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Performance and Brake Specific Fuel Cost of Constant Speed Diesel Engine for Acetylene As Alternative Fuel

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***Abstract:** Historical growth for development of power to fulfil the demands, together provides a challenge for depletion of fossil fuels. The internal combustion engines have a major share used to develop power. To fulfil the increasing demands, many researchers worked on diesel engine with biodiesel blends derived from edible and non-edible oils as an alternative fuel. Some researcher's experimented gaseous fuels along with diesel also in which diesel will be primary fuel and gaseous fuels like acetylene will be secondary fuel. Increased rates of pollutants again required more focus in modification of engine sub-assemblies. The present study carried out to find the cost effectiveness while the constant speed diesel engine supplied 2 liter per minute flow rate of acetylene at different compression ratios. It realized that the brake specific fuel consumption and required cost to operate the engine, in case of duel fuel mode operation will be less for the compression ratio of 17. It was also noted that for idling or low load the operation of engine will be costly with duel fuel mode of operation and for maximum load the cost of operation will be barely same as the operation on only diesel. The results from performance analysis states that in duel fuel mode of operation by decreasing compression ratio to 17, no change in power out with decreased sound pressure. Also from emission analysis decreased CO_2, HC emission found than only diesel operation.*

***Index Terms**: Alternative fuel, Acetylene, Brake specific fuel consumption cost, Diesel engine, Performance analysis*

I. INTRODUCTION

Internal combustion engines consumes about 80% of total energy in the form of fossil fuels, to fulfil the demand of power [1] [2]. They are more famous because of their portability. As they consume fossil fuel in such huge amount will increase the world's pollution and also as they emit greenhouse gas disturbs the nature's cycle of operation [3] [4]. Thus use of internal combustion engine in large scale provides a big challenge in front of researchers. The research required to develop different alternative fuels for different engines. The developed alternative fuel should run the engines at lower cost without disturbing its overall performance [5] [6].

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Using gaseous fuels as alternatives will help to decrease the chemical delay in combustion process of diesel engines [7] [8]. Acetylene is having good combustion characteristics and we can use it as secondary fuel for diesel engine [9] [10]. Many researchers experimented the different flow rates of acetylene as secondary fuel for diesel engine operation [11] [12]. In this study, we experimented 2 litre per minute flow rate of acetylene for different compression ratio. The study conducted also covered the effect on pollution and sound measurement. The analysis also made for cost of brake specific fuel consumption at low load, medium load and high load application.

II. EXPERIMENTAL PROCEDURE

A. ENGINE SELECTION

In this study, a constant speed diesel engine selected with specification as listed in table 1.

Table No 1- Engine and performance measurement parameters

Engine details	Kirloskar make single cylinder, four stroke, water cooled, constant speed diesel engine
Power output	3.5 kW at 1500 rpm
Bore diameter and stroke length	87.50 mm and 110 mm respectively
Compression ratio	Variable compression ratio from 18 to 12
Orifice diameter and coefficent of discharge	20 mm and 0.6 respectively
Dynamometer arm length	185 mm

The acetylene gas from acetylene tank supplied to engine through Rota-meter and a fire arrester tank. The fire arrester was a vertical tank containing ¾ filled water and placed next to acetylene tank before the gas enters the engine [13] [14]. This arrangement ensures that if back fires comes from engine will be arrest because of presence of water in the arrester tank and will not go towards acetylene tank. It required the safety precautions as acetylene is explosive. The variable compression ratio achieved by changing the clearance volume and we maintained the flow of acetylene from Rota-meter.

In this experimented, we applied the engine different loads from minimum to maximum and for a fix flow of acetylene as 2 litre per minute and changing compression ratio from 18 to 13. The observations carried out, and we analysed the results for performance parameters like power, efficiency, and pollution from exhaust and also sound because of combustion from engine.

B. Experimental set up and instrumentation

Figure 1 shows the experimental setup used to perform the experiment as explained above. The eddy current dynamometer used to apply load and measured with the help of strain gauge. The thermocouples of K type used to measure different temperatures of water and exhaust gas. Piezo sensor used to measure the combustion chamber pressure for respective measured crank degree angle by crank angle position sensor. Fuel flow DP transmitter and air flow pressure transmitter measured the respective fuel flow and air consumption against applied load. Rota meter for water used to measure amount of water in litre per hour flowing to the engine for cooling. Rota meter for acetylene used to measure acetylene gas flow in litre per minute flowing to inlet manifold of engine. AVL Di gas analyser used to measure percentage CO, CO_2, HC and NOx in exhaust gas. FFT analyser with sound pressure measurement attachment used to measure the sound pressure generated due to combustion.

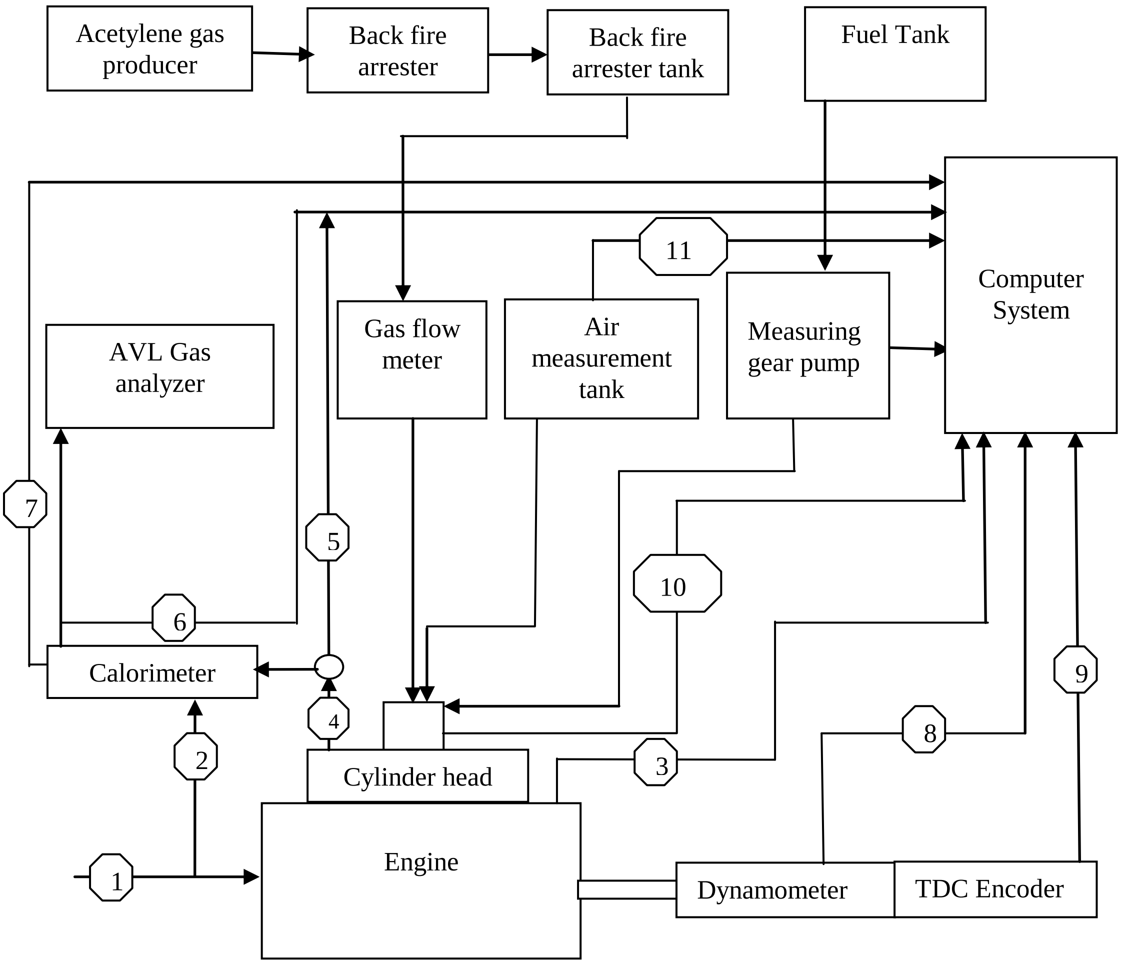


Fig.1 Experimental Setup

Process No	Process	Parameter	Process No	Process	Parameter
1	Cooling water in to engine	T1	7	Calorimeter water out	T5
2	Cooling water in to calorimeter	T1	8	Load cell	F
3	Engine water out	T2	9	TDC Encoder	Position
4	Exhaust gas in to calorimeter	T3	10	Pressure Sensor	P
5	Exhaust gas out from engine	T3	11	Air measurement	mmwc
6	Exhaust gas out to calorimeter	T4			

III. RESULTS AND DISCUSSION

Figure 2 represent the brake power Vs Load graphical representation. We observed it that the brake power increases as load increases and about the 6% increase of brake power found when the engine operated on duel fuel mode. The maximum brake power found when the compression ratio reduced to 14. Thus for same engine by reducing the compression ratio the output power found increased in duel fuel mode operation.

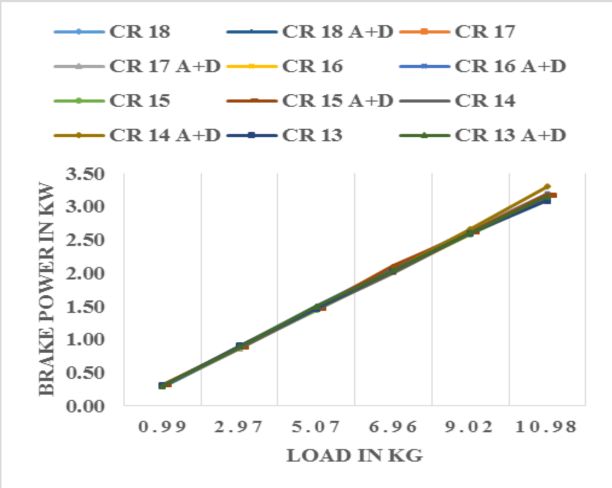


Fig.2 Brake Power Vs Load

Figure 3 (a) and (b) shows the graphical representation of Mechanical efficiency and Brake thermal efficiency Vs load. We found it that the mechanical efficiency increased for decreased compression ratio of 17, 16, 15, 14 and 13 in duel fuel mode operation. A maximum increased mechanical efficiency found with the compression ratio of 16. Brake thermal efficiency found nearly same in all decreased compression ratio and found the maximum for the compression ratio of 14. Same or increased brake thermal efficiency with increased mechanical efficiency represents the less frictional loss in duel fuel mode of operation.

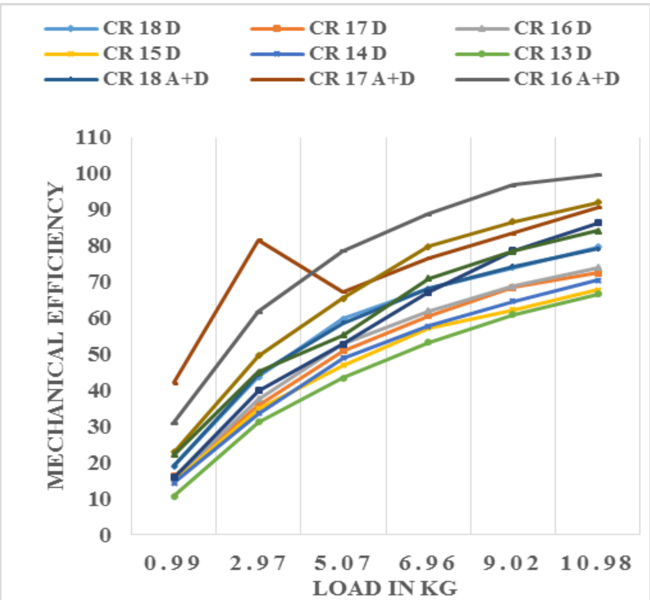


Fig.3 (a) Mechanical Efficiency Vs Load

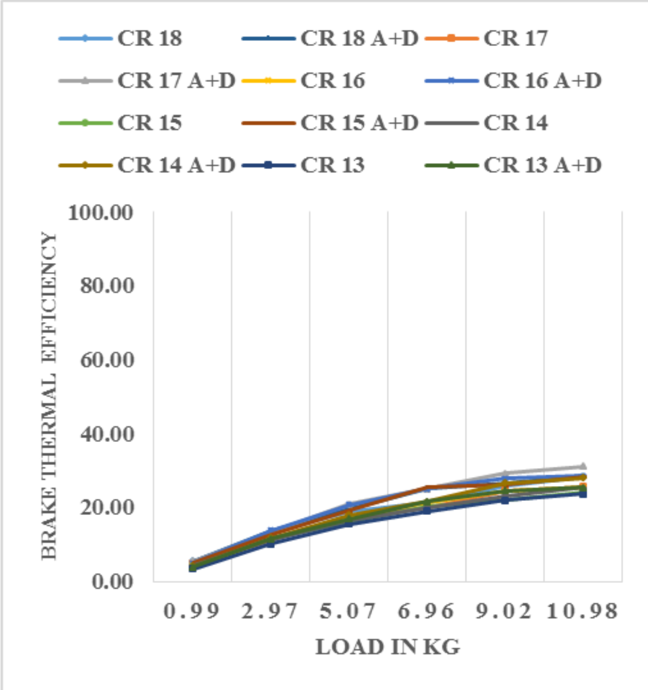


Fig.3 (b) Brake Thermal Efficiency Vs Load

Figure 4 represents the graphical analysis of brake specific fuel consumption (BSFC) cost with load for different compression ratios. We found it that with low load conditions the BSFC cost increased for duel fuel operation. With high load operations the cost decreased but with today available fuel cost still the duel fuel operation will require more cost to operate the engine. In future as the diesel cost increases the cost of duel fuel mode will be suitable as an alternative fuel for diesel engines to develop the power.

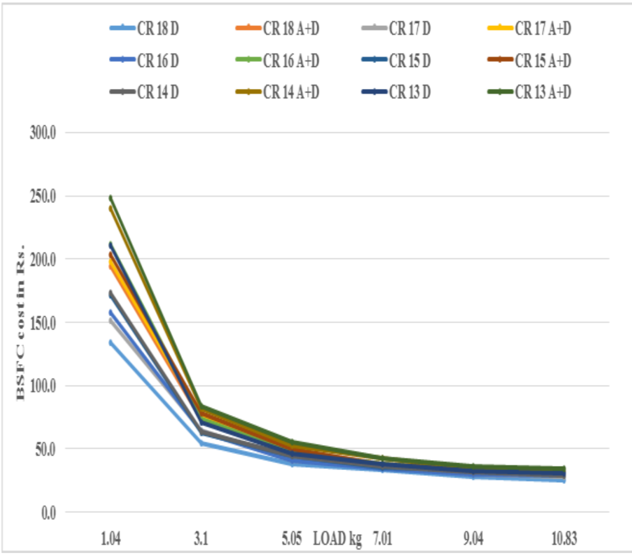


Fig. 4 Brake Specific fuel consumption cost Vs Load

Figure 5 (a-f) represents the exhaust gas temperature measured against the load. We observed it that for compression ratio of 18 and 14 the exhaust gas temperature increased in duel fuel mode operation and for other compression ratio it was nearly same or decreased than normal diesel fuel operation.

This shows that the decreased exhaust gas temperature means the charge inside the combustion chamber was incomplete burned and this leads to increase either CO, CO_2 or HC emission.

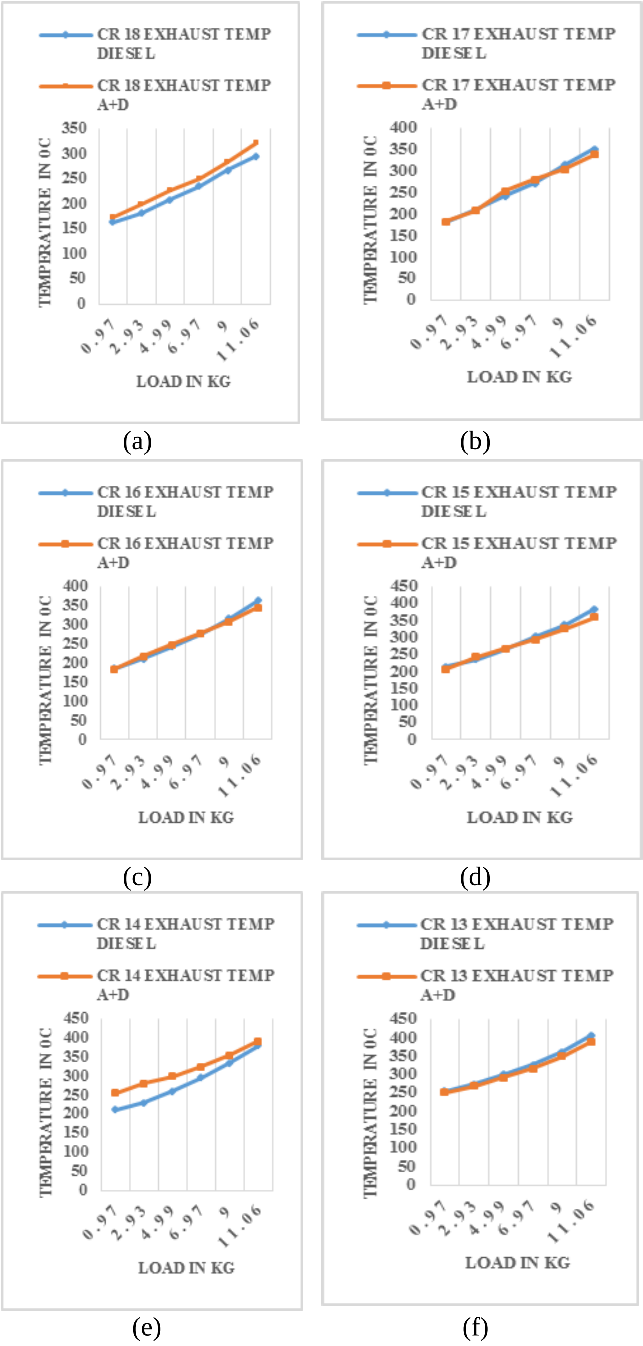


Fig. 5 (a-f) Exhaust gas temperature Vs Load

Figure 6 (a-e) represents the sound pressure measurement against the load. The study carried out to understand the effect of acetylene on delay period. We observed it that for low loads during duel fuel mode operation the delay period increased resulting in increased sound of combustion. Again for full load operation the delay period decreased resulting in decreased sound pressure. As the flow is constant for acetylene as 2 litre per minute with all load conditions, the charge inside the combustion chamber becomes cool in case of low loading. This will increases the delay period resulting in increased sound pressure during combustion.

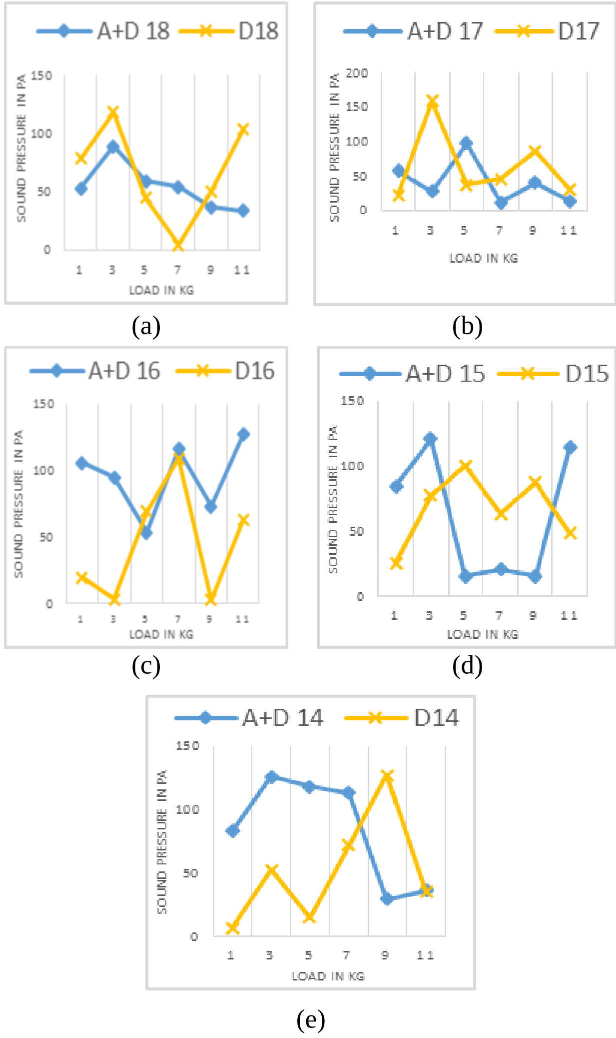
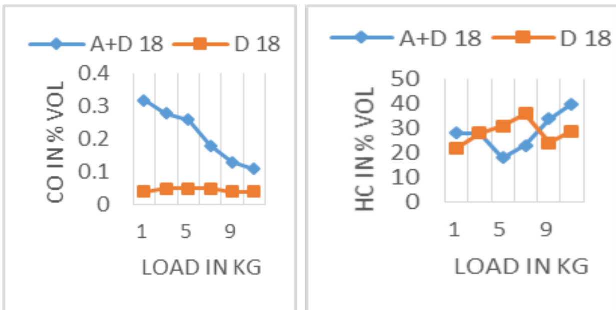


Fig. 6 (a-e) Sound Pressure Vs Load

Figure 7 shows the valid results as stated with figure 5, that for compression ratio of 18 and 14 emission of CO, CO_2 and HC were close or decreased in duel fuel mode and increased for other compression ratios. This represents complete combustion in duel fuel mode operation for compression ratio of 18 and 14.



Also, the NOx emission which will again validate the increased delay period or cool charge inside the combustion process for remaining compression ratios. The increased NOx will again represent the less availability of oxygen inside the combustion chamber while combustion process start.

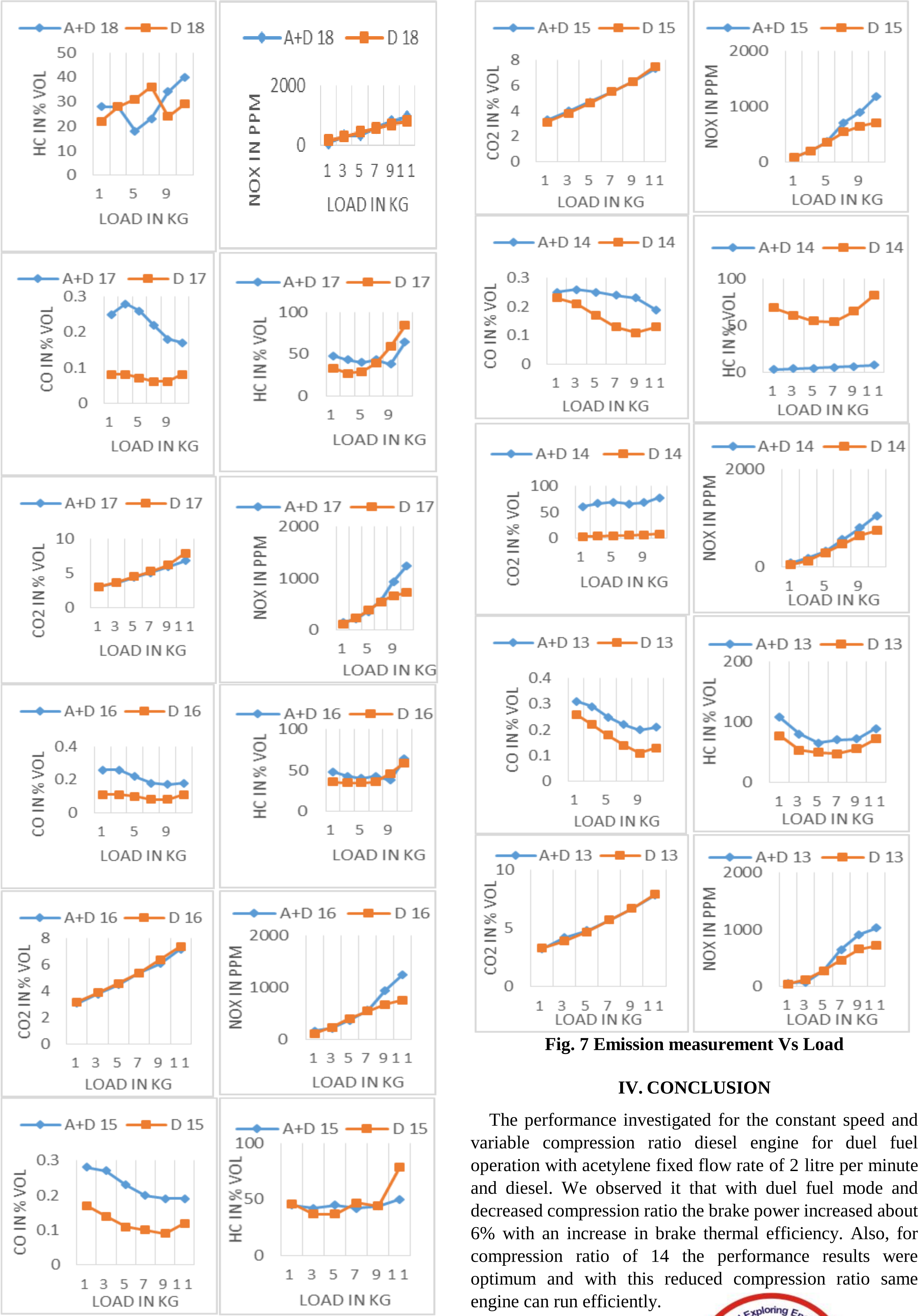


Fig. 7 Emission measurement Vs Load

IV. CONCLUSION

The performance investigated for the constant speed and variable compression ratio diesel engine for duel fuel operation with acetylene fixed flow rate of 2 litre per minute and diesel. We observed it that with duel fuel mode and decreased compression ratio the brake power increased about 6% with an increase in brake thermal efficiency. Also, for compression ratio of 14 the performance results were optimum and with this reduced compression ratio same engine can run efficiently.

The brake specific fuel consumption cost found more with low load conditions and nearly same as like diesel for full-load conditions.

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