Increasing community participation in the green technology program through design and application of alternative mufflers

by Warju Warju

PAPER · OPEN ACCESS

Increasing community participation in the green technology program through design and application of alternative mufflers

To cite this article: D Dewanto *et al* 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1098** 052038

View the article online for updates and enhancements.

Increasing community participation in the green technology program through design and application of alternative mufflers

D Dewanto*, I M Muliatna and W Warju

Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Surabaya, Jl. Ketintang Surabaya 60231, Indonesia

*dewanto@unesa.ac.id

Abstract. The high number of motorized vehicles on one side is very beneficial for humans because it can facilitate transportation. But on the other hand, it turns out to cause a big problem, namely air pollution. Because 70% of air pollution is caused by motor vehicle exhaust emissions. This study aims to find the design and product of motor vehicle mufflers with innovative catalytic converters from cheaper alternative catalyst materials, to increase community participation in Green technology programs. The research method used is experimental. The products produced through this research are innovative muffler designs and products at low prices, using an alternative catalyst of manganese-coated copper (Cu), which is proven to be able to reduce CO 96.36% exhaust gas pollutants, and HC 94.74%. Thus this research product has great potential to support and increase public participation in the manufacture and use of environmentally friendly technology products.

1. Introduction

Air pollution is now reaching alarming levels. It has even had serious toxicological effects on human health, such as the onset of respiratory infections and inflammation, cardiovascular dysfunction, and widespread cancer [1]. World Health Organization (WHO) states that air pollution has caused around 3.7 million premature deaths worldwide [2].

According to Dessy Gusnita [3], air pollution can come from various sources, one of which is from vehicle exhaust gases [4]. Vehicle exhaust gas is the biggest contributor to air pollution, which is 70% and is distributed in urban areas [5]. Vehicle exhaust gas produces 60% carbon monoxide (CO), 15% hydrocarbons (HC), and the rest consists of nitrogen oxides (NOx), sulfur oxides (SOx), and particulates [6]. While the biggest contributor to pollutants is CO gas [7]. CO is a gas that comes from incomplete combustion [8].

Along with the rapid development of online motorcycle taxis (OJOL), recently, there has been a sharp increase in the number of motor vehicles, especially motorbikes. In 2016 the number of Indonesian motorcycles was still 105,150,082 units. In 2017 it increased 6,838,601 units to 111,988,683 units. In 2018 it increased again by 8,112,364 units so that the number reached 120,101,047 units [9]. Exponential motorcycle growth conditions like this, on the one hand, will be very beneficial, because it is beneficial and facilitates the community in getting transportation. But on the other hand, it becomes a problem, because it triggers air pollution which is getting bigger and increasingly dangerous to humans and the environment. Therefore, it is necessary to find a solution as soon as possible.

Thakre, Famesh D Talukdar, Bidyut K Gosavi, Gaurav S [10], in their results concluded that CO and HC gas from motorcycle exhaust gases can be reduced by 20% by installing wood charcoal on the muffler. With almost the same media, namely S. Sameer, V. P, and R. MS granular charcoal in their experiments have succeeded in controlling carbon dioxide emissions from diesel engines operated, which is around 9.266% of the total emissions from vehicles [11].

To reduce levels of air pollution, motor vehicle exhaust gas can be passed through a catalyst converter [12]. Commonly used converter catalysts are catalysts containing precious metals (Pt, Pd, Rh) [13]. But the price of this catalyst is relatively high, so all levels of society cannot reach it.

This research seeks to produce innovative muffler designs and products from alternative catalyst materials that are cheaper than standard converter catalysts so that they can be used to encourage and increase public participation in green technology programs. Namely, a program that aims to minimize the potential risk of environmental and human damage associated with the manufacture and use of products that are environmentally friendly technology [14].

Methods
The method used in this study is the experimental method (experimental research). The stages of the research began with the design of alternative (alternative) catalysts, the design of mufflers and the placement of catalysts, the results of muffler design tests on the ability to reduce pollutants, results, and discussion, and concluding.

Data analysis was carried out by examining the data from the test results that had been entered into the table. Next is to make the data in graphical form. Then compare the test results using the catalytic converter (the experimental group) with those not using the catalytic converter (the control group).

Data analysis from the graph was carried out by the descriptive method. The purpose of this descriptive method is to make a description, picture, or painting systematically, factually, and accurately about the facts, properties, or relationships between the phenomena under investigation [15]. This was done to provide an overview of the phenomenon that occurred after the addition of a catalytic converter in the muffler flue gas channel that was designed by the researchers.

3. Results and discussion

### 3.1. Results of substitute catalyst design (alternative)
From the relevant research results obtained, a catalyst that has great potential to replace the catalyst that has been used (alternative catalyst). The catalyst in question is Manganese (Mn). Mn is used as an active metal catalyst in the form of powder (powder). By using copper (Cu) as a buffer metal, the active metal catalyst serves as an oxidation catalyst for CO and HC pollutants [16].

In this study, eight variations of active metal catalyst composition were used, each variation weighing 200 gr, namely: 1) 170 gr Cu + 30 gr Mn; 2) 160 gr Cu + 40 gr Mn; 3) 150 gr Cu + 50 gr Mn; 4) 140 gr Cu + 60 gr Mn; 5) 130 gr Cu + 70 gr Mn; 6) 120 gr Cu + 80 gr Mn; 7) 110 gr Cu + 90 gr Mn, and 8) 100 gr Cu + 100 gr Mn.

3.2. Muffler design results and catalyst placement
Muffler results of the design of researchers can reduce air pollutants to the maximum because the design is done by considering the principles of a good muffler design, namely the principle of resonance, energy kinetic, sound waves/sound, and pressure, and acoustics [17]. Besides that, it also strives to fulfill functional requirements such as backpressure, size, durability, desired sound, cost, shape, and style.

The active placement of the catalyst metal in the muffler takes place in chambers two, three, and four. The installation of the active weight of the catalyst metal in each chamber is adjusted according to the volume of the chamber. The first room is used as a place of resonance so that this space is not occupied by active metal catalysts. Figure 1 follows the muffler design and catalyst placement.
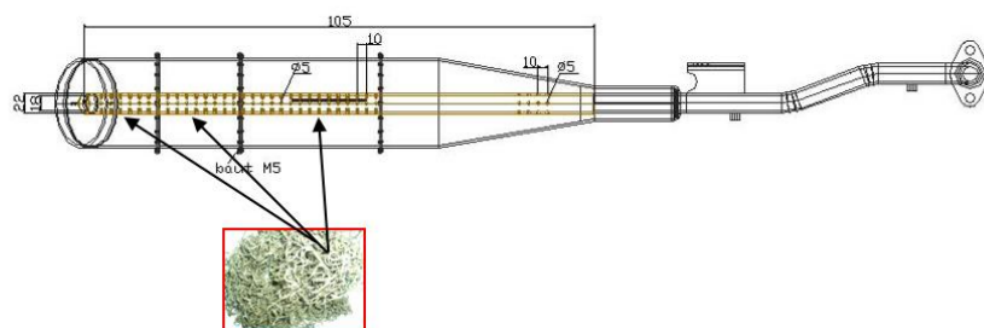
**Figure 1.** Muffler design and catalyst placement.

3.3. Best catalyst ability to reduce CO pollutant levels [5]

In general, the use of copper (Cu) coated manganese (Mn) catalytic converters can significantly reduce CO pollutant levels produced by the engine. The level of CO pollutants turns out to decrease with the increasing amount of manganese coated on copper to a certain extent.

Of the eight variations of the composition of the manganese-coated copper catalyst tested, the best composition was produced in reducing the level of CO pollutants produced by the engine, namely 110 gr Cu + 90 gr Mn. Whereas the 110 gr Cu + 90 gr Mn catalyst is effective as a catalyst in the oxidation reaction of CO (CO + ½ O2 $\longrightarrow$ CO2) at Air/Fuel ratio (A/F) 15 or a temperature range of 273 - 340oC. The highest reduction in CO pollutant levels by 96.36% occurred at 9000 rpm rotation. While the average reduction in CO pollutant levels in this composition is 91.03%.

Figure 2 below shows a clear trend of decreasing CO pollutant levels in test group 7 (110 gr Cu + 90 gr Mn), when compared to control groups 1 and 3.
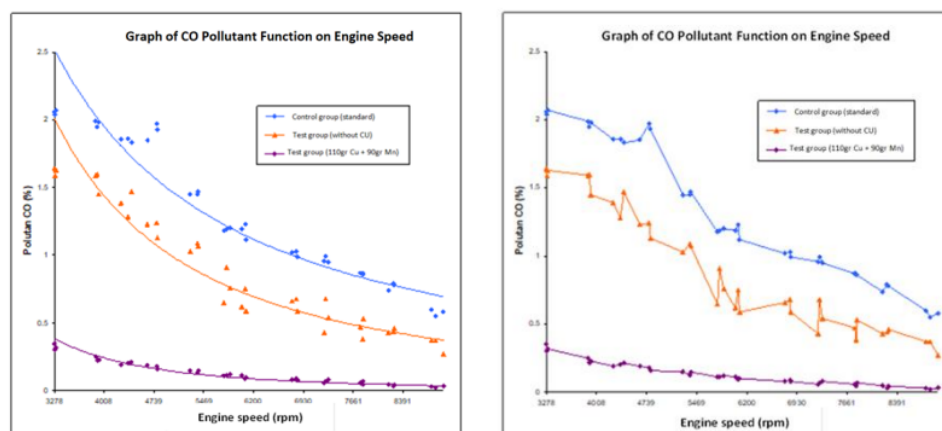
Figure 2. Graph of relationship between CO pollutant levels in control groups I, III, and test group 7 on engine speed (Point to point and trendline).

From the graph, it can be seen that in each cycle, there was a significant decrease in CO pollutant levels with a catalyst composition of 110 gr Cu + 90 Mn. In this composition, a more porous catalyst surface is obtained so that the optimal surface area of the catalyst is obtained, which can ultimately reduce CO pollutant levels significantly at each engine speed. This is consistent with the theory that the catalytic

reaction on a solid catalyst occurs on the catalyst surface, and the more extensive the catalyst surface area, the faster the reaction rate so that the resulting product content is lower. The high decrease in levels of CO pollutants produced by the engine, apart from being caused by the increased surface area of the effective catalyst that is in direct contact with the exhaust gas, is also influenced by temperature factors. High temperatures (reaching 340oC) will cause the activation energy to decrease so that the oxidation process of CO + ½ O2   CO2 becomes faster. As a result, this composition results in a significant reduction in CO pollutant levels at each engine speed when compared to other catalyst composition variations.

3.4. Ability of manganese-plated copper catalysts in lowering HC levels
From eight variations of the composition of the manganese-coated copper catalyst tested, the best composition was produced in reducing the level of HC pollutants produced by the engine, which is 110 gr Cu + 90 gr Mn. While the 110 gr Cu + 90 gr Mn catalyst is effective as a catalyst in the HC oxidation reaction (2HC + 1½ O2 $\longrightarrow$ H2O + 2CO2) at A / F 14.7 or a temperature range of 240 - 306ºC. The highest decrease in HC pollutant levels of 94.74% occurred at around 6500 rpm. While the average decrease in HC pollutant levels in this composition is 74.61%. More details can be seen in Figure 3 below:

Figure 3. Relationship between HC pollutant level I control group I, III, and test group II against engine speed (Point to point and trendline).
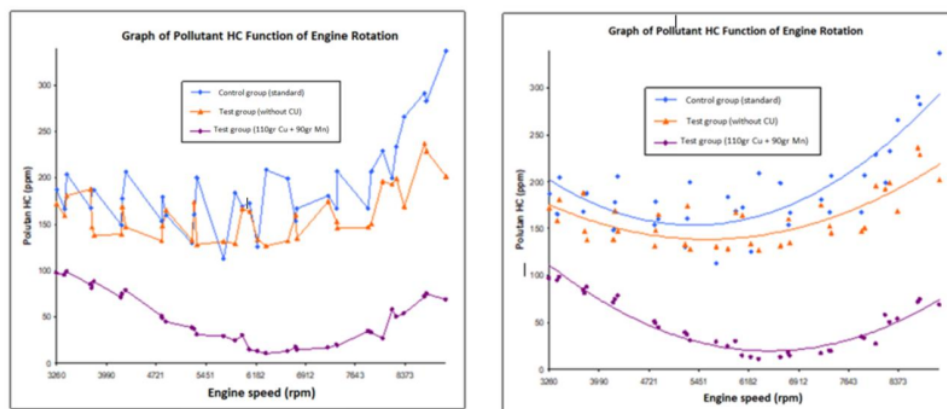
From the graph, it can be seen that at each cycle, there is a significant decrease in HC pollutant levels with a catalyst composition of 110 gr Cu + 90 Mn. In this composition, the catalyst surface is obtained, which is more porous so that the optimal surface area of the catalyst is obtained, which is finally able to reduce levels of HC pollutants at each engine speed significantly. This is consistent with the explanation of Berzelius (1835) that the catalytic reaction on a solid catalyst occurs on the surface of the catalyst, and the more extensive the catalyst surface area, the faster the reaction rate, so that the resulting product content is lower.

The high decrease in levels of HC pollutants produced by the engine, apart from being caused by the increased surface area of the effective catalyst that is in direct contact with the exhaust gas, is also influenced by temperature factors. High temperatures (reaching 306oC) will cause the activation energy to drop so that the oxidation process of 2HC + 1½ O2

H2O + 2CO2 is faster achieved. As a result, in this composition, there is a significant reduction in HC pollutant levels at each engine speed when compared with other catalyst composition variations.

The reduction of HC pollutant levels in the catalyst composition of 110 gr Cu + 90 gr Mn is influenced by the weight of manganese superimposed on copper (Cu). This is because Mn functioned as an active metal catalyst, whereas Cu only worked as a support metal (catalyst support).

The addition of copper growling weight to the exhaust gas channel will reduce levels of CO and HC pollutants. This can be understood because, with the presence of a manganese-coated copper catalyst in the flue gas channel, the catalyst will become rising in temperature. As the temperature of the catalyst increases, the reaction speed for the formation of CO2 and H2O is faster, so that some carbon monoxide and hydrocarbon gases will react with oxygen to form CO2 and H2O gases. With the formation of CO2, the concentrations of CO and HC pollutants in the flue gas will decrease.

The catalyst weighting has an optimum limit, where if the catalyst is filled too dense, the exhaust gas cannot come into contact with the catalyst, so the catalyst temperature also decreases, resulting in the speed of oxidation reaction to the formation of CO2 and H2O will be reduced. From the eight variations of the catalyst composition tested, it was seen that the temperature of the exhaust gas increased with the increasing amount of copper lathe filled into the muffler. This is due to the composition of 170 gr Cu + 30 gr Mn (the highest weight of the copper lathe growling) still looks tenuous if the catalyst is inserted into the chambers in the muffler so that exhaust gas freely enters the room. As a result, the temperature is getting higher.

4. Conclusion

Based on the results of data analysis and discussion, it can be concluded that this study has been able to produce innovative muffler designs and products at low prices, and use an alternative catalyst of copper (Cu) manganese coated (Mn). This research product has been proven to be able to reduce carbon monoxide (CO) flue gas pollutants 96.36%, and hydrocarbons (HC) 94.74%. Thus this research product has great potential to support and increase public participation in the manufacture and use of environmentally friendly products (green technology).

Acknowledgement

References

[1]   Riahi-zanjani B and Balali-mood M 2016 Effects of air pollution on human health and practical measures for prevention in Iran *J. Res. Med. Sci.* ·1–11

[2]   Sivaramanan S 2015 Air Pollution sources , pollutants and mitigation measures *Research Gate* 1–11

[3]   Gusnita D 2012 Pencemaran logam berat timbal (Pb) di udara dan upaya penghapusan bensin bertimbal *Berita Dirgantara* **13**(3)

[4]   Choudhary M P and Garg V 2013 Causes, consequences and control of air pollution In *All India seminar on methodologies for air pollution control, Jaipur, Rajasthan*

[5]   Marlita D D S 2014 Pencemaran Udara Akibat Emisi Gas Buang Kendaraan Bermotor *J. Manaj. Transp. Logistik* **01**(03) 241–248

[6]   Warju S and Harto S P 2017 The Performance of Chrome-Coated Copper as Metallic Catalytic Converter to Reduce Exhaust Gas Emissions from Spark-Ignition Engine *MS&E* **288**(1) 012151

[7]   Jansen F, Sengkey S L and Wallah S 2011 Tingkat Pencemaran Udara CO Akibat Lalu Lintas Dengan Model Prediksi Polusi Udara Skala Mikro *J. Ilm. MEDIA Eng.* **1**(2) 119–126

[8]   Pénard-Morand C and Annesi-Maesano I 2004 Air pollution: from sources of emissions to health effects *Breathe* **1**(2) 108–119

[9]   Badan Pusat Statistik 2018 *sheet001* (Jakarta: BPS)

[10] Thakre F D, Talukdar B K, Gosav G S and Tayade P R 2017 Paper publish - Copy *J. Sci. Eng. Technol.* **4**(3) 161–168

[11] Sameer S, Vijayabalan P and Rajadurai M S 2016 Control of Carbon Dioxide and other Emissions from Diesel Operated Engines using Activated Charcoal *Adv Automob Eng* **5**(149) 2

[12] Sendilvelan S and Bhaskar K 2016 Experimental analysis of catalytic converter for reducing environmental pollution from SI engine using electrically initiated and chemically heated catalyst *ARPN J. Eng. Appl. Sci.* **11**(23) 13735–13739

[13] Osipov A R, Borisov V A, Suprunov G I, Mukhin V A, Ivanov A L, Sigaeva S S and Tsyrul'Nikov P G 2016 Catalytic coatings for improving the environmental safety of internal combustion engines *Procedia Engineering* **152** 59-66

[14] Das Soni G 2015 Advantages of green technology *Soc. Issue Environ. Probl.* **3**(9) 1

[15] Nasir M 2011 *Metode Penelitian* (Jakarta: Ghalia Indonesia)

[16] Diniardi E, Ramadhan A I and Basri H 2016 Pengujian desain muffler untuk mengurangi emisi suara pada mesin diesel *jurnal.umj* 1–5

[17] Sherekar V and Dhamangaonkar P R 2014 Design Principles for an Automotive Muffler *Int. J. Appl. Eng. Res.* **9**(4) 483–489

Increasing community participation in the green technology program through design and application of alternative mufflers

PRIMARY SOURCES

1	Submitted to Universitas Negeri Jakarta Student Paper	4%
2	www.karyailmiah.trisakti.ac.id Internet Source	2%
3	G Setyono, M Ulum, Z Lillahulhaq. "An experiment on different type of muffler on spark Ignition engine 110 cc performance", IOP Conference Series: Materials Science and Engineering, 2021 Publication	1%
4	journal.uinjkt.ac.id Internet Source	1%
5	download.atlantis-press.com Internet Source	1%
6	www.intechopen.com Internet Source	1%
7	Submitted to University of Dundee Student Paper	1%

8 Submitted to University of North Texas
Student Paper
1 %

9 eprints.utm.my
Internet Source
1 %

10 D V Chugunkov, E A Zhuravlev, G A Seyfelmlyukova, K C Fomenko. "Study of the acoustic efficiency of a plate silencer of the original design", IOP Conference Series: Materials Science and Engineering, 2020
Publication
1 %

11 www.omicsonline.org
Internet Source
<1 %

12 Inga Zinicovscaia, Nikita Yushin, Konstantin Vegel, Dmitrii Grozdov. "chapter 24 Moss Biomonitoring in Former Sovet Union Countries", IGI Global, 2020
Publication
<1 %

13 journal.unj.ac.id
Internet Source
<1 %

14 www.hindawi.com
Internet Source
<1 %

15 www.ijsrd.com
Internet Source
<1 %

16 Sendari, S., D. Lestari, Y. Rahmawati, and A. Prabowo. "Developing prototype of web-based home controlling for teaching trainer",
<1 %

2016 IEEE Region 10 Symposium (TENSYMP), 2016.
Publication

17   www.science.gov
      Internet Source   <1%

18   Nirendra N. Mustafi, Avinash Kumar Agarwal.
      "Chapter 12 Combustion and Emission   <1%
      Characteristics, and Emission Control of CNG
      Fueled Vehicles", Springer Science and
      Business Media LLC, 2020
      Publication

Exclude quotes   On   Exclude matches   Off
Exclude bibliography   On