# Effect of Intake Manifold Porting and Polishing and Throttle Body Venturi Diameter Modification on Motorcycle Performance

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***Abstract*** *The automotive industry, particularly in the motorcycle sector, is experiencing rapid growth where manufacturers compete to market products with appealing aesthetics and superior engine performance. However, motorcycles equipped with EFI systems may experience performance degradation within two to three years, especially in automatic models, characterized by slower responsiveness and increased vibrations. One effective method to enhance engine performance is by modifying the intake system to optimize air and fuel delivery, thereby increasing power and torque. This study aims to explore the impact of modifying the intake manifold and throttle body on the performance of the Yamaha Mio M3 125cc motorcycle engine. Using a two-level factorial experimental design, the study investigates two main variables: intake manifold diameter (27 mm and 30 mm) and throttle body diameter (26 mm and 28 mm). Testing is conducted using a dynamometer and analyzed using statistical methods. The research findings demonstrate that modifications to the intake manifold and throttle body significantly affect the performance of the Yamaha Mio M3 125cc engine. The combination of a 27 mm intake manifold and a 28 mm throttle body produces the highest torque of 23.1 Nm at 2058 RPM, while the combination of a 27 mm intake manifold and a 26 mm throttle body yields the highest power output of 11.2 HP at 7155 RPM. These modifications result in a 10.53% increase in torque and a 16.67% increase in power compared to the standard configuration. Thus, modifying the intake manifold and throttle body can significantly enhance the performance of the Yamaha Mio M3 125cc motorcycle engine.*

***Keywords*****:** *Intake manifold modification, Throttle body modification, Engine performance, Yamaha Mio M3 125cc*

## 1. INTRODUCTION

Currently, the automotive industry, especially the motorcycle industry, is growing rapidly. Motorcycle manufacturers compete to market their products by offering various advantages in terms of design and engine performance. An engine is considered to have good performance if it can produce high power with high fuel efficiency. Generally, motorcycle engine performance can be improved by making various modifications to the engine components and construction[1].

Fuel injection is a technique used by motor vehicles to mix fuel and air to achieve perfect combustion[2]. Air is directed into the cylinder according to the driver's input. When the throttle valve opens wider, the amount of air flowing into the cylinder also increases[3]. EFI (Electronic Fuel Injection) is a fuel injection system controlled by the ECU (Engine Control Unit) to ensure the air-fuel mixture meets the requirements of the combustion engine[4]. A four-stroke engine is an internal combustion engine that undergoes four piston strokes in one combustion cycle[5].

The performance of a motorcycle engine with an EFI system is superior to that of a conventional system (carburetor) because the operation of an EFI motorcycle is electronically controlled, improving efficiency. However, using a motorcycle with an EFI system for two to three years can lead to a decline in performance, characterized by symptoms such as reduced responsiveness and vibrations, especially in automatic models[6].

Several factors can influence the capabilities of a motorcycle, including cylinder volume, compression ratio, fuel quality, and volumetric efficiency [7]. In this context, the desired performance should meet very specific requirements for acceleration and maximum speed for the vehicle user. There are many ways to improve engine performance, either by modifying the engine itself or by adjusting the valve diameter[8]. Improving engine performance in gasoline motorcycles can also be achieved in various ways, such as increasing piston diameter, lengthening piston stroke, raising compression ratio in the combustion chamber, modifying inlet and outlet ports, or adjusting the timing of cylinder port openings [9].

One method to enhance vehicle engine performance is by modifying the air intake channels to achieve increased power and torque. This modification involves enlarging and smoothing the inner surfaces of the air intake channels, thereby improving the flow of air and fuel into the combustion chamber. This results in a greater piston thrust[10]. Porting and polishing involve reconfiguring the intake and exhaust ports to increase the volume of air and fuel entering the combustion chamber more smoothly than before. Meanwhile, polishing is done to smoothen the ported components as well as other components within the engine to enhance the intake of fuel and air more smoothly[11].

Improving airflow and fuel flow can also be achieved through venturi modifications. These modifications are influenced by the shape, diameter, and smoothness of the venturi surface. A rough-surfaced venturi will produce a different airflow pattern compared to a smooth surface. A smaller venturi diameter increases air velocity, resulting in low air pressure, causing fuel in the float chamber to be drawn in and mixed with the continuously flowing air into the cylinder. However, if the venturi is too narrow, power will decrease because the supply of air and fuel becomes limited[8].

The intake manifold plays a role in channeling the air-fuel mixture processed by the carburetor into the combustion chamber[12]. Many field observations indicate various methods of engine component modifications are undertaken to enhance efficiency and engine performance. One of these methods involves altering the diameter size of the intake manifold, aiming to improve the smoothness and acceleration of the fuel-air mixture flow entering the combustion chamber[13].

Several previous studies aimed at enhancing motor performance have found that the highest power is achieved when using a 30mm throttle body, reaching 11 Hp at 3500 rpm. Similarly, the highest torque also occurs when using a 30mm throttle body, which is 27.58 N.m at 1500 rpm. The larger the throttle body size, the greater the airflow entering the intake manifold due to the difference in its cross-sectional area. This incoming air is detected by the oxygen sensor (O2), which then sends a signal to the ECU to increase the fuel injection duration. This results in an improved air-fuel mixture, consequently increasing the generated power. Torque also increases because torque is directly proportional to power; the greater the power, the greater the torque[10].

Performance testing of a 110cc automatic motorcycle with variations in throttle body diameters of 22 mm, 24 mm, and 26 mm has been conducted to enhance performance. The results indicate that the best torque is achieved when using a 24 mm throttle body, reaching 7.765 N.m at 6000 rpm. This represents a 5.8% increase in torque compared to testing with the standard throttle body. Meanwhile, the best power occurs with the 24 mm throttle body, reaching 6.6075 HP at 7000 rpm. This indicates a 4.5% increase in power from testing with the standard throttle body. This research aims to improve the engine performance of the motorcycle with variations in throttle body diameter[14].

The Yamaha Mio M3, which is one of the popular automatic motorcycles in Indonesia, is equipped with a 125cc SOHC 2-valve engine capable of producing power of 9.3 HP and torque of 9.6 Nm. The potential of the Yamaha Mio M3 to enhance its performance can be achieved through Porting Polish modifications on the intake manifold and throttle body[15].

Among the numerous methods to enhance motorcycle performance through venturi modifications on the carburetor or throttle body, there hasn't been research conducted combining both modification techniques simultaneously, namely venturi throttle body modification and porting intake manifold. This combination is expected to yield a more optimal performance enhancement compared to performing only one modification.

## 2. METHODOLOGY

### 2.1 Research Object

The object of this research is the 2014 Yamaha Mio M3 125 CC motorcycle, which utilizes Pertamax fuel. This research at GRC Racing is located in Cisagasar Hamlet, North Sumedang District, Sumedang Regency, West Java 4562.

### 2.2 Research Instrument

The instrument used in this research is the Dyno test, which functions to measure torque and power on the vehicle.

### 2.3 Research Procedure

Before researching the vehicle, the equipment to be used must be prepared, including the research material, namely the Yamaha Mio with a standard 24 mm throttle body and 27 mm intake manifold already installed. The experimental design used is a two-level factorial design with two factors, namely intake manifold diameter (27 mm and 30 mm) and throttle body diameter (26 mm and 28 mm). The combination of these two factors produces four treatments that will be tested.

### 2.4 Data Collection Technique

The data collection method in this research involves experimental studies comparing combinations of intake manifold and throttle body. Data is directly collected from the motorcycle, with speed measured using a dynamometer, as well as power and torque test results. Tables are used as data collection instruments, which are then processed into graphs to show the proportion of power and torque usage on the tested motorcycle. Analysis of the power and torque test results is conducted by comparing combinations of the standard intake manifold and throttle body with modifications to provide clarification regarding the differences observed.

## 3. RESULTS AND DISCUSSION

The analyzed test data includes the standard intake manifold and throttle body, as well as modifications 1, 2, 3, and 4. The following are the torque and power test results:

**Table 1.** Torque Test

| NO | INTAKE MANIFOLD | THROTTLE BODY | TYPES | RPM | TORQUE (N.m) |
|---|---|---|---|---|---|
| 1 | 27nm | 24nm | Standard | 2403 | 20.9 N.m |
| 2 | 27nm | 26nm | Combination 1 | 2132 | 21.3 N.m |
| 3 | 27nm | 28nm | Combination 2 | 2058 | 23.1 N.m |
| 4 | 30nm | 26nm | Combination 3 | 2073 | 22.2 N.m |
| 5 | 30nm | 28nm | Combination 4 | 1653 | 20.5 N.m |

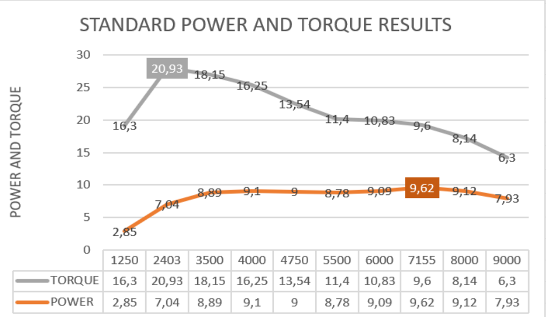
From Table 1, we can see the specifications of the four combinations and the dyno test results for torque (N.m). Among the four dyno tests with accurately measured sizes, the first combination yielded a torque of 21.3 N.m at 2132 RPM, the second combination produced a torque of 23.1 N.m at 2058 RPM, the third combination resulted in a torque of 22.2 N.m at 2073 RPM, and the fourth combination generated a torque of 20.5 N.m at 1653 RPM.

**Table 2.** Power Test

| NO | INTAKE MANIFOLD | THROTTLE BODY | TYPES | RPM | POWER (HP) |
|---|---|---|---|---|---|
| 1 | 27nm | 24nm | Standard | 7155 | 9.6 HP |
| 2 | 27nm | 26nm | Combination 1 | 6696 | 11.2 HP |
| 3 | 27nm | 28nm | Combination 2 | 6015 | 10 HP |
| 4 | 30nm | 26nm | Combination 3 | 6104 | 9.5 HP |
| 5 | 30nm | 28nm | Combination 4 | 6679 | 10.67 HP |

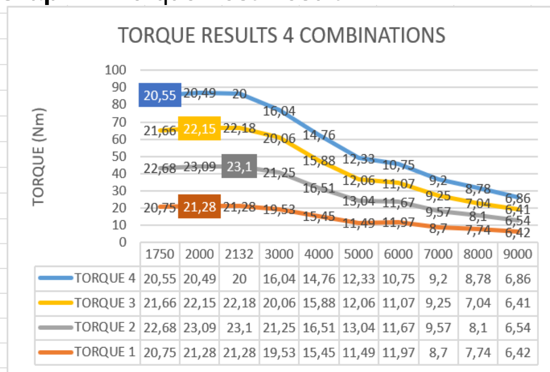
From Table 2, we can see the specifications of the four combinations and the dyno test results for Power (HP). Among the four dyno tests with accurately measured sizes, the first combination yielded a Power of 11.2 HP at 7155 RPM, the second combination produced a Power of 9.8 HP at 6015 RPM, the third combination resulted in a Power of 9.5 HP at 6104 RPM, and the fourth combination generated a Power of 10.67 HP at 6679 RPM.

**Graph 1.** Standard Torque and Power Test Results



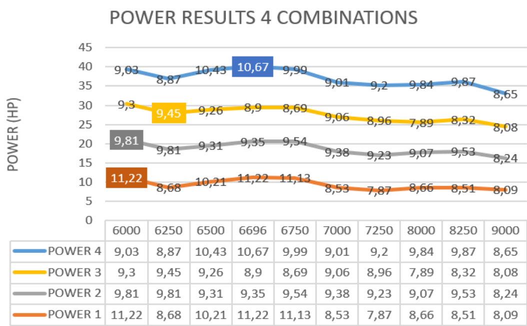

From the dyno test results of the standard intake manifold and throttle body without porting and polishing processes and modifications, the engine produced a maximum power of 9.6 HP at 7155 RPM and a maximum torque of 20.93 N.m at 2403 RPM.

**Graph 2.** Torque Test Result




Graph 2 above, explains the torque test data results (N.m) from the four combinations. From the calculation results between the standard intake manifold and throttle body and the modified intake manifold and throttle body, combination 2 shows an increase in torque (N.m) of 10.53%. From the analysis results, it can be seen that performing Porting Polish modifications can result in a greater torque (N.m) because the performance of the engine after Porting Polish on the intake manifold and throttle body produces a better air-fuel mixture, thus leading to more perfect combustion. In accordance with previous research [14].

**Graph 3.** Power Test Result




Graph 3 above, explains the power test data results (HP) from the four combinations. From the calculation results between the standard intake manifold and throttle body and modified intake manifold and throttle body, combination 1 shows an increase in power (HP) of 16.67 % more. From the analysis results, it can be seen that performing Porting Polish modifications can result in greater power (HP) because the engine's performance after Porting Polish on the intake manifold and throttle body produces a better air-fuel mixture, thus leading to more perfect combustion. In accordance with previous research [14].

## 4. CONCLUSION AND SUGGESTIONS

### 4.1 Conclusion

1. The results of the modifications to the intake manifold and throttle body combination 1 yield a torque of 21.3 N.m at 2132 RPM, combination 2 produces a torque of 23.1 N.m at 2058 RPM, combination 3 results in a torque of 22.2 N.m at 2073 RPM, and combination 4 generates a torque of 20.5 N.m at 1653 RPM. From the calculation results comparing the standard intake manifold and throttle body with the modified intake manifold and throttle body, combination 2 shows an increase in torque (Nm) of 10.37%.
2. The power test data results (HP) from the four combinations indicate that for the modifications to the intake manifold and throttle body, combination 1 can produce a power of 11.2 HP at 6696 RPM, combination 2 yields a power of 10 HP at 6015 RPM, combination 3 produces a power of 9.5 HP at 6104 RPM, and combination 4 generates a power of 10.67 HP at 6679 RPM. From the calculation results comparing the standard intake manifold and throttle body with the modified intake manifold and throttle body, combination 1 shows an increase in power (HP) of 16.67%.

### 4.2 Suggestions

After conducting testing and data collection, several suggestions emerged from this research:

1. Adjustments to the automatic transmission settings are necessary due to their impact on torque and power output.
2. During testing, it is crucial to address any issues with the automatic transmission beforehand as this can influence the final test results.
3. To achieve optimal engine performance, remapping the ECU is also essential to ensure improved outcomes. This step is critical for aligning engine parameters with desired efficiency and performance levels.

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