The Effectiveness of the Brass Based Catalytic Converter to Reduce Exhaust Gas Emissions from Four-stroke Motorcycle Engines

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ABSTRACT
The development of automotive technology to reduce exhaust emissions from vehicles with spark-ignition engines uses catalytic converter technology. This experiment aims to determine the effectiveness of using brass as a catalyst in the spark-ignition engine. For carbon monoxide (CO) measurements on the spark-ignition engine, two muffler measurements were made. First using the AHM 18350-KEV-880 muffler, and second, using a muffler with a brass metal catalytic converter. Measurement of CO exhaust emission levels using an exhaust gas analyzer. The exhaust emission from the spark-ignition engine is measured according to SNI-19-7118.1-2005. The experiment results show that brass metal catalytic converters can significantly reduce CO and HC emission levels. The average reduction in CO emissions at each RPM is 52%, while the average reduction in HC emissions at each RPM is 29%.

Keywords: *Catalytic converter, Spark-ignition engine, Reduce exhaust gas emissions.*

1. INTRODUCTION

In the fourteenth century, there were natural disasters, and the proliferation of industrial developments, air pollution in motor vehicle exhaust emissions became a serious problem [1]. Based on previous research, the most significant cause of air pollution came from motor vehicle exhaust emissions [2]. The use of a catalytic converter reduces the increase in exhaust emissions from motor vehicle exhaust [3]. Most of the catalytic converters that are widely applied and used in motor vehicles are monolithic pellets and catalysts made of precious metals, for example, Platinum (Pt), Rhodium (Rh) and palladium (Pd) [4]. A catalytic converter is a tool to reduce exhaust gas emissions from the spark-ignition engine. Then the catalyst reaction is the reaction between the metal catalyst and the vehicle exhaust emissions that come out of the exhaust [5].

Catalytic converters generally consist of a chemical wrapped in a metal casing specially designed to direct the exhaust gas flow towards a metal catalyst [6, 7]. Carbon monoxide (CO) is one of the most dangerous poisons in the atmosphere. Carbon monoxide (CO), obtained from incomplete carbon combustion systems, emissions of carbon monoxide (CO) are harmful to all living things and the environment [8, 9]. The carbon monoxide (CO) oxidation process is essential for the support of life in the atmosphere. The increasing price of precious metals raises carbon monoxide (CO) oxidation concerns using metal catalysts [10, 11]. Developing catalytic converters without using precious metal materials to reduce exhaust emissions of carbon monoxide (CO) in internal combustion engines is a difficult challenge. The catalytic converter made from copper manganese oxide is one of the oldest catalysts to reduce carbon monoxide (CO) exhaust emissions in internal combustion engines [12, 13].

The turbulence system flow pattern visualized exhaust gas flow with a rotating blade layout is more efficient in increasing metal catalytic converters used for catalysts [14]. The metal catalyst design has been recognized as an essential catalyst in the combustion process, pollution reduction, etc. The structure of this material has the characteristics of a costly chemical for efficient catalytic converter applications [15]. Catalytic converter researchers say that maximum material selection is needed for components in catalytic converter manufacturing. A catalytic converter is a perfect choice to tackle the increased pollution of motor vehicles to meet environmental requirements [16].

Catalytic converter materials containing copper (Cu) are important in oxidation reactions which help control vehicle exhaust emissions. In catalytic converters in internal combustion engines, copper (Cu) has been recognized by researchers as an excellent substitute for catalysts made from precious metals in reducing vehicle exhaust emissions [17]. At high pressure, the reduction of carbon monoxide (CO) occurs most rapidly on a metal catalyst made from copper (Cu) at a temperature of about 30^{o} C. Copper oxide (CuO) is very good in the oxidation reaction to carbon monoxide (CO). However, if copper (Cu) is combined with several other metal oxides, its performance will improve. The density functional theory (DFT) states that it will be very efficient if the catalytic converter activity uses copper metal (Cu) and also copper oxide (CuO) for the carbon monoxide (CO) oxidation reaction [18, 19]. Copper dioxide (Cu2O) has an excellent effect on the structure and performance of the catalytic converter in reducing exhaust emissions of carbon monoxide (CO) compared to copper oxidation. The performance of a catalytic converter made from copper oxide (CuO) can be related to the ratio of copper dioxide (Cu2O) and the temperature in the reducing environment [20, 21].

The copper (Cu) based catalyst is considered the most efficient metal-based catalytic converter for the methanol industry through hydrogenation of carbon dioxide (Co2) due to its meagre cost and excellent catalytic capability. Copper catalysts unsupported by a mixture of other metals will be less efficient when compared to copper materials supported by a mixture of other metals, such as Cu+Mn, Brass, and Cu+Cr [22]. With the presence of ZnO and ZrO2 metal catalysts, the performance of catalytic converters made from CuZnO and CuZrO2 will be outstanding [23]. The catalyst made of chrome-plated brass metal (CuZn+Cr) can reduce exhaust emissions of carbon monoxide (CO) and hydrocarbon (HC) in internal combustion engines, the percentage of respectively 88.41% and 39.84% [2]. A catalyst made from copper metal coated with manganese (Cu+Mn) can reduce exhaust emissions of carbon dioxide (CO2) on motorbikes, an average percentage of 91.03% [2].

2. STYLE PALETTE

Experimental research is research conducted to determine the effect of giving a treatment or treatment to the research subject. For this study, the authors used experimental research to determine the effectiveness of using a brass catalytic converter in mufflers to reduce vehicle exhaust emissions. Exhaust gas emission testing was based on SNI-19-7118.3-2005. This test determined the level of exhaust gas emissions produced by an engine. The tool used for this test was an exhaust gas analyzer. The exhaust end had installed a pipe that leads to the exhaust gas analyzer, and then it will be read by the exhaust gas analyzer. Next, the test results can be printed and photographed.

2.1. Research design

In this study, the muffler form used is a muffler with a variation of the addition of a brass catalytic converter placed in the exhaust manifold 150 mm away from the end of the exhaust port.

2.1.1. Muffler standard

Motorcycle mufflers have not been modified and are still in original factory standards, using AHM 18350-KEV-880 mufflers.

Figure 1 Muffler AHM 18350-KEV-880.

2.1.2. Muffler experiment

This muffler has been modified with the addition of a Brass catalytic converter on the exhaust manifold. The exhaust gas flows from the rest of the combustion is channelled directly to the exhaust manifold. The exhaust gas will flow into the free air from the exhaust manifold and then flowed to the catalytic converter in the exhaust manifold to be reduced. The position of the catalytic converter is located at a distance of 150 mm from the exhaust port to maximize the heat temperature of the vehicle exhaust gases so that the CO and HC exhaust gas oxidation-reduction is perfect.

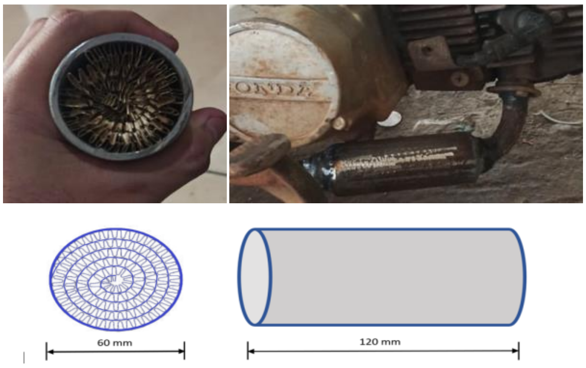

Figure 2 (a) The design of catalytic converter (Brass), (b) The installation of a catalytic converter in the muffler AHM 18350-KEV-880.

2.2. Research instruments

Research equipment is a measuring tool and test equipment used to obtain research data. This study used a tachometer, exhaust gas analyzer, bike lift, blower and stopwatch. The equipment used in this research can be seen in the schematic image of the research instrument as follows.

Figure 3 Research instruments.

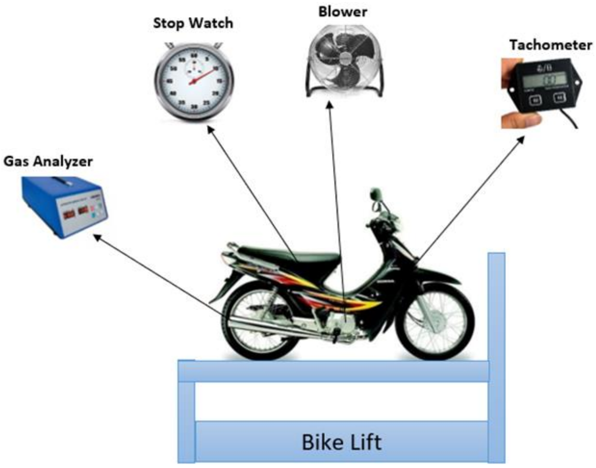

Table 1. Engine test bench specifications

No	Item	Specification
1	Engine	4 stroke, Single Overhead Camshaft, 1 cylinder
2	Engine capacity	100 cc, real (97.1 cc)
3	Bore x Stroke	50 x 49.5 mm
4	Compression ratio	9.0 : 1
5	Max. power	7.3 ps @ 8000 rpm
6	Max. torque	0.74 kgf.m on 6000 rpm
7	Coolent	Air
8	Transmission	4 speed (N 1 2 3 4)
9	Clutch	double, automatic centrifugal, wet type
10	Ignition	AC-CDI, Magneto
11	Battery/accu	12 Volt, 3.5 Ampere
12	Spark Plug	NGK code C6HSA, and C7HSA
13	Starter	Electric start and kick start
14	Length x width x height	1907 x 702 x 1069 mm
15	Wheelbase	1234 mm
16	ground clearance	147 mm
17	Engine oil capacity	0.70 L
18	Fuel tank	3.7 L
19	Weight	99.4 kg

Table 2. Exhaust gas analyzer specifications

No	Item	Specification
1	Merk	Heshbon
2	Type	HG 510
3	Made in	Indonesia
4	The year of production	2015

2.3. *Testing method*

The testing standards of exhaust gas emission for vehicles use SNI-19-7118.3-2005 [24]. The emission testing procedure is carried out at idle position (1200 rpm), but if you want to know the condition of exhaust gas emissions at all engine speed variations, test the exhaust emissions at 1200-9000 rpm. The results data of exhaust gas emissions testing at idle will be compared with the Regulation of the State Minister for the Environment Number 05 of 2006 concerning the Threshold for Exhaust Gas Emissions in Old Motor Vehicles [25] to find out whether the research data from the emission test match the threshold or not.

3. RESULTS AND DISCUSSION

Testing exhaust emissions from catalytic converter experiments on spark-ignition engines were conducted at the ATA MOTOR Workshop in Lamongan, East Java. The test used standard and experimental mufflers (brass catalytic converter).

3.1. *Research data*

The research data were obtained after a series of research processes were carried out, from manufacturing brass catalytic converters to testing CO and HC emissions using an exhaust gas analyzer. In detail, the research data is shown in Table 3.

Table 3. Emission test data

RPM	Standard			Experiment		
	λ	CO (% Vol)	HC (ppm Vol)	λ	CO (% Vol)	HC (ppm Vol)
1500	0.587	5.62	501	0.794	3.12	425
2000	0.662	5.16	418	0.803	2.86	342
2500	0.737	4.56	322	0.813	2.56	246
3000	0.812	4.13	274	0.823	2.23	165

RPM	Standard			Experiment		
	λ	CO (% Vol)	HC (ppm Vol)	λ	CO (% Vol)	HC (ppm Vol)
3500	0.887	3.57	201	0.864	1.97	125
4000	0.962	3.17	145	0.869	1.54	106
4500	1.037	2.76	95	0.896	1.21	97
5000	1.112	2.13	98	1.056	1.01	71
5500	1.187	1.66	102	1.076	0.89	74
6000	1.262	1.43	108	1.094	0.78	77
6500	1.337	1.4	112	1.101	0.66	72
7000	1.412	1.35	129	1.111	0.59	76
7500	1.487	1.29	134	1.284	0.55	81
8000	1.562	1.25	170	1.583	0.51	104
8500	1.637	1.22	199	1.811	0.47	138
9000	1.712	1.12	237	1.822	0.41	158

3.2. Discussion

The use of brass catalytic converters is proven to accelerate the process of CO emission oxidation. Empirically, the percentage comparison between standard and experimental mufflers can be seen in Table 4.

Table 4. Percentage reduction in CO and HC emissions between standard and experimental mufflers

RPM	Δ CO	Δ HC	RPM	Δ CO	Δ HC
1500	44%	15%	5500	46%	27%
2000	45%	18%	6000	45%	29%
2500	44%	24%	6500	53%	36%
3000	46%	40%	7000	56%	41%
3500	45%	38%	7500	57%	40%
4000	51%	27%	8000	59%	39%
4500	56%	-2%	8500	61%	31%
5000	53%	28%	9000	63%	33%
Δ Average				52%	29%

The data in Table 4 shows a decrease in CO and HC emissions after using the muffler experiment (brass catalytic converter). Empirically, reductions in CO and HC emissions occur at every RPM from 1500 to 9000 RPM. If the CO and HC emission data are presented in graphical form, they can be seen in Figure 4 and Figure 5.

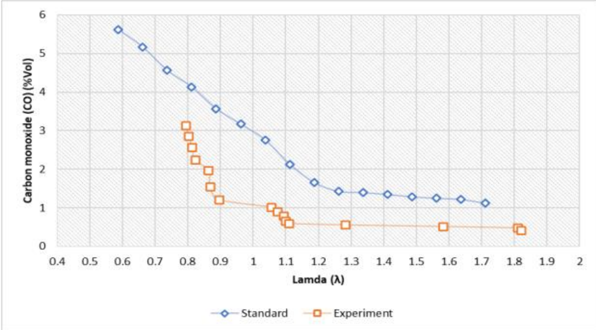

Figure 4 CO emission graph versus lambda.

The data in Table 4 and the graph in Figure 4 show that, at idle rotation, the CO emission produced by the standard muffler is 5.62 % Vol and then decreases after using a brass catalytic converter by 3.12. From these results, when comparing the CO emissions produced by the standard muffler and the experimental muffler, there was a decrease of 44%. The results of the CO emission test, when compared with the Regulation of the State Minister of the Environment number 5 of 2006, can be seen in Table 5.

Table 5. Comparison of CO emission test results against government regulations

Muffler	Results	Regulation	Criteria
Standard	5.62 %Vol	4,5%Vol	Fail
Experiment	3.12 %Vol	4,5%Vol	Succeed

Besides being proven to reduce CO emissions, brass catalytic converters are also able to reduce HC emissions at every RPM. The results of the HC emission test can be seen in Table 4, while the graph of HC emission reduction is illustrated in Figure 5.

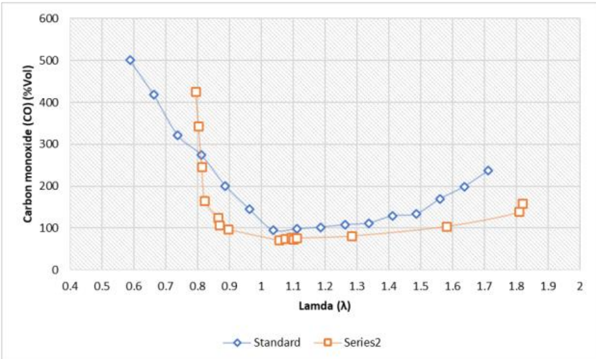

Figure 5 HC emission graph versus lambda.

The data in Table 4 and the graph in Figure 5 show that, at idle, the HC emission produced by the standard exhaust is 501 ppm Vol and then decreases after using a brass catalytic converter by 425 ppm Vol. From these results, when comparing the HC emissions produced by the standard exhaust and the experimental exhaust, there is a decrease of 15%. In Table 5, it can be seen that the standard exhaust failed the CO emission test, while the experimental muffler was successful in the CO emission test. The results of the HC emission test, when compared with the Regulation of the State Minister of the Environment number 5 of 2006, can be seen in Table 6.

Table 6. Comparison of HC emission test results against government regulations

Muffler	Results	Regulation	Criteria
Standard	501 ppm Vol	2000 ppm Vol	Succeed
Experiment	435 ppm Vol	2000 ppm Vol	Succeed

Meanwhile, in Table 6 for the HC emission test, both the standard and experimental mufflers were successful in the HC emission test. Thus it can be stated that the experimental muffler has been successful and has complied with government regulations in terms of reducing CO and HC emissions.

4. CONCLUSION

Based on the results of testing and discussion of the research, it is known that the use of brass catalytic converters is proven to reduce CO and HC emissions through the oxidation process. The average reduction in CO emissions at each RPM is 52%, while the average reduction in HC emissions at each RPM is 29%. The most negligible CO emission is produced at 9000 RPM, which is 1.12 % Vol for standard mufflers and 0.41 % Vol for experimental mufflers. In contrast to CO emissions, the smallest HC emission in standard mufflers is found at 4500 RPM, which is 95 ppm Vol, while for experimental mufflers it is found at 5000 RPM, which is 71 ppm Vol.

AUTHORS CONTRIBUTION

All authors conceived and designed this study. All authors contributed to the process of revising the manuscript, and at the end all authors have approved the final version of this manuscript.

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