Optimization of Variable Compression Ratio Accompanied with Variable Injector Location in Di Diesel Engine using Renewable Fuels

Ashish J. Chaudhari, Zubair Shaikh, Pranjal Lokhande, Prem Pandey,Rishabh Tiwari
Vidyavardhini's College of Engineering and Technology,
Vasai

Abstract:- Owing to the depletion of non-renewable fuels by the next fifty years, world energy outlook 2018 emphasis on the search of alternative fuels to the conventional fuels such as petrol, diesel, LPG etc. Simultaneously there are lot of efforts put by researchers in improving the performance of the vehicle. The outcome of which, the technology such as CRDI, KAPPA, DTSI, VVT, GDI were evolved and commercially implemented in the engine. The technology improvement has been carried out keeping the objective of minimum fuel consumption with maximum power output. One of the technology of variable compression ratio was established in recent years by researchers and it improves the performance of the engine. In addition to this the variable injector location is a novel technique wherein the point of injection of diesel may be adjusted as per load and speed of the engine. By this way the fuel atomizes efficiently causing the uniform combustion inside combustion chamber. The combined study of variable compression ratio with variable injector location has been carried out prior on diesel fuel. Further the renewable fuels such as compressed biogas and raw producer gas will be utilized in the diesel engine in dual fuel mode. The selection of optimum compression ratio and optimum variable injector location based on load and speed of the engine will be the outcome of the study. The environment pollution components such as CO, NOx and HC due to diesel fuel combustion will be substantially reduced with use of renewable fuels.

INTRODUCTION

Biogas, an alternative fuel is derived from anaerobic process. To overcome these obstacles, we must look into some alternative options for the fossil fuels. Alternating to the renewable energy resources (biomass, biogas, wind, hydro power, etc.,) is the only way to cope up with the increasing demand and pollution. Existing stationary diesel engines can be retrofitted fairly easily for operation with alternative gaseous fuels, such as natural gas and biogas. Natural gas is now being widely used to fuel combustion engines, however its reserves limited in many areas of the world. Hence, biogas is a potential alternative fuel that is renewable in nature and thereby does not contribute to the net atmospheric concentration of the greenhouse gas carbon dioxide. The performance studies, both experimental and modeling, of a direct injection diesel engine for two modes of operations – one with straight diesel fueling and another in dual-fuel mode using natural gas and biogas.

Experimental setup

A variable CR engine head is installed at the top of engine which has an auxiliary piston. The position of auxiliary piston can be adjusted as required to change the clearance volume.

Diesel fuel was introduced in various proportions which helped us to know that the engine will not run when 50% fuel is cut off.

By changing the position of auxiliary piston various CR were obtained.

Performance parameters of CR1-2-3-4 were noted like wise.

By changing the position of auxiliary piston various CR were obtained. Performance parameters of CR1-2-3-4 were noted like wise. At present all the connections regarding the biogas input has also been done. A lever mechanism is used to cut off the diesel supply as required. Engine is started with the help of diesel and cut off slowly in order to reduce diesel usage and increase biogas. Biogas is supplied from the Biogas cylinder at 100 bar pressure which is controlled with the help of Lovato kit as required. In the inlet stroke when piston moves from TDC to BDC during air inlet, the air is mixed with the biogas with the help of Air Gas venturi mixer. Water is circulated to cool the engine at a rate of 0.133 Litre/second with the help of motor. Brake power is calculated at different loads for experimental calculations. Temperatures at different important points are noted for analysis purpose.

Fuel consumption, air consumption all these parameters are found at various load to compare the results.

Graphs were plotted that give us direct comparisons of the Engine at various Compression ratios. It was found that at higher CR the engine was vibrating vigorously and higher temperatures were noted.

Power output was better at higher CR and reduced as we started reducing the CR by increasing the Clearance volume.

Equipment used during the experiment

Various equipments were used to monitor the performance of the diesel engine. A gas mixer was used to mix the air and biogas before supplying to the engine as input. Rope brake dynamometer was used to find the power output. Lovato kit was used to reduce the pressure of biogas as required. Tachometer was used to measure the speed of engine in rpm. Temperature indicator was used to find the temperatures at various important points. U-tube manometer was used to find the flow rate of air. A 0.5 HP motor was used to supply the cooling water for engine with a rate of 0.133 m3/sec.

<u>Observation table and Result</u>

- **Observation table for CR 1**

LOAD KG	SPEED RPM	FUEL CONSUMPTION	MANOMETER READING (mm)	WATER FLOW RATE LITRE/SEC
0	1953	5.8	68	0.133
3	1841	5.2	58	0.133
6	1592	4.9	51	0.133
9	1400	5.5	34	0.133

LOAD KG	T1 (◦C)	T2 (◦C)	T3 (◦C)	T4 (◦C)	T5 (◦C)	T6 (◦C)	T7 (◦C)	T8 (◦C)
0	24	24	237	88	25	26	612	243
3	26	28	484	210	23	21	593	612
6	27	29	450	213	25	20	592	598
9	29	30	420	186	25	19	559	559

- **Observation table for CR 2**

LOAD KG	SPEED RPM	FUEL CONSUMPTION	MANOMETER READING (mm)	WATER FLOW RATE LITRE/SEC
0	1898	4.8	62	0.133
3	1760	4.7	55	0.133
6	1624	5.2	48	0.133
9	1276	7	37	0.133

- **Observation table for CR 3**

LOAD KG	SPEED RPM	FUEL CONSUMPTION	MANOMETER READING (mm)	WATER FLOW RATE LITRE/SEC
0	1910	6	62	0.133
3	1750	5.2	57	0.133
6	1633	5	52	0.133
9	1300	6.1	41	0.133

❖ **Observation table for CR 4**

LOAD KG	SPEED RPM	FUEL CONSUMPTION	MANOMETER READING (mm)	WATER FLOW RATE LITRE/SEC
0	1910	5.2	63	0.133
3	1796	5	56	0.133
6	1561	6.1	42	0.133
9	1136	5.9	32	0.133

❖ **Result table for CR 1**

SR NO	Load (kg)	BP (kw)	Mf (kg/sec)x10e-4	Heat Ip (kw)	Ma (kg/hr)	AFR	η_{bth}	BSFC
1	0	0	0.12	6.3	5.3	18	0	0
2	3	1.85	0.41	6.7	4.9	15.2	24.4	0.35
3	6	3.2	0.6	8.2	3.7	13	31.1	0.287
4	9	4.2	1.1	12	3.5	11	36	0.254

❖ **Result table for CR 2**

SR NO	Load (kg)	BP (kw)	Mf (kg/sec)x10e-4	Heat Ip (kw)	Ma (kg/hr)	AFR	η_{bth}	BSFC
1	0	0	0.14	6.9	5.45	16.5	0	0
2	3	1.72	0.49	7.1	5	14.3	22.15	0.42
3	6	2.9	0.65	8.4	3.9	12.2	29.34	0.29
4	9	4	1.3	12.2	3.6	10.2	34.23	0.26

❖ **Result table for CR 3**

SR NO	Load (kg)	BP (kw)	Mf (kg/sec)x10e-4	Heat Ip (kw)	Ma (kg/hr)	AFR	η_{bth}	BSFC
1	0	0	0.15	7.1	5.6	16	0	0
2	3	1.6	0.55	7.3	5.1	14.1	20.4	0.53
3	6	2.75	0.71	8.4	4.2	12.3	27.6	0.33
4	9	3.89	1.5	12.6	3.9	10.2	32.6	0.27

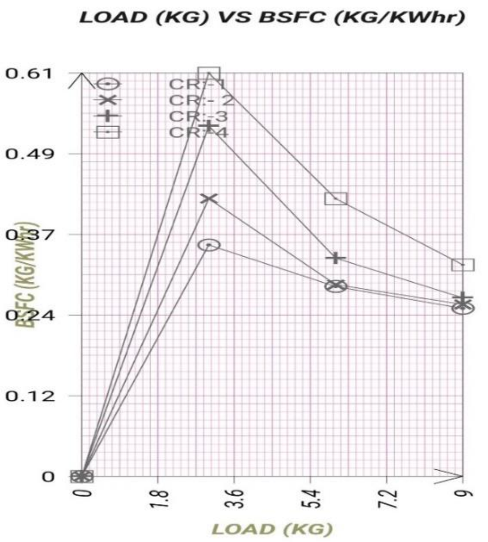
❖ **Result table for Cr 4**

SR NO	Load (kg)	BP (kw)	Mf (kg/sec)x10e-4	Heat Ip (kw)	Ma (kg/hr)	AFR	η_{bth}	BSFC
1	0	0	0.18	7.3	5.8	15.2	0	0
2	3	1.5	0.6	7.6	5.3	14	19.12	0.61
3	6	2.4	0.8	8.8	4.6	11.9	24.2	0.42
4	9	3.2	1.9	12.8	3.9	9.8	30.9	0.32

Graph

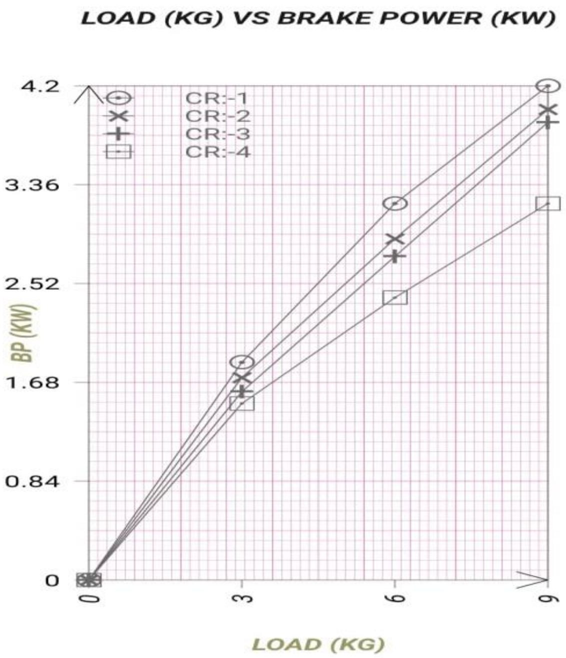
Brake specific fuel consumption (BSFC):

It is the ratio of the mass flow of the fuel or fuel consumption per hour to the power output. As power output increases, BSFC decreases. BSFC found increased after addition of gasket. It has been proved that increased clearance volume leads to increased BSFC.



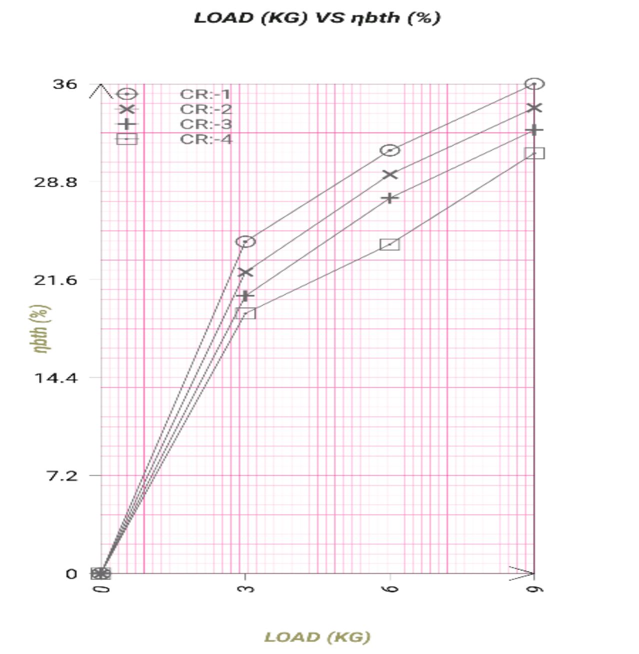
Brake power

As distance between piston and surface of head changed, then brake power first increases up to 78 mm and after that it decreases.



Brake thermal efficiency:

Brake thermal efficiency is the percentage ratio of the output and the input. In this testing, the output is set to a certain load and the input can be calculated based on the amount of fuel used and time taken. With decreasing of input power, the efficiency of the engine increases. The engine efficiency is proportional combustion efficiency. Improving the other factor such as input power, specific fuel consumption will lead to increase in brake thermal efficiency.



CONCLUSION

- From the experiment it is found that brake power does not impacted by variation of clearance volume or VCR.
- After VCR i.e. variable compression ratio, considerable change in the fuel consumption is observed.
- Similar to the fuel consumption, Brake thermal efficiency is found to be increased by 15%.
- Due to change in clearance volume exhaust temperature increased by 40˚C.
- Approximately 15% change in AFR is observed practically at higher speed.
- All engine characteristics i.e. BSFC, brake power, brake thermal efficiency increases up to 78 mm and after that it decreases.

REFERENCES

[1] Design and development of VCR (diesel) by auxiliary mechanism.
a. Dr. Ashish j Chaudhary.
[2] Design and Simulate Mixing of Compressed Natural Gas with Air in a mixing device. K. Kadirgama, M.M.Noor, A.R.N.A. Rahim, R.Devarajan, M.R.M.Rejab, N.M.Zuki N.M.
[3] Mixer Design for A High Performance Biogas SI Engine Converted from A Diesel Engine. Bui Van Ga, Tran Van Nam the University of Danang 41 Le Duan, Danang, Vietnam.
[4] Performance and emission characteristics of biogas used in diesel engine operation Violeta Makareviciene, Egle Sendzikiene, Saugirdas Pukalskas, Alfred's Rimkus, Ricardas Vegneris .

[5] Saket Verma, L.M. Das, S.S. Bhatti, S.C. Kaushik. Centre for Energy Studies, Indian Institute of Technology Delhi, India
[6] Akhilesh Pratap Singh, Anuj Pal, Avinash kumar Agarwal, Indian Research Laboratory, Indian Institute of Technology, Kanpur.
[7] Balu Naik Banoth, Hyderabad, T.S, India.
[8] Mahesh p. Joshi, aparna v. Kulkarni, september-2012," variable compression ratio (VCR) engine", international journal of mechanical Engg. Research and development (IJMERD), ISSN 2228 – 9355, ISSN 2248-9347.