EFFECTS OF OXYGENATED ADDITIVE DIETHYL ETHER ON PERFORMANCE PARAMETERS OF VCR ENGINE FUELLED WITH DIESEL-COTTONSEED OIL METHYL ESTER BLEND AT THREE COMPRESSION RATIOS (16-18)

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Abstract: Global Energy Consumption or World Energy Consumption is increasing significantly over the last years. Persistent use energy sources and rapid advance of technology strides towards degradation of natural habitat and infiltrates the living quality of human beings, need of the hour is to look for suitable alternative fuels. Biodiesel has a great potential to completely replace conventional diesel. Biodiesel has a neat and clean combustion, higher cetane number, no aromatics, no sulphur and contains enough oxygen (10-11% by weight). The abundance of cottonseed oil in India has inclined the present research to be on cottonseed oil biodiesel using diethyl ether as an additive to improve the performance of variable compression ratio diesel engine. Addition of DEE to cottonseed oil biodiesel increases the Brake Thermal Efficiency and reduces the Brake Specific Fuel Consumption of an engine at all the compression ratios(i.e16-18).

***IndexTerms*: - Biodiesel, Cottonseed Oil Biodiesel, Additive, Diethyl Ether, Brake Thermal Efficiency, Brake Specific Fuel Consumption.**

I. INTRODUCTION

Total energy used by the entire human civilization known as Global Energy Consumption or World Energy Consumption is increasing significantly over the last years. Persistent use energy sources and rapid advance of technology strides towards degradation of natural habitat and infiltrates the living quality of human beings [1]. Rapid growth of population and use of fossil fuels have posed two major threats to the civilization i.e. increasing degradation of the environment and scarcity of resources (Fossil fuels). The U.S Energy Information Administration (EIA) has projected that global energy consumption will grow 44% by 2030 due to vigorous economic growth and increasing populations in the world's developing countries [2].

Consumption of limited energy resources and their negative impacts on the environment has led to the significant interest in alternative energy sources. Industries and vehicles heavily depend on conventional fossil fuels which are available in limited quantities and are expected to be close to depletion in the near future. Moreover the consumption of fossil fuels has increased the emission of greenhouse gasses and pollutants. Increased fuel prices, environmental pollution and extinction of fossil fuels have led to the significant increase in research and development in the field of environmentally acceptable alternative fuels [3].

Biodiesel has a great potential to completely replace conventional diesel. Biodiesel has a neat and clean combustion, higher cetane number, no aromatics, no sulphur and contains enough oxygen (10-11% by weight). The efficiency and consumption of biodiesel is comparatively more than diesel. But the neat combustion and renewability of biodiesel inclined the researchers to commercially adopt biodiesel as regular fuel to replace conventional diesel fuel. Biodiesel can be used directly with slight or no alteration in the diesel engine. Biodiesel can be used directly or in blends with diesel like B10, B20, B30, etc. the designation indicates the percentage of it in the blend. The use of biodiesel significantly reduces the amount of harmful emissions like carbon monoxide (CO), hydrocarbon (HC), greenhouse gasses (CO2) and particulate matter (PM). Biodiesel being produced domestically is cost effective. The production process of biodiesel is simple and doesn't involve any complex process [3]. The use of biodiesel will significantly reduce the demand of petroleum and hence the petroleum prices.

The abundance of cottonseed oil has inclined the present research to be on cottonseed oil biodiesel. Cotton seed oil is extracted from the seeds of cotton seeds after the removal of cotton lint. Besides the rare usage of cottonseed oil as edible oil it is widely used in industries like soap and glycol lubricants. Due to the abundance cottonseed oil is available at lower prices. The higher cetance number, calorific value, good oxygen content also favors the cottonseed oil to be used as an alternative. Pure cottonseed oil can be used in diesel engines as a replacement, but its higher viscosity has various disadvantages like chocking of nozzles and pumps, higher carbon deposits, lower calorific value etc which limit the use of pure cottonseed oil as a fuel [3]. Cottonseed oil biodiesel also known as Cottonseed oil methyl ester is a potential replacement of conventional diesel. The problems of pure cottonseed oil can be remedied by transesterification. Cottonseed oil when transesterified with alcohol (methanol) is converted into biodiesel that can be used straight B100 or in blends with some percentage of biodiesel added to diesel (B05, B10, B15, B20, etc). Cottonseed oil methyl ester has lower viscosity, reduced emissions, better BTE & BSFC than pure cottonseed oil. In present research work cottonseed oil methyl ester blend B20 is used as it is found to be an optimum fuel out of other blends of cottonseed oil.

The efficiency of cottonseed oil biodiesel is lower and specific consumption is higher as compared to diesel fuel, in order to get a comparable efficiency of biodiesel some chemicals known as additives are added to improve stability of fuel, viscosity index, flash point, ignition and so forth and reduce wear and ruinous emissions. Additives that are used to improve the combustion properties such as cetane number, to reduce carbon deposit formation, to avoid contamination of fuel and clogging of filters by rust are known as flame additives [4]. Additives intended to reduce harsh effects after combustion of fuel like minimization of carbon deposits in the engine, smoke and emissions are known as post flame additives. Biodiesel is the most widely used alternative fuel.

Its natural friendly and renewable characteristics have increased its significance as an alternative to conventional diesel fuel. One of the chemical used as an additive is diethyl ether, it is an organic compound sometimes in the ether class with the chemical formula (C2H5)2O. DEE at an ambient condition is a colourless liquid with highly volatile and flammable nature. It is produced as a by-product of the vapour phase hydration of ethylene. Diethyl ether has a high cetane number of 85-96 and is used as a starting fluid, in combination with petroleum distillates for gasoline and diesel engines, due to its high volatility and low flash point [5].

The extraordinary cetane number, higher oxygen content, reasonable energy density, low auto ignition temperature and high volatility favors DEE as an additive. It belongs to the oxygenated group of fuel additives. DEE is used as an additive to improve properties like cetane number, viscosity, fire and flash point, cloud and pour point and heating value.

II. Material and methods

The current research is done on the cottonseed oil biodiesel, cottonseed oil was procured from local market of Bikaner (Rajasthan) which was later on transesterified to cottonseed oil biodiesel. KOH was used as a catalyst 10% by weight during the process of transesterification. Magnetic stirrer was used for the process of transesterification. B20 blend of cottonseed oil biodiesel and diesel was used for the experimental investigation with variable percentage 2% and 4% of diethyl ether as additive. Fuel samples used during the investigation are:

- B20 : 20% Cottonseed oil biodiesel + 80% Diesel
- B20+2% : 20% Cottonseed oil biodiesel + 80% Diesel with 2% diethyl ether as additive
- B20+4% : 20% Cottonseed oil biodiesel + 80% Diesel with 4% diethyl ether as additive

III. Experimental setup

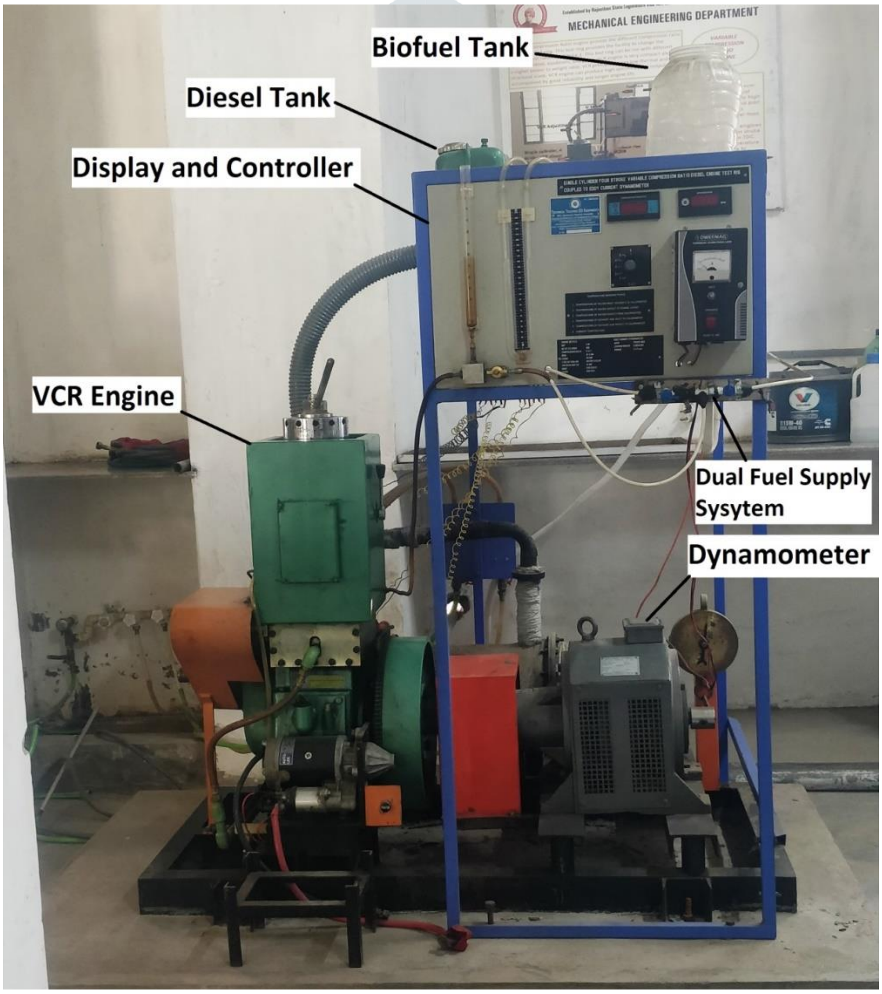

Figure 1: Experimental Setup

Single cylinder, 4-stroke, water cooled, variable compression ration diesel engine test rig coupled with eddy current dynamometer was used to carry out the experiments. The engine selected has a provision to adjust its compression ratio by lowering or raising the engine head by rotating the lever. A scale is provided in front of the engine head to indicate the compression ratio. Test rig is provided with the dual fuel supply system that allows the engine to switch between the two fuels diesel and biodiesel without turning off the engine. The specification of the engine is provided in the Table 1.

Table 1: Engine Specification

S. No	Features	Specification
1	Manufacturer	Kirloskar Diesel Engine
2	Type	4 Stroke, Variable Compression Ratio, Multi Fuel Water Cooled Diesel Engine
3	No of cylinders	Single Cylinder
4	Maximum speed	1500 rpm
5	Compression ratio	14 to 18
6	Loading	Eddy Current Dynamometer
7	Load (max)	23.86N-M
8	Maximum power	3.75Kw
9	Bore & Stroke	80mm & 110mm
11	Temperature sensor	Type K nickel chromium based thermocouples
12	Load sensor	Strain gauge load cell

IV. RESULTS AND DISCUSSIONS

The experimental investigation are carried out by using B20 blend with 2% and 4% diethyl ether as additive. In the current investigation cottonseed oil biodiesel B20 blend with 2% and 4% is tested over varying loads for compression ratios 16-18 and the observations are compared with that of diesel fuel. The detailed analysis of the engine performances are discussed in this section.

a. Brake Thermal Efficiency

Brake thermal efficiency is the power generated by the engine with respect to input supplied in form of heat generated. Increasing the compression ratio generally increases the thermal efficiency as heat losses are reduced at higher compression ratios. Increasing the load also increases BTE for test fuels, maximum value of BTE for each compression ration can is obtained at 75% of full load. This is because at full load there is more power losses due friction and higher engine temperature. BTE was found to be least for B20 due to its lower heating value and higher viscosity but with addition of oxygenated additive (diethyl ether) BTE increases. As the percentage of additive increases in the blend, the available oxygen increases which improves the thermal efficiency.

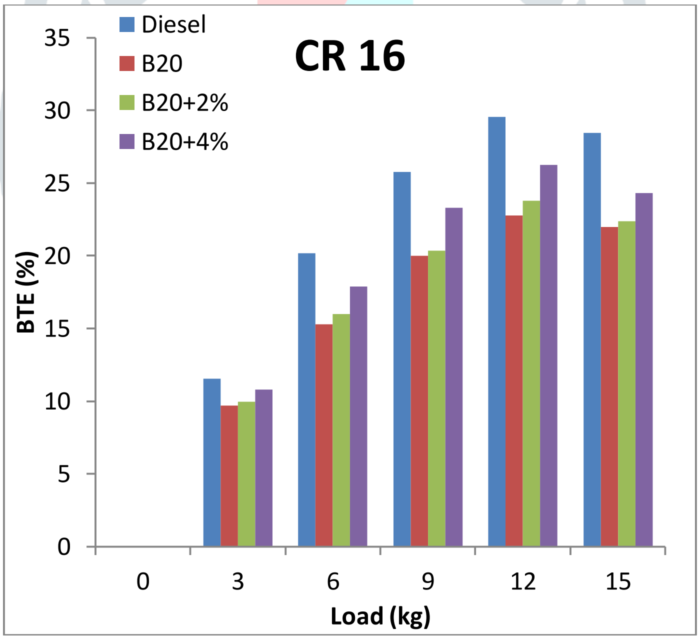

Figure 2: Load vs BTE at Compression Ratio 16

Figure 2 a graph between BTE and load at CR 16 shows the variation of BTE under varying load conditions. It is observed from the graph that BTE is maximum 29.56% for diesel and least 22.78% for B20. BTE increases with the addition of diethyl ether additive as BTE is greater for B20+2% and B20+4% fuel samples. It may be because of the increasing oxygen content in the cottonseed oil biodiesel fuel which eases the process of combustion hence increases thermal efficiency. It is also observed that BTE for every fuel sample increases with increase in load and is maximum at 75% of full load i.e. 12kg.

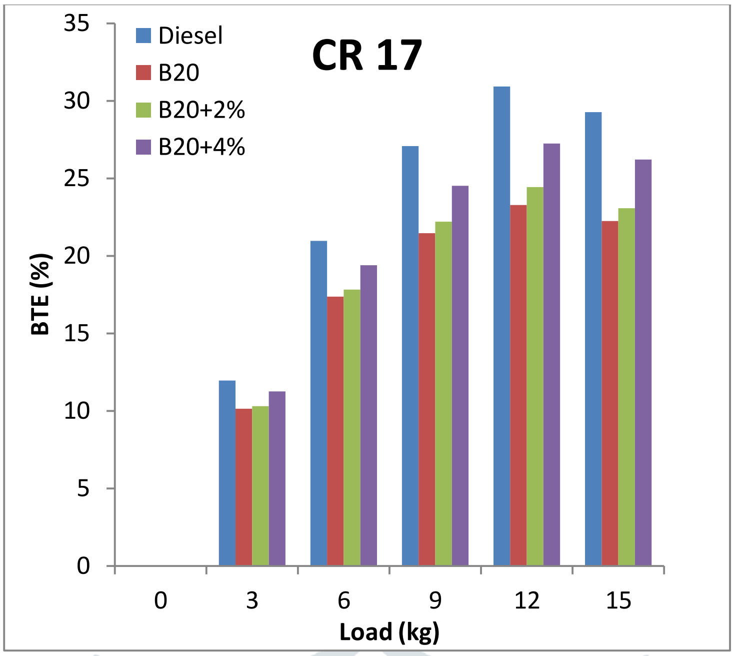

Figure 3: Load vs BTE at Compression Ratio 17

Figure Load vs BTE at Compression Ratio 17 Figure 3 shows the variation of BTE under varying loads at compression ratio 17. The maximum value of BTE 30.90% can again be seen for diesel with 23.27%, 24.41% and 27.24% for B20, B20+2%, and B20+4% respectively. As discussed above, the maximum values for all test fuels are observed at 75% of full load. It is evident from the graph that BTE of B20 cottonseed oil blend increases with increase in diethyl ether additive percentage as BTE of fuel sample B20+2% and B20+4% is higher than B20.

Figure 4 shows the variation of BTE under varying loads for all test fuels at compression ratio 18. It can be seen from the graph that diesel among all the other test fuels is standing tall with maximum efficiency and B20 with minimum thermal efficiency. The maximum values of efficiencies are 31.11%, 23.99%, 25.18% and 28.16% for diesel, B20, B20+2% and B20+4% respectively.

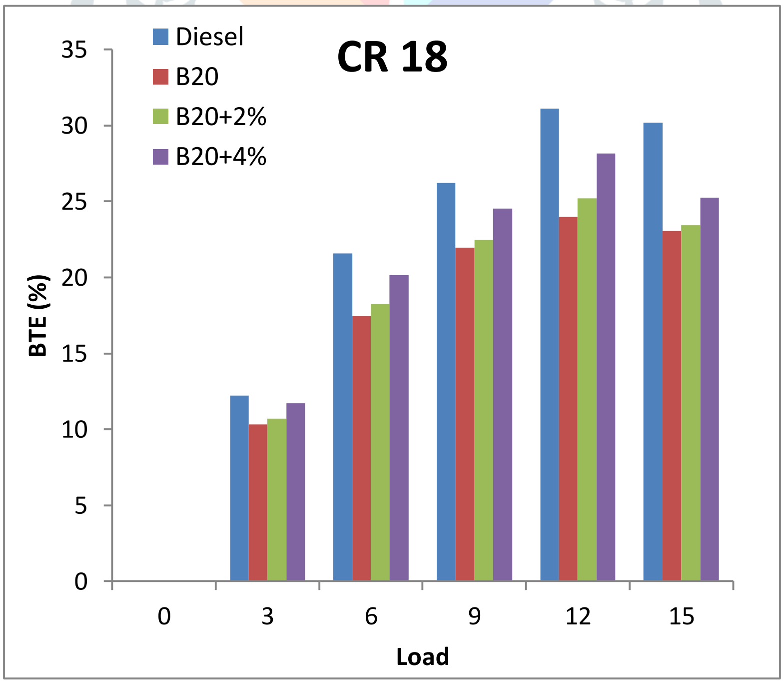

Figure 4: Load vs BTE at compression ratio 18

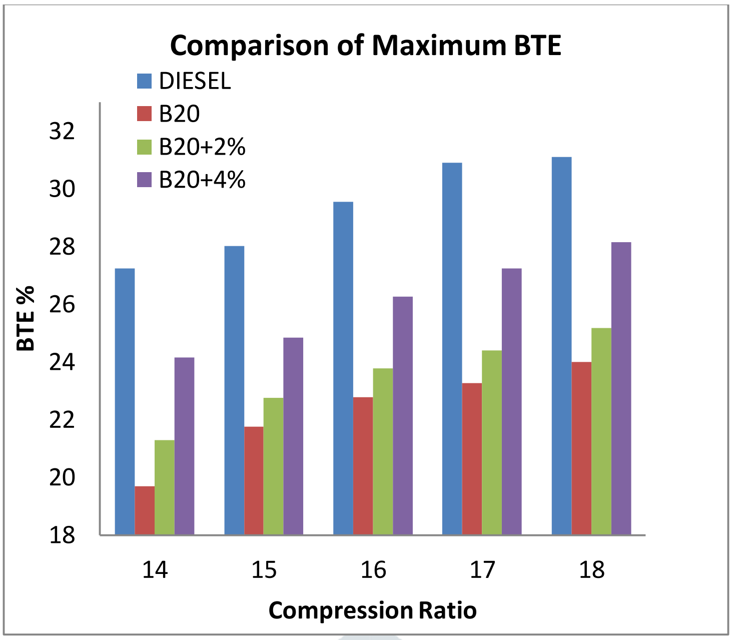

Figure 5: Comparison on maximum BTE

Figure 5 shows the variation of maximum BTE obtained at all compression ratios for all the test fuels used. It is found that for all the compression ratios maximum efficiency is at 75% i.e. 12 kg of full load condition. It can be seen that diesel dominated all other test fuels and stands out with maximum efficiency while B20 blend test fuel being the least efficient at all the compression ratios. With the addition of oxygenated additive (diethyl ether) BTE of B20 blend improves. This may be due to sufficient availability of oxygen required for efficient combustion which results in higher power output. Further the graph also shows that the thermal efficiency increases with increasing the compression ratio of the engine as at higher compression ratios heat losses are reduced and power generated is higher.

b. Brake Specific Fuel Consumption

Brake-specific fuel consumption (BSFC) also known as power specific fuel consumption is the fuel efficiency of an engine. It is the ratio of fuel intake or consumption to power output or produced. From the experimental investigation it was observed that fuel consumption of diesel fuel is lesser as compared to other fuel samples over all the compression ratios. The fuel consumption of B20 fuel sample was seen higher among all the other fuel samples as the heating value of B20 blend is lesser than diesel hence more B20 blend is required to get the same output hence more fuel is consumed than diesel. It was observed that BSFC improves by the addition of diethyl additive in the B20 blend as the fuel becomes oxygen rich with the addition of oxygenated additives. BSFC decreases with increase in load the reason for the this reduction is that BSFC being the ratio of fuel intake to power output, the proportion of power output increased with increase in load applied is higher than increase in fuel intake.

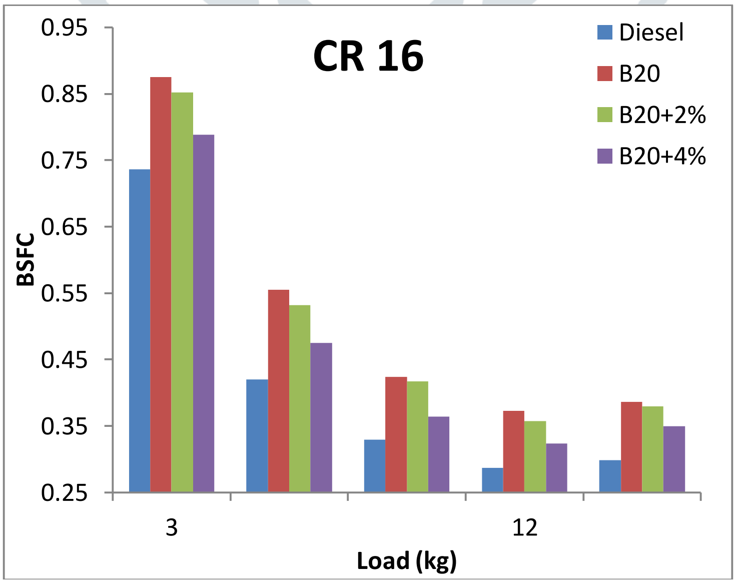

Figure 6: BSFC vs Load at compression ratio 16

Figure 6 shows how BSFC varies upon changing the applied load at compression ratio 16. The minimum BSFC 0.30 kg/kJ is for diesel at all the loading conditions. The minimum value of BSFC for all the fuel samples is seen at 75% of full load i.e. 12 kg load. The minimum values of BSFC at compression ratio 16 are 0.30 kg/kJ.h for diesel, 0.39 kg/kJ.h for B20, 0.37 kg/kJ.h for B20+2% and 0.34 kg/kJ.h for B20+4%.BSFC can be observed to decrease by the addition of diethyl ether additive to B20 blend of cottonseed oil biodiesel as discussed earlier.

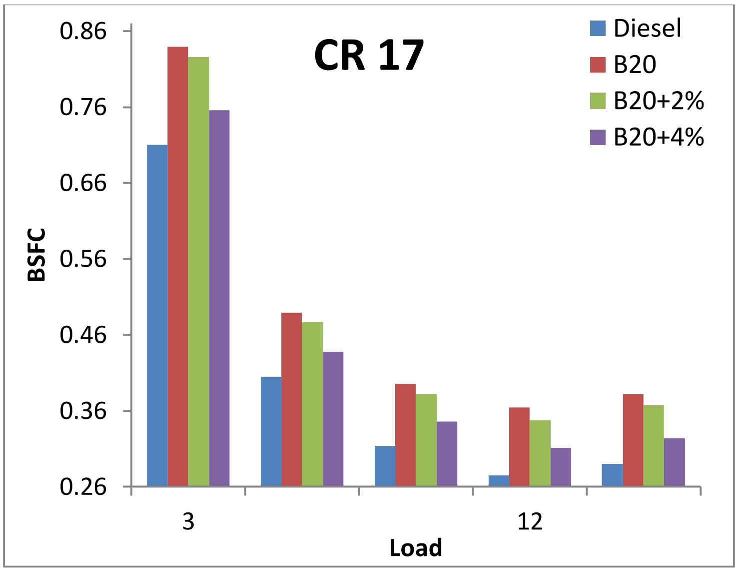

Figure 7: BSFC vs Load at compression ratio 17

Figure 7 shows the variation of BSFC with varying load conditions at compression ratio 17. It is observed that BSFC decreases with increasing the load and it also decreases with the addition of DEE in B20 blend. BSFC of Diesel is observed to be minimum and highest for B20 among tested fuel sample.

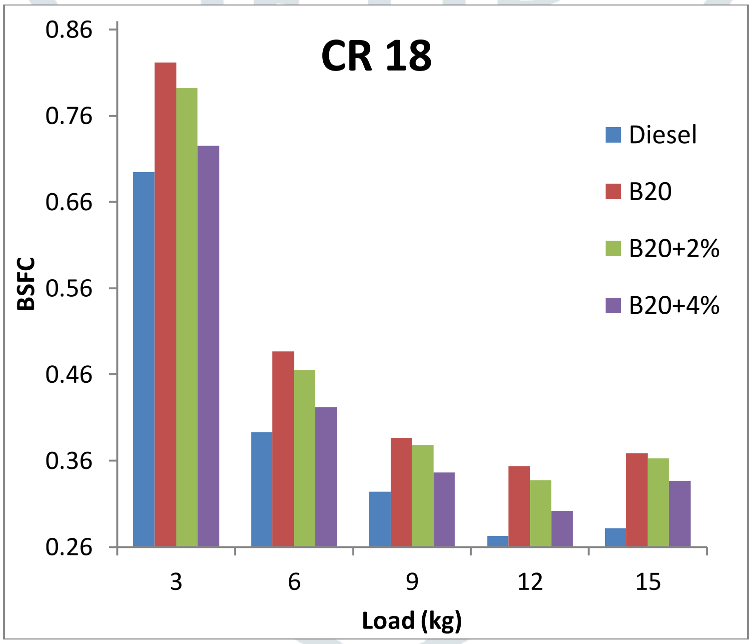

Figure 8: BSFC vs Load at compression ratio 18

Figure 4.11 shows variation of BSFC at compression ratio 18 under varying load conditions. BSFC can be seen decreasing with increase in load applied for all the test fuels used. BSFC can be seen minimum for diesel at all the applied loads. The minimum values of BSFC are 0.27 kj/kg.h, 0.31 kj/kg.h, 0.28 kj/kg.h and 0.28 kj/kg.h for diesel, B20, B20+2% and B20+4% respectively. It is evident from the graph that BSFC improves by the addition of DEE as BSFC values for B20+2% and B20+4% are higher than BSFC values for B20.

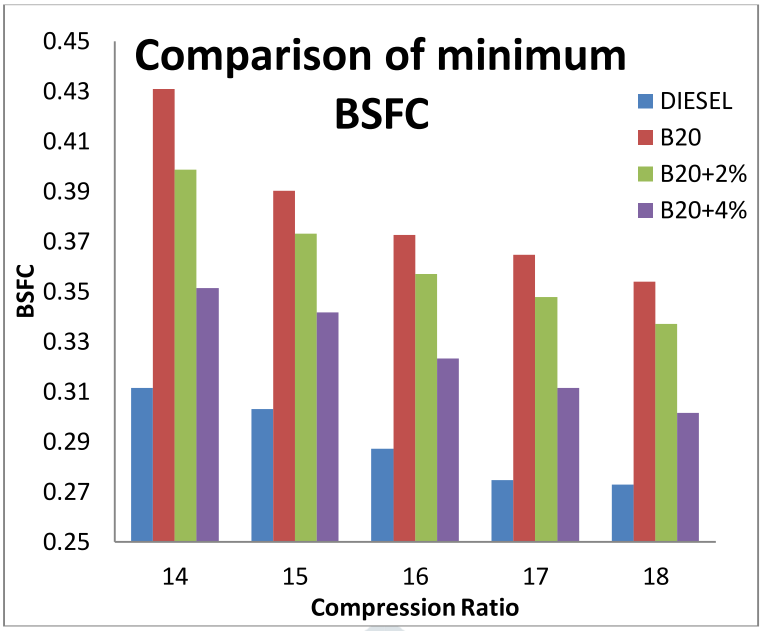

Figure 9: BSFC vs Compression ratio at 12kg load

Figure 4.12 shows the variation between the BSFC at various compression ratios at 12kg load on engine. The graph shows that for the test fuels BSFC decreases with increase in compression ratio. It is observed from the graph that diesel have the lowest BSFC among all other test samples used. Increasing the additive diethyl ether content in the biodiesel improves the fuel consumption of cottonseed biodiesel blend. This may be due to the reason that increasing the additive increases the oxygen content in the fuel which assists the efficient combustion of fuel and higher power generation hence decreases the BSFC.

V. CONCLUSION

i. Cottonseed oil biodiesel has a great potential to replace conventional diesel fuel.
ii. Addition of diethyl ether as an additive to cottonseed oil biodiesel improves BTE and BSFC of cottonseed oil biodiesel.
iii. BTE increases with increasing the diethyl ether content in B20 CSOME.
iv. BTE increases with increase in compression ratio (16-18) and is maximum for compression ratio 18.
v. BSFC decreases with decreasing the diethyl ether content in B20 CSOME.
vi. BSFC decreases with decrease in compression ratio and in minimum at compression ratio 18.

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