TO DESIGN AND STUDY THE PERFORMANCE ANALYSIS OF SINGLE CYLINDER DIESEL ENGINE WITH VARIABLE COMPRESSION RATIO.

Sameeran Sukale[1], Abhishek Rawat[2], Kalpesh Paradhi[3] ,Shubham Takale[4],

Asst. Prof. K.B Kshirsagar [5]

[1,2,3,4]*Students, Department of Mechanical Engineering, Dr. D. Y. Patil Institute of Technology, Pimpri, Pune, India.*
[5]*Assistant Professor, Department of Mechanical Engineering, Dr. D. Y. Patil Institute of Techology, Pimpri, Pune, India.*

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Abstract - *The Automotive industry is under great stress due low efficiency and low engine life. And also the greenhouse gas emissions and health impacts of pollutants. Variable Compression Ratio technology has been recall a method for improving the automobile engine performance, efficiency, fuel economy with reduced emission. The main function a VCR is to operate at different compression ratio at any load by changing the clearance volume. VCR engines can be used to minimize the risks of irregular combustion of high power and low power. This paper describes the moving cylinder head technique by which VCR is being implemented and provides the comparative study of diesel engine with VCR and without VCR on the basis of efficiency, brake power, specific fuel consumption, etc. This paper also refers to the specific design to modify the compression ratio.*

***Key Words*: Variable Compression Ratio Diesel Engine, Moving cylinder head, Design and Comparision.**

1.INTRODUCTION

1.1 VARIABLE COMPRESSION RATIO

Variable Compression Ratio is a technology to adjust the compression ratio of an internal combustion engine while the engine is in operation. The main function of VCR engine is to operate at different compression ratio at different load, by changing the clearance volume. This method is used to improve the performance factors like the engine efficiency, fuel consumption, engine life, etc.

1.2 COMPRESSION RATIO

It is the ratio by which the fuel/air mixture is compressed before it is ignited.

CR = Maximum Cylinder Volume/Minimum Cylinder Volume

$$\mathrm{CR} = \frac{(\pi b^2 s)/4 + V_c}{V_c}$$

Where,

b = cylinder bore (diameter)

s = piston stroke length

V_c = Clearance volume

1.3 COMPRESSION RATIO SETTING

In single cylinder four stroke diesel engine we can modify the fixed compression ratio by providing "Extra Variable Combustion Space" . This is not the only method, there are many methods by which this can be achieved. Here, the method we used is titling cylinder block to vary the combustion space volume. By providing the tilting cylinder block arrangement to VCR engine, we can change the compression ratio to any desired value without stopping the engine and without altering the combustion chamber geometry.

The arrangement consists of:-

1. Supporting Plates.
2. Pressure Bolts.
3. Base Plate.
4. Compression Ratio Adjuster with Locknut.
5. Compression Ratio Indicator.
6. Bearing.

For changing or setting certain compression ratio the pressure bolts are slightly loosened which are fitted on supporting plate. After, the locknut on adjuster is to be loosed and then cylinder head is lifted up to increase the clearance volume to make the changes to compression ratio adjuster to set compression ratio by referring the indicator and lock using locknut. After all this is done tightened all the pressure bolts gently.

2. WHY VCR?

1. Need of high specific power output accompanied by a good reliability and longer engine life.
2. High peak pressure problem occurs at full load.
3. Can be minimized by reducing CR.
4. But CR should be sufficiently high for good starting and part load operation.
5. VCR concept is beneficial in low load, for better multi-fuel capacity.

3. OBJECTIVE OF PROJECT

1. To propose a new design of VCR for Diesel Engine that can solve the problem.
2. To analyze the performance of VCR.
3. To study and compare the results with VCR & without VCR for diesel engine.

4. PROBLEM STATEMENT

All engines have common problem i.e low efficiency and low engine life. As the system is not used to its maximum potential, fuel is also wasted. This overall results in increase of expenditure on the engine which mainly includes fuel economy and maintenance.

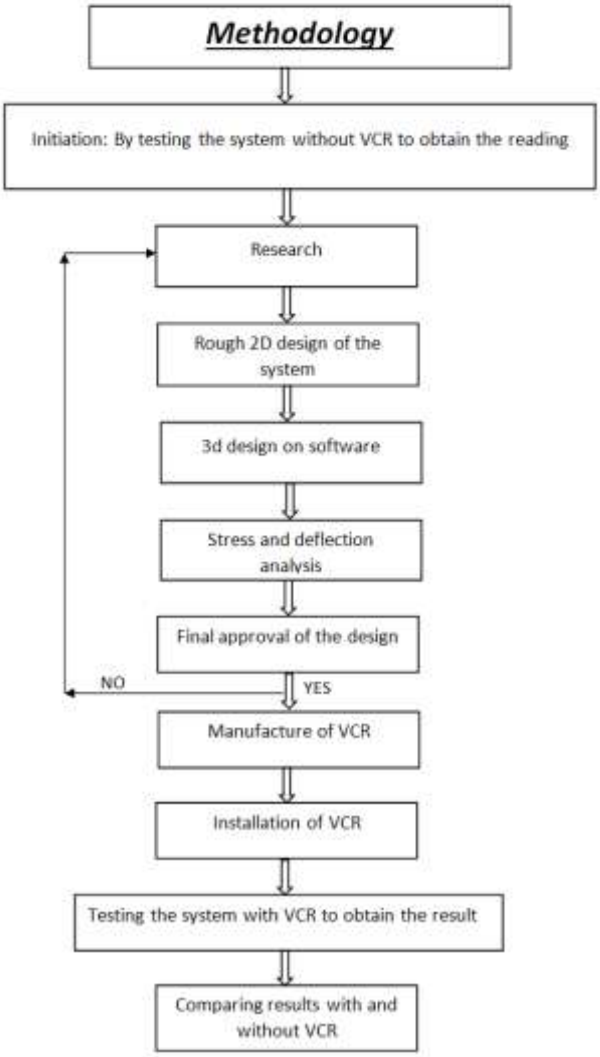
- As the engine requires the different compression ratio for different loads to properly utilize the fuel, the requirement will be sufficed with the implementation of VCR.
- To minimize the cost by reducing fuel consumption by proper usage of fuel and also reduce maintenance cost.

5. SPECIFICATIONS VARIABLE COMPRESSION RATIO 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 to 18

6. METHODOLOGY

The methodology of the project has been simply explained by following flow diagram



7. DESIGN

1. First step in designing fixture is material selection. As the material used is Cast Iron. As cast iron has low tensile strength and high compressive strength. It also has low melting point and resistance to deformation and oxidation and other significant properties.
    - MATERIAL SELECTION:

   Material: Cast Iron

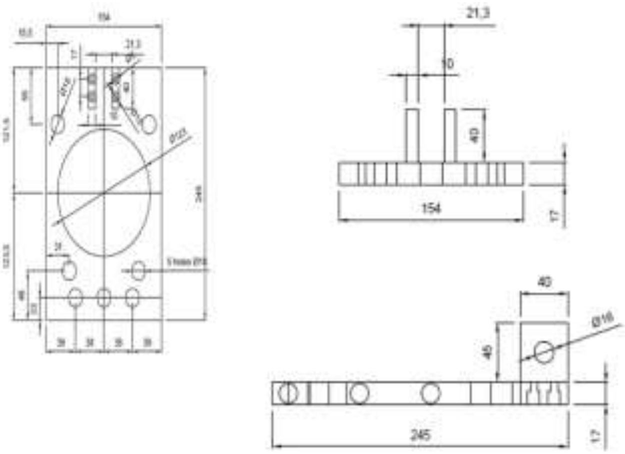
   Properties:

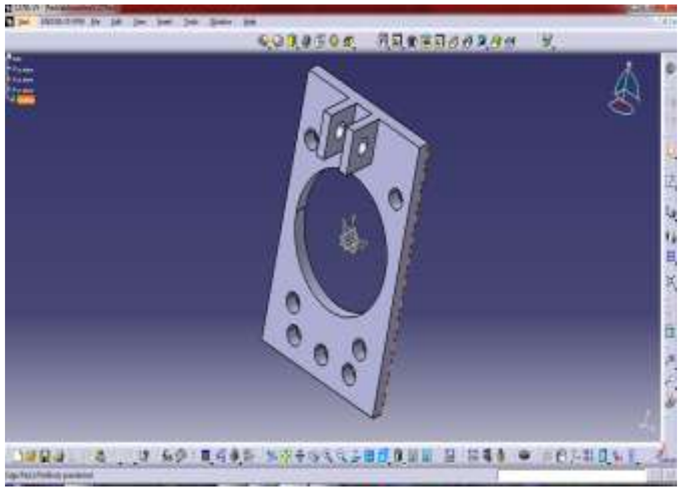
- Carbon = 2.5 to 3.7%
- Silicon = 1.0 to 3.0%
- Manganese = 0.5 to 1.0%
- Phosphorus = 0.1 to 0.9%
- Sulphur = 0.07 to 0.10%

7.1 2D DIGRAM WITH DIMENSION AND 3D CATIA MODELS

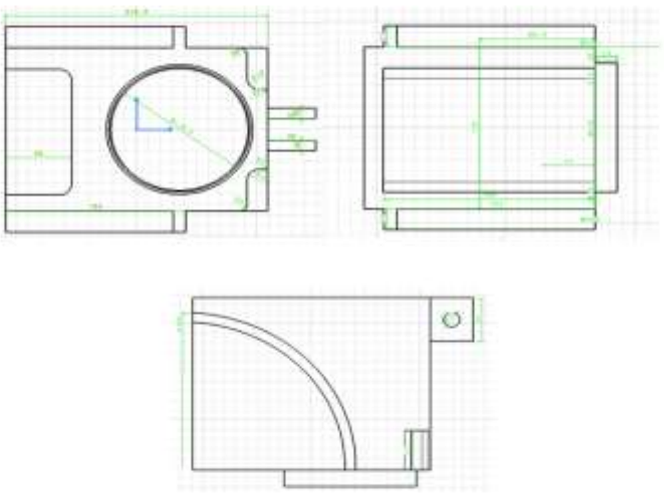
The Diagram and Catia model consists of the following parts:

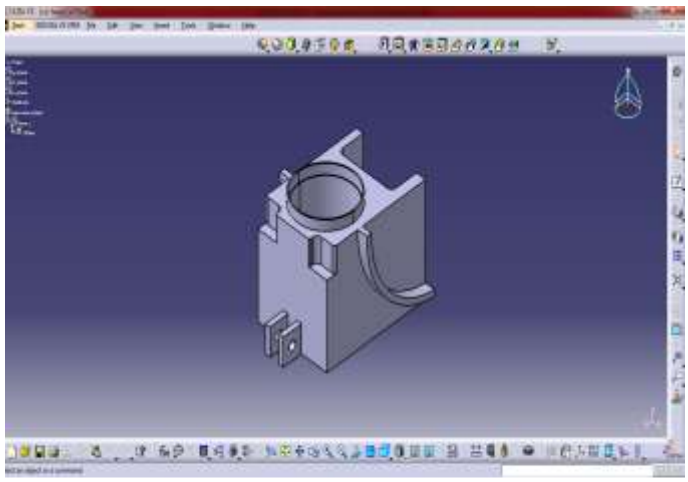
- BASE PLATE : The base plate is sufficiently rigid plate whose work is to support the variable compression ratio (VCR) head.



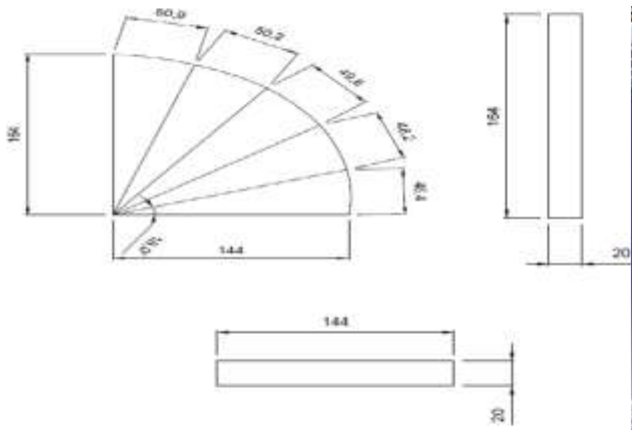


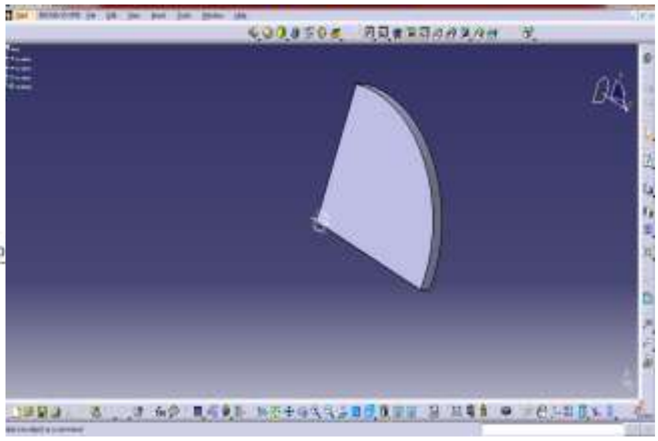
- VCR HEAD : The basic function of VCR head is to contain and lead the reciprocating motion of piston in the cylinder head. It is made up of cast iron.



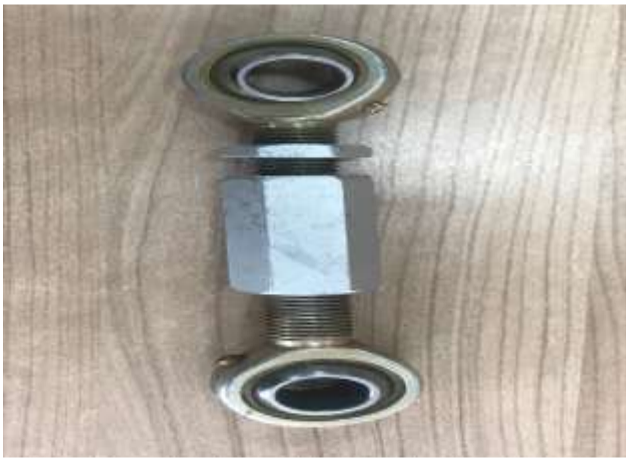


- SUPPORTING/PRESSURE PLATES : The functional purpose of pressure plate is to support the VCR head. There are two rigid plates attached to the base plate of VCR head which can be loosen/tighten for varying the compression ratio. It is also known as support plates. This plates are also made up of cast iron. This part is one of the important part and should be install properly.





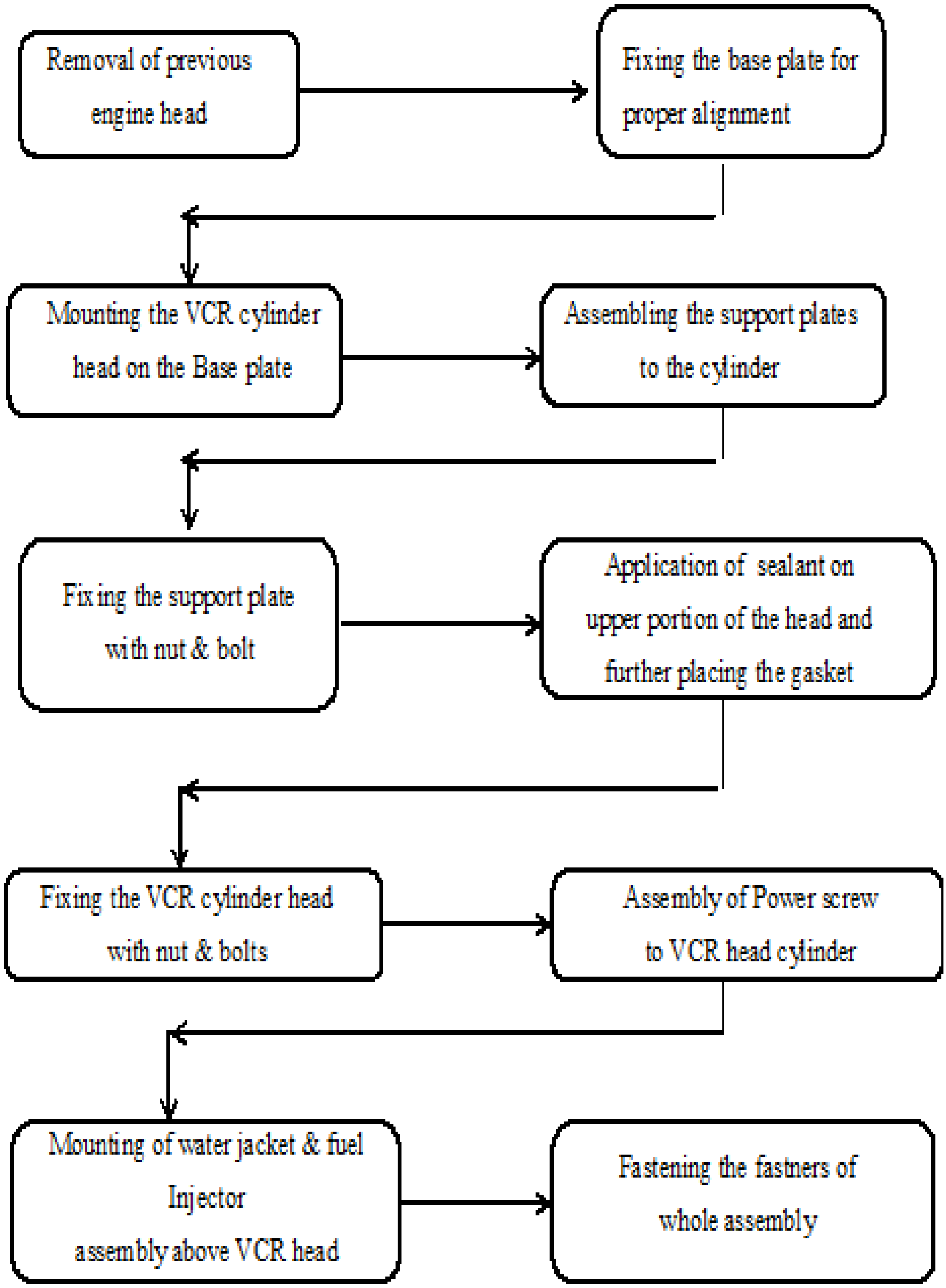
- STANDARD COMPONENT [Rode end, hexagonal long sleeve nut, lock nut]: These components acts as a single unit which works as a power screw to lift the VCR head as desired by manual adjustment.



8. ASSEMBLY

FIG:-FINAL ASSEMBLY

Assembly of component is explained in the following flow chart.



9. PERFORMANCE ANALYSIS

A. WITHOUT VCR (Compression Ratio:- 17.5:1):-

- **Observation Table 1:**

Sr. No.	Torque (N-m)	Engine Speed (RPM)	Fuel Consumption (kg/sec)	Air Intake Pressure (mm of Water)	Calorimeter Cooling Water Flow (LPH)	Engine Cooling Water Flow (LPH)
1.	3.01	1518.51	0.24416	26.62	245	270
2.	4.37	1518.58	0.25845	27.60	245	270
3.	5.69	1509.61	0.25605	23.22	245	270
4.	6.89	1512.39	0.25452	24.91	245	270
5.	8.22	1512.88	0.26123	20.68	245	270

- **Observation Table 2:**

Sr. No.	Calorimeter Gas Inlet 'T1'(C)	Calorimeter Gas Outlet 'T2'(C)	Calorimeter Water Inlet 'T3'(C)	Calorimeter Water Outlet 'T4'(C)	Engine Cooling Water Inlet 'T5'(C)	Engine Cooling Water Outlet 'T6'(C)	Ambient Temperature 'T7'(C)
1.	95.8	29.8	29.4	27.2	29.4	35.3	29.3
2.	98.4	30.0	32.9	26.6	32.9	35.6	29.4
3.	112.0	29.9	28.4	26.0	28.4	36.4	29.3
4.	115.2	29.9	27.6	26.3	27.6	36.0	29.4
5.	114.4	30.1	24.8	25.2	24.8	34.5	29.6

- **Engine Performance Test Result:**

Sr. No.	Brake Power (Kw)	Brake Mean Effective Pressure (Bar)	BSFC (kg/Kw-hr)	Mechanical Efficiency (%)	Brake Thermal Efficiency (%)	Volumetric Efficiency (%)	Air Fuel Ratio
1.	0.30	0.46	2.885538	15.20	2.84	68.84	0.02
2.	0.44	0.66	2.102087	20.66	3.89	70.10	0.02
3.	0.57	0.87	1.608988	25.21	5.09	64.68	0.02
4.	0.70	1.05	1.317843	29.03	6.21	66.86	0.02
5.	0.83	1.25	1.133479	32.80	7.22	60.91	0.02

- **Heat Balance Sheet:**

Sr. No.	Heat Input (kW)	Heat Utilized for Brake Power (kW)	Heat Carried By Exhaust Gas (kW)	Heat Carried By Cooling Water (kW)	% Heat Utilized for Brake Power	% Heat Carried By Exhaust Gas	% Heat Carried By Cooling Water	% Heat Unaccounted
1.	10.7	0.3	-0.7	1.8	2.8	-6.1	17	86.2
2.	11.4	0.4	-1.8	0.9	3.9	-15.9	7.5	104.5
3.	11.3	0.6	-0.7	2.5	5.1	-6.1	22.3	78.7
4.	11.2	0.7	-0.3	2.7	6.2	-3.1	23.7	73.2
5.	11.5	0.8	0.1	3.1	7.2	1.0	26.7	65.1

B.WITH VARIABLE COMPRESSION RATIO:-

1. At an offset of 1mm (Compression Ratio-15.55:1)

- **Observation Table 1:**

Sr. No.	Torque (N-m)	Engine Speed (RPM)	Fuel Consumption (kg/sec)	Air Intake Pressure (mm of Water)	Calorimeter Cooling Water Flow (LPH)	Engine Cooling Water Flow (LPH)
1.	1.99	1514.50	0.25034	22.19	300	305
2.	3.16	1523.46	0.23827	20.77	300	305
3.	4.44	1520.82	0.23964	22.98	300	305
4.	5.71	1510.87	0.24379	20.12	300	305
5.	6.97	1513.22	0.25071	23.09	300	305
6.	8.22	1510.65	0.25723	23.35	300	305

- **Observation Table 2:**

Sr. No.	Calorimeter Gas Inlet 'T1'(C)	Calorimeter Gas Outlet 'T2'(C)	Calorimeter Water Inlet 'T3'(C)	Calorimeter Water Outlet 'T4'(C)	Engine Cooling Water Inlet 'T5'(C)	Engine Cooling Water Outlet 'T6'(C)	Ambient Temperature 'T7'(C)
1.	63.5	34.9	5.2	8.2	5.2	9.4	34.3
2.	94.6	34.7	29	29.1	29	33	34.2
3.	99.4	34.7	27.5	27.1	27.5	32.3	34.1
4.	104.5	34.7	30.3	28	30.3	33.1	34.1
5.	103.5	34.7	28.9	27.9	28.9	31.5	34.1
6.	107.5	34.8	26.2	26.4	26.2	29.8	34.3

- **Engine Performance Test Result:**

Sr. No.	Brake Power (Kw)	Brake Mean Effective Pressure (Bar)	BSFC (kg/Kw-hr)	Mechanical Efficiency (%)	Brake Thermal Efficiency (%)	Volumetric Efficiency (%)	Air Fuel Ratio
1.	0.20	0.30	4.48866	10.56	1.82	63.01	0.02
2.	0.32	0.48	2.671291	15.89	3.06	60.62	0.02
3.	0.45	0.68	1.915624	20.94	4.27	63.87	0.02
4.	0.58	0.87	1.525989	25.28	5.36	60.15	0.02
5.	0.70	1.06	1.283142	29.27	6.38	64.33	0.02
6.	0.83	1.25	1.117913	32.76	7.32	64.82	0.02

- **Heat Balance Sheet:**

Sr. No.	Heat Input (kW)	Heat Utilized for Brake Power (kW)	Heat Carried By Exhaust Gas (kW)	Heat Carried By Cooling Water (kW)	% Heat Utilized for Brake Power	% Heat Carried By Exhaust Gas	% Heat Carried By Cooling Water	% Heat Unaccounted
1.	11.0	0.2	1.1	1.5	1.8	9.5	13.6	75.0
2.	10.5	0.3	0.0	1.4	3.1	0.3	13.6	83.0
3.	10.5	0.5	-0.2	1.7	4.3	-1.5	16.1	81.1
4.	10.7	0.6	-0.8	1.0	5.4	-7.3	9.4	92.6
5.	11.0	0.7	-0.4	0.9	6.4	-3.4	8.3	88.7
6.	11.3	0.8	0.1	1.3	7.3	0.6	11.45	80.7

2. At An Offset of 2mm (Compression Ratio-13.69:1)

- **Observation Table 1:**

Sr. No.	Torque (N-m)	Engine Speed (RPM)	Fuel Consumption (kg/sec)	Air Intake Pressure (mm of Water)	Calorimeter Cooling Water Flow (LPH)	Engine Cooling Water Flow (LPH)
1.	3.26	1531.51	0.24521	19.16	300	305
2.	4.43	1526.79	0.24135	25.57	300	305
3.	5.65	1520.32	0.24707	17.64	300	305
4.	7.10	1510.80	0.25109	20.10	300	305
5.	8.30	1513.00	0.25841	23.88	300	305

- **Observation Table 2:**

Sr. No.	Calorimeter Gas Inlet 'T1'(C)	Calorimeter Gas Outlet 'T2'(C)	Calorimeter Water Inlet 'T3'(C)	Calorimeter Water Outlet 'T4'(C)	Engine Cooling Water Inlet 'T5'(C)	Engine Cooling Water Outlet 'T6'(C)	Ambient Temperature 'T7'(C)
1.	87.1	35.2	15.6	19.5	15.6	22.3	34.8
2.	92.5	35.3	17.2	18.6	17.2	23.1	34.7
3.	94.6	35.3	18.7	19.7	18.7	23.1	35.0
4.	98.2	35.4	18.0	18.0	18.0	24.6	34.8
5.	103.3	35.3	18.4	17.6	18.4	23.9	34.8

- **Engine Performance Test Result:**

Sr. No.	Brake Power (kW)	Brake Mean Effective Pressure (Bar)	BSFC (kg/kW-hr)	Mechanical Efficiency (%)	Brake Thermal Efficiency (%)	Volumetric Efficiency (%)	Air Fuel Ratio
1.	0.33	0.50	2.650899	16.38	3.09	57.91	0.02
2.	0.45	0.67	1.924480	20.98	4.25	67.11	0.02
3.	0.57	0.86	1.552463	25.20	5.27	55.97	0.02
4.	0.72	1.08	1.263692	29.26	6.47	60.12	0.02
5.	0.84	1.26	1.110817	33.00	7.37	65.44	0.02

- **Heat Balance Sheet:**

Sr. No.	Heat Input (kW)	Heat Utilized for Brake Power (kW)	Heat Carried By Exhaust Gas (kW)	Heat Carried By Cooling Water (kW)	% Heat Utilized for Brake Power	% Heat Carried By Exhaust Gas	% Heat Carried By Cooling Water	% Heat Unaccounted
1.	10.8	0.3	1.4	2.4	3.1	12.7	21.8	62.4
2.	10.6	0.5	0.5	201	4.3	4.7	19.8	71.2
3.	10.9	0.6	0.4	1.6	5.3	3.4	14.4	76.9
4.	11.0	0.7	-0.00	2.3	6.5	-0.2	21.2	72.5
5.	11.4	0.8	-0.3	2.0	7.4	-2.4	17.2	77.8

3. **At An Offset Of 3mm (Compression Ratio-12.38:1)**

- **Observation Table 1:**

Sr. No.	Torque (N-m)	Engine Speed (RPM)	Fuel Consumption (kg/sec)	Air Intake Pressure (mm of Water)	Calorimeter Cooling Water Flow (LPH)	Engine Cooling Water Flow (LPH)
1.	3.14	1512.43	0.24558	19.10	315	310
2.	4.46	1511.97	0.25070	25.15	315	310
3.	5.67	1503.51	0.25108	25.01	315	310
4.	7.04	1510.77	0.25802	29.17	315	310
5.	8.22	1499.32	0.26578	18.58	315	310

- **Observation Table 2:**

Sr. No.	Calorimeter Gas Inlet 'T1'(C)	Calorimeter Gas Outlet 'T2'(C)	Calorimeter Water Inlet 'T3'(C)	Calorimeter Water Outlet 'T4'(C)	Engine Cooling Water Inlet 'T5'(C)	Engine Cooling Water Outlet 'T6'(C)	Ambient Temperature 'T7'(C)
1.	119.0	35.4	35.0	33.3	35.0	36.3	35.0
2.	117.0	35.5	35.5	33.9	35.5	36.4	35.0
3.	112.7	35.4	31.5	33.5	31.5	37.3	34.9
4.	120.1	35.4	30.1	32.5	30.1	35.3	35.0
5.	119.1	35.5	33.5	32.7	33.5	37.4	35.0

- **Engine Performance Test Result:**

Sr. No.	Brake Power (kW)	Brake Mean Effective Pressure (Bar)	BSFC (kg/kW-hr)	Mechanical Efficiency (%)	Brake Thermal Efficiency (%)	Volumetric Efficiency (%)	Air Fuel Ratio
1.	0.32	0.48	2.790376	15.71	2.93	58.55	0.02
2.	0.45	0.68	2.006103	20.93	4.08	67.20	0.02
3.	0.57	0.86	1.590864	25.05	5.14	67.39	0.02
4.	0.71	1.07	1.308436	29.46	6.25	72.43	0.02
5.	0.82	1.25	1.163391	32.61	7.03	58.25	0.02

- **Heat Balance Sheet:**

Sr. No.	Heat Input (kW)	Heat Utilized for Brake Power (kW)	Heat Carried By Exhaust Gas (kW)	Heat Carried By Cooling Water (kW)	% Heat Utilized for Brake Power	% Heat Carried By Exhaust Gas	% Heat Carried By Cooling Water	% Heat Unaccounted
1.	10.8	0.3	-0.6	0.5	2.9	-5.9	4.5	98.5
2.	11.0	0.4	-0.6	0.3	4.1	-5.4	3.0	98.4
3.	11.0	0.6	0.7	2.1	5.1	6.89	18.9	69.2
4.	11.4	0.7	0.9	1.9	6.3	7.8	16.5	69.5
5.	11.7	0.8	-0.3	1.4	7.0	-2.7	11.8	83.9

10. RESULT

Thus, after analyzing the study of performance and comparing it; we have find that when the cylinder head is not changed the compression ratio obtained is constant which is 17.5:1.
As when the original head of the engine is replace by the Variable Compression Ratio (VCR) head with increasing its clearance volume we have observed that the compression ratio of the engine differs.
The set Compression Ratio are as (15.55:1),(13.69:1),(12.38:1).So, at different loads we have seen that, at compression ratio (13.69:1) the Mechanical Efficiency, Brake Thermal and Volumetric Efficiency increases as compared to other compression ratio. And, also the Brake Power and Brake Mean Effective Pressure also increases.

11. CONCLUSIONs

- The implemented fixture will satisfy researcher production goal and increase the efficiency.
- Variable Compression Ratio engines have great potential to increase engine power and fuel economy.
- This technology will likely become common place due to increasing energy and environmental concerns and the ease of integration.

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