Improvement of Gasoline Engine Performance: A Study on Modified Cylinder Block

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Abstract. Improving the performance and fuel efficiency of motorcycles can be achieved through vehicle modifications. One common modification is enlarging the cylinder volume, as it is considered more economical. However, information and research supporting engine performance improvement based on experimental test data are still limited. Therefore, this study aims to compare the performance of a 150 CC automatic motorcycle with a standard piston cylinder block and a modified cylinder block with a diameter of 62 mm. This comparison involves initial engine specification calculations and performance tests on a dynamometer. The test results show that the average power produced by the standard engine is 10.6 HP, while the modified engine produces 13.02 HP. This means that the average power produced by the modified engine is 23% higher, or an increase of 2.42 HP compared to the standard engine. Additionally, there is a 22% increase in the average torque produced by the modified engine, which is 2.96 Nm higher than the average torque of the standard engine. Overall, modifying the cylinder volume has a positive impact on improving the performance of the motorcycle while maintaining fuel consumption equivalent to the standard engine. The results of this study are expected to provide useful data and information related to motorcycle modifications.

Keywords: Engine Performance, Gasoline Engine, Combustion Chamber, Power, Torque.

1. Introduction

Motorcycles, as a versatile mode of transportation that is widely favored, continue to experience increased usage due to their affordable prices, ease of use, and simple maintenance. Small engines with a single combustion chamber can only produce low power and torque. Many people desire motorcycles with higher performance than standard ones, while still aiming to maintain fuel efficiency. One method to enhance engine performance while preserving fuel efficiency is through modifications to the combustion chamber [1]. The objective of these modifications is to achieve better engine performance compared to standard vehicles by altering the specifications of combustion chamber components or

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adding additional components. One common modification to the combustion chamber frequently employed to enhance engine performance and fuel efficiency is by increasing the volume of the combustion chamber [2] [3].

The engine performance, including power and torque, is greatly influenced by several factors or variables such as piston stroke length, piston diameter, and combustion chamber size [4]. The higher the values of these variables, the higher the engine power and torque values. One way to increase the combustion chamber volume is by extending the piston stroke and enlarging the cylinder volume through a machining process. However, it is important to note that using machining on the inner diameter of the cylinder can result in thin cylinder walls, reducing the cylinder's durability and causing damage to the cylinder walls. Therefore, another more practical alternative is to replace the cylinder with a new one that has a larger volume [5] [6].

Several previous studies have investigated modifications to the combustion system in diesel engines. Modifying the geometric structure of the diesel engine piston with variations in bowl size has a significant impact on combustion performance, engine efficiency, and fuel mixture uniformity [7]. Additionally, testing on gasoline engines using a blend of n-butanol and gasoline has shown a slight reduction in torque, power, volumetric efficiency, exhaust gas temperature, and cylinder pressure, but a dramatic decrease in CO emissions [8]. Camshaft modifications have been carried out by adjusting the intake and exhaust valve durations, resulting in improved engine performance. The increase in torque and power indicates that camshaft modifications can have a positive impact on motorcycle performance [9]. Despite some modifications being conducted, there is limited research on modifications involving an enlargement of the combustion chamber.

Based on the researcher's experience working in a motorcycle workshop, many motorcycle users still do not understand the extent of engine performance improvement based on test data. The researcher aims to compare the performance of standard and modified engines by increasing the cylinder volume in motorcycles, with the results serving as a reference for further modifications. This study aims to analyze the influence of the Cylinder Volume of Gasoline Engines on the performance of motorcycles with the same fuel consumption. Factory-produced standard motorcycles are compared with modified motorcycles that have replaced combustion chamber components with a larger volume. Gasoline fuel consumption into the combustion chamber is regulated using an injection system controlled by the Engine Control Unit (ECU). Engine performance tests are conducted using a dynamometer to determine changes in engine power and torque.

2. Methods

2.1. Preparation of Equipment

In this study, factory-produced automatic motorcycles with a capacity of 150 CC were chosen. After collecting vehicle data, initial calculations were conducted to determine theoretical power and torque as a comparison with experimental tests. The initial stage of calculations involves the compression ratio comparison (Σ) using equation 1.

$$\sum = V_L - V_c / V_c \tag{1}$$

Where V_L is the volume of the piston stroke, and V_c is the combustion chamber volume. The determination of the compression temperature in the combustion chamber was carried out by calculating the initial compression temperature and the final compression temperature. Considering the theoretical air and fuel consumption, the values of effective power (Ne) and torque (T) are obtained using equations 2 and 3.

$$Ne = Ni \,.\, \eta m \tag{2}$$

$$HP = T.n.2\pi / 33000 \tag{3}$$

Where Ni is the indicator power, ηm is the mechanical efficiency at 0.83, and n is the engine speed. After theoretical calculations were performed, data is obtained as shown in Table 1. Experimental tests were conducted by analyzing the power and torque comparison of a standard engine with a cylinder diameter of 57.3 mm and a modified engine with a cylinder diameter of 62 mm. Testing was done using a dynamometer and additional equipment such as a tool set. The research flowchart is illustrated in Figure 1.

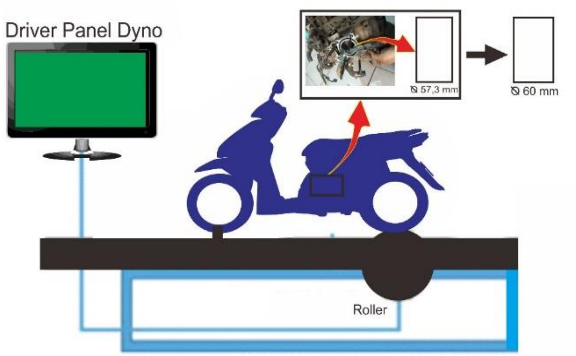

Fig 1. Experimental setup

2.2. Dynamometer Testing

The testing was conducted on both standard and modified motorcycles. Prior to initiating the tests, the engine was warmed up for approximately 5 minutes to reach optimal temperature conditions. The throttle was then adjusted until a change in engine speed was observed on the computer screen connected to the dynamometer. The engine was run until reaching a rotational speed of 8000 RPM. The testing was performed several times to obtain average results related to the power and torque of the engine. After completing the testing of the standard motorcycle, the engine was disassembled to carry out modifications to the combustion chamber. During the testing process, gasoline with an octane number of 90 was used as fuel, and the injection system was controlled by the Engine Control Unit (ECU). In this regard, the fuel consumption of the standard and modified motorcycles was the same.

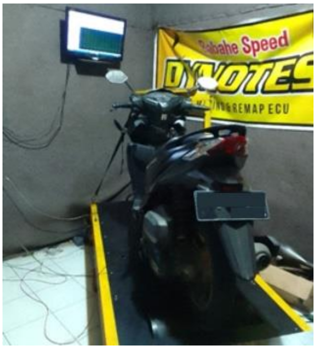

Fig 2. Engine performance testing using a dynamometer

Table 1. Calculation Results of Standard and Modified Engine Specifications

Calculation Results	Standard	Modified
Cylinder Volume	149,23 ≈ 150 cc	174,715 ≈ 175 cc
Combustion Chamber Volume	15,545 cc	17,476 cc
Compression Ratio	10,599 ≈ 10,6	10,998 ≈ 11
Initial Compression Temperature (Ta)	341,346°K	341,346°K
Final Compression Pressure (Pc)	20,6 atm	21,6 atm
Compression Temperature (T_c)	780°K	790°K
Theoretical Average Indicator Pressure (P_{it})	10,69 Kg/cm^2	11.052 Kg/cm^2
Actual Average Indicator Pressure (P_i)	9,621 Kg/cm^2	9.94 Kg/cm^2
Indicator Power (Ni)	13,05 HP	16,4 HP
Effective Power (Ne)	10,83 HP	13,6 HP
Torque (T)	12,85 Nm	16,14 Nm

3. Result and Discussion

The testing of standard and modified motorcycle engines was conducted using a dynamometer. Below is the comparison data of power between the standard and modified engines from the dynamometer testing results. Figure 3 illustrates the power comparison between the standard and modified motorcycles. The test results indicate an increase in engine power after modification. This power increase is quite significant, with an average power increase of 23%. Power increases rapidly when the throttle is opened, especially in the engine speed range of 2500 to 3000 rpm. In the standard engine, there is a tendency for power stability in the speed range of 2000 to 8000 rpm, with an increase even observed in the speed range of 4000 to 6000 rpm. On the other hand, in the modified engine, there is a decrease in power in the speed range of 3000 to 8000 rpm. Although the enlarged combustion chamber volume after modification leads to a decrease in piston work pressure, overall, this modification still results in a beneficial power increase in the modified engine [5] [10] [6].

Table 2 shows the difference in power values between the standard and modified engines at 4000 to 8000 rpm. The average power increase in the modified engine is 23%, equivalent to a power increase of 2.42 HP compared to the average power of the standard engine. The highest percentage increase in power occurs at an engine speed of 6000 rpm, reaching 26%, while the lowest power increase occurs at 5000 rpm with a 17% increase.

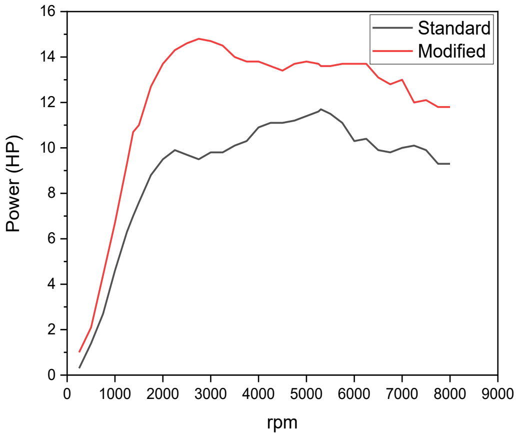

Fig 3. Engine Power Comparison

Table 2. Calculation Results of Standard and Modified Engine Specifications

Rotational speed (rpm)	Power (HP)		Percentage
	Standard	Modified	
4000	11,1	13,55	22%

Rotational speed (rpm)	Power (HP)		Percentage
	Standard	Modified	
5000	11,6	13,6	17%
6000	10,7	13,45	26%
7000	10,3	12,85	25%
8000	9,4	11,65	24%
Average	10,6	13,02	23%

Figure 4 shows the results of torque testing on standard and modified motorcycles. From the test results, it is evident that the modified engine produces an increase in torque. The peak torque of both engines occurs in the 1500-2000 rpm range. The increase in torque at a speed of 2000 rpm reaches the highest level compared to other speeds. After surpassing the speed of 2000 rpm, the torque starts to decrease until it reaches 8000 rpm. The decrease in torque is caused by the increase in engine speed, which makes the engine torque lower, influenced by the different transmissions used at low and high speeds [8] [11] [4] [3]. The average torque value produced by the modified engine is higher by 22%, or equivalent to 2.96 Nm compared to the standard engine.

The comparison between theoretical calculations and dynamometer testing aims to assess the differences in power and torque between the standard and modified engines. Figure 5 shows the comparison of theoretical calculations with experimental dynamometer results. The difference in power values between theoretical calculations and dynamometer testing for the standard engine is 2%, or equivalent to a greater value of 0.23 HP in theoretical calculations. Meanwhile, the torque comparison for the standard engine indicates a difference of 5%, or equivalent to a greater value of 0.7 Nm in dynamometer testing.

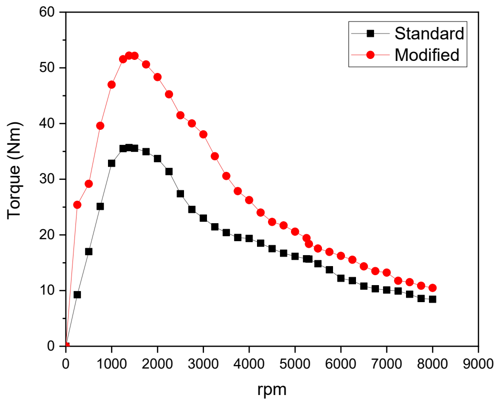

Fig 4. Torque Test Results

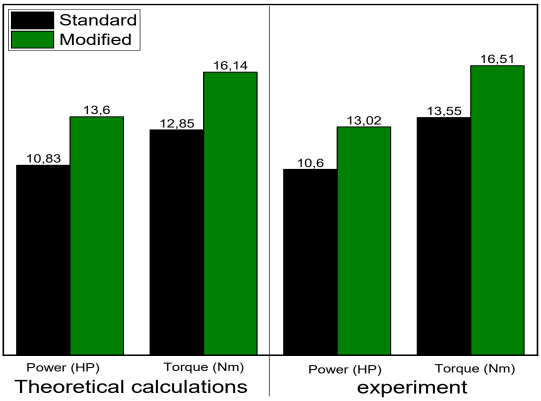

Fig 5. Comparison between Theoretical Calculations and Dynamometer Test Results

Meanwhile, the power comparison in the modified engine shows a difference of 4%, equivalent to a larger value of 0.58 HP in theoretical calculations. The torque comparison in the modified engine shows a difference of 2%, equivalent to a larger value of 0.37 Nm in the dynamometer test. The torque and power comparisons between theoretical calculations and dynamometer tests for both standard and modified engines do not exceed 5%. The differences in values between theoretical calculations and dynamometer tests may be attributed to various factors, including the vehicle's usage history.

4. Conclusion

Research on the analysis of the effect of combustion chamber volume on engine performance improvement has been conducted. Based on the experimental analysis results, it can be concluded that the average power generated by the standard engine is 10.6 HP, while the modified engine produces 13.02 HP. This indicates that the modified engine is capable of producing a higher average power, 23% higher than the standard engine. The highest power for the standard engine is recorded at 11.6 HP at 5000 RPM, while for the modified engine, it reaches 13.6 HP at the same engine speed. The comparison of power values between theoretical calculations and dynamometer tests shows a difference of 2% for the standard engine, where the theoretical calculation is higher by 0.23 HP. Meanwhile, for the modified engine, the difference is 4%, with the theoretical calculation being higher by 0.58 HP. The average torque for the modified engine is higher, 22% larger than the standard engine. The highest torque for the standard engine is recorded at 19.71 Nm at 4000 RPM, while for the modified engine, it reaches 23.98 Nm at the same engine speed. In theoretical calculations, there is a torque difference of 5% for the standard engine, where the theoretical calculation is higher by 0.7 Nm. Meanwhile, for the modified engine, the difference is 2%, with the theoretical calculation being higher by 0.37 Nm. Overall, the modifications made have successfully improved the engine's performance with consistent fuel consumption. The results of this study can be used as a reference for the application of cylinder volume to enhance motorcycle performance.

Authors' Contributions

Slamet Saefudin: Conceptualization, Methodology, Investigation, Visualization, Formal analysis, Writing – original draft, Writing – review & editing. Samsudi Raharjo: Conceptualization, Methodology, Validation, Writing – review & editing, Supervision. Ilham Yustar Afif: Conceptualization, Methodology, Writing – review & editing, Supervision. Dini Cahyandari: Conceptualization, Validation, Writing – review & editing, Supervision, Muhammad Subri: Methodology& editing, Agus Awaludin: Investigation, Visualization

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Conflicts Of Interest

The authors declare they have no conflicts of interest.

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