International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 04 | April - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Analysis and Performance Statistics of Variable Compression Ratio Diesel Engine

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ABSTRACT

Variable Compression Ratio (V.C.R) engine test rig can be used to determine the effect of Compression Ratio (C.R) on the performance and emissions of the engine. It can also be used to study the combustion phenomena, when provided with a pressure transducer. The performance frequency parameters like efficiencies, power adopted, specific fuel consumption are determined. Further, the smoke intensity is also measured and combustion phenomenon is also observed through this work, we can find the optimum compression ratio for which the best performance is possible. In order to find out optimum compression ratio, experiments were carried out on a single cylinder four stroke variable compression ratio diesel engine. Tests were carried out at compression ratios of 16.5, 17.0, 17.5, 18.0 and 19.0 at different loads_The performance characteristics of engine like Brake power (BP), Brake Thermal Efficiency (BTE), Brake Specific Fuel Consumption (BSFC) . Results shows a significant improved performance at a compression ratio 19.0. The compression ratios lesser than 19.0 showed a drop in break thermal efficiency, rise in fuel consumption.

Keywords: Diesel engine, variable compression ratio

INTRODUCTION

The ever increasing demand for the petroleum based fuels and their scare availability has lead to extensive research on Diesel fuelled engines. A better design of the engine can significantly improve the combustion quality and in turn will lead to better break thermal efficiencies and hence savings in fuel. [1]India though rich in coal abundantly and endowed with renewable energy in the form of solar, wind, hydro and bio-energy has a very small hydro carbon reserves (0.4%of the world's reserve) [2]. India is a net importer of energy. Nearly 25% of its energy needs are met through imports mainly in the form of crude oil and natural gas [3]. The rising oil bill has been the focus of serious concerns due to the pressure it has placed on scarce foreign exchange resources and is also largely responsible for energy supply shortages. The sub-optimal consumption of commercial energy adversely affects the productive sectors, which in turn hampers economic growth.[4].

The present work deals with finding the better compression ratio for the Diesel fuelled C.I engine at variable load and constant speed operation. The compression ratio of an internal-combustion engine or external combustion engine is a value that represents the ratio of the volume of its combustion chamber from its largest capacity to its smallest capacity. It is a fundamental specification for many common combustion engines.

Computerized VCR diesel engine specifications and Description:

Description:- The setup consists of single cylinder, four stroke, VCR (Variable Compression Ratio) Diesel engine connected to eddy current type dynamometer for loading. Setup is provided with necessary instruments for combustion pressure and crank-angle measurements. These signals are interfaced to computer through engine indicator for Pθ−PV diagrams. Provision is also made for interfacing airflow, fuel flow, temperatures and load measurement. The setup has stand-alone panel box consisting of air box, two fuel tanks for duel fuel test, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator. Rota meters are provided for cooling water and calorimeter water flow measurement. The setup enables study of VCR engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/ F ratio and heat balance. Lab view based Engine Performance Analysis software package "Engine soft" is provided for on line performance evaluation. computerized Diesel injection pressure measurement is optionally provided

Test Rig Engine specifications:-

Features	**Specifications**
Make	Kirloskar oil Engine
Type	Four stroke, Water cooled Diesel
No of cylinders	One
Combustion Principle	Compression ignition
Max speed	1500
Crank Radius	55mm
Connecting Rod length	300mm
Cylinder diameter	80mm
Stroke length	110mm
Compression ratio	variable from 14.0 to 20.0
Loading	Eddy current dynamometer
Load	23.86 N-M
Maximum power	3.75 kW

The entire experimentation was carried out while keeping the cooling water

Problem Definition:To find out the Optimum Compression Ratio of the Computerized Variable Compression Ratio (VCR) Single Cylinder Four Stroke Diesel Engine using Experimentation analysis.

3. Experimental Analysis and Calculations

The main components of the system are given below.

The engine (2) Fuel injection pump (3) Dynamometer (4) Device for changing starting of fuel (5) Supercharging system(6) Dynamic injection indicator(7) Data acquisition system (8) Smoke meter(9) Exhaust gas analyzer (10) Pressure transducer . The engine chosen to carryout experimentation is a single cylinder, water cooled, vertical, direct injection, CI engine

Thermal Calculations:

Based on this inputs following boundary conditions for thermal analysis unknowns are calculated:

Total heat generated in the piston is (Q) 39.81 watts

Total heat lost through water jacket is 20.59 watts

Average temperature in the piston calculated by using variation of temperature with crank angle graph

Average temperature in the piston is 412.125 ^{0}C

Heat transfer coefficient on top surface (h) is 174.125 w/m^{2}k

Heat transfer coefficient on bottom surface (h_b) is 8.6193 w/m^{2}k

Heat flux on lateral surface is 780 w/m^2

Break power calculations

4.1 Friction Power(FP):-It is obtained by plotting the graph between Brake Power(X-axis) and Fuel flow rate(Y-axis) .We obtain a straight line. if we extend this line towards south-west then it will touch the X-axis .the X-coordinate at that point is Friction Power

4.2Indicated Power(IP):- It is the sum of Friction Power and Brake Power

4.3 Indicated Mean effective pressure:-it is obtained by the Formulae

IP= (Imep)LAN

60

So, $\text{Imep} = \frac{60IP}{LAN}$ ……(4.1)

Where L=Length of the Stroke

A=Area of the Piston

N=Speed of engine(n/2 as 4-Stroke engine)

4.4 Specific fuel Consumption(SFC):-It is obtained by using the formulae

$$SFC = \frac{Mf}{CV} \quad \ldots\ldots (4.2)$$

Where Mf is Fuel flow rate

CV is Calorific Value

4.5 Break Thermal Efficiency:-It is obtained by using the formulae

$$BTE = \frac{BP*3600}{Mf*CV} \quad (4.3)$$

4.6 Indicated Thermal Efficiency:-It is obtained by the relation

$$ITE = \frac{IP*3600}{Mf*CV} \quad \ldots(4.4)$$

4.7Mechanical Efficiency:- It is given by the relation

$$ME = \frac{BP}{IP} \quad \ldots(.4.5)$$

Experiment the Variable Compression Engine is started by using Diesel and when the engine reaches the stable operating conditions applied under a certain Load. To cool the Engine Socket, water is flowing at a rate of 60 mL and the cooling water Temperature is 26.7 degrees. The tests are conducted at a constant speed of 1500rpm.In every test all the performance parameters like Indicated Power(IP) , Indicated Mean effective pressure, Specific fuel Consumption(SFC), Break Thermal Efficiency, Indicated Thermal Efficiency, Mechanical Efficiency are determined at different Compression ratios of 16.5, 17, 17.5, 18, 19.

5.Results & Discussions:

Test was carried out at compression ratios of 16.5 at different loads like 17,18, 19, 20, 21. and The performance characteristics of engine like Brake power (BP), Fuel flow rate is noted and from these two a graph is plotted between these two keeping Brake power on X-axis and Fuel flow rate(Y-axis) .We obtain a straight line. if we extend this line towards south-west then it will touch the X-axis .the X-coordinate at that point is Friction Power.

From Friction Power, Brake Power. We calculate the remaining performance Characteristics like Indicated Power(IP) , Indicated Mean effective pressure, Specific fuel Consumption(SFC), Break Thermal Efficiency, Indicated Thermal Efficiency, Mechanical Efficiency are determined.

5.1. Brake thermal efficiency:

Figure-5.1 shows that the maximum brake thermal efficiency is obtained at a compression ratio of 19.0; the least brake thermal efficiency is obtained at a compression ratio 16.5 Hence.

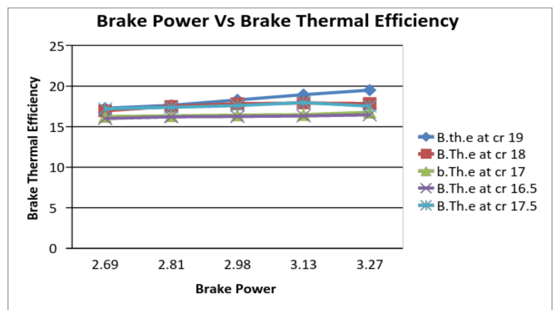

Figure:5.1 Brake Power Vs Break Thermal Efficiency

with respect to brake thermal efficiency, 19 can be treated as optimum power output. This can be attributed to the better combustion and better intermixing of the fuel and air at this compression ratio

5.2.Fuel Consumption:-

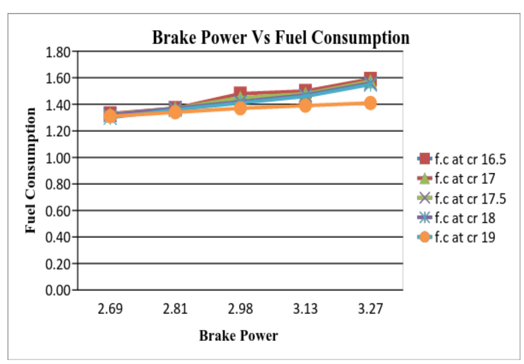

Figure:5.2 Brake Power Vs Fuel consumption

The better fuel consumption was obtained at a compression ratio of 19(Figure-2). The higher and lower compression ratios than 19 resulted in high fuel consumptions. The fuel consumption at a compression ratio of 17 and 17.5 was almost the same. The high fuel consumption at higher compression ratios can be attributed to the effect of charge dilution. At the lower sides of the compression ratios, the fuel consumption is high due to incomplete combustion of the fuel.

5.3.Specific Fuel Consumption:-

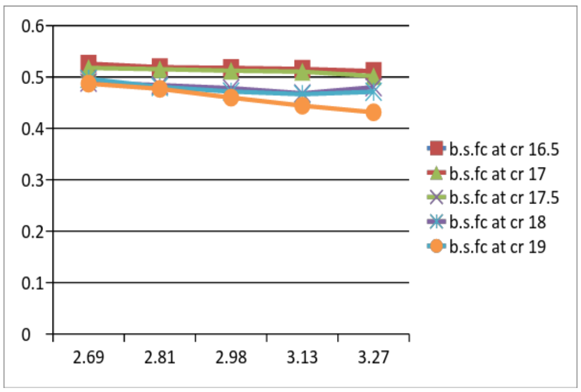

Figure- 5.3 Brake power Vs specific fuel consumption

The better specific fuel consumption was obtained at a compression ratio of 19.0 (Figure-2). and lower compression ratios than 19.0 resulted in high specific fuel consumptions. The specific fuel consumption at a compression ratio of 18.0 and 17.5 was almost the same. At the lower sides of the compression ratios, the specific fuel consumption is high due to incomplete combustion of the fuel

5.4.Mechanical efficiency:

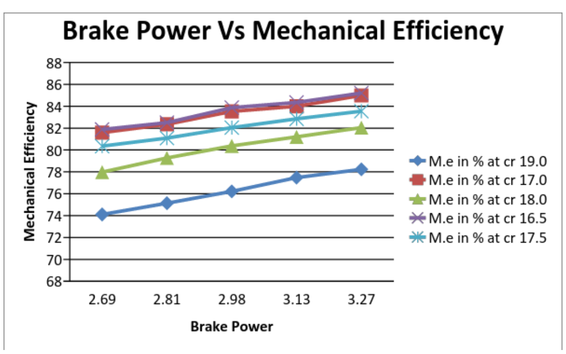

Figure:5.4 Brake Power Vs Mechanical Efficiency

The variation in mechanical efficiency at different loads for different compression ratios is shown in Fig.4. It is observed that mechanical efficiency increases with the increase in the load due to increase in the BP and IP. With the decrease with compression ratio the mechanical efficiency is also increases. And the mechanical efficiency at compression ratio of 16.5 and 17.0 was almost the same

5.5.Exhaust gas temperatures:

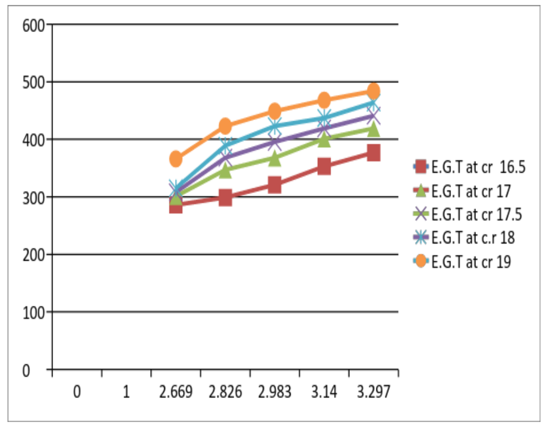

Figure 5.5. Brake power Vs Exhaust gas temperature.

Exhaust gas temperatures were found to be increasing with the increase in load and the compression ratio . The highest exhaust gas temperature was recorded for the compression ratio 19.0 while the least was for 16.5.

5.6.Mean Effective Pressures:

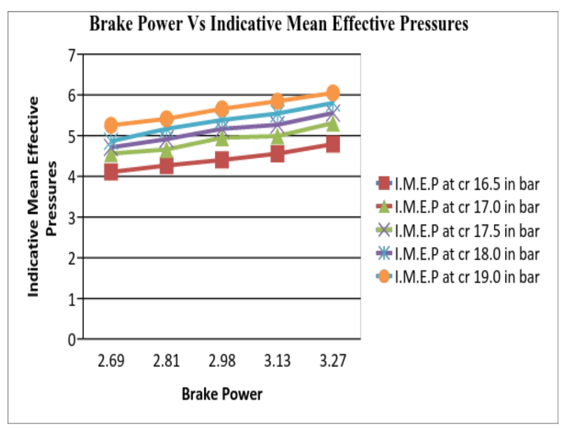

Figure-5.6. Brake power Vs IME pressure

Indicative Mean Effective Pressures were found to be increasing with the increase in load and the compression ratio (Figure-3). The highest Indicative Mean Effective Pressures was recorded for the compression ratio 19.0 while the least was for 16.5.

6. CONCLUSIONS

Following conclusions can be drawn from the experimentations carried out on the C.I engine with diesel at various compression ratios

The optimum compression ratio is 19 as operation for the given engine.
Better fuel economy is obtained at the compression ratio 19.
Fuel consumption is higher at compression ratio 16.5.
Smoke density is less at compression ratio 19.0.
Exhaust gas temperatures are moderate at compression ratio 16.5.
For more power at high loads the engine should operate at compression ratio 19 due to less specific fuel consumption.
For lower power output at light loads the engine should operate at compression ratio 16.5 due to less fuel consumption.

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