INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH AND ANALYSIS

ISSN(print): 2643-9840, ISSN(online): 2643-9875

Volume 06 Issue 01 January 2023

DOI: 10.47191/ijmra/v6-i1-28, Impact Factor: 6.261

Page No. 231-235

Optimization Design of Reducting Co & HC Gas through Alloy Converter Catalyst Prototype Model

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ABSTRACT: Technological developments have an impact on increasing the number of motorized vehicles such as motorcycles, cars, and other modes of transportation. This causes air pollution impacts such as gas emissions from fossil fuels. Substances from hazardous exhaust gases consist of carbon monoxide (CO), carbon dioxide (CO^2), nitrogen oxides (NO or NOx), and hydrocarbons (HC). Therefore, the purpose of this research is to design a catalytic converter through a mixture of several metals obtained from various wastes in Small and Medium Enterprises. A mixture of copper, brass, aluminium and zinc to be created as a muffler or exhaust on the test vehicle, namely the 2005 Car. The observed exhaust emissions are CO & HC using a Gas Analyzer. Measurements were observed at vehicle rotation of 1000 rpm, 2000 rpm, 3000 rpm, 4000 rpm and 5000 rpm. The results showed that the highest proportion of reduced CO levels was the use of a catalyst at 2000 rpm engine speed, which was 5.23 with Pertamax fuel, while petrolite fuel using a catalyst with 2000 rpm engine speed was 5.5. The highest percentage reduction in HC levels was when using a catalyst with engine speed of 1000 rpm of 645% with Pertamax fuel, while for pertalite fuel using a catalyst with engine speed of 1000 rpm was 705.5%

KEYWORDS: Copper, Aluminum, Zinc, Catalytic Converter, Gas Analyzer

1. INTRODUCTION

A healthy and comfortable living environment is one of the humans needs to live life in society. A healthy environment is created as a result of a balanced ecological relationship between humans and their environment (Flamarz et.al, 2019). Healthy environmental conditions are indicated by low pollution. Pollution has an impact on the disruption of human activity and health. Pollution is a substance, energy or component that is destructive, pollutes and disrupts the balance when it enters the environment (Dewanto et.al, 2021). The impact of pollution is contaminating the environment and can cumulatively damage human health.

Pollution can contaminate air, sound, water and soil. One of the pollutions that affect humans is air pollution. Air pollution is a source of pollution that is harmful to humans which can cause 41-53 percent of cases of premature death related to air quality (Jaichandar et.al, 2012). The transportation sector is the biggest contributor to environmental pollution, which is around 83% (Hasan et.al, 2018). Vehicles with conventional engines or vehicles with a carburettor system are not widely used by Indonesian people. In general, Indonesian people switch to using machines with Electronic Fuel Injection systems. or EFI not only cars but also motorcycles (Disel et.al, 2016). In general, Indonesian people use motorbikes a lot in their daily activities because motorbikes are more practical to use than cars. The fuel used for motorcycles is liquid mineral fuel. The results of the combustion of fuel coming out of the engine are a source of air pollution that disturbs the environment and human health (Amin & Subri, 2016). According to Mohanti et.al (2020) Burning fossil fuels produce pollutants that can cause smog, acid rain, global warming and climate change. At a certain concentration level, the effects of the gas will be inhaled by humans continuously. This can endanger the health and cause death. According to Primasanti & Aryani (2022) Gas is exposed to the body and inhaled by humans causing respiratory tract irritation, eye irritation and skin allergies to cause lung cancer. Source and health standards for exhaust emissions are presented in the table, while the standards for health or thresholds for health are shown in Table 1 below:

Table 1. Pollutant Threshold Value for Health (Twigg, 2011)

Pollutant	Description
Carbon dioxide(CO)	Health standard: 10 mg/m3 (9 ppm)
Sulfur oxide (SOx)	Health standard: 9 ug/m3 (0.03 ppm)
Particulate matter	Health standards: 50 ug/m3 for 1 year; 150ug/m3
Oksida nitrogen (NOx)	Health standard: 100 pg/m3 (0.05 ppm) for 1 hour
Ozone (O^3)	Health standard: 235 ug/m3 (0.12 ppm) for 1 hour

The catalytic converter is a tool that is installed on the muffler or after the exhaust manifold. This tool serves to reduce pollution from incomplete fuel combustion results when the gas comes out of the exhaust will be more perfect. According to Hamid et.al (2022) a catalytic converter is a tool used to reduce imperfect exhaust emissions in motorized vehicles. Installing a catalytic converter aims to reduce excess pollution, especially in older model vehicles, for example in vehicles manufactured under 2005. Vehicle with years of manufacture under 2005 are included in the category of vehicles with older years, so they are more wasteful in fuel consumption. However, this type of vehicle is still widely used for transportation facilities on the island of Java. More pollutant gases produced by older model vehicles are caused by an imperfect combustion process

(stoichiometry) due to the age of vehicle components (Chen & Lv, 2015). Besides that, gasoline-powered four-wheeled vehicles with years of manufacture under 2005 have not been equipped with a catalytic converter and require a special design that must be adapted to transportation type. The catalytic converter is a device that is installed in the exhaust (muffler) of a vehicle to filter certain gases contained in the exhaust gases. Initially catalytic converters were used break down CO and HC gases. HC and CO gases are catalyzed into CO2 which plants can use as a basic ingredient for photosynthesis (Naufal et.al, 2022). As the research progresses, it resulted that catalytic converters can also reduce NOx levels by converting to N_2 (Telaoembanoea, 2016).

In the catalytic converter, the exhaust gas passes through a large surface with a certain model that has been coated with a catalyst. Alternative materials to replace palladium and rhodium, which are often used for catalysts, are ceramics monolith, aluminum, copper, or other transition metals (Dedoussi, 2020). Transition metals and metal materials are effective for reducing and oxidizing CO and HC (Majedi & Puspitasari, 2017; Ghaly & Winoko, 2019). To replace precious metals which are quite expensive, in this study a combination of aluminum, brass, copper and zinc materials was used as a catalytic converter material. This study aims to review the effectiveness of these materials in reducing CO and HC exhaust gases (Istiqomah & Marleni, 2020). From this research it is hoped that the exhaust gas produced will be more environmentally friendly because there are 4 absorbent metal materials. The aims of this research using variations of the catalytic converter material are: to analyze the effect of the combined arrangement of catalytic materials on CO emissions, to analyze the effect of the combined arrangement of catalytic materials on HC emissions and to analyze the amount of exhaust gas reduction and its effect on environmental health.

2. MATERIAL AND METHOD

2.1 MATERIAL

The catalytic converter manufacturing process

1. The steps of the catalytic converter manufacturing process: *Preparation of Design Drawings*

The catalytic converter design drawings used for research are in accordance with Figure 1

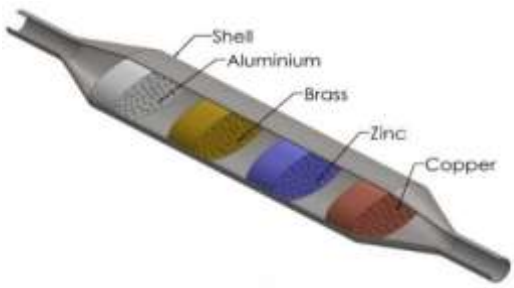

Figure 1. Catalytic Converter Image Design

2. The materials used as catalytic converters are aluminum, brass, copper and zinc, respectively. Each material is cast with a thickness of 50 mm then drilled with a hole diameter of 3mm with a distance between the holes 3 mm after finishing the edges drilled with a diameter of 2 mm with a depth 4 mm as much as 6 points.
3. Cut a stainless steel sheet with a size of

300 mm x 700mm as a cover and connection directly with the converter catalytic material.

4. Assemble the catalytic converter material by stainless steel sheet with size fixing bolts 2mm by 4mm deep.

5. Cut a low carbon steel plate with a size of 310 mm x 710 mm then form the outer cover with an oval shape with the road connected by the SMAW welding process then raft between the materials catalytic converter which has been discovered stainless steel with inserted into the outer cover and fastened with bolts 3 mm in diameter and 5 mm in depth.

6. Weld the top and bottom covers of the assembled catalytic converter sections

7. Connect the top and bottom ends with a 3 inch steel pipe.

8. Install the catalytic converter device that has been made on the exhaust system on the front

2.2 METHODS

This research includes survey and laboratory research, namely research that takes samples from a field and laboratory test as the main data collection tool. The research flow can be seen in the following

flowchart:

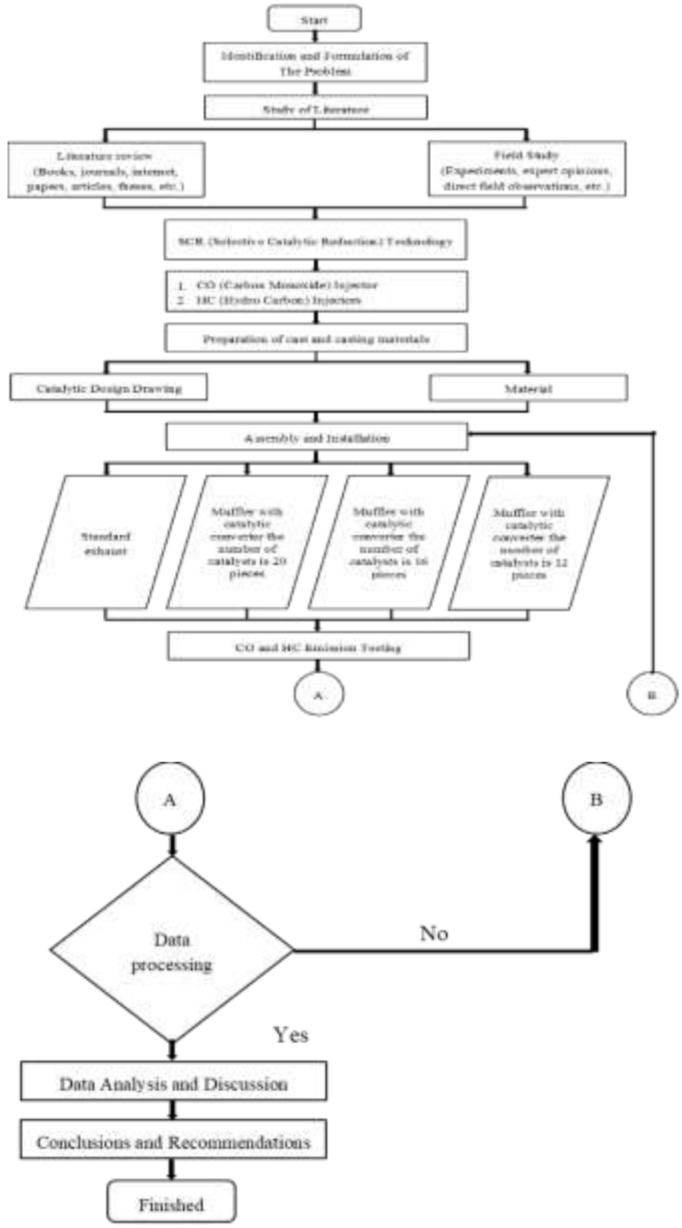

Figure 2. Research Flowchart

3. RESULTS AND DISCUSSION

3.1 CO testing with a catalytic converter and not using a catalytic converter

The exhaust emission test results for CO catalytic converters used and no catalytic converters used can be seen in Tables 1 and 2.

Table 1. Exhaust Emission Test Results in not used Catalytic Converter for CO Testing on 2005 Cars with Petrolite fuel

Machine Rotation	Experimenta l				Total	Average
	1st	2nd	3rd	4th		
1000	2,2	2,8	2,5	2,7	10,2	2,55
2000	5,14	5,23	6,12	5,62	22,11	5,53
3000	1,29	1,35	2,01	1,72	6,37	1,59
4000	0,29	0,32	0,26	0,33	1,2	0,3
5000	0,47	0,36	0,38	0,42	1,63	0,41

Table 2. Exhaust Emission Test Results with Catalytic Converter for CO Testing on 2005 Cars with Pertamax Fuel

Machine Rotation	Experimental				Total	Average
	1st	2nd	3rd	4th		
1000	1,29	1,5	1,69	2,66	7,14	1,79
2000	4,6	5,45	4,44	6,44	20,93	5,23
3000	0,39	0,39	1,83	1	3,61	0,9
4000	0,21	0,19	0,24	0,2	0,84	0,21
5000	0,19	0,27	0,24	0,27	0,97	0,24

Tables 1 and 2 show the test results for CO exhaust emissions using a catalytic converter and without using a catalytic converter. In general, there is a decrease in exhaust emissions for both 1000 rpm, 2000 rpm, 3000 rpm, 4000 rpm and 5000 rpm engine speed by using a catalytic converter. In detail, for the 1000 rpm rotation, the decrease is around 29.8%, for the 2000 rpm rotation the decrease is around 5.4%, for the 3000 rpm rotation the decrease is around 44.2%, and for the 4000 rpm rotation the decrease is around 30%. As for the 5000 rpm rotation, the decrease is around 17%.

3.2 HC Testing with a Catalytic Converter and Without Using a Catalytic Converter

The exhaust emission test results for HC catalytic converters used and no catalytic converters used can be seen in Tables 3 and 4.

Table 3. Exhaust Emission Test Results in not used Catalytic Converter for HC Gas Tests on 2005 Cars with Pertamax Fuel

Machine Rotation	Experimental				Total	Average
	1st	2nd	3rd	4th		
1000	788	621	769	652	2830	707,5
2000	601	751	676	533	2561	640,25
3000	399	225	256	255	1135	283,75
4000	221	124	170	144	659	164,75
5000	444	110	142	116	812	203

Table 4. Exhaust Emission Test Results in Catalytic Converter used for HC Gas Tests on 2005 Cars with Pertamax Fuel

Machine Rotation	Experimental				Total	Average
	1st	2nd	3rd	4th		
1000	590	703	668	619	2580	645
2000	430	405	437	543	1815	453,75
3000	136	139	258	224	757	189,25
4000	84	102	101	142	429	107,25
5000	80	79	90	105	354	88,5

Following are the results of emission tests for HC with and without catalytic converters as shown in Tables 3 & 4 above. In general, there is a decrease in HC exhaust emissions for engine speed of 1000 rpm, 2000 rpm, 3000 rpm, 4000 rpm and 5000 rpm by using a catalytic converter. In detail for the 1000 rpm rotation the decrease is around 8.8%, for the 2000 rpm rotation the decrease is around 29.1%, for the 3000 rpm rotation the decrease is around 33.3%, and for the 4000 rpm rotation the decrease is around 30%. As for the 5000 rpm rotation, the decrease is around 56.4%. These results are in accordance with research conducted by previous researchers that transition metals are very effective for reducing and at the same time for oxidizing CO and HC (Majedi & Puspitasari, 2017).

4. CONCLUSION

Based on the research data and discussion, several conclusions can be drawn. In the addition of catalytic converters made from waste metal copper, aluminum, brass and zinc in the form of a filter for carbon monoxide (CO) exhaust emissions, it is generally obtained that with catalytic converters there is a decrease in exhaust emissions, the greatest decrease occurs at 3000rpm of 44.2% . As for HC emissions, it is generally obtained that with a catalytic converter there is a decrease in exhaust emissions, the greatest decrease occurs at 5000 rpm of 56.4%.

5. ACKNOWLEDGMENT

The author would like to thank the Department of Mechanical Engineering,
Adhi Tama Institute of Technology Surabaya, which has provided support and facilities in carrying out this research until the writing of this paper is complete.

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