

The Effectiveness of Using Heaters on Mufflers to Reduce Exhaust Emissions from Spark Ignition Engines

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The Effectiveness of Using Heaters on Mufflers to Reduce Exhaust Emissions from Spark Ignition Engines

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Abstract. The increasing population of motor vehicles can result in increased levels of exhaust emissions. The most significant contributor to exhaust emissions comes from motor vehicle exhaust. This study aims to reduce exhaust emissions, which will have an impact on reducing air pollution caused by motor vehicle exhaust gases. This research method is quantitative descriptive experimental with exhaust gas emission testing standards based on SNI 19-7118.3-2005. The test results show that the use of a heater in a Yamaha New Vixion Lighting motorcycle exhaust can reduce exhaust emissions CO and HC. By using an experimental exhaust one heater, it can reduce CO exhaust emissions by an average of 27.74%, and HC exhaust emissions by an average of 5.55. Whereas using experimental exhaust two heaters can reduce CO exhaust emissions by an average of 35.02%, and HC exhaust emissions by an average of 16.31.

Keywords-heater; muffler; CO; HC; SIE

1. Introduction

In Indonesia, the motor vehicle population continues to increase massively, more than 65 million vehicles have been produced since 2014 [1]. In 2014 the number of motor vehicles was 228,418,520 units, which then increased by 29% to 293,717,519 units in 2018. Of the four types of motorized vehicles, the number of motorbikes experienced the most massive increase, wherein 2014 there were 92,976,240 units, then increased by 29% to 120,101,047 units in 2018 [2]. This increase certainly has a positive impact on economic growth in both the financial sector and services of a country [3,4]. Unfortunately, not only the positive impacts produced but there are also many negative impacts



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produced. The increasing population of motor vehicles is the main trigger for increased exhaust emissions and decreased air quality [5]. Motor vehicle exhaust emissions are the most significant contributor to air pollution [6]. Air pollution occurs when the air in the atmosphere is mixed with substances or radiation that adversely affect living organisms. Air pollution is a fundamental problem to overcome because it can reduce oxygen levels in the air, which can cause interference with the respiratory tract [7,8].

On the other hand, the use of motorized vehicles can hurt the environment, especially the exhaust gases that result from burning combustion. Exhaust gases are toxic and pollute the environment in the form of air pollution [9]. Toxic gases such as CO, HC, NOx, and SOx from millions of exhausts everyday cause problems because it has an impact on decreasing air quality, various chronic diseases when inhaled by humans, plants and other living things, and can damage other objects [10]. The pollutant gas is very dangerous because it can cause interference with humans, animals, plants and other purposes [11]. Besides, if CO is mixed with oxygen that is inhaled by humans, then CO will react with hemoglobin (Hb), which causes the blood's ability to transfer oxygen to begin to decrease [12]. Many technologies have been installed in motor vehicles as one solution to reduce the harmful effects of motor vehicle exhaust emissions. Some commonly used technologies are catalytic converters for spark-ignition engines, whereas for compression engine vehicles use diesel particulate filters (DPF) [13,14]. For spark-ignition engines or petrol-engined vehicles, there are other technological alternatives on offer, namely by installing a heater on the muffler. The goal is to provide treatment (heat) on the muffler so that the oxidation process of hydrocarbon (HC) and carbon monoxide (CO) emissions can be accelerated, and nitrogen oxides (NOx) can be reduced to the maximum [15,16].

The use of heaters or thermal reactors is certainly based on relevant research results. Ning & Yan (2016), through their scientific articles prove that the use of Electrically Heated Catalyst (EHC) is auspicious when used to promise to reduce cold-start emissions. Simulation results based on a 500-second heating phase and a 200-second post-heating phase (FTP-75 first 200 seconds) show that composite controllers can have a fast performance with few errors [17]. Besides, Romocki, Zarkesh, Melloy, Cheung, & Le Fouest (2018) from their research found that the use of Immersion Tube Thermosiphon Heater (ITTH) can achieve an average efficiency of 90%. This allows annual savings of around 7660 tons of CO₂ with a load factor of 50% [18]. Meanwhile, Gao, Tian, & Somiotti (2019) concluded that the use of electrically heated catalysts (EHC) emissions, especially in the case of carbon monoxide and hydrocarbons, decreased significantly with the application of electrically heated catalysts, for example, at least 50% of cold start [19]. Then, Nur, Sumariyah, & Suseno (2019) through their research found that using a non-polluting plasma muffler as a thermal reactor was proven to reduce COx emissions by 95.52%, CO by 88.93%, HC by 97.34%, and NOx at 4600 rpm by 76.19%. Where COx, CO, and HC emissions are optimally reduced at 2200 rpm, while NOx emissions at 4600 rpm [20]. Based on the background description and relevant research, the researcher wants to conduct a similar study by installing a heater on the muffler. Thus the main purpose of this study is to analyze the effectiveness of using a heater on a muffler to reduce exhaust emissions from spark-ignition engines

2. Research method

2.1. Research Object

This experimental research uses the 2013 Yamaha New Vixion Lightning as a research object. The research object specifications include: (1) type of engine is 4 stroke, 4 Valve SOHC-Fuel Injection, Liquid Cooled; (2) bore and stroke of 52.4 mm x 57.9 mm; (3) piston displacement of 124.8 cc; (4) maximum power of 9.2 PS / 7,500 rpm; and (5) maximum torque of 1.03 Kg.m / 4,000 rpm [21].

2.2. Testing method

Experiments were carried out experimentally with a variation of the research of one heater, two heaters, a standard Yamaha New Vixion Lightning muffler without a catalytic converter, and a

Yamaha New Vixion Lightning standard muffler with a catalytic converter. Experiments carried out starting from 1200 rpm idle rotation to 9000 rpm with a range per 500 rpm. Each research variation was tested three times, and then the test results were averaged. The schema of the research instrument can be seen in Figure 1.



Figure 1. Objects and research instruments.

2.3. Testing method

Examination of exhaust emissions based on SNI 19-7118.3-2005. This test is to determine the high and low emissions of exhaust gas produced by an engine. The instrument used for this test is the exhaust gas analyzer [22]. The tip of the exhaust pipe is installed, which leads to the exhaust gas analyzer, and then the exhaust gas analyzer will read it, and the test results can be printed (printed).

19

3. Results and Discussion

3.1. Results

Following the research instrument scheme shown in Figure 1, the results of the study can be seen in Table 1 for CO and HC emissions.

18

Table 1. Data on CO and HC emission test results

Muffler	CO emissions (% Vol)	HC emissions (ppm Vol)
Standard 1	3.12	267
Standard 2	4.01	340
Experiment 1	2.19	241
Experiment 2	1.96	218

3.2. Discussion

Data on CO emission test results in Table 1 if the percentage and presented in diagram form, and the results can be seen in Figure 2 below.

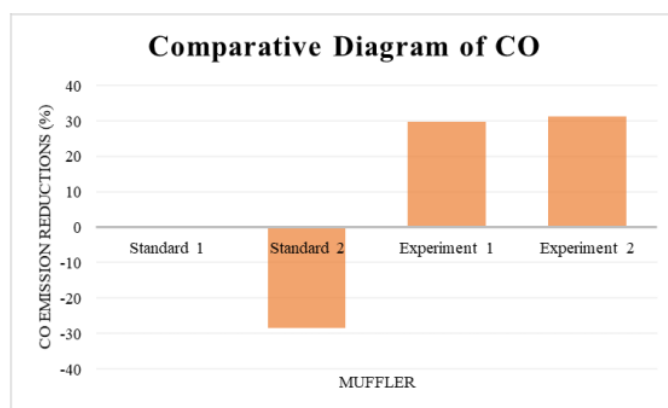


Figure 2. Comparative Diagram of CO.

In general, it can be concluded that the use of stainless steel heaters can significantly reduce CO and HC exhaust emissions of Yamaha New Vixion Lightning motorcycles. The most massive emission reduction level of CO and HC exhaust gas for Yamaha New Vixion Lightning motorcycle occurred in mufflers with the experiment of adding two heaters. The use of a heater on a Yamaha New Vixion Lightning motorcycle exhaust affects the reduction of CO exhaust emissions. All heater variations meet the standard quality of CO exhaust emissions based on the Decree of the State Minister for the Environment No. 4 of 2009 concerning Threshold Emissions Threshold for New Type Motorized Vehicle Gases. This is evidenced by the reduction of CO exhaust emissions by an average of 27.743% using exhaust experimental one heater, and 35.020% using the experimental two heater exhaust.

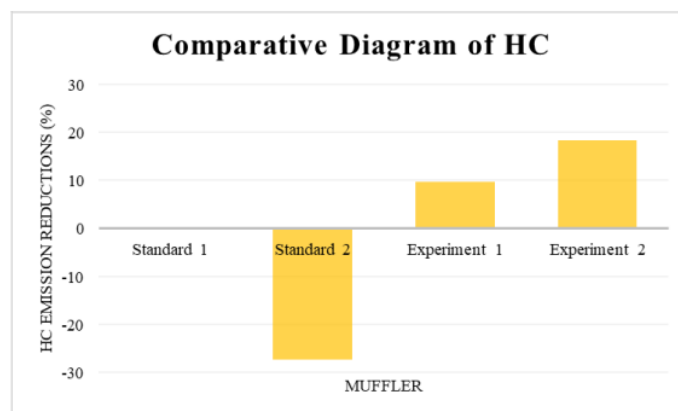


Figure 3. Comparative Diagram of HC.

From Figure 3, it can be seen that the use of a heater on a Yamaha New Vixion Lightning motorcycle exhaust affects the reduction of HC exhaust emissions. All heater variations meet the HC exhaust emission-quality standard based on the Decree of the Minister of Environment No. 5 of 2006 concerning the Limit on Old Type Motorized Vehicle Exhaust Emissions in the L> 2010 category. This is evidenced by the reduction of HC exhaust emissions by an average of 5.558% using the experimental exhaust heater one heater, and 16.318% using the experimental exhaust heater two. The use of a heater on a 2013 Yamaha New Vixion Lightning motorbike also meets the maximum

allowable CO and HC exhaust emission standards by the Decree of the State Minister for the Environment No. 4 of 2009 concerning the New Type of Motor Vehicle Exhaust Emission Limits in category L, and the Ministerial Decree The State of the Environment Number 5 of 2006 concerning Threshold Emission Limits for Old Type Motorized Vehicle L> 2010, it is necessary to make a comparison between the use of a standard exhaust and heater use can be seen in Tables 3 and 4 below.

Table 2. Comparison of CO exhaust emissions test results against government regulations

Muffler	CO Emissions (% Vol)	Threshold (% Vol)	Information
Standard 1	3.12	4,5	Pass Emissions Test
Standard 2	4.01	4,5	Pass Emissions Test
Experiment 1	2.19	4,5	Pass Emissions Test
Experiment 2	1.96	4,5	Pass Emissions Test

Table 3. Comparison of HC exhaust emissions test results against government regulations

Muffler	HC Emissions (ppm Vol)	Threshold (ppm Vol)	Information
Standard 1	267	2000	Pass Emissions Test
Standard 2	340	2000	Pass Emissions Test
Experiment 1	241	2000	Pass Emissions Test
Experiment 2	218	2000	Pass Emissions Test

4. Conclusions

The test results show that the use of a heater in a Yamaha New Vixion Lighting motorcycle exhaust can reduce exhaust emissions CO and HC. By using an experimental exhaust one heater, it can reduce CO exhaust emissions by an average of 27.74%, and HC exhaust emissions by an average of 5.55. Whereas using experimental exhaust two heaters can reduce CO exhaust emissions by an average of 35.02%, and HC exhaust emissions by an average of 16.31.

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