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The effects of the turbulator blade-angle variation on the intake manifold for improving the power and torque of 4-stroke motor cycle engine

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Abstract. The motorcycle is a two-wheeled vehicle driven by a motor fuel. The motor fuel is a machine converting the thermal energy into the mechanical energy. The power and torque are one of the parameters that maintained in improving the motorcycle performances. One of the appropriate ways that can be generated use of enhancing the power and torque is to upgrade the combustion process by pairing the turbulators in the intake manifold. The pairing aims at producing the air vortex into the combustion chamber. The research finding of power and torque using the dynotest indicated that the turbulator used in the intake manifold at a 25 degree blade-angle decreased the power by 22% and torque by 9%. The use of turbulator in the intake manifold at a 40 degree blade-angle increased the power by 12% and torque by 3%. The use of turbulator in the intake manifold at the 55 degree blade-angle, on the other hand, decreased the power by 9% and the torque by 7%.

1. Introduction

In today's era, the motorcycle is a means of transportation that is ridden by mostly Indonesians. Motorcycle is a two-wheeled vehicle driven by a motor fuel. The motor fuel is a machine which converts the thermal energy into the mechanical energy. Based on the ignition system, the motorcycle was classified into the motor gasoline which is also called automotive motor.

The power of the motorcycle is the parameter of determining the performance of the machine that is made as a reference to choosing the product. This means that product should be prior the power of its engine. One of the factors that can affect the power and torque of the motorcycle is its incomplete combustion. The incomplete combustion is influenced by the entry system before the fuel and the air get into the combustion chamber. The entry system consists of an injector, throttle body and intake manifold. The shape of the intake manifold affects the shape of the fluid flow inside which will get into the combustion chamber. The curved intake manifold will only produce a sour stream, so the fuel mixture with the air does not necessarily mix well. However, for a complete combustion, it is necessary to make a stream that is random (turbulent).

One of the ways that can be made use of forming the flow of air and fuel into the combustion chamber is more turbulent by pairing the turbulators in the intake manifold. With the formation of the vortex and randomness of the air into the combustion chamber, they will cause the air mixture with more homogeneous fuel. The purpose of this researchers was to examine and create the high power to form the air for more random and trumpling (turbulen) into the combustion chamber. The trick was to pair the tool on the intake manifold called turbulator.



2. Fundamental theory of the turbulator system

2.1. The effect of turbulator instalation

Turbulator will form a vortex-shaped flow and make the incoming air through throttle body and the fuel that was sprayed by the injectors in the form of mist will be more homogeneous when there is randomness or turbulence between two types of this fluid. This is because the air will be strangle in the presence of the turbulent angle until the air passing through the turbulent angle will form a compressed wind vortex.

The installation of turbulator causes the changes in the airflow characteristics. One of them is the emergence of turbulence [1]. The addition of turbulence will cause the increase in the turbulence causing the mixing of the air with the fuel to be more homogeny [2]. Turbulent manufacturer (turbo cyclone) explains their product superiority where the turbo cyclone can increase the power by 30% to enable the use of gear 3 and 4 at low and medium speeds. The mileage gets longer, so the fuel is more efficient at least 10%. Due to the wind velocity, the remaining carbon is pushed out, the combustion chamber becomes clean, and the pollution contained in the exhaust gases becomes reduced. Then the piston motion is more consistent (Horizontal/vertical), the friction power is smaller until the engine age grows longer. The engine is more stable and has a smoother sound.

Based on the statement above, the perfection of the combustion process of the air and fuel is capable of producing a large explosive power on the piston so that the pressure generated is also greater. This pressure pushes the piston from the top dead point to the bottom dead point with the great power. The weight on the crankshaft with a predetermined alpha angle helps the pistons return from the bottom dead point to the top dead point. With a strong thrust force caused by an explosion of combustion, the reaction of the weight on the crankshaft is also getting faster. This causes a crankshaft rotation that changes the translational motion into faster rotational motion. The faster the engine speed is calculated at a certain time the greater the power and torque of the motor generated.

2.2. Renold number

Reynolds number is a comparison between the inertial force $[\rho V^2 A]$ to the viscosity force. The Reynolds number, which has no dimension, expresses the ratio of viscosity forces (viscosity). Reynolds is a comparison between the effects of inertia and viscous inflow [4]. For pipeline flow, the Reynolds number is defined by $\rho \times U \times d$ divided by μ [5]. In the full flowing circular pipes applies the equitation as follows.

$$Re = \frac{\rho u d}{\mu} \text{ or } \frac{V d}{\nu} = \frac{V(2r_0)}{\nu} \quad (1)$$

Where:

U : Average speed in m/s

d : Pipe diameter in m

ν : Fluid kinematic viscosity in m^2/s

ρ : Fluid mass density in kg/m^3

μ : Absolute viscosity in Pa/s or kg/m.s

2.3. Laminar flow

The laminar flow is a fluid flow that moves with the conditions of the layers (the fifths) to form flow lines that do not intersect with each other. Laminar flow is a flow of fluid that glides smoothly. This is shown by Reynolds. At low flow rates, laminar flow is depicted as long filaments flowing along the stream as shown in figure 1.

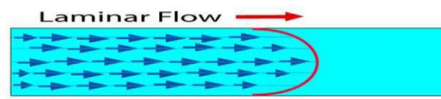


Figure 1. Laminar flow

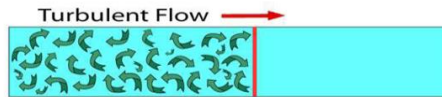


Figure 2. Turbulent flow

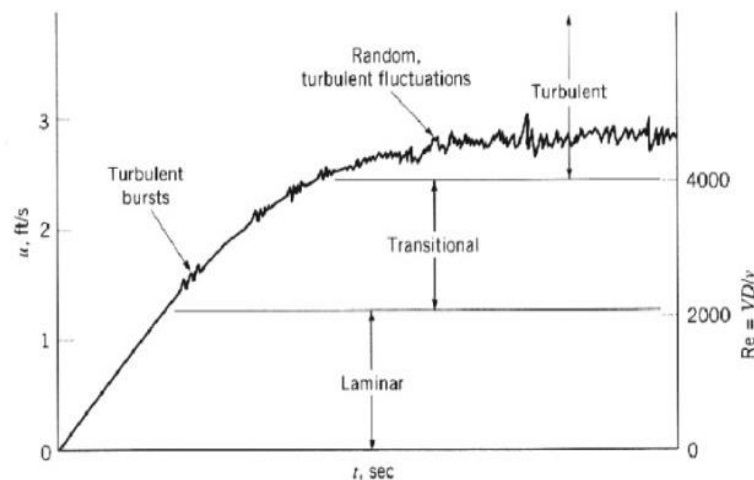


Figure 3. Transition Graph from Laminar Flow becomes Turbulent in a Pipe

2.4. Transitional and turbulent flow

Transitional Flow is a flow of transition from laminar flow to turbulent flow. Furthermore, The fluid flow in a pipe may be a laminar flow or turbulent flow. Turbulence is a diffuse flow spread with the different sizes of gas molecules described as irregular small flow moves away from the flow centre. Turbulent flow is a flow where the speed component is nonzero and exhibits randomness [5].

Turbulence flow increases along with the increase in speed of engine speed ". The fluid flow in the round pipe is said to be turbulent depending on the Reynolds (Re) number generated. From the statements and graphs above, it can be said that turbulent flow is a small irregularly shaped flow which is away from the midpoint of a pipe having Reynolds numbers over four thousand.

2.5. Burning process

Burning process is a physical process that takes place inside a cylinder during combustion. This corresponds to an increase in temperature and pressure within the cylinder [7]. The combustion process of a gasoline engine is part of the energy change process (change of energy) to produce the machine work [8]. The combustion process is a chemical process between fuel and air which is then followed by rising pressure and temperature (thermal energy).

2.6. Power and torque

Power is defined as the result of work, or in other words, power is the work or energy the machine generates per unit of time when the machine is operating [9] [13]. Power is the work done within a certain time limit [F.c/t]. On a motorcycle, the power is the multiplication between the moment (Mp) with the engine rotation (n) [10]. Power is the rate measured by the amount of work performed by a

motor at a given time, generally calculated in 1 second 75-kg [9] [10]. To calculate the power, it can be calculated with the following equation:

$$P = \frac{2\pi nT}{60000} \quad (2)$$

Where, P is Power, n is engine rotation, and T is engine torque Power is the amount of engine work or energy generated per unit of time the machine operates. The results of the performance of a machine one of them are refer to the power of a motor.

Torque is the turning moment at the crankshaft output generated by the combustion pressure inside the cylinder causing the piston to go up. The movement of this piston causes the crankshaft to rotate and then forwarded to the wheels of the movers.

2.7. Turbulator

Turbulator is an additional tool that serves to form a fluid vortex that is placed in the air intake in the engine. Turbulator blades are like propellers where the mechanism works in contrast to the propeller, meaning that when the blades rotate, it will push the fluid but on the fluid turbulent rotated by the silent blades. This can happen because the fluid being rotated has a speed that allows it to be rotated by a silent blade. The fluid which is rotated will form a vortex so that when turbulator paired into the intake manifold then the air passing turbulent will be vortex and random because in turbulence blades there are also holes. Given the vortex and randomness of air coming into the combustion chamber will produce a more homogeneous mixture with fuel sprayed by the injector. "The addition of turbulent (turbo cyclone) to intake manifold as a vortex and homogeneous builder can improve the effectiveness of combustion [12].

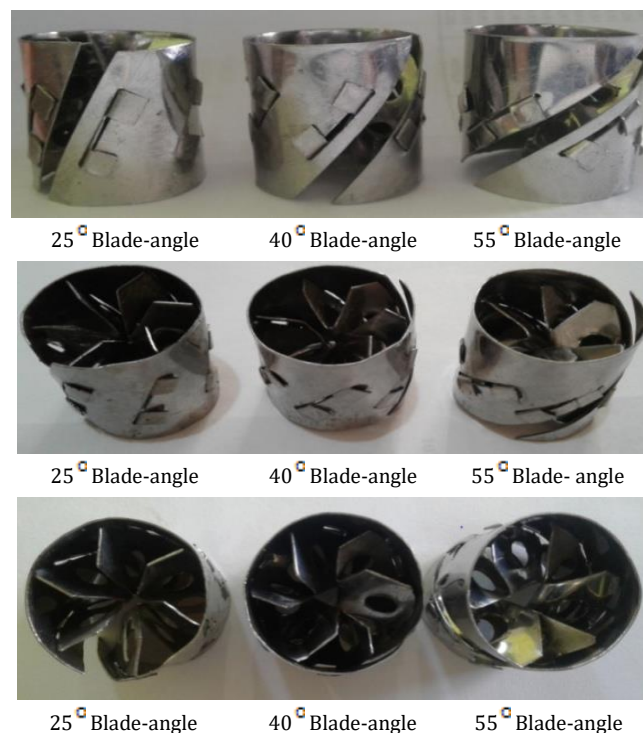


Figure 4. Turbulator with Blade Angle Variations

3. Research methodology

This study used post-test-only control design. This study was intended to determine the effect of turbulent use on the intake manifold on power and torque on the motorcycle. Locus of research and

testing conducted at Draco Motor which is located at Jl. Durian, Simpang TVRI No. 21C Pekanbaru City, Riau Province. As for the object of this research was a four-stroke motorcycle, the Honda Vario Techno 125 PGM-FI in 2012. The specifications were as follows.

Table 1. The specification of Honda Vario Techno 125 PGM FI

Specifications	
Empty Weight	112 Kg
Machine Type	4 steps, SOHC
Cooling System	Fluid
Diameter x Step	52,4 x 57,9
Compression Comparison	11,0 : 1
Maximum Power	11,3 Ps/8500 rpm
Maximum Torque	1,1 kgf.m/8500 rpm

Data collection technique in this research was directly undertaken on motorcycle which was being tested by using dynamometer test instrument. This technique aimed at obtaining the motorcycle power data, while the instrument of collecting the data in the form of tables that would be further processed, resulting in a graph of percentage of motor power being tested. To analyse the overall data obtained and show the results of the testing of the power and torque that did not use turbulator and which used turbulator, and to show the effect of turbulator blade-angle variation to the power and torque on the four-step motorcycle.

4. Experimental results and discussion

Table 2. The power of experimental motor cycle

No	Standard without turbulator	Angle blade 25	Angle blade 40	Angle blade 55	rpm
1	7.4	5.7	8.4	7.1	8500
2	7.6	5.8	8.6	6.8	8500
3	7.5	5.9	8.6	6.6	8500
Total	22.5	17.4	25.6	20.5	
Average	7.5	8.5	8.53	6.83	

Table 3. The torque of the experimental motor cycle

No	Standard without turbulator	angle 25	angle 40	angle 55	rpm
1	9.73	8.88	9.8	9.11	5000
2	9.61	8.67	9.83	8.95	5000
3	9.55	8.66	10.2	8.54	5000
total	28.89	26.21	29.83	26.6	
Average	9.63	8.73	9.94	8.86	

The experimental results in this study as shown in table 2 and 3. Then described in the Figure 5, from the experimental results show that the power ratio at Rp 8500 and torque at 5000 rpm generated by a motorcycle without using turbulator and with using turbulator blade-angle variations. The red colour shows the motorcycle power chart. The green colour shows the motorcycle torque chart. On the graph, it can be noticed that the use of turbulator on the intake manifold significantly affect the engine power and torque of the Honda Vario Techno 125 PGM-FI's four-stroke motorcycle. It decreased the power at 8500 rpm using turbulator at a 25° blade-angle by 7,5 HP to 5,8 HP and reduction of torque at 5000 rpm by 9,63 Nm to 8,73 Nm. There was the increase in power at 8500 rpm using turbulator

with the 40-degree blade angle by 7.5 HP to 8.53 HP, the increase in torque at 5000 rpm using turbulence with 40-degree blade angle by 9.63 Nm to 9.94 Nm. The decreased power at 8500 rpm using turbulator with 55-degree blade angle by 7.5 HP to 6.83 HP and the decreased the power at 5000 rpm using turbulator with 55 degree blade angle by 9.63 Nm to 8.86 Nm.

In accordance with the purpose of research to be achieved, namely to find the effect of the variation of the turbulence's blade angle of the intake manifold on the four-step motorcycle. So based on research that has been done on the Honda Vario Techno 125 PGM FI's motorcycle with the testing at maximum engine speed and was conducted three times of testing using a chassis dynamometer. Then, the data of the test results were taken the average data used in the data analysis.

The data collection in table 1 and table 2 of the power and torque test result data showed a very clear difference between the use of turbulator blade angle variations in the intake manifold and the one that did not use turbulator in affecting the power and torque of Honda Vario Techno 125 PGM FI's motorcycles. In the use of turbulator at a 25-degree blade angle, the motorcycle power was 5.8 HP while the motor power that does not use turbulator was 7.5 HP. This was clear that there was a decrease in the motor power using turbulator at a 25-degree blade angle with the decrease in 22%. Similarly, the torque also decreased the motor torque using turbulator at a 25-degree blade angle to 8.73 N.m and motorcycle torque that does not use turbulator was 9.63 N.m with the decrease in 9%. This decrease occurred because the turbulence generated by the turbulator at a 25-degree blade angle was smaller than the condition of turbulator addition at a 40,55-degree blade angle. So the homogeneity of the air and fuel mixture was not so perfect. Turbulence is also affected by the speed, so the pipe/intake manifold without turbulator produces higher speed compared to the addition of turbulator. This meant that the higher the speed the Reynolds number produced the higher and the greater the occurrence of turbulence in the air flow.

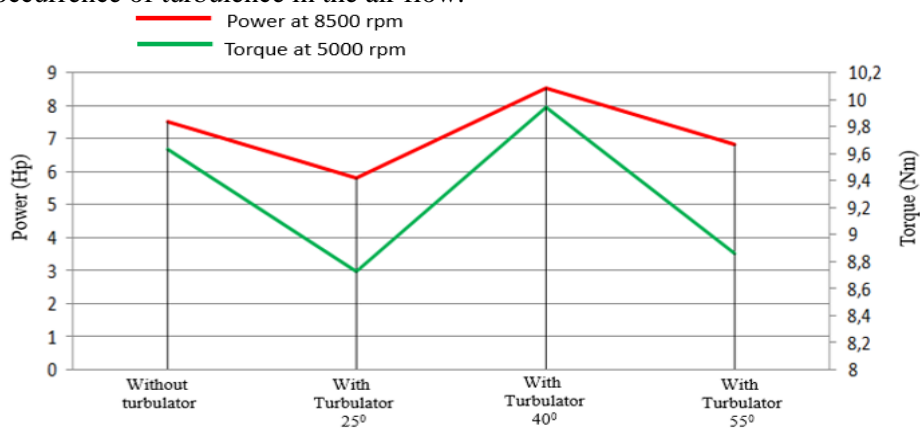


Figure 5. Torque and power curve

In the use of turbulator at a 40-degree blade angle, the motorcycle power was 8,53 HP while the motor power that does not use turbulator was 7.5 HP. This was clear that there was a increase in the motor power using turbulator at a 40-degree blade angle with the increase in 12%. Similarly, the torque also increased the motor torque using turbulator at a 40-degree blade angle to 9,94 N.m and motorcycle torque the one that does not use turbulator was 9.63 N.m with the increase in 3%. The increase occurs due to the formation of a more turbulent airflow but the airspeed is not so disturbed. The holes on the turbulent blades are more open and allow the piston to suck in the air or not so affect volumetric efficiency. In the use of turbulator at a 55-degree blade angle, the motorcycle power was 6,83 HP while the motorcycle's power that does not use turbulator was 7.5 HP. This was clear that there was a decrease in the motorcycle's power using turbulator at a 55-degree blade angle with the decrease of 9%. Similarly, the torque also decreased the motor torque using turbulator at a 55-degree blade angle to 8,86 N.m and motorcycle torque that does not use turbulator was 9.63 N.m with the decrease of 7%. This decrease occurred because the turbulence produced was smaller than the standard condition.

The description above explains that the use of variation of the turbulators' blade angles indicates the quality of combustion. This can be seen with the increase and decreases of power and torque on the motorcycles that use turbulence blade angle variations in the intake manifold compared to those that did not use them (turbulators). In conclusion, turbulence affects the form of air coming into the combustion chamber will be more turbulent and affect the combustion process in the combustion chamber. This is in line with the more homogeneous mixture the more easily combustible, while turbulence will also help the speedup flame diffusion and cause the combustion evenly faster [7].

In contrast, the addition of turbulence affected the amount of the air being inhaled/sucked by the piston because the resistance created by the turbulence blades affected the volumetric efficiency. Turbulator at a 40° blade angle positively affected compared to the turbulator at a 25° and 55° blade angles respectively. This can be seen in figure 10 of the test result graph. From the graph it can be seen that the decrease and the increased power and torque of the motorcycles using the turbulence blade angle variations in the intake manifold.

5. Conclusion

The use of turbulence in the intake manifold at a 25-degree blade angle reduced power by 22% and torque by 9%. The use of turbulence in the intake manifold at a 40-degree blade angle increased the power by 12% and torque by 3%. The use of turbulence in the intake manifold at a 55-degree blade angle decreased the power by 9% and torque by 7%. This means that the uses of turbulent blade angles variations in the intake manifold significantly affected the power and torque of four-step motorcycles.

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