International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869 (O) 2454-4698 (P), Volume-5, Issue-3, July 2016

The Effect of Compression Ratio upon the Performance and Emission of spark ignition engine

Mohammed Kadhim Allawi

Abstract— **The need to improve the performance of the gasoline engine (SI) has necessitated the present research. Increasing the compression ratio (CR) below detonating values to improve the performance is an option. The compression ratio is a factor that influences the performance characteristics of internal combustion engines. The objective of this study is on experimental analysis the performance of SI engine operating with variable compression ratios 6, 7, 8 and 9. The results from the laboratory the maximum compression ratio corresponding to maximum brake thermal efficiency (ηbth, brake mean effective pressure (BMEP) and lowest specific fuel consumption is CR 9.**

Index Terms— **Compression ratio, thermal efficiency**

I. INTRODUCTION

Improving internal combustion engine efficiency is a large interest today. The most of the engineering research has gone into the improvement of the thermal efficiency(ηth) of the engine. Utmost of the energy produced by these engines lost as heat. In addition to friction losses and losses to the exhaust, other operating performance parameters affect the thermal efficiency (ηth). Those include the fuel lower calorific value, compression ratio (CR) and ratio of specific heats,[1]
Compression ratio is the ratio of the total volume of the combustion chamber when the piston is at the bottom dead centre to the total volume of the combustion chamber when piston is at the top dead center. Theoretically, increasing the compression ratio of an engine can improve the thermal efficiency of the engine by producing more power output. The ideal theoretical cycle, the Otto cycle, upon which spark ignition (SI) engines are based, has a thermal efficiency which increases with compression ratio CR and is given by [2].

Yuh and Tohru conducted a research on the effect of higher compression ratios in two-stroke engines. The results show that the actual fuel consumption improved by 1-3% for each unit increase in the compression ratio range of 6.6 to 13.6. It was concluded that the rate of improvement was smaller as compared to the theoretical values. The discrepancies were mainly due to increased mechanical and cooling losses, short-circuiting at low loads and increased time losses at heavy loads. Power output also improved, but the maximum compression ratio was limited due to knock and the increase in thermal load. In addition, the investigation covered the implementation of higher compression ratio in practical engines by retarding the full-load ignition timing.[3] Conducted a research on performance evaluation of a single cylinder four stroke petrol engine. In the research, the actual size of the engine parameters like the bore, stroke, swept volume, clearance volume, compression ratio and engine speed were recorded and computed. Based on the actual size of the engine parameters, the indicated horse power, brake power, and friction horse power were determined and were found to be 1.54, 1.29 and 0.25 respectively.. [4].

Study on impact compression ratio spark-ignition engine efficiency to theoretical and experimental. In the test, compression ratio ranges from 8 to 13And calculated indicatedׄ BRAKE efficiency and effectiveness. The investigation concludes that increasing increased compression ratio for SI engine efficiency and compression 10-13 relative increases of 5.1% for brake efficiency ", 4.6% for gross and 4.5% indicatedׄ efficiency.[5]

Mohammed Kadhim Allawi, *M.Sc.,* Technical Engineering College-Baghdad, Middle Technical University

II. EXPERIMENTAL SETUP

A single cylinder, variable compression ratio engine type GR used in the experiments. The engine made by the " Prodit" Company. The engine is 4 strokes; has popped overhead valve and connected to a hydraulic dynamometer. The engine adapted to run on an SI engine. The engine compression ratio varies from (4 to 17). Table 1 presents the specifications of the engine while Fig. 1 shows a photographic of the tests used the rig.

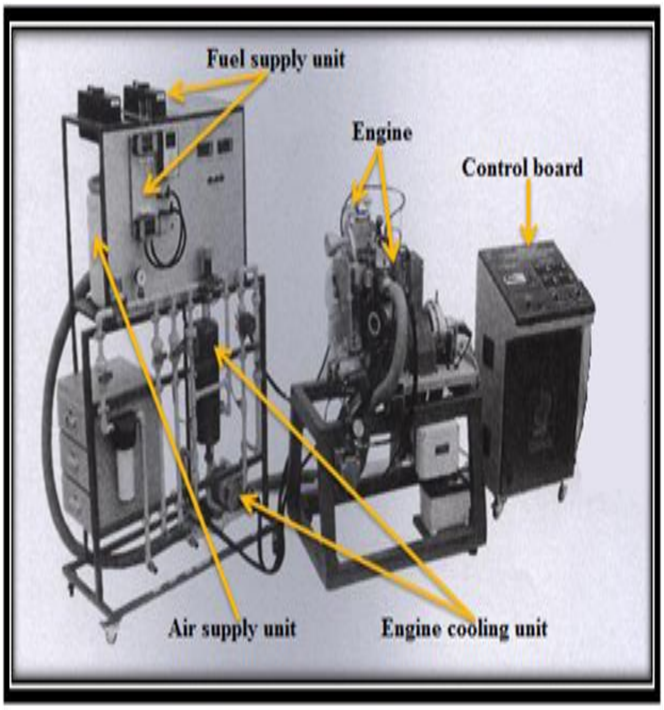

Fig. 1 shows a photograph of the engine

Table 1 Engine Specifications

Gasoline Engine	
Engine type	4cyl., 4-stroke
Engine model	PRODIT gasoline engine rig
Combustion type	water cooled, natural aspirated
Swept volume	541cm^3
Valve per cylinder	two
Bore	90 mm
Stroke	85 mm
Compression ratio	4-17.5
Fuel injection pump	Unit pump 26 mm diameter plunger
Max power	4kW at 2800 rpm
Max Torque	28Nm at 1600 rpm

The exhaust gas analyzer type (TEXA) was used to analyze the emissions of exhaust. The analyzer the CO-CO2-HC-O2 emissions contents. The Compression Ratio measured by the cylinder-head position

The transducer whose output signal is proportional to the applied extension of the sensor itself. GEFRAN Company manufactures this sensor; model PZ-12-A-025

III. RESULTS AND DISCUSSION

3-1 -Comparison of Brake Thermal Efficiency with varying speed

The Fig 2 shows the variations of brake thermal efficiency on varying speed at different compression ratios for gasoline fuel engine operation. The thermal efficiency increases with increase in load. The maximum brake thermal efficiency is obtained at a compression ratio of 9, due to the superior combustion and better intermixing of the fuel. The least brake thermal efficiency is obtained at a compression ratio of 6.

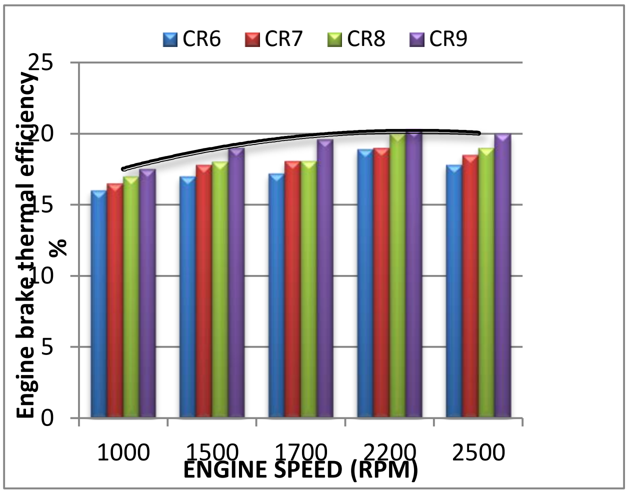

Figure 2. Variation of brake thermal efficiency by compression ratio for different engine speeds (RPM).

3-2-The comparison of Brake specific fuel consumption with varying speed

The comparison is presented in Fig3 at (1000 to 2550 rev/min). The least Brake specific fuel consumptions are obtained at the compression ratio of 9. The lower compression ratios than 6 have resulted in high fuel consumptions. At the lower sides of the compression ratios, Brake specific fuel consumption is high due to incomplete combustion of fuel. The maximum fuel consumption is measured at CR 6.It is observed that as the compression ratio of the engine is increased, Brake specific fuel consumptions decreases (improves).

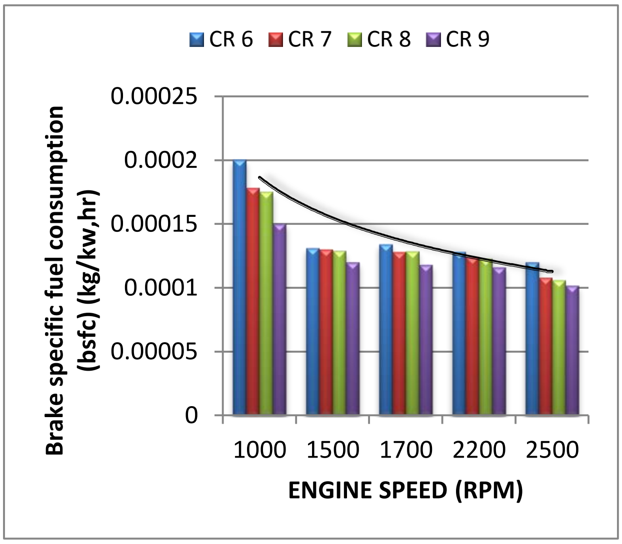

Figure 3. Variation of brake specific fuel consumption with compression ratio for different engine speeds.

3-3- CO emissions in the exhaust gases with varying speed

The CO emissions in the exhaust gases represent the lost chemical energy that is not fully sued in the engine. CO emission is effected by air-fuel ratio, fuel type combustion chamber design and atomization rate, the start of injection timing, injection pressure, engine load, and speed. The most important among these parameters is the air-fuel ratio. The variation in the CO emissions of the engine is shown in Fig (4).CO increase at compression ratio CR6 as well as on CR7, experimental data shows their optimum value at CR9.

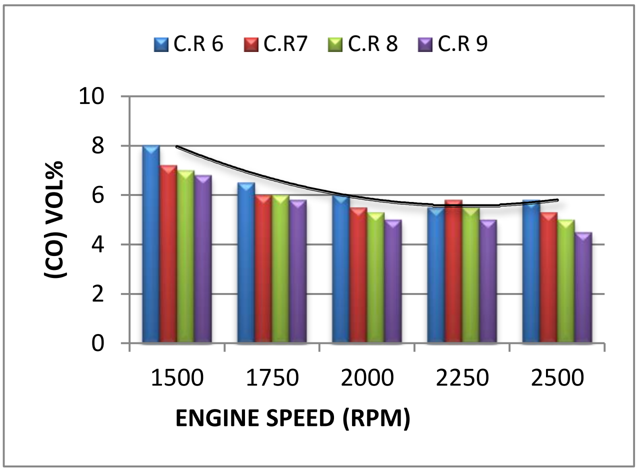

Figure 4. Carbon monoxide versus engine speeds.

3-3- HC emissions in the exhaust gases with varying speed

Unburned hydrocarbon emissions (UBHC) consist of fuel that is a combination of completely unburned and partially burned. UBHC emission is mostly due to the retention of unburned fuel in crevices in the cylinder. Fig5 show the changes in the UBHC emission of the engine using compression ratio. The emission of HC dropped with the increase in compression ratio.

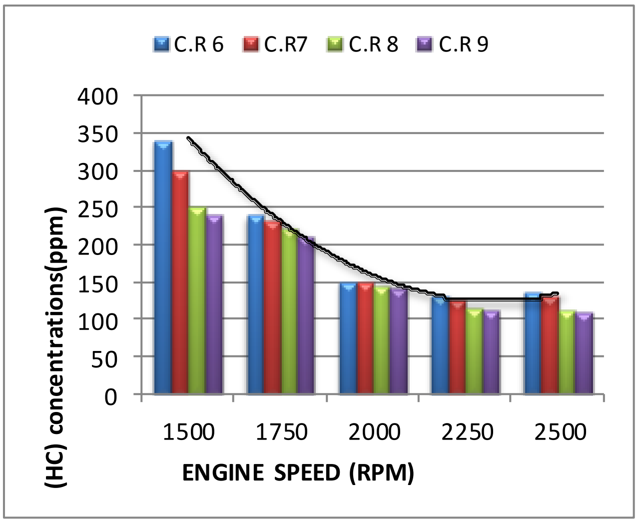

Figure 5 : Unburned hydrocarbon emissions (UBHC) versus engine speeds.

IV. CONCLUSION

The general conclusions drawn from the results of this research work are as follows:

1. he increase in compression ratio on the variable compression ratio engine increases the brake thermal efficiency about 3% when using (CR 6-7),(CR 6-8=5.6%) and (CR 6-9=9.8%).
2. Focusing on emission it was found that CO of the (S.I. engine) decreased when the compression ratio was increased. Reduced the amount of the percent of (CO) about 6.3% when using (CR 6-7), (CR 6-8=7.3%) and (CR 6-9=15%).

Emission of HC decreased when the compression ratio increased. Reduced the amount of the percent of HC about 5.7% when using (CR 6-7), (CR 6-8=15.2%) and (CR 6-9=18.5%).

REFERENCES

[1] Mohit, S. and Lamar S., 2010, *Making more efficient combustion engines*, Bright Hub Publisher.

[2] Chaiyot, D. and Somrat, K.., 2005, Experimental Influence of Compression Ratio on to Performance and Emission of Compressed Natural Gas Retrofit Engine, King Mongkut's Institute of Technology North Bangkok.

[3] Yuh, M. and Tohru, G., 2010, The Effect of Higher Compression Ratio in Two-Stroke Engines, Yamaha Motor Co, Ltd. pp 355-362.

[4] Asif, A.M., Jandool, K., Saeed, A.S. and Ali, A.C., 2008, Performance Evaluation of a Single Cylinder Four Stroke Petrol Engine, Farm machinery institute, National Agricultural Research Centre, Islamabad, Pakistan.

Appendix (A)

Symbol	Meaning	Unit
A/F	Air to fuel ratios	
Bp	Brake power	KW
bsfc	Brake Specific fuel consumption	kg/(kW.hr)
CO	Carbon monoxide	/
CO_2	Carbon dioxide	/
S.I.engine	spark ignition engine	/
HC	Unburned hydrocarbons	Ppm
Ho	Differential manometer	Cm
m ̇a	Air mass flow rate	kg⁄sec
m ̇f	Fuel mass flow rate	kg⁄sec
L.C.V	Lower calorific value	(kJ/kg)
T	Torque of h engine	(N.m)
N	rotational speed	(rpm)
CR	Compression Ratio	/

The following equations were used in calculating engine performance parameters:

1- The brake specific fuel consumption.

bsfc = $\frac{\dot{m}f}{bp} \times 3600 \quad kg/(kW.hr)$………………………..(1)

2- Brake thermal efficiency is defined as in Eq.

ηbth = $\frac{bp}{\dot{m}f \; L.C.V}$ ……………………………………….……. (2)

3- Air mass flow rate

$\dot{m}a, act = \frac{12\sqrt{(h\_o)}}{3600} \times \rho \; air \quad kg/sec$…………..(3)

4- Fuel mass flow rate

$\dot{m}f = \frac{vf \times 10^{-6}}{time} \times \rho_f$ kg⁄sec………….......…….(4)

5- Air-fuel ratio

A/F= $\frac{\dot{m}a}{\dot{m}f}$……………………………….………..… (5)