Experimental Study on the Effect of Bore Up, Stroke Up, and the Use of Valves on 105 cc Engine Perfomance

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Abstract On a 4-stroke engine, valve work and function have a very big influence on engine performance and characteristics. To improve engine performance, one of them is by way of bore up. This study aims to determine and compare the performance of a standard 4 stroke 105 cc engine before and after bore ups, stroke ups and the use of racing valves in testing power (P), torque (T) and fuel consumption (m_f). This research method uses a 4 stroke 105 cc standard engine and a 150 cc bore up engine with a variety of standard and racing valves. The testing method uses the throttle method spontaneously from 4000 rpm to 1100 rpm and the throttle method per 1000 rpm from 4000 rpm then is increased to 8000 rpm gradually. Data taken in this study are torque (T), power (P), and fuel consumption (m_f). The results showed that by changing the volume of the cylinder (bore up) by using variations of the racing valve can significantly improve engine performance. The average value of the percentage increase in torque power and fuel consumption compared to the results on a standard 4-stroke engine. On a standard 105 cc engine for 8000 rpm engine speed, 4.63 (N.m) of torque, 3.90 (kW) of power obtained and 0.879 (kg/h) of fuel consumption. In a semi racing engine at 8000 rpm, torque is 9.45 (N.m)(104,10%), power is 8.13 (kW)(108,46%) and fuel consumption is 1.118 (kg/h)(27%). In a full 150 cc racing engine for 8000 rpm engine speed the torque is 12.87 (N.m)(177,97%), the power is 10.79 (kW)(176,67) and fuel consumption is 1.116 (kg/h)(26,96%).

Keywords: bore up, stroke up, intake valve, exhaust valve, throttle

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1. Introduction

The need for practical transportation equipment that has advantages both machine performance and the technology that is applied is very attractive to people in Indonesia. Currently, motorbikes are the most common means of transportation in Indonesia. Based on statistical data center, the use of motorcycle transportation in Indonesia has increased by 40.81% from 2014-2017 [1]. Aside from being a means of transportation, motorbikes are also used for competitions, namely racing. The motorcycle used for the competition certainly has a different arrangement than the motorcycle used for daily transportation. In motor racing has been modified on several systems and components to improve the performance of the engine. Regulation of the Minister of Transportation of the Republic of Indonesia Number 33 of 2018 concerning testing of the type of motorized vehicle in Article 1: Paragraph 2 explains that the design and engineering of motorized vehicles is a careful examination of noise in accordance with technical requirements; paragraph 17 explains that the modification of a motorized vehicle is to change the technical specifications of the dimensions, machinery, and / or the carrying capacity of a motorized vehicle [2].

Modifications are made by changing standard components or replacing components and adding components that support to improve the performance of a vehicle engine, especially modifying the combustion chamber by changing the cylinder volume to be bigger (bore up) and raising the piston stroke to be longer (stroke up) [3]. Motor performance which includes power and torque is greatly influenced by the magnitude of the variable length of the crankshaft, the diameter of the piston and the size of the combustion chamber, so that the greater the variables, the greater the value of power and torque [4].

Cylinder boring is a technique used to increase the diameter in cylindrical bore, to produce high power performance from burning fuel under high pressure [5]. This process is used to achieve three different qualities for boring: 1) Concentricity (geometry); 2) Straightness (holes); 3) Sizing (diameter)

From literature, the optimal position angle of the throttle valve opening is used to reduce CO exhaust gas and noise and vibration, because the throttle body can control the flow of air into the engine cylinder (fuel ratio) and mixing of HC fuel [6]

The purpose of this study was to determine the performance of the engine produced by the use of racing valves, bore up and stroke up on the cylinder head

2. Experimental Setup

Experiment settings that consist of engine specifications, tools, materials, and test equipment schemes for taking torque, power and fuel consumption data contained in tables and figures.

The engine specification data is in Table 1.

2.1. Research Tool and Material

In this experimental study, the tools and materials used are as in Table 2, Table 3 and Table 4.

2.1.1. Material

The materials used in this study are in the Table 2.

The fuel used in this study is Pertamax. Pertamax is a fuel that has an octane number (RON) of at least 92.0 intended for vehicle engines that have a compression ratio between 9: 1 to 10: 1, as shown in Table 3.

Table 1. 4-Stroke engine spesifications

Brand	Yamaha
Type	Vega
Machine	
Machine type	4 Stroke Air Cooled
Bore x Stroke	49,50 x 54 mm
Cylinder Volume	103,9 cc
Cylindrical Arrangement	Horizontal one
Transmission gears	4 speed
Operating pattern	N-1-2-3-4 (return)
Coupling	Manual, Wet, Multiplate
Carburettor	VM 17 x 1 Mikuni with a venturi hole 17 mm
Chamshaft standar	Duration 260˚
Starter system	Motor Starter dan Crank Starter
Valve	Intake 26 mm Exhaust 22 mm
Electricity	
Battery	12V5AH
Spark plugs	C6HSA/W20FS-U
Ignition system	CDI 5ER-10
Frame	
Frame type	Pipe
Front suspension	Telescopic Fork
Back suspension	Swing Arm
Front tire	70/90-17M/C38P
Back tire	80/90-17M/C44P
Front brake	Hydraulic discs
Rear brake	Drum brake
Dimension	
Long x Wide x High	1890 x 675 x 1030 mm
Wheelbase	1195 mm
Lowest distance to the ground	146 mm
Tank capacity	4,2 liters
Weight	95,1 kg

Table 2. research material

Fuel	Pertamax
Brand valve	Sonic
Valve size	Inlet 14711-KGH-900 diameter 28 mm
	Exhaust 14721-KTY-H50 diameter 24 mm
Piston racing	Diameter 57 mm The length of the piston rod is 57.9 mm with a stroke of 6 mm
Chamshaft racing	Duration 280˚
Carburettor	PE venturi hole diameter of 28 mm
Ignition Coil	YZ-125 with a voltage value of 25000-30000 volts

Table 3. characteristic of pertamax (Source: Pertamina Industrial Fuel Marketing, 2019)

NO.	CHARACTERISTIC	UNIT	LIMITATION		TEST METHOD	
			MIN	MAX	ASTM	OTHERS
1.	Research Octana Numbers	RON	92,0	-	D 2699	
2.	Oxidation Stability	Minutes	480	-	D 525	
3.	Sulfur content	% m/m	-	0,05 [1]	D 2622 / D 4294	
4.	Lead Content (Pb)	gr/liter	-	0,013 [2]	D 3237	
5.	Phosphorus content	mg/l	-	-	D 3231	
6.	Metal content (Mn, Fe, dll)	mg/l	-	-	D 3831	
7.	Silicon Content	mg/kg	-	-	IICP-AES (Refer to the in house method with detection limits = 1 mg/kg)	
8.	Oxygen content	% m/m	-	2,7 [3]	D 4815	
9.	Olefin content	% v/v	-	[4]	D 1319	
10.	Aromatic Content	% v/v	-	50,0	D 1319	
11.	Benzene content	% v/v	-	5,0	D 4420	
12.	Distillation:				D 86	
	10% vol. evaporation	°C	-	70		
	50% vol. evaporation	°C	77	110		
	90% vol. evaporation	°C	130	180		
	Titik didih akhir	°C	-	215		
	Residu	% v/v	-	2,0		
13.	Sediment	mg/l	-	1	D 5452	
14.	Unwashed Gum	mg/100 ml	-	70	D 381	
15.	Washed Gum	mg/100 ml	-	5	D 381	
16.	Steam Pressure	kPa	45	60	D 5191 / D 323	
17.	Specific Gravity (at 15 oC)	kg/m³	715	770	D 4052 / D 1298	
18.	Copper Blade Corrosion	merit	Class 1		D 130	
19.	Doctor Test		Negative			IP 30
20.	Sulfur Mercaptans	% massa	-	0,002	D 3227	
21.	Visual appearance		Clear and bright			
22.	Color		Blue			
23.	Coloring Contents	gr/100 l	-	0,13		

Table 4. research tool

Dyno test: An instrument for measuring the torque of an engine	
Tachometer: Tool for measuring engine speed	
Burrete: Tool for measuring fuel volume	
Fullset key	
Stopwatch	

2.1.2. Tool

The tools used are dynotest, tachometer, burrete, fullset key, and stopwatch as shown in Table 4.

2.2. Equations

The calculation of engine performance is based on the results of testing the conditions performed at 4000 rpm (rpm) up to the maximum rotation, with the throttle system as follows:

Torque (T), measured in test results.
Power (P), measured on the test results

P = 7,657 HP
1HP = 0,7457 kW
P = 5,709 kW

Calculation of fuel consumption (m_f) using a burette:

$$m_f = \frac{b}{t} \cdot \frac{3600}{1000} \cdot \rho bb \left(kg / h \right) \text{ [7]}$$

Where, b = volume of the burette (cc); t = waktu (seconds); ρbb = fuel density (kg/liter).

Formula for calculating cylinder volume:

$$Vs = \frac{\pi}{4} \times D^2 \times S \text{ [8]}$$

Where, Vs = volume of the piston rod step (cm^3) or (cc); D = piston diameter (cm); S = piston step length/stroke (cm).

The formula calculates the compression ratio

$$r = \frac{VL + Vc}{Vc} = \frac{VL}{Vs} + 1 \text{ [8]}$$

Where, r = compression ratio (cc); VL = volume of the piston rod step (cm^3) or (cc); Vc = combustion chamber volume or residual volume (cc).

2.3. Test Tool Scheme

The test results are the results of testing the power, torque and fuel consumption of each test. Power and torque data are taken from the spontaneous throttle system and fuel consumption data is taken from engine speed (rpm). Retrieval of data each carried out as many as 3 testing cycles and then taken an average value. Test tool scheme can be seen in Figure 1.
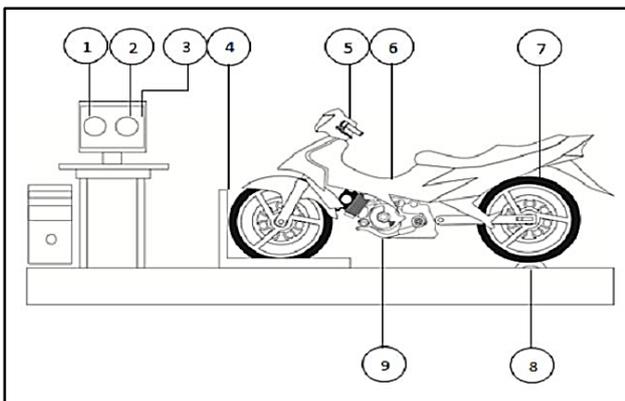

Figure 1. machine test tool scheme

schema description:
1) Torquemeter
2) Tachometer
3) Computer
4) Motorcycle body brace
5) Fuel indicator
6) Carburettor
7) Exhaust Manifold
8) Dynamometer
9) Machine.

3. Result and Discussion

3.1. Torque and Power on Standard Engine Conditions, Semi Racing (Bore up 150 cc Standard Cylinder Head) and Full Racing (Bore up 150 cc Racing Valve)
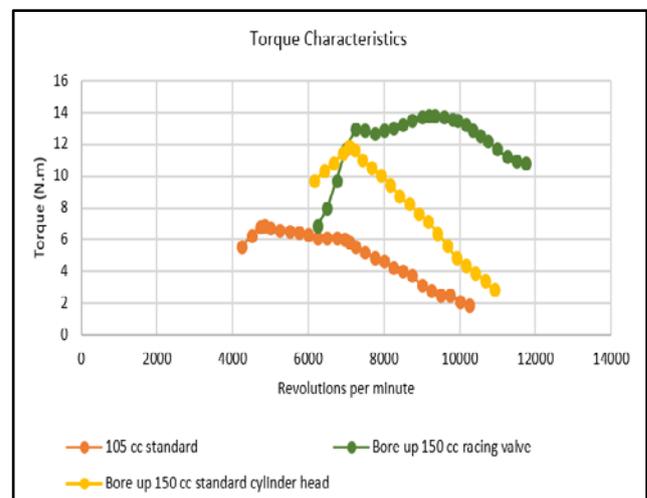

Figure 2. Torque characteristic

Seen in Figure 2 shows that the torque of the 150 cc standard cylinder head bore up and 150 cc racing valve bore up is higher than the 105 cc standard due to the enlargement of the cylindrical volume and the replacement of other components such as racing carburetors, cylinder head racing, spark plug racing, CDI racing, racing coil, and racing exhaust so that the higher compression ratio will affect the pressure of the combustion results in the cylinder and enhance the work efficiency of the engine.

The torque obtained at the standard 150 cc cylinder head bore up is lower than the 150 cc torque racing valve bore up due to the use of standard cylinder heads and standard valves so that fuel is able to enter and meet the cylinder volume a little, and affect the cylinder volumetric efficiency. the higher the efficiency of the motor, the higher the ability of the motor to produce power

With increasing engine speed (rpm) to obtain an increase in maximum torque, the maximum torque will return to the minimum even though engine speed continues to increase. this is because the time available to carry out the combustion process at high speed is very short, so that the fuel in the fuel chamber does not burn completely.
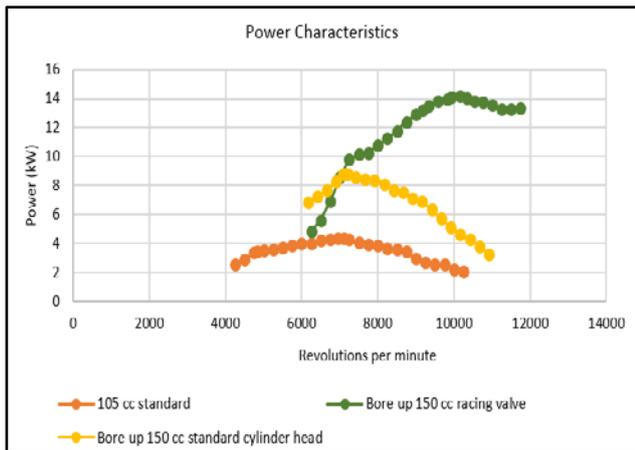
Figure 3. Power characteristic

Shown in Figure 3 shows that the power of the 150 cc standard cylinder head bore up and 150 cc racing valve bore up is higher than the 105 cc standard due to the enlargement of the cylinder volume and the replacement of other components. Maximum power of 150 cc standard cylinder head bore up is lower than 150 cc racing valve bore up due to the use of standard cylinder head and standard valve so that the fuel that is able to be sucked and meets the cylinder volume is a little, it affects the volumetric cylinder efficiency. The higher the engine efficiency, the higher the engine's ability to produce power.

The maximum power of a standard 150 cc cylinder head bore up is lower than the 150 cc torque racing valve bore up due to the use of standard cylinder heads and standard valves so that fuel is able to enter and meet the cylinder volume a little, and affect the cylinder volumetric efficiency, the higher the efficiency of the motor, the higher the ability of the motor to produce power

With increasing engine speed (rpm) to obtain an increase in maximum power rotation, the maximum power will decrease again even though the engine speed continues to increase. at the end of each cycle of the combustion engine has decreased performance due to the higher engine rotation, the greater the friction generated so that the power obtained is used to withstand the friction force

3.2. Fuel Consumption (m_f) on Standard Engine Conditions, Semi Racing (150 cc Standard Bore up Head) and Full Racing (150 cc Bore up Racing Valve)
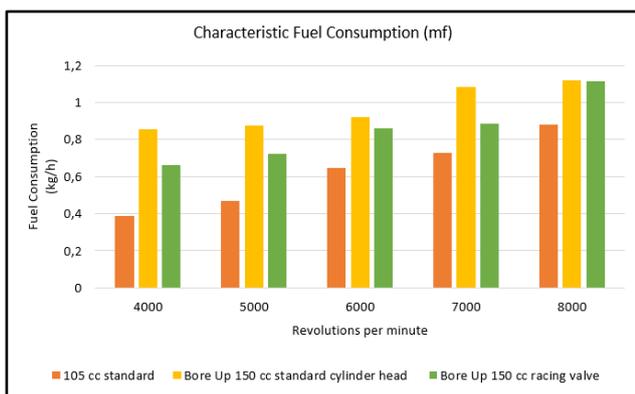

Figure 4. Fuel consumption

Seen in Figure 4. Fuel consumption (mf) at 150 cc standard cylinder head bore up is higher than 150 cc racing valve bore up. Fuel consumption at 105 cc standard at least than 150 cc standard cylinder head bore up and 150 cc racing valve bore up. at 105 cc 4000 engine speed requires a fuel consumption of 0.388kg / hour, at 150 cc the standard cylinder head bore up requires a fuel consumption of 0.855kg / hour, and at 150 cc racing valve bore up requires a fuel consumption of 0.660kg /hour

This is influenced by the use of standard head and standard valve. In the combustion chamber, the engine's volume capacity is getting wider, while the distance of the standard head to the cylinder block is too close so that the cylinder head gasket needs to be added. The addition was made to minimize the possibility of collisions between standard valves and piston racing. However, the impact of the addition of the gasket is the deviation of the opening and closing of the valve caused by fuel leakage due to the seal of the piston ring and valve which cannot be perfect

3.2.1. Standard 105 Cc Engine Fuel Consumption over Time (Seconds)

Standard 105 cc engine fuel consumption at each engine speed is shown in Table 5 and Figure 5.

Table 5. Fuel consumption over time (seconds)

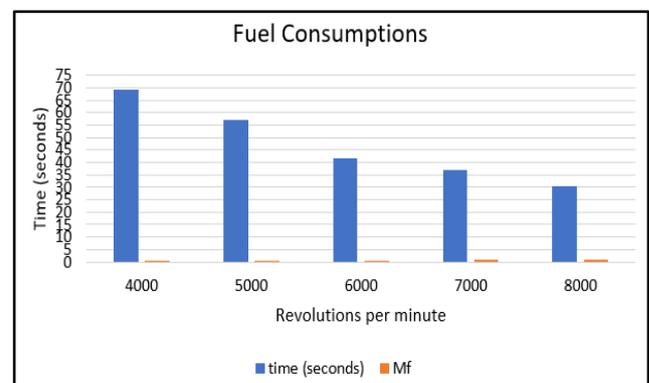| RPM	time (seconds)	m_f
4000	69,33	0,388
5000	57,17	0,47
6000	41,54	0,647
7000	37,06	0,729
8000	30,6	0,879

Figure 5. Standard 105 cc engine fuel consumption

3.2.2. Bore up 150 cc (Standard Cylinder Head) Fuel Consumption over Time (Seconds)

Bore up 150 cc (standard cylinder head) engine fuel consumption at each engine speed is shown in Table 6 and Figure 6.

Table 6. fuel consumption over time (seconds)

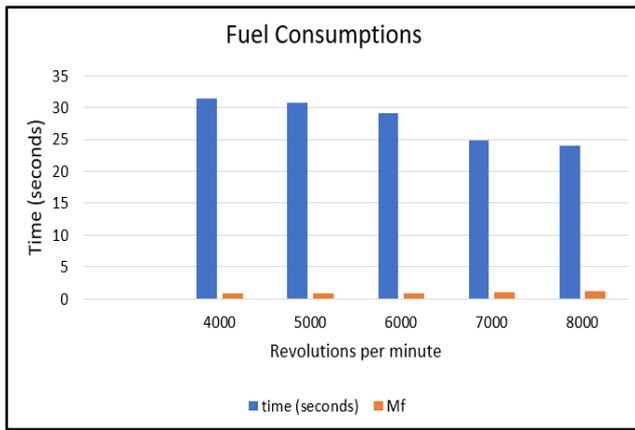| RPM	time (seconds)	m_f
4000	31,47	0,855
5000	30,79	0,874
6000	29,18	0,922
7000	24,89	1,081
8000	24,06	1,118

Figure 6. Bore up 150 cc (standard cylinder head) fuel consumption

3.2.3. Bore up 150 cc (Racing Valve) Fuel Consumption Over Time (Seconds)

Bore up 150 cc (racing valve) fuel consumption at each engine speed is shown in Table 7 and Figure 7.

Table 7. Fuel consumption over time (seconds)

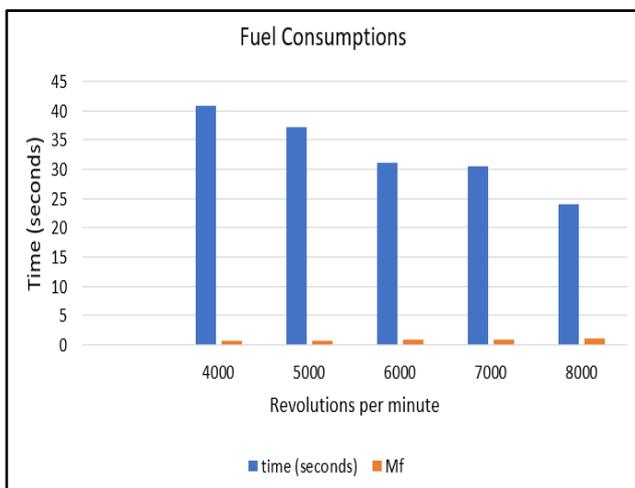| RPM	time (seconds)	m_f
4000	40,78	0,66
5000	37,3	0,721
6000	31,22	0,861
7000	30,45	0,883
8000	24,1	1,116

Figure 7. Bore up 150 cc (standard cylinder head) fuel consumption

3.3. Torque (T), Power (P), and Fuel Consumption (m_f) Results

The percentage increase in torque, power and fuel consumption under conditions of 150 cc standard cylinder head bore up and 150 cc racing valve bore up compared to the standard 105 cc conditions are shown in Table 8 and Figure 8.

In the condition of 150 cc standard cylinder head bore up increased torque of 4.82, power by 4.23, and fuel consumption by 0.24, whereas in conditions of 150 cc racing valve bore up experienced torque of 8.24, power by 6.89, and fuel consumption by 0.24.
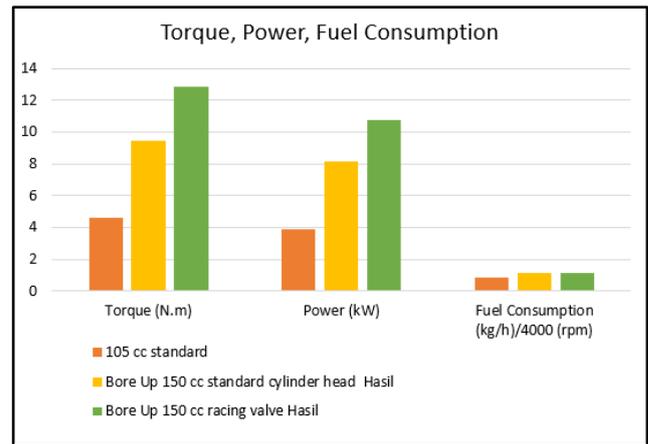

Figure 8. Torque, power, and fuel consumption result

Table 8. Torque, power, and fuel consumption result on percentage

Parameter	105 cc standard	Bore up 150 cc (standard cylinder head)		
		Result	Increase	Percentage (%)
Torque (N.m)	4,63	9,45	4,82	104,10
Power (kW)	3,9	8,13	4,23	108,46
Fuel consumption (kg/h)	0,879	1,118	0,24	27,19
Parameter	105 cc standard	Bore up 150 cc (racing valve)		
		Result	Increase	Percentage (%)
Torque (N.m)	4,63	12,87	8,24	177,97
Power (kW)	3,9	10,79	6,89	176,67
Fuel consumption (kg/h)	0,879			

4. Conclusion

By reviewing research activities that include the overall data collection process, it can be concluded that:

1) In full racing conditions, torque and power are higher compared to standard and semi racing conditions
2) In semi-racing conditions, fuel consumption is higher compared to standard and full racing conditions

Acknowledgements

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