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Mekanika: Majalah Ilmiah Mekanika

Experimental Study Influences Changes in Compression Ratio To Performance of Single Cylinder Otto Engine

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Abstract

Increasing the compression ratio is an attempt to increase the efficiency and performance of the engine. The purpose of the study was to analyze the effect of changes in the compression ratio on engine performance. Tests using a single-cylinder Otto engine by comparing the performance of an enlarged compression ratio of 9.7:1 and 10.4:1 with a standard compression ratio of 9.0:1. The result of the research is that the compression ratio of 9.7:1 produces a peak torque of 7.51 Nm at 6000 rpm, a peak power of 5.30 kW at 8000 rpm, and the lowest Brake-Specific Fuel Consumption (BSFC) is 0.146 kg/kWh at 6000 rpm. Torque and power increased by 0.09 Nm and 0.28 kW, and Brake-Specific Fuel Consumption (BSFC) decreased by 0.018 kg/kWh compared to the standard compression ratio of 9.0:1. Using a compression ratio of 10.4:1 produces a peak torque of 7.69 Nm at 6000 rpm, a peak power of 5.38 kW at 8000 rpm, and the lowest Brake-Specific Fuel Consumption (BSFC) is 0.116 kg/kWh at 6000 rpm. Torque and power increased by 0.27 Nm and 0.36 kW, and Brake-Specific Fuel Consumption (BSFC) decreased by 0.030 kg/kWh compared to the standard compression ratio of 9.0:1.

1 Introduction

The growth of the number motorcycles in Indonesia is very rapid because motorcycles can serve mobility on narrow roads or congested traffic conditions better than other types of vehicles bigger. Two-wheeled vehicles are circulating, prioritizing fuel efficiency and increasing motor performance [1]. Increasing the compression ratio is a form of effort to get better efficiency and improve engine performance, such as torque, power, and fuel consumption [2]. The compression ratio is the ratio of the total cylinder volume to the importance of the compressed cylinder minimum [3]. In a broader sense, the compression ratio is the ratio of the magnitude of the combustion chamber when the piston is in the Bottom Dead Center (BDC) position with the volume of the chamber fuel when the piston is in the Top Dead Center (TDC) position [4]. Kwon et al. [5] looked at the impact of compression ratio on the performance of small power engines under 5 kW. The compression ratio was boosted to 9.22:1 from the conventional 8.01:1 by reducing the combustion.

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Chamber volume to 16.6 cc from the initial value of 19.3 cc. This study shows that increasing the compression ratio can increase. Engine power to 2.68 kW from the previous 2.2 kW, decreased BSFC from 290.6 $\frac{g}{h\times PS}$ to 218.6 $\frac{g}{h\times PS}$ [5]. Hotta et al. [6] researched the effect of ignition timing and ratio compression on engine performance. The compression ratio varies from 10:1 to 14:1, and the ignition timing varies from 23° to 47° before the point dies on the piston. The results showed that the increase in the compression ratio from 10:1 to 12:1 could increase power and decrease BSFC, with each value being 12.72% and 5.42% at 1400 rpm engine speed [6].

In-vehicle engine performance has several parameters: torque, power, average adequate pressure, specific fuel consumption, efficiency thermal, air-fuel, and fuel-air ratios. Torque measures a machine's ability to move or move a car or motor from rest to moving [7]. Engine power is the ability of the engine to produce maximum torque at a particular engine speed [8]. BSFC is the amount of material fuel required by the engine to have brake power or shaft power machine [9] so that the BSFC can be used to compare the efficiency of various devices directly. Based on the described background above, researchers will conduct research and experiments on the effect of compression ratio on the performance of a single-cylinder four-stroke Otto engine.

2 Experimental Methods

2.1 Engine compression ratio adjustment

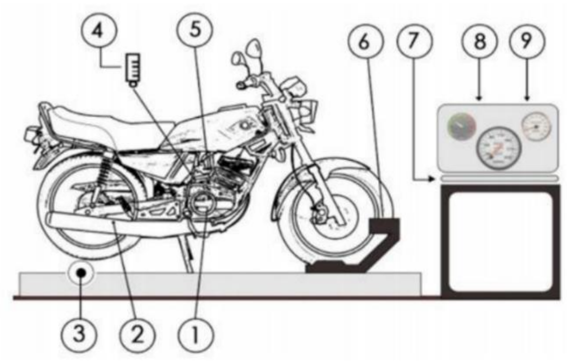
The use of thinner block cylinder gaskets causes the deck. The clearance between the piston and the upper lip of the cylinder block will decrease. With a smaller deck clearance, the compression ratio will be higher. The thickness of the cylinder block gasket used in the study is 1.5 mm (standard), 1 mm, and 0.5 mm, producing compression ratios of 9:1 (measure), 9.7:1, and 10.4:1. Value change engine compression ratio uses a tool kit, dial gauge, protractor, and other auxiliary tools. The protractor and dial gauge are used to help maintain the 0° point of the piston against the crankshaft and to assert the value of unscrewing the intake and exhaust valves to remain the same in all variations of the ratio compression used as shown in Figure 1.

Figure 1. Engine compression ratio adjustment

2.2 Machine performance test

A dynamometer test, often known as a dyno test, is measuring equipment used to measure the torque of a prime mover's output shaft [10]. This amount is used to calculate the power that the prime mover can generate. The dyno test also measures power (power) and torsion (torque) [8,11,12]. A motorized vehicle engine's power, for example, may be determined by concurrently measuring torque and rotational speed per minute/revolutions per minute [13-15]. The primary advantage of a dynamometer (dyno) is obtaining the highest value of torque and power shown by the engine at a given revolutions per minute [16-18].

Machine performance testing in this study was carried out with a Dynojet 250i dynamometer. Dynojet 250i is an inertial type dynamometer with eddy current load control. Dynojet 250i measures torque and power vehicle on the vehicle wheel output. The measurement method is carried out by putting the wheel on the Dynojet 250i roller. The roller is then connected with the disk rotating in a controlled magnetic field. This thing causes a braking effect on discs with an eddy current brake system. This braking effect is intended to control the loading when engine torque measurement. The output of the Dynojet 250i size is power in brake horse power and torque in ft-lbf. Fuel consumption measurements are measured with a buffet or measuring tube in ml. (see Figure 2).



Caption:
1. Machine
2. Muffler
3. Chassis Dynamometer
4. Fuel indicator indicator
5. Carburettor
6. Motor holder
7. Laptops
8. Torsimeter
9. Tachometer

(a)

(b)

Figure 2. (a) Schematic, and (b) Machine performance test

The quantity of fuel consumed per power unit per operation hour is referred to as specific fuel consumption. The Equations 1 and 2 below can be used to calculate specific fuel consumption [19].

$$bsfc = \frac{\dot{m}_f}{Bp} \tag{1}$$

$$\dot{m}_f = \left(\frac{V}{t}\right) \times \rho \tag{2}$$

Brake thermal efficiency is a dimensionless measure of the engine's thermal performance divided by the total units of heat in the fuel burned. The following expression can be used to calculate thermal efficiency [9,20] (as shown as in Equation 3).

$$\eta_{tb} = \frac{Bp}{\dot{m}_f \, Q_{hv} \, \eta_c} \tag{3}$$

3 Results and Discussion

3.1 Torque test

The effect of changing the value of the compression ratio on the relationship between torque and engine speed is shown in Figure 3. The most considerable torque value at the standard ratio compression of 9.0:1 is obtained at 4000 rpm engine speed. In contrast, the compression ratio is enlarged at 9.7:1 and 10.4:1, and the most considerable torque is obtained at an engine speed of 6000 rpm. Using a standard compression ratio of 9.0:1, The peak torque value is 7.42 Nm, and the compression ratio is 9.7:1. The peak torque value is 7.52 Nm, and the compression ratio of 10.4:1 is obtained. The peak torque value is 7.70 Nm. Using a compression ratio of 9.7:1 resulted in a decrease in the torque value at 4000 rpm engine speed of 0.15 Nm compared to the standard compression ratio of 9.0:1. But in the range of rotation from 5000 rpm to 9000 rpm engine, the torque value has increased compared to the standard compression ratio of 9.0:1. Torque value increase respectively 0.15, 0.19, 0.21, 0.32, and 0.39 Nm. Meanwhile, when using a compression ratio of 10.4:1, the torque experienced an increase in the engine speed range from 4000 rpm to 9000 rpm compared to the standard compression ratio of 9.0:1. The increase in torque values is 0.09, 0.32, 0.38, 0.30, 0.35, and 0.50 Nm, respectively.

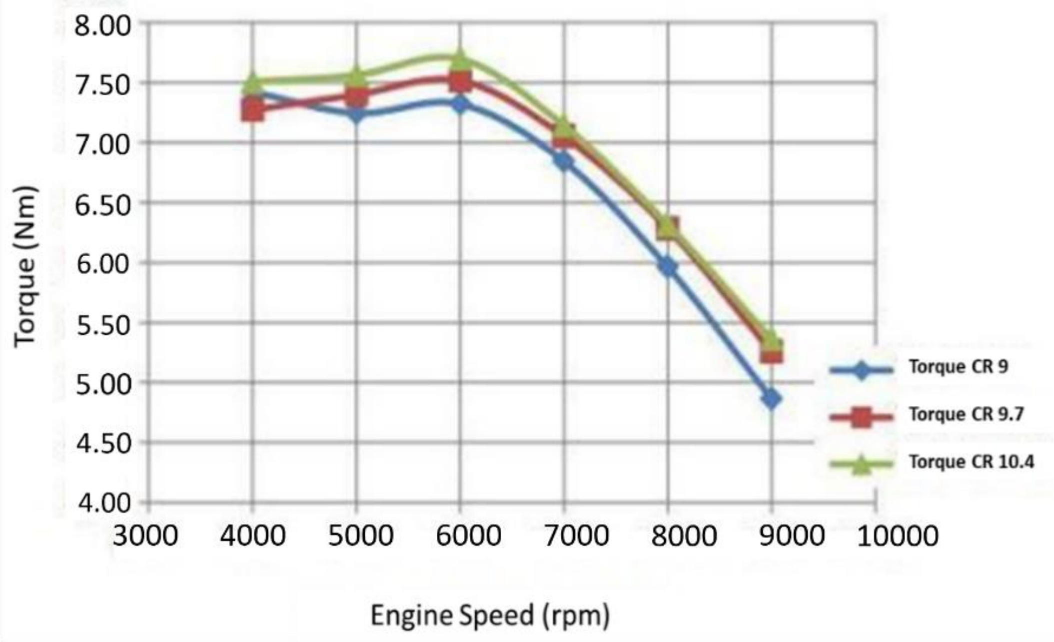


Figure 3. Torque test results for all variations of compression ratio

3.2 Power test

The effect of changing the value of the compression ratio on the power and relationship engine speed is shown in Figure 4. Based on these data, it is known that by using the compression ratio variation, the power value increases at almost all engine speeds. Peak power on all compression ratio variations is obtained at the same engine speed of 8000 rpm. For a standard compression ratio of 9.0:1, the peak power value is 5.03 kW. For a compression ratio of 9.7:1, the peak power value is 5.31 kW and at a ratio of compression of 10.4:1 obtained a peak power value of 5.39 kW. With a variations compression ratio of 9.7:1, the power value decreases at engine speed 4000 rpm at 0.03 kW compared to the standard compression ratio Figure 3. Torque test results for all variations of the compression ratio 9.0:1, but at an engine speed of 5000 rpm to 9000 rpm, the power value has increased compared to the use of variations in the compression ratio standard 9.0:1. The increase in the power value is 0.07 and 0.15 kW, respectively. 0.16, 0.28, and 0.28 kW. While using a compression ratio of 10.4:1, rated power has increased in all ranges of the engine speed compared to the standard compression ratio of 9.0:1 and the ratio of 9.7:1 compression. Increase in rated power of 0.04, 0.16, 0.23, 0.25, 0.36, and 0.38 kW.

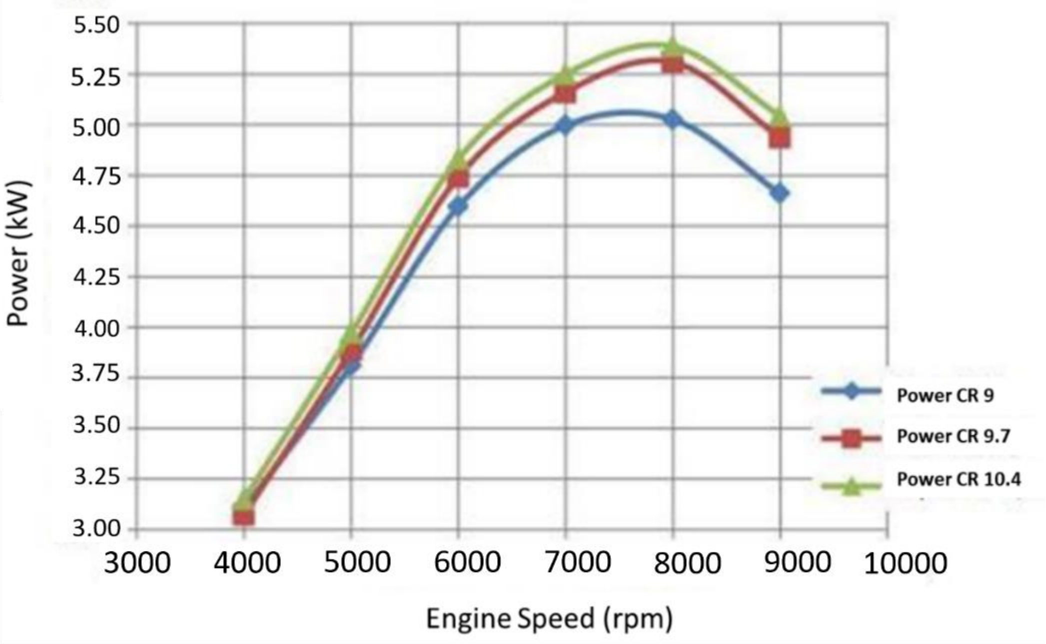


Figure 4. Power test results for all variations of compression ratio

3.3 Brake specific fuel consumption test

The effect of changing the value of the compression ratio on the consumption relationship between Brake-Specific Fuel Consumption (BSFC) and engine speed is shown in Figure 5. Tests using a compression ratio of 9.7:1 resulted in an increase in the value of specific fuel consumption at 4000 rpm engine speed of 0.028 kg/kWh compared to the standard compression ratio of 9.0:1, but at engine speed range 5000 rpm to 9000 rpm, rated fuel consumption specificity decreased compared to the standard 9.0:1.

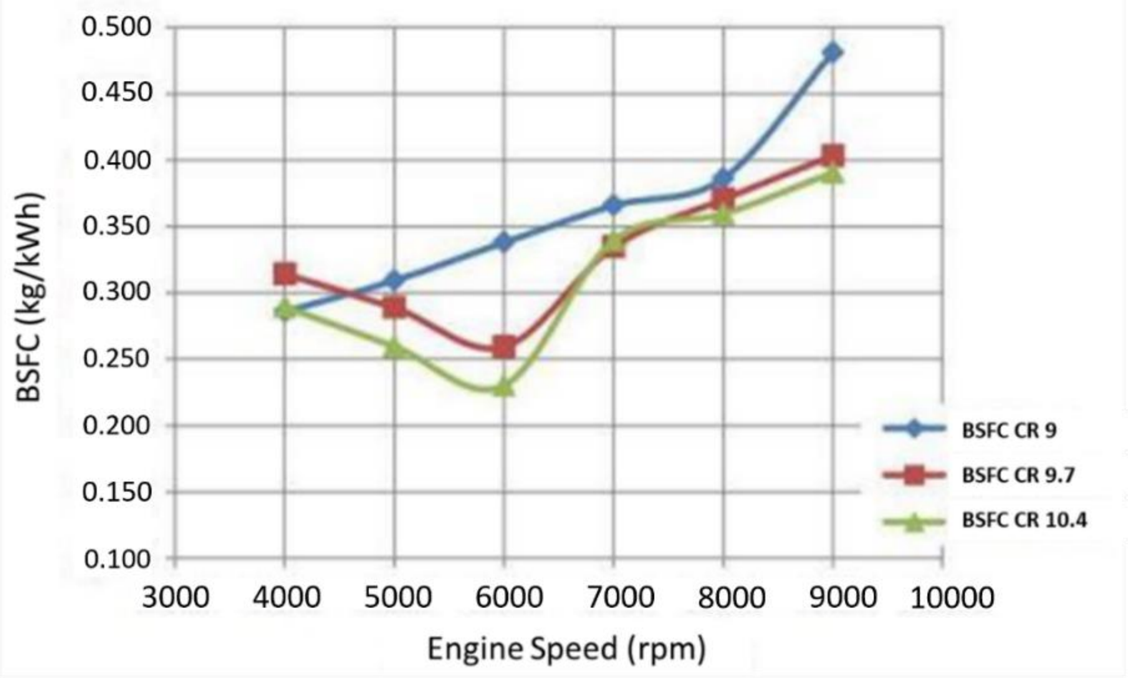


Figure 5. BSFC test results for all variations of compression ratio

3.4 Brake thermal efficiency test

Successive decrease of 0.020, 0.079, 0.031, 0.016, and 0.078 kg/kWh. Using a compression ratio of 10.4:1 resulted in an increase in the value of specific fuel consumption at a 4000-rpm engine speed of 0.004 kg/kWh compared to the standard compression ratio of 9.0:1. However, at engine speed range 5000 rpm to 9000 rpm, rated fuel consumption specificity decreased compared to the use of compression ratio standard 9.0:1. Successive decrease of 0.050, 0.108, 0.026, 0.027, and 0.090 kg/kWh.

The effect of changing the value of the compression ratio on the efficiency relationship between thermal Brake Thermal Efficiency (BTE) and engine speed is shown in Figure 6. Test using a compression ratio of 9.7:1 resulted in a decrease in BTE at 4000 rpm engine speed of 2.50% compared to the compression ratio standard 9.0:1. Still, in the engine speed range of 5000 rpm to 9000 rpm, the BTE value has increased compared to the compression ratio standard of 9.0:1. The increase in the BTE value was 1.82 and 7.11%, respectively. 2.02, 0.87, and 3.17%. While the use of the compression ratio 10.4:1 BTE value decreased at 4000 rpm engine speed by 0.35% compared to the standard compression ratio of 9.0:1. Still, at the engine speed range from 5000 rpm to 9000 rpm, the value of BTE experienced an improvement over the standard compression ratio of 9.0:1. Enhancement BTE values were 4.89, 10.97, 1.67, 1.55, and 3.81%, respectively.

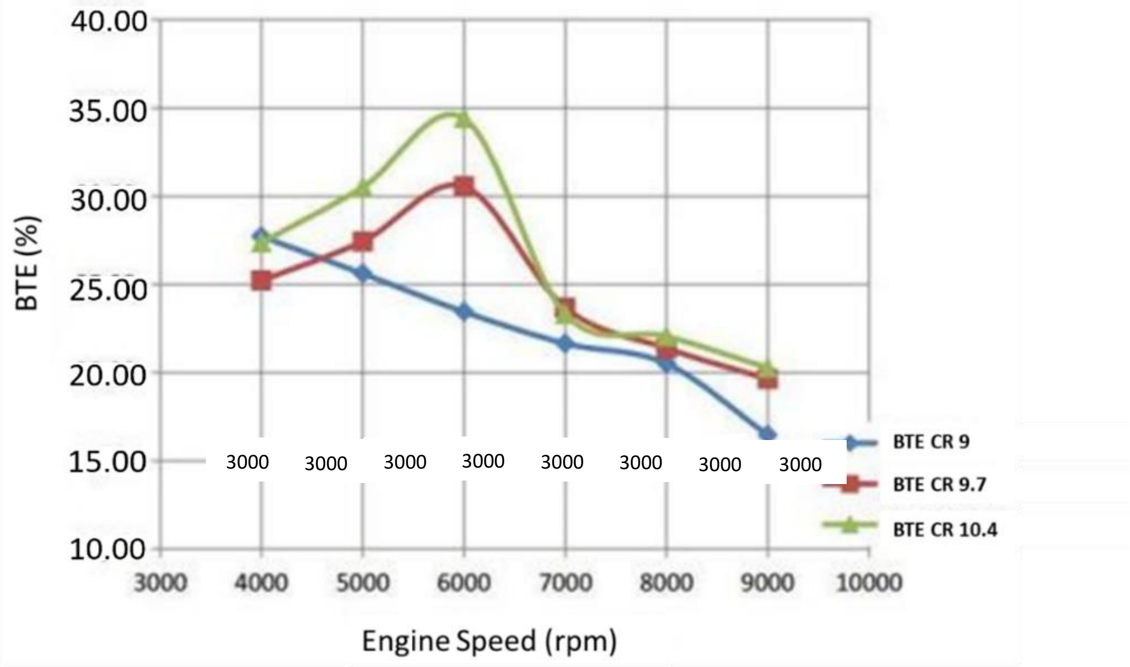


Figure 6. BTE test results for all variations of compression ratio

4 Conclusions

According to data analysis and test results relating to the effect of compression ratio changes on torque, power, and fuel consumption on a single-cylinder Otto engine with a capacity of 100 cc, the peak torque value at the standard compression ratio is 9.0:1 at 4000 rpm engine speed, while compression ratio 9.7:1 and 10.4:1 at 6000 rpm engine speed. The highest value of the conventional 9.0:1 compression torque ratio is 7.42 Nm, while the maxima of the 9.7:1 and 10.4:1 compression ratios are 7.51 and 7.69 Nm, respectively. The maximum power ratio at 8000 rpm engine speed is standard compression 9.0:1 and extended 9.7:1 and 10.4:1, correspondingly 5.02, 5.30, and 5.38 kW. At 6000 rpm engine speed, compression ratios of 9.7:1 and 10.4:1 achieve the lowest specific fuel consumption, although the average compression ratio is 9.0:1 at 4000 rpm engine speed. At 6000 rpm engine speed, a compression ratio of 10.4:1 produces the best thermal efficiency of 34.41%. In contrast, a compression ratio of 9.7:1 produces the highest thermal efficiency of 30.55 percent, and a compression ratio of 9.0:1 produces the highest thermal efficiency of 27.71%. Compression ratio changes to 9.7:1 and 10.4:1 can affect the engine performance. Further research is required to investigate the effect of more significant compression ratio fluctuations in producing better torque and practical power values utilizing alternative fuels. To achieve even higher fuel efficiency, in addition to changing the compression ratio, it is essential to adjust the settings on the motor, such as modifications to environments that are more suited for ignition timing and Air Fuel Ratio (AFR) when using Compressed Natural Gas (CNG) fuel.

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