Carbon Monoxide exhaust emissions.
4. Optimum Design of Model 2 Catalytic Converter was able to reduce exhaust emissions of Carbon Monoxide.

Reference

[1] Dowden, *Catalytic Hand Book*, Verlag New York, Inc. 1970.

[2] V.A.W Heller, , *Fundamental Motor Vehicle Technology,* Edisi ke-4, FIMI Stanley Thorne (Publisehers) Ltd, 1995.

[3] Warju, Influence of Usage of laminated Converter Copper catalytic of Manganese To Rate of Polutan Motor Gasoline Four Step. Institut Teknologi Surabaya. 2006.

[4] Obert, *Internal Combustion Engine & Air Pollution,*Third Edition.Harper & Row,Publisher,Inc,New York , 1973.

[5] Heisler, *Advanced Engine Tecnology Hodder Headline Group,* London. 1995,

[6] Springer - Verlag New York Inc, , *Catalyst Hanbook. Walfe Scintific Book,* London - England. 1970.

[7] Onogawa, , *Environmental Sustainable Transportation* (EST), Jurnal, 2007

[8] Irawan, B. Rancang Bangun Catalytric Converter dengan Material Substrat Tembaga (Cu) untuk Mereduksi Emisi Gas CO (Design To wake up Catalytic Converter with Material of Substrat Copper (Cu) to Reduce Emission Gas of C), Tesis MIL UNDIP, 2003

[9] Irawan, B., Pengaruh Catalytic Converter Kuningan Terhadap Keluaran Emisi Gas Carbon Monoksida dan Hidro Carbon Motor Bensin (Influence Of Catalytic Converter Brass To Output Of Emission Gas of Carbon Monoxide and Hydro Carbon Motor Gasoline), Traksi. 2006

[10] Irawan, B. Modifikasi catalytic converter Tembaga Untuk Mereduksi Emisi gas Buang Carbon Monoksid dan Hidro Karbon (Modification of Catalytic Converter Copper To Reduce Emission Gas of Carbon Monoksida and Hydro Carbon Motor Gasoline), Traksi, 2010,

[11] Pelangi, , *The Study on The Intregated air Quality Management for Jakarta Metropolitan Area* (Jurnal). 1997

[12] Jenbacher. *Combustion Engines I Vol I,* 1996,

[13] Jenbacher. *Combustion Engines II Vol II,* 1996, ,

[14] Jenbacher. Spark Ignition Engine Design Vol 3, 1996
[15] M. Diaz, *Modeling a Catalytic Converter for CO and NO Emissions.* 2008,