Variable Compression Ratio Diesel Engine Performance Analysis

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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. The combustion phenomena, when provided with a pressure transducer. The performance frequency parameters like efficiencies, power adopted, and specific fuel consumption are determined. Further, 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 show 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, performance, smokes density.*

1. INTRODUCTION

Worldwide pressure to reduce automotive fuel consumption and CO2 emissions is leading to the introduction of various new technologies for the C.I engine as it fights for market share with the petrol. So far, variable compression ratio (VCR) engines have not reached the market, despite patents and experiments dating back over decades. VCR technology could provide the key to enable exceptional efficiency at light loads without loss of full load performance. This paper will review the many embodiments of VCR, the implications for volume manufacture and the strategy for VCR implementation in order to produce the maximum benefit.

2. LITERATURE REVIEW:

.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 brake thermal efficiencies and hence savings in fuel..(M.K.G. Babu et.al, 2008) The potential of Diethyl ether (DEE) as a supplementary oxygenated fuel in a compression ignition engine has been identified through an experimental investigation. In this study the tests were conducted on a single cylinder DI diesel engine fueled with neat diesel fuel and addition of 2, 5, and 10% DEE in diesel fuel to find out the optimal blend on the basis of performance and emission characteristics 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 (Kapilan N et.al 2008).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. Experimental results showed that there is a slight increase in brake specific fuel consumption, brake power and brake thermal efficiency as compared to diesel fuel. In addition, it was found that there is a decrease in smoke, oxides of nitrogen, unburned hydrocarbon, carbon monoxide and ignition delay along with increase in carbon dioxide. (Ashok M.P et.al 2007).The performance of the diesel engine is increased with the addition of oxygenates to the fuel prior to the combustion. This paper presents the effect of blending of Diethyl ether (DEE) with diesel at various proportions (5%,7.5% and 10%)on the performance of diesel engine. The experimental results indicated that with the increase in the concentration of DEE to diesel increases the brake thermal efficiency, mechanical efficiency and decreases the specific fuel consumption. The performance of diesel engine at different compression ratios (18, 16 and 14) for diesel with 5% DEE blend was also evaluated in this work. (Subramanian K.A. et.al 2002).The data obtained from experimentation is presented analyzed in this paper.To find out the Optimum Compression Ratio of the Computerized Variable Compression Ratio (VCR) Single Cylinder Four Stroke Diesel Engine using Experimentation analysis.Various parameters defining the performance of V.C.R diesel engine are calculated and they areused as means for obtaining optimum compression ratio. By plotting performance graphs of different loads and different compression ratios from that optimum compression ratio obtained.

3. EXPERIMENTAL SETUP

The layout of the experimental setup is shown in fig 3.1. The main components of the system are given below. The engine, Fuel injection pump ,Dynamometer , Device for changing starting of fuel, Supercharging system, Dynamic injection indicator , Data acquisition system , Smoke meter Exhaust gas analyser, Pressure transducer

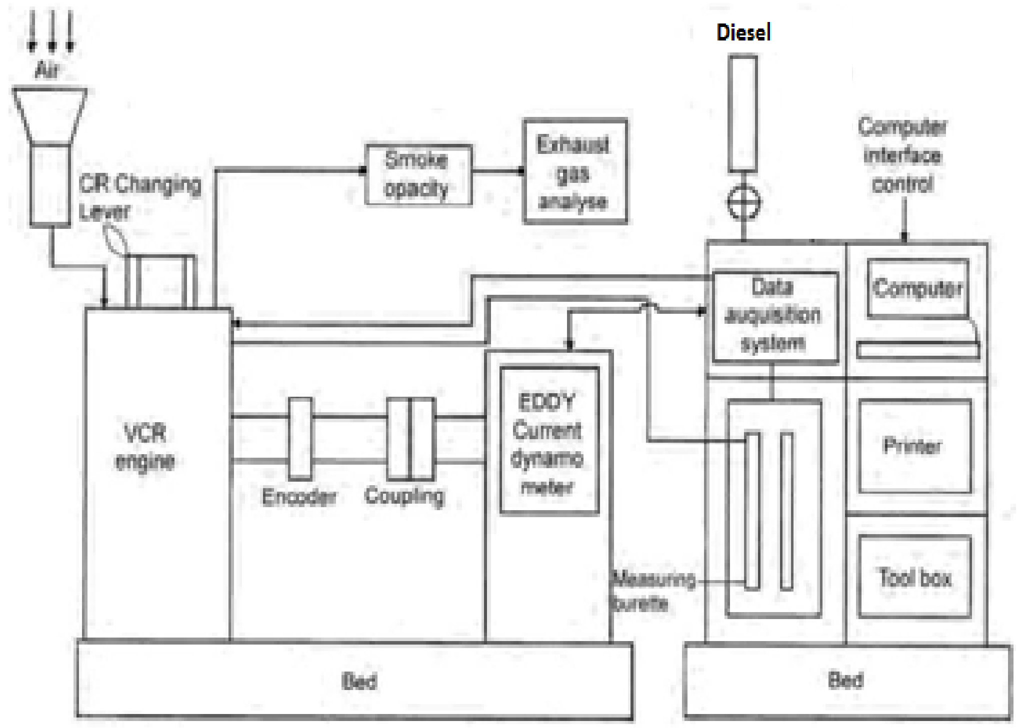


Figure 3.1: Block Diagram of VCR Engine

Figure3.2 Experimental setup of VCR Diesel engine

TABLE I: V.C.R ENGINE (TEST RIG) SPECIFICATIONS

S .NO.	*Features*	*Specifications*
1	Make	Kirloskar diesel Engine
2	Type	Four stroke, Water cooled Diesel
3	No of cylinders	one
4	Combustion Principle	Compressionignition
5	Max speed	1500
6	Crank Radius	55mm
7	Connecting Rod length	300mm
8	Clinder diameter	80mm
9	Stroke length	110mm
10	Compression ratio	variable from 14.0 to 20.0
11	Loading	Eddy current dynamometer
12	Load (Max.)	23.86 N-M
13	Maximum power	3.75 kW

II.THEORETICAL CALCULATIONS

PERFORMANCE

A. Calculations:

***Friction Power (FP)*:** The link between the brake power output and indicated power output of an engine is its friction. Friction has a dominating effect on the performance of an engine. Almost invariably, the frictional losses are ultimately dissipated to cooling system (and exhaust) as they appear in the form of frictional heat and this influences the cooling capacity required. Moreover lower friction means availability of more brake power, Hence brake specific fuel consumption is lower. This fuel economy is important because it decides the speed at which an engine can be run economically. Thus the level of friction decides the maximum output of the engine which can be obtained economically. In design and testing of an engine measurement of friction power is important for getting an insight into the methods by which the output of an engine can be increased. In the evaluation of IP and mechanical efficiency measured friction power is also used. By following methods:

Willan's Line Method

Morse Test

Motoring Test

Difference between IP and BP

***Indicated Power (IP)*:** However while calculating the Mechanical efficiency another factor called Indicated Power (IP) is considered. It is defined as the power developed by combustion of fuel in the combustion chamber (IP). It is always more than brake power. It is the sum of Friction Power and Brake Power.

Indicated Mean Effective Pressure (IMEP): When quoted as an indicated mean effective pressure or IMEP (defined below), it may be thought of as the average pressure acting on a piston during a power stroke of its cycle.

It is obtained by using the formula.

$$IP = \frac{(Imep)\ LAN}{60}$$

$$\text{So,}\quad Imep = \frac{60IP}{LAN}$$

Brake Specific Fuel Consumption (BSFC): Brake Specific fuel consumption (BSFC) or sometimes simply Brake specific fuel consumption, BSFC, is an engineering term that is used to describe the fuel efficiency of an engine design with respect to thrust output. Brake Specific Fuel Consumption may also be thought of as fuel consumption (grams/second) per unit of thrust (kilo newtons, or kN).

It is obtained by using the formulae.

$$BSFC = \frac{M}{BP}$$

Indicated Specific Fuel Consumption (ISFC): Indicated Specific fuel consumption (ISFC) or sometimes simply Indicated specific fuel consumption, ISFC, is an engineering term that is used to describe the fuel efficiency of an engine design with respect to thrust output. Indicated Specific Fuel Consumption may also be thought of as fuel consumption (grams/second) per unit of thrust (kilo newtons, or KN).

It is obtained by using the formulae.

$$ISFC = \frac{M}{IP}$$

Brake Thermal Efficiency (BTE): Brake Thermal Efficiency is defined as brake power of a heat engine as a function of the thermal input from the fuel. It is used to evaluate how well an engine converts the heat from a fuel to mechanical energy.

It is obtained by using the formulae

$$BTE = \frac{BP*3600}{M*CV}$$

Indicated Thermal Efficiency (ITE): The ratio between the indicated power output of an engine and the rate of supply of energy in the steam or fuel.

It is obtained by the relation

$$ITE = \frac{IP*3600}{M*CV}$$

Mechanical Efficiency (ME): Mechanical efficiency measures the effectiveness of a machine in transforming the energy and power that is input to the device into an output force and movement. Efficiency is measured as a ratio of the measured performance to the performance of an ideal machine:

It is given by the relation.

$$ME = \frac{BP}{IP}$$

B. Experiment Procedure: The Variable Compression Ratio Engine is started by using Diesel and when the engine reaches the stable operating conditions at a constant compression ratio. Start applying under a certain Load. To cool the Engine Socket, water is applied at a rate of 40 cc/Sec 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), Brake Thermal Efficiency, Indicated Thermal Efficiency, Mechanical Efficiency are determined at different Compression ratios of 16.5, 17, 17.5, 18, 18.5, 19.

V.RESULTS AND DISCUSSIONS

Test was carried out at compression ratios of 16.5 at different loads or torque like

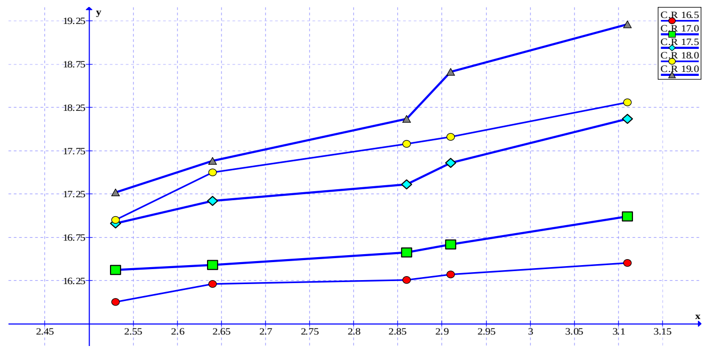
17, 18, 19, 20, 21 N-m and The performance characteristics of engine like Brake power (BP), Fuel flow rate is noted and from graphs fuel consumption (Kg/Hr) vs. B.P (KW) at a constant Speed is plotted and the graph is extrapolated back to zero fuel consumption as shown in figure (a) the point where this graphs cuts the B.P (KW) axis in an indication of the friction power of the engine at that speed.

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

A. Performance Analysis

1) ***Brake Thermal Efficiency (BTE):*** Figure 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, with respect to brake thermal efficiency, 19 can be treated as optimum power output. This

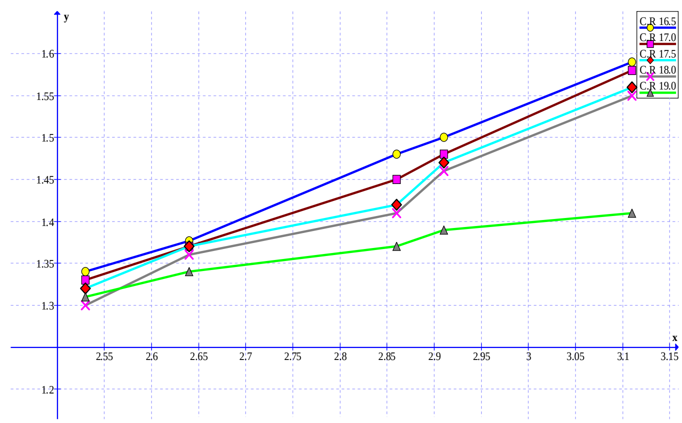
can be attributed to the better combustion and better intermixing of the fuel and air at this compression ratio.



Fuel Consumption (Kg/hr)

Brake power (KW)

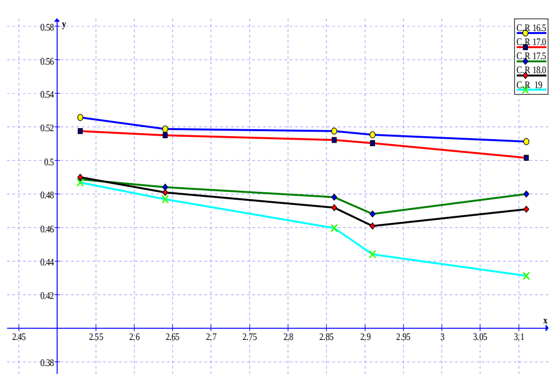
2) Fuel Consumption:



Brake power (KW)

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.

3) Specific Fuel Consumption:

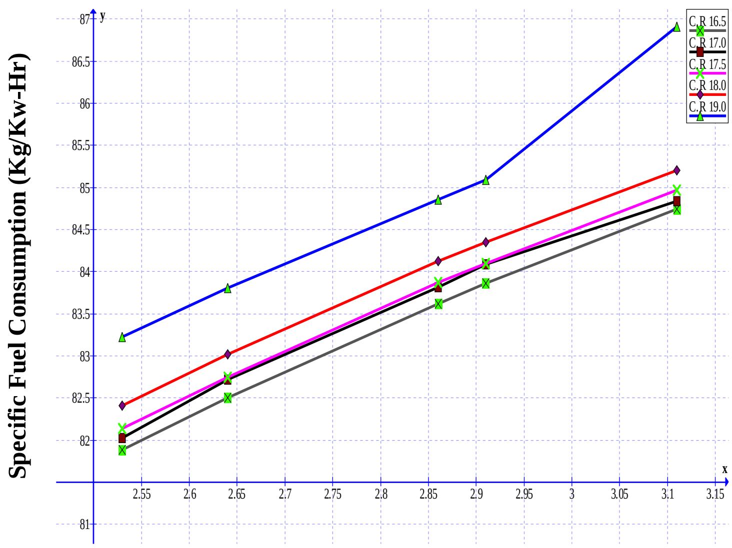


Mechanical efficiency (%)

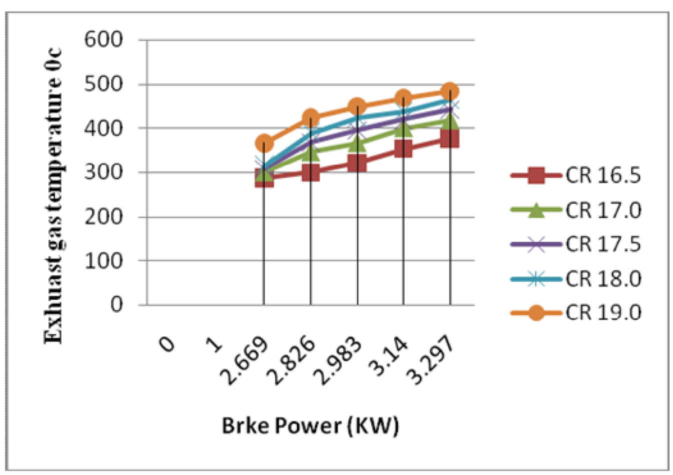
Brake power (KW)

The better specific fuel consumption was obtained at a compression ratio of 19.0 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 fuelThe better specific fuel consumption was obtained at a compression ratio of 19.0 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.

4) ***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 increase in compression ratio the mechanical efficiency also increases. And the mechanical efficiency at compression ratio of 16.5 and 17.0 was almost the same.

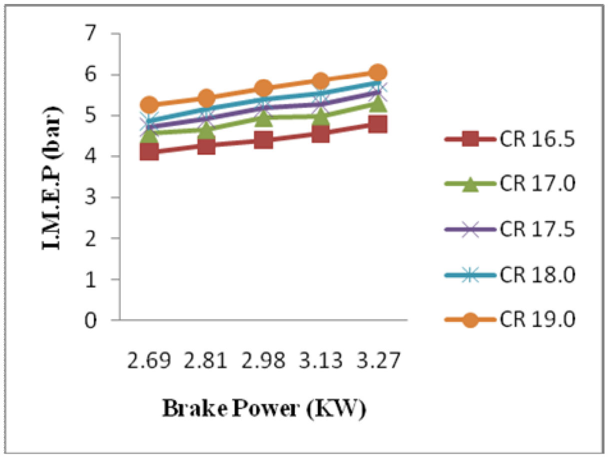


Break Power



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) Indicative Mean Effective Pressures:



Indicative Mean Effective Pressures were found to be increasing with the increase in load and the compression ratio. 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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