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ANALYSIS OF EMISSIONS IN FOUR STROKE VCR DIESEL ENGINE

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ABSTRACT

One of the hazardous problems faced by the world is global warming. The entire world is looking to search for the best methods to reduce global warming effect. Global warming is caused due to many reasons. Even though, there are many sources contributing the global warming, automobiles play a vital role for this. The emissions coming out from the internal combustion engine causes global warming.

The present work focuses on the emissions from the 4-stroke diesel engine. The data is related to the engine emissions from VCR engine which is taken experimentally. The data of emissions such as(Hc,No_x,so_2,co) hydrocarbons, nitrous oxides, sulpherdioxide and carbon monoxide and other emissions of percentage based according to the variable compression ratios.
Engine emissions are measured with AVL gas analyzer. The readings of 4-stroke VCR diesel engine are taken at constant speed but varying the compression ratios and loads. The work concentrates on achieving optimized compression ratio of the VCR engine which can reduce the emissions from the chosen engine effectively. The analysis has conducted on the emissions from 4-stroke single cylinder VCR diesel engine with respect to different compression ratios and loads but keeping the speed constant.

The present work gives the details of compression ratio, its effects on emissions from the engine, overview of VCR engine, methods of obtaining VCR, experimental setup, details of experimentation and results.

INTRODUCTION

1.1Variable compression ratio: It is a technology to adjust the compression ratio of an internal combustion engine while the engine is in operation. This is done to increase fuel efficiency while under varying loads. Higher loads require lower ratios to be more efficient and vice versa. Variable compression engines allow for the volume above the piston at 'Top dead centre' to be changed. For automotive use this needs to be done dynamically in response to the load and driving demands.

1.2 NECESSITY OF VCR:-

The present challenge in automotive engine technology is the improvement of thermal efficiency and hence the fuel economy and lower emission levels. Compression ratio is the key features which affect thermal efficiency of engine, the formula for air standard cycle efficiency is

$\eta=1-(1/r)\ k-1$

Higher compression ratio results in higher thermal efficiency and improved fuel economy in the internal combustion engine. Generally, the operating conditions vary widely, such as stop and go city traffic, highway motoring at constant speed, or high- speed freeway driving. In a conventional SI, the maximum compression ratio is set by the conditions in the cylinder at high load, when the fuel when the fuel and air consumption are at maximum levels. If the compression ratio is higher than the designed limit, the fuel will pre-ignite causing knocking, which could damage the engine. Unfortunately, most of the time SI engines in city driving conditions operate at relatively low power levels under slow accelerations, low speeds, or light loads, which lead to low thermal efficiency and hence higher fuel consumption. As the engine load decreases, the temperature in the end on thermal efficiency is compression ratio and air–fuel mixture strength. The fuel–air cycle Efficiency gas drops, so that high compression ratio could be employed without the risk of knocking in naturally aspirated or boosted engines. Raising the compression ratio from 8 to 14 produces an efficiency gain from 50 to 65 per cent (15%), whereas going from 16 to 20 produces a gain from 67 to 70

LITERATURE REVIEW

2.1 De Souza et al 1998, Evaluate the effects of compression ra- tio with EGR for 4 cylinder one liter capacity engine. The engine performance was evaluated on two compression ratio 8.9 and 9.6. The compression ratio is increased by reduction of the volume of combustion chamber and which improve overall engine perfor- mance. The emissions of (NO X) and carbon monoxide (CO 2)reduced. There is a loss of torque and power and emission ofunburned hydrocarbons (HC) increased and it depends on engine speed.

2.2 Porpatham et al 2012, Investigate the performance, emis- sion and combustion characteristics with different compression ratios. The investigation concludes that thermal efficiency for the engine is high at high compression ratio and compression ratio above 13:1 increased NOx, HC and CO emissions. The re- duction in the ignition delay and higher heat release rate with increase in compression ratio. Power and thermal efficiency reached their highest values with the compression ratio between13:1 and 15:1 and the equivalence ratio between 1.08 and 0.95.

2.3 Changup Kim et. al in 1999. Study the emissions characteristics for two compression ratios (8.6 : 1 and 10.6 : 1) and various EGR ratios. The results conclude that at high compres- sion ratio and lean burn method lead to the increase in the engine efficiency and decrease in NOx & CO2 emissions. Increasing CR, which makes more stable combustion by higher combustion pressure, temperature and turbulence intensity, extended engine lean operation limit. At the same A/F, increasing the EGR (%) resulted in less NOx emissions. However HC emission, engine efficiency and the production of ozone were not greatly affected by the change of EGR (%)

2.4 Takagaki et. al ,1997 Study the effects of compression ratio on NOx and HC emissions on a single cylinder SI engine fuelled with natural gas. The engine was tested at different equivalence ratio, spark timing and for the compression ratio of 8 and 15 at constant throttle. Investigation concludes at wide open throttle increase in NO concentration with increasing CR when compared at constant spark timings. The relative effect of CR on NO emissions decreased as CR was increased. For part throttle at MBT timing, the measurements showed that as CR was increased, the NO emissions initially increased but then decreased. Increasing CR resulted in an in- crease in HC emissions when compared at constant spark tim- ing.

2.5Amjad Shaik el at reviews the geometric approaches and solutions used to Achieve VCR, consider the results of prior research, and forecasts what benefits, if any, a VCR would bring to present engine design.

Experimental Test Rig

The experimental test rig consists of a variable compression ratio compression ignition engine, eddy current dynamometer as loading system, fuel supply system for both Diesel oil oil supply and biodiesel supply, water cooling system, lubrication system and various sensors and instruments integrated with computerized data acquisition system for online measurement of load, air and fuel flow rate, instantaneous cylinder pressure, injection pressure, position of crank angle, exhaust emissions and smoke opacity. the photographic image of the experimental setup used in the laboratory to conduct the present study .

The schematic representation of the experimental test setup. The technical specifications of different components used in the test rig. The setup enables the evaluation of thermal performance and emission constituents of the VCR engine. The thermal performance parameters include brake power, brake mean effective pressure, brake thermal efficiency, volumetric efficiency, brake specific fuel consumption, exhaust gas temperature, heat equivalent of brake power and heat equivalent of exhaust gas. Commercially available labview based Engine

Performance Analysis software package ―EnginesoftLV‖ is used for on line performance evaluation. The exhaust emissions of the engine are analysed using an exhaust gas analyser. The constituents of the exhaust gas measured are CO (% and ppm), CO_2 (%),O_2 (%), HC (ppm), NO_x (ppm) and SO_x (ppm). The smoke intensity is measured in terms of Hartridge Smoke Unit (HSU in %) /K(the light absorption coefficient (m^{-1}).

fig 3.1 Experimental Test Rig

3.2 Variable Compression Ratio (VCR) Diesel Engine

The variable compression ratio (VCR) diesel engine used to conduct the experiments is a single cylinder, four stroke, water cooled, direct injection engine. The technical specifications of the engine are given in Table 3.2. The engine is mounted on a stationary frame with a suitable cooling system. The lubricating system is inbuilt in the engine. Two different photographic images of the engine are given in Plates 3.2 and **3.1Technical Specifications of VCR Diesel ENGINE**

No of cylinders	1
No of strokes	4
Cylinder diameter	87.5mm
Stroke length	110mm
Connecting rod length	234mm
Orifice diameter	20mm
Dynamometer arm length	185mm

FULE	DIESEL
Power	3.5kW
Speed	1500rpm
CR range	12:1 to 18:1
Injection point variation	0 to 25^0BTDC

3.3 Compression Ratio Setting

The engine with fixed compression ratio can be modified by providing additional variable combustion space. There are different arrangements by which this can be achieved. Tilting cylinder block method is one of the arrangements which can be used to vary the combustion space volume. A photographic image of the tilting cylinder block installed on the engine cylinder is given in Plate 3.4. The engine is made to operate as a variable compression ratio (VCR) engine by providing a tilting block arrangement to suitably change the compression ratio (CR) to the desired value in the given range without stopping the engine and without altering the combustion chamber geometry.

The tilting cylinder block arrangement consists of a tilting block with six allen bolts, a compression ratio adjuster with lock nut and compression ratio indicator. For setting a chosen compression ratio, the allen bolts are to be slightly loosened (refer Plate 3.5). Then, the lock nut on the adjuster is to be loosened and the adjuster is to be rotated to set a chosen compression ratio by referring to the compression ratio indicator and to be locked using lock nut. Finally all the allen bolts are to be tightened gently. The compression ratios considered for conducting the experiments are 14, 15, 16, 17, 17.5 and 18. Due to rough running of the engine and greater vibration, the compression ratio below 14 is not set though there is a provision to set the CR value up to 12.

The basic principle of the tilting cylinder block assembly is as shown in Figure 3.2 and Plate 3.5. When the CR is to be reduced the block is tilted so that the clearance volume increases and swept volume remains a constant (indicated by red colour in the Figure 3.2).

Fig 3.2 Compression Ratio Setting

3.4 Emission Measurement System

The emission measurement system is used to measure the constituents of exhaust gas and its opacity (smoke number). This system consists of an exhaust gas analyzer and a smoke meter. The exhaust gas analyzer measures the exhaust gas constituents of Carbon dioxide (CO_2), Carbon monoxide (CO), Oxides of nitrogen (NO_x), Unburnt Hydrocarbons (HC), Oxygen (O_2) and Oxides of sulphur (SO_x). The smoke meter is used to measure the intensity of exhaust smoke and it is measured in terms of Hartrigde Smoke Unit (%) and light absorption coefficient (K expressed in m^{-1}). A photographic image of the assembly of the emission measurement systems used in the experiment is given in Plate 3.17. The range, data resolution and accuracy of the exhaust measurement systems are given in Table 3.6. The calibration certificate of exhaust gas analyser and smoke meter are given in Appendix V.

3.5 Exhaust Gas Analyzer

An instrument used to analyze the chemical composition of the exhaust gas released by a reciprocating engine is called exhaust gas analyzer. An image of the exhaust gas analyzer used in this study is given in Plate 3.18. The analyser (Model PEA205) is of make INDUS *Scientific* Pvt Ltd, Bengaluru. The instrument measures the concentrations of Carbon monoxide (CO in % & ppm), Carbon Dioxide (CO_2) and Oxygen (O_2) in percentage, Hydrocarbons (HC), Nitric Oxide (NO_x) and Oxides of Sulphur (SO_x) in ppm in the engine exhaust gas. The technical specifications of the exhaust gas analyser are given in the Table 3.7

RESULTS AND DISCUSSIONS

The table which is given below gives the information about emissions from the VCR diesel engine . The experiment has been done at constant speed by varying the compression ratios and at different loads.

At CR 16:1

SPEED (rpm)	LOAD KG	Co	Hc	Co2	Nox
1500	0	0.06	8	0.4	69
1500	3	0.054	10	2.24	614
1500	6	0.053	16	3.36	716
1500	9	0.045	14	3.93	716
1500	12	0.036	15	4.59	666

AT CR 15:1

SPEED (rpm)	LOAD KG	Co	Hc	Co2	Nox
1500	0	0.06	10	0.4	0
1500	3	0.031	11	2.21	116
1500	6	0.093	12	3.02	537
1500	9	0.055	12	4.29	716
1500	12	0.045	13	5.03	716

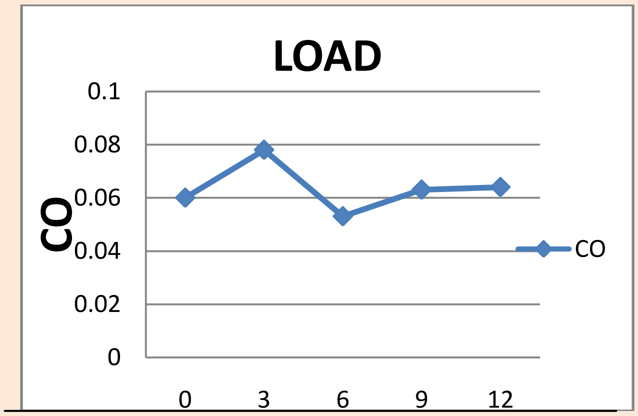
AT CR 18:1

SPEED (rpm)	LOAD KG	Co	Hc	Co2	Nox
1500	0	0.06	10	0.4	153
1500	3	0.078	16	2.63	706
1500	6	0.053	24	3.48	665
1500	9	0.063	40	5.03	712
1500	12	0.064	35	5.33	705

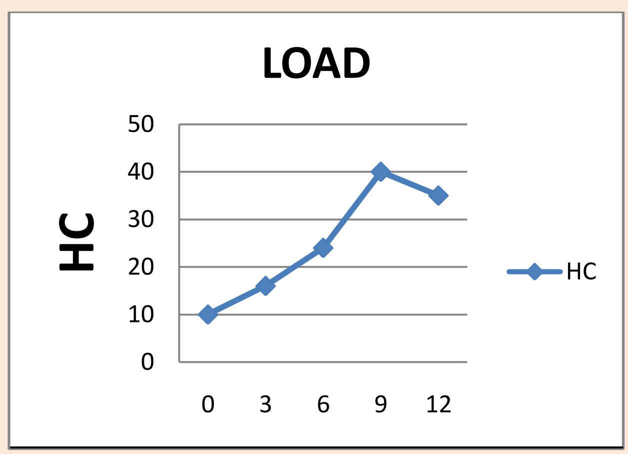
Table4.1 emissions from the VCR diesel engine

The experimentation is done at constant speed by varying the loads and compression ratios. The data related to emissions is simultaneously taken at a time.The tests are carried out without exhaust gas recirculation. The results obtained from experimentation is plotted and explained in this section

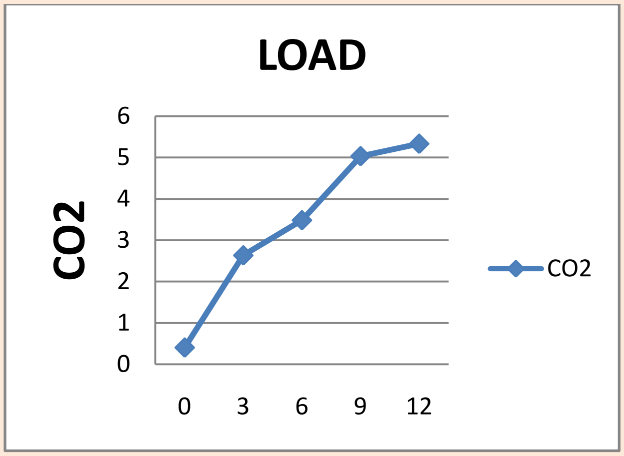
4.1 EMISSIONS FROM THE ENGINE AT COMPRESSION RATIO 18:1



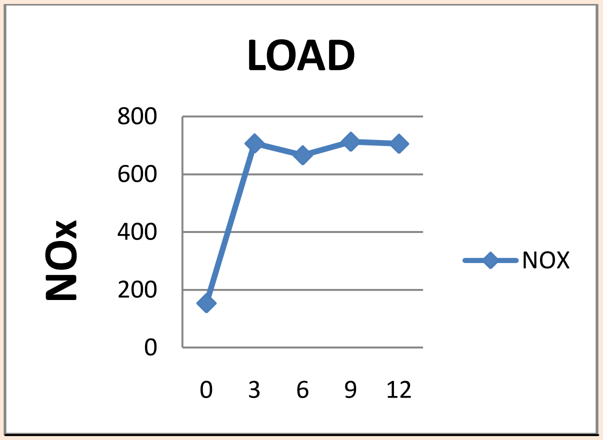
The above figure describes emission of co at compression ratio 18:1. As shown in the figure emission of co increases with increase in the load and it reaches maximum value at load 3kg and then decreases by increasing the load. It reaches the minimum value at load 6kg. it gives the low emission at optimum load 6kg.



The above figure describes that emission of HC increases with increasing load and it reaches the maximum load at 6 kg at compression ratio 18:1.

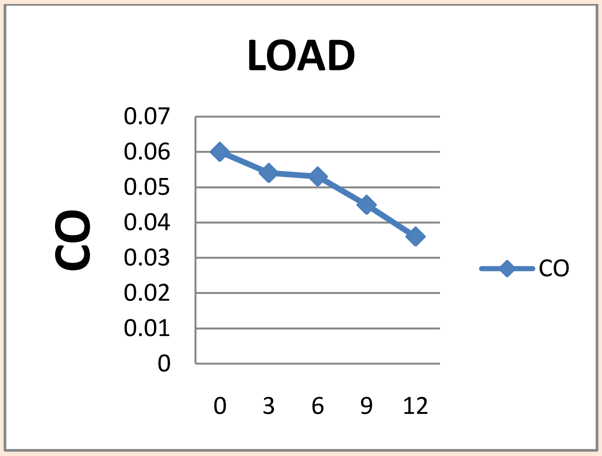


The above graph shows that the emission of CO_2 increases with increase in the load at compression ratio 18:1

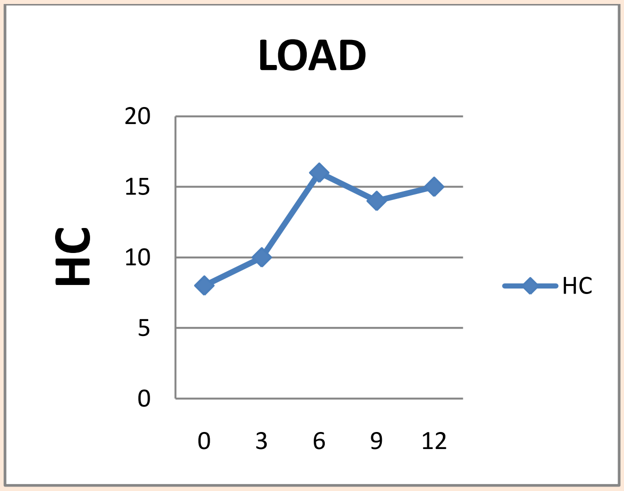


The above graph shows that emission of NO_X increases with increase in the load upto 3kg and then it attains the constant value even though increase in the load.

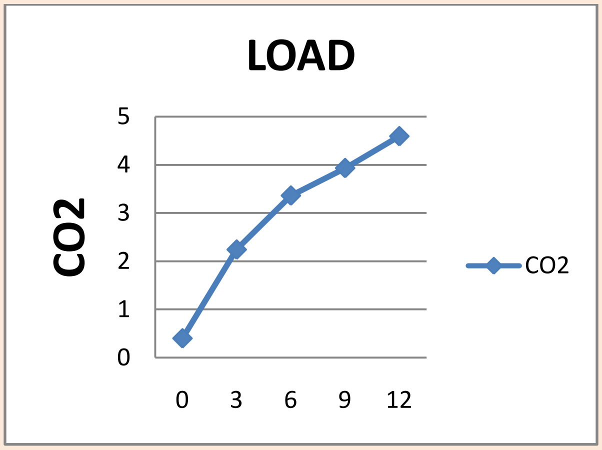
4.2 EMISSIONS FROM THE ENGINE AT COMPRESSION RATIO 16:1



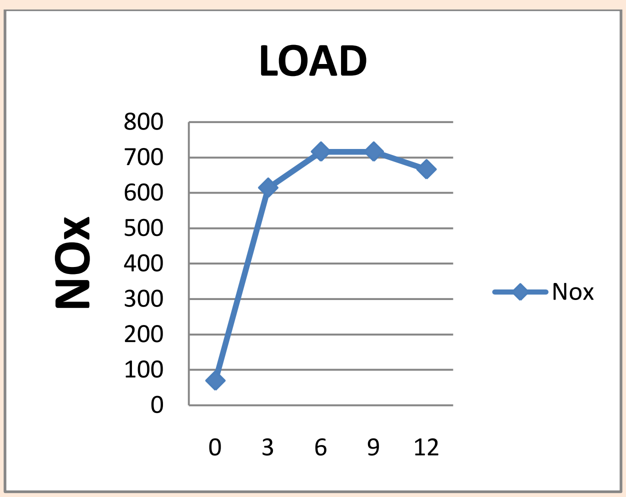
The above graph shows that emission of CO decreases with increase in the load at compression ratio 16:1



The above graph shows that emission of HC increases up to load 6kg and then decreases with increase in the load at compression ratio 16:1.

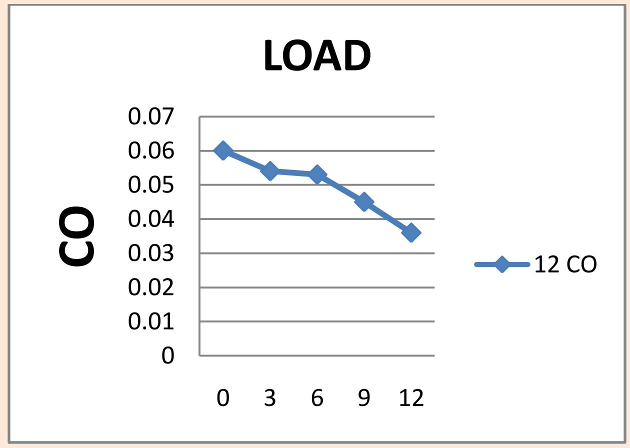


The above figure shows that emissions of CO_2 increases with increase in the load at compression ratio 16:1.

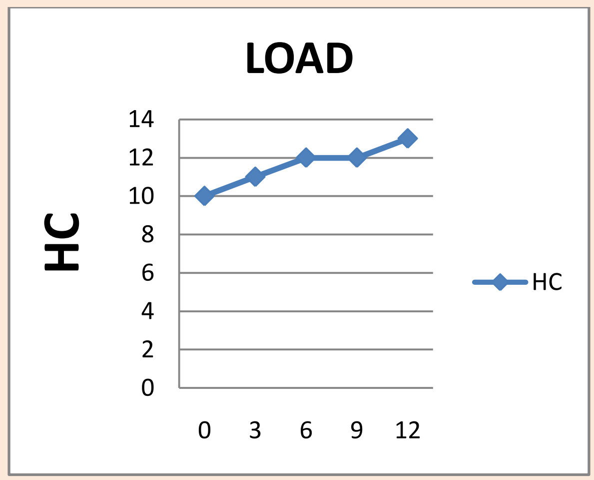


The above figure shows that emission of NO_x increases up to load 3kg and then it reaches the constant value with increase in the load at compression ratio 16:1.

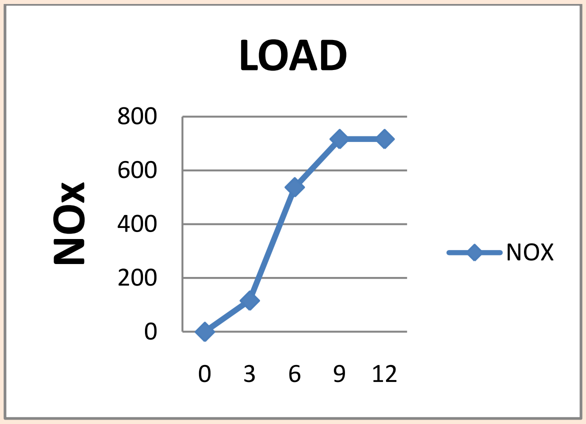
4.3 EMISSIONS FROM THE ENGINE AT COMPRESSION RATIO 15:1



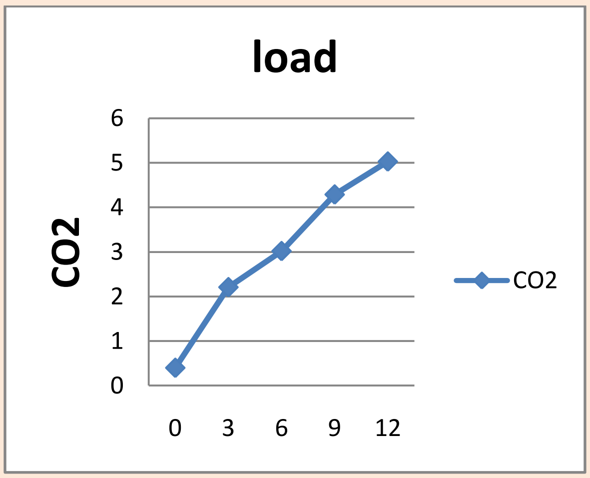
The above graph shows that emission of CO decreases with increase in the load at compression ratio 15:1.



The above graph shows that emission of HC increases with increase in the load at compression ratio 15:1.



The above graph shows that emission of NO_X increases with increase in the load at compression ratio 15:1



The above graph shows that emission of CO_2 increases with increase in the load at compression ratio 15:1

CONCLUSION

- In this experimental analysis study on emissons is conducted on single cylinder VCR engine at different loads with constant speed.
- From the study of emissions at compression ratios 18:1,16:1,15:1, it is observed that CO_2,CO,HC,NO_X contents of emissions decreases at 16:1 and 15:1 compression ratios with the comparasion of 18:1 CR.
- The desirable results of emissions of CO2,CO,HC,NO_X are coming at 16:1 CR by comparison with 15:1 CR.
- This project concludes desirable emissions are getting at 16:1 compression ratio at 6kg and speed 1500 rpm.

FUTURE SCOPE:

- The same experimental analysis can also be done on BIO DIESEL VCR ENGINE.

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