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ENHANCING PERFORMANCE OF VCR DIESEL ENGINE USING ADDITIVE DEE IN COTTONSEED METHYL ESTER DIESEL BLEND

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Abstract: The issue of inflation of petroleum products and exploitation of the petroleum reserves which are already at the extreme of getting abolished. Also, the Environmental concerns and fuel availability are significantly influencing fuel trends for transportation vehicles. Renewable fuels like biodiesel are ahead of other technologies to meet increasing energy demands. Additives are also used to improve ignition and combustion efficiency and elevate the engine performance. In the current study, it is attempted to optimize the brake thermal efficiency (BTE) and reduce the brake specific fuel consumption (BSFC) of cottonseed oil methyl ester by introduction of diethyl ether as an additive. In this investigation blend B20 is optimized for performance parameters by varying the percentage of diethyl ether additive as 4%, 5%, & 6% at different compression ratios i.e. 16 to 18. The BTE increased and BSFC decreased with the addition of diethyl ether in B20 blend for all the compression ratios 16-18. The highest BTE and and lowest BSFC were observed for B20+6% at compression ratio 18.

Keywords- brake thermal efficiency, brake specific fuel consumption, biodiesel, compression ratio

I. INTRODUCTION

India is emerging economically around the globe. The development objectives are focused on equity, human well-being and economic growth. The major and critical input to the social economic development is energy. The world mainly aims the energy policy such as security, efficiency, and accomplishment of a most favorable blend of primary resources for energy production and to afford access which being environment friendly[1]. Environmental degradation is a great threat to the modern society posed by the indefinite civilization. The industrialization had a great curse to our surroundings. The growing number of vehicles on the roads on one side is the indication of modernization but at the same time there is a great danger of environmental degradation[2]. The emission of vehicles contains harmful products that affects directly or indirectly to the human beings. The emission of vehicles contains greenhouse gasses, harmful pollutants like nitrogen oxides, sulphur oxides, carbon monoxide, soot etc. [3]. One of the major causes of global warming is the greenhouse gasses emission of automobiles [4] [5]. Particulate matter, carbon monoxide and hydrocarbons affect human health directly by causing fatal diseases [6].

Transportation sector consumes energy for shipping of goods and services from one place to another. The transportation sector mainly depends on crude oil. The crude oil products like diesel, petrol, liquefied petroleum gas etc. are used to propel vehicles. Transportation sector energy consumption is increasing at a rapid pace over the last decade mainly in developing countries. The main carriers of transportation sector are diesel and petrol (diesel being the major component used in heavy engines). The increasing number of vehicles in developing countries increases the demand of crude oil; this not only increases the price of fuel but also has some harsh effects on the environment[7]. There are three main disadvantages of using conventional fuels:

i. Scarcity of fossil fuels
ii. Environmental Pollution
iii. Increasing prices of petroleum products

Non-edible vegetable oils were the first alternative fuels used instead of diesel fuel. The easy availability, renewability, liquidity and lower aromatic & sulphur content, which reduce the harmful emission upon combustion, are the merits of vegetable oils over diesel fuel [8]. However, there are various disadvantages associated with vegetable oils some of them are associated with fuel properties like higher viscosity, and lower volatility and others are the impacts on the engine like choking of injectors and nozzles, higher carbon deposits, sticking of oil ring, gelatination and consolidation of the engine lubricant oil [9].

Table 1: Properties of Diethyl Ether [12]

S No	Property	
1	Chemical Formula	$C_4H_{10}O$
2	Molecular Weight	74
3	Density at NTP (kg/L)	0.710
4	Viscosity at NTP (cP)	0.23
5	Oxygen content (w%)	21
6	Boiling Temperature (°C)	34.6
7	Self-ignition Temperature (°C)	160
8	Flammability limit in air (°C)	1.9-9.5
9	Stoichiometric air-fuel ratio	11.1
10	Cetane number	125

RESEARCH GAP

From the above literature review and comparison of different researches have been carried out on various alternative fuels, their blends and their production methods. It is observed from the comparison of various researches that optimisation of Cottonseed oil biodiesel blend with diethyl ether as an additive at different compression ratios has a considerable scope.

The objectives of current research work are:

i. Production of cottonseed oil biodiesel from cottonseed oil by transesterification process.

ii. Optimization of performance of cottonseed oil methyl ester-diesel blend with diethyl ether as an additive at two compression ratios.

II. MATERIALS AND METHODS

This chapter deals with materials and methods including cottonseed oil transesterfication and the performance analysis of cottonseed oil methyl ester biodiesel. Cottonseed oil was brought from the local market of Jaipur and the chemicals methanol and additive diethyl ether was brought from RS Enterprises Jaipur.

Fuel Samples Used

The fuel used during the experimental procedure is cottonseed oil methyl ester (CSOME) blended with diesel in proportion of 80% Diesel and 20% CSOME known as B20 blend. The amount of diethyl ether additive percentage is varied to find the optimized value of additive percentage for engine performance parameters.

Fuel samples:

- **B20:** The fuel sample B20 is composed of 80% Diesel and 20% Cottonseed Oil Biodiesel.
- **B20+4%:** 80% Diesel + 20% CSOME+ 4% DEE.
- **B20+5%:** 80% Diesel + 20% CSOME+ 5% DEE.
- **B20+6%:** 80% Diesel + 20% CSOME+ 6% DEE.

III. EXPERIMENTAL SETUP

The experimental setup used to perform and compute the experiments was consists of a liquid-cooled, single-cylinder, 4-stroke, multi-fuel, VCR engine having eddy current dynamometer for varying test load.

Table 2: Engine Specification

S. No	Features	Specification
1	Engine	4-Stroke, VCR, DI, Compression Ignition Engine.
2	No. of cylinders	1
3	Maximum rotational speed	1500 revolution per minute.
4	C.R.	Can vary 14 to 18
5	Loading	Eddy Current Dynamometer
6	Load (max)	23.86N-M
7	Maximum power	3.75Kw
8	Bore & Stroke	80mm & 110mm
9	Sensor	Type K Ni-Cr based thermocouple
10	Load sensor	Strain gauge load cell

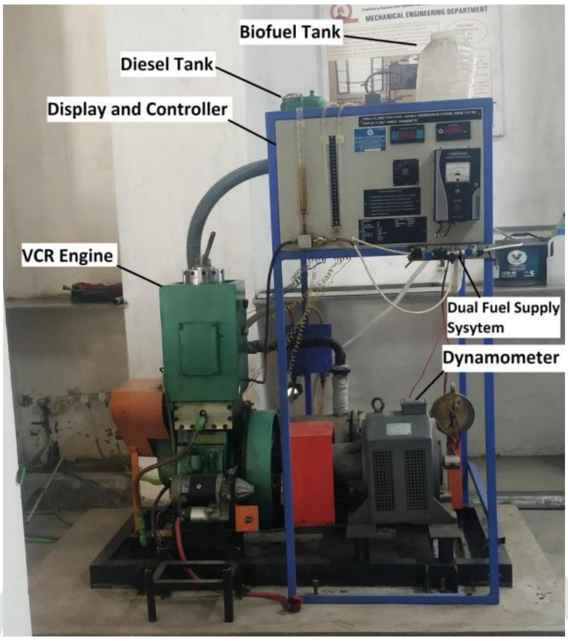

Figure 1: Experimental Setup

The experimental setup consists of:

i. VCR Engine
ii. Dynamometer (Eddy Current)
iii. Thermocouples or Sensors
iv. Data Display and Controller
v. Dual fuel supply system

III. RESULTS AND DISCUSSION

Experimental studies are performed using a four-stroke, VCR, multi-fuel, water-cooled diesel engine running on a cottonseed biodiesel blend with diethyl ether as additives. Changes in parameters were observed and computed and are discussed.

1. Brake Thermal Efficiency

Brake thermal efficiency is the ratio of output to the heat supplied to the engine. In this investigation brake thermal efficiency is monitored over a range of CR (16-18). For all test fuels BTE increases with increase in compression ratio as heat losses due to friction are reduced at higher CR and hence increasing the power output [10]. BTE also rises with the increase of test loads for all test fuels; the maximum value of BTE is obtained at 75% of full load for each compression ratio. This is because of higher frictional losses at maximum load. The BTE of diesel is higher among all the test fuels due to its high heating value, higher volatility and lower viscosity than the other. The lowest value of BTE was found at B20, due to high viscosity and low heating value among all test fuels. The DEE is an oxygenated additive, its presence increases available oxygen for combustion in the mixture which improves the thermal efficiency. It is also observed that for all test fuels the BTE first increases with increase of additive in the blend up to a maximum value than decreases, this may be because after a certain percentage the additive makes blend leaner which results in decrease of BTE [11].

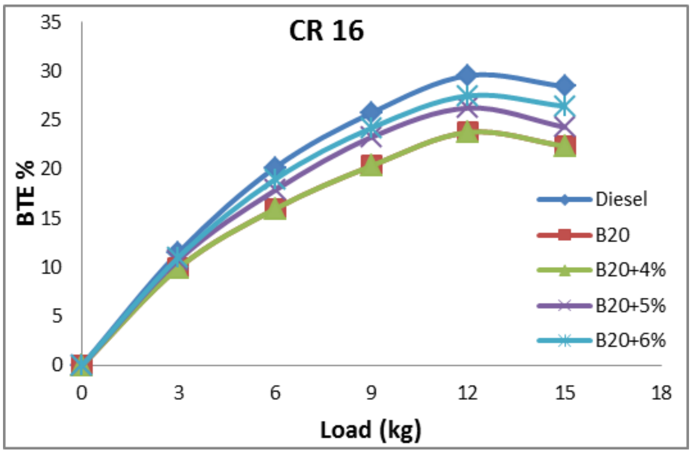

Figure 2: Load vs BTE at CR 16.

Figure 2, a graph between BTE and load at CR 16 shows the variation of BTE under varying load conditions. The maximum value of BTE at CR16. This result shows the maximum efficiency among the biodiesel blends is 27.3 at B20+6% at 75% of highest load as compared to other test fuel blends.

Figure 3, shows Load vs BTE graph at CR 17, the maximum value of BTE. For all test fuels peak values of BTE are observed at 75% of full load. The maximum value of BTE at compression ratio 17 is observed for B20+6% test fuel, the reason as stated above is the efficient combustion of fuel by increasing oxygen content due to addition of diethyl ether.

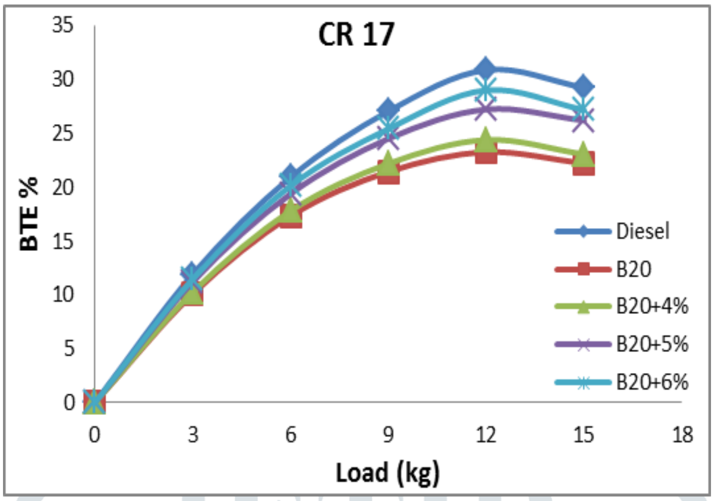

Figure 3: Load vs BTE at CR 17

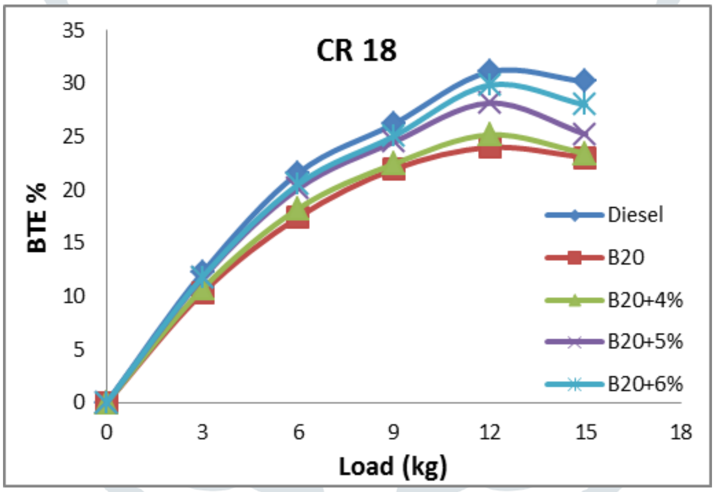

Figure 4: Load vs BTE at CR 18

Figure 4, shows the variation of BTE for all test fuels under different load conditions at CR 18. It is clearly observed from the figure that among the entire test fuels diesel is having maximum efficiency and test fuel with 6% diethyl ether concentration approaching closest to the efficiency of diesel.

2. Brake Specific Fuel Consumption

The brake-specific fuel consumption (BSFC) is the ratio of fuel supplied to power output. Among all, diesel has low BSFC as compared to other fuel samples during the current experimental investigation for all the CR. From the investigation it is also observed that the BSFC decreases with the addition of DEE in the B20 blend as the fuel becomes oxygen rich which results in better combustion, power produced, and lesser consumption of fuel [12]. The variation of BSFC with respect to load shows that it decreases with an increase in load, this is may be due to the fuel consumption increases with load but simultaneous increment in power output is higher than increase in fuel intake.

Figure 5, shows BSFC variation upon load at CR 16. The minimum brake specific fuel consumption is for diesel at all the applied load conditions. BSFC can be seen minimum for all the tested fuel at 75% of maximum load i.e. 12 kg load. The minimum BSFC 0.299 kg/kJ.h can be seen for diesel lowest among all the test samples. The lowest BFSC closest to diesel 0.309 kg/kJ.h among other test samples is observed in B20+6% at all the loading conditions.

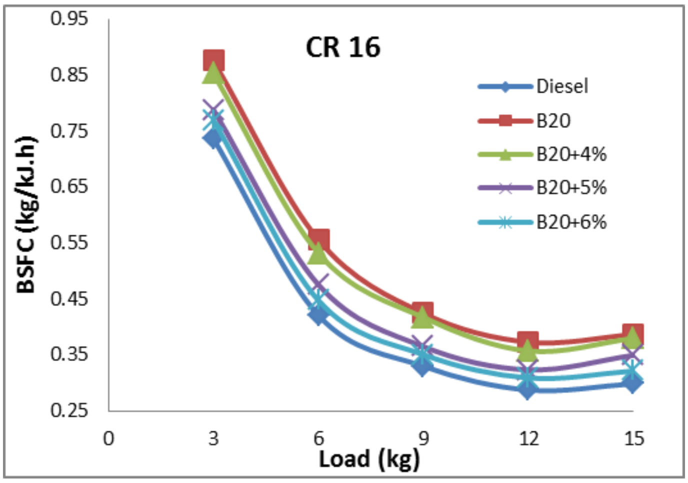

Figure 5: BSFC vs Load at CR 16

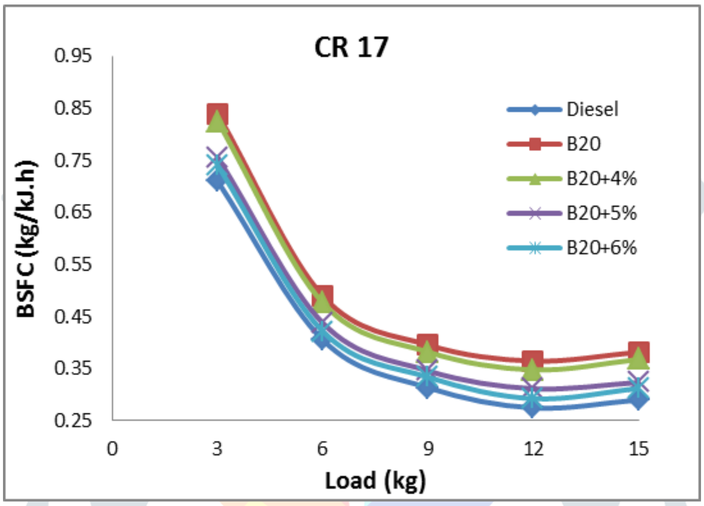

Figure 6: BSFC vs Load at CR 17

Figure 6, shows the variation of BSFC with varying load at CR 17. It is otained that BSFC decreases with increasing load. It is observed that all the test samples display their minimum BSFC at 75% of full load condition. BSFC of cottonseed oil methyl ester can be seen improving with addition of diethyl ether percentage. The best result of diethyl ether additive can be seen at 6% addition of diethyl ether with 0.293% BSFC nearest to BSFC of diesel. Further addition of diethyl ether reduces the heating value of diesel and hence increases the fuel consumption. The test sample approaching the BSFC of diesel fuel is B20+6% at the compression ratio 17.

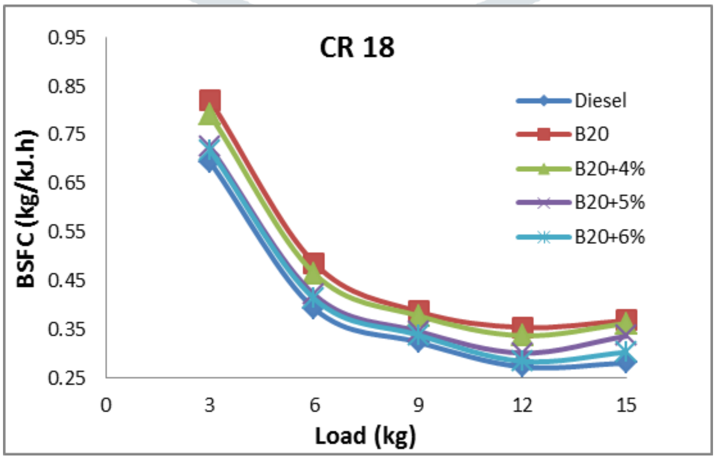

Figure 7: BSFC vs Load at CR 18

Figure 7. BSFC vs Load at CR 18. A decrease in BSFC can be observed with increasing load applied for all test fuels. The BSFC curve obtained for diesel is the minimum among all the blends and load conditions. The closest BFSC of the cottonseed oil biodiesel test fuels to diesel can be found in B20+6% (0.291 kg/kJ.hr).

4.4 Exhaust Gas Temperature

During the experimental investigation it was found that exhaust gas temperature increases with increase in load for all test fuel samples this may due to the reason that at higher loads more fuel is injected and more heat is generated which increases the temperature of exhaust gases also. The temperature of exhaust gases increases with increase in additive content as with the increase in oxygen content more fuel is combusted and more heat is generated [13]. The maximum temperature for all the test fuels can be found at full load condition of engine.

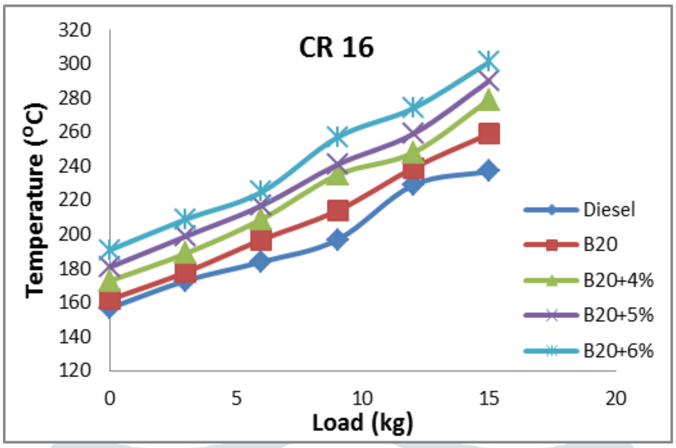

Figure 8: Temperature vs Load at CR 16

Figure 8, shows the temperature variation of exhaust gases at CR 16 with different test fuels. Exhaust gas temperature increases as the percentage of additive content increases as the reason stated above. It is also observed that temperature of exhaust gases follows the same trend, increases with increase in load.

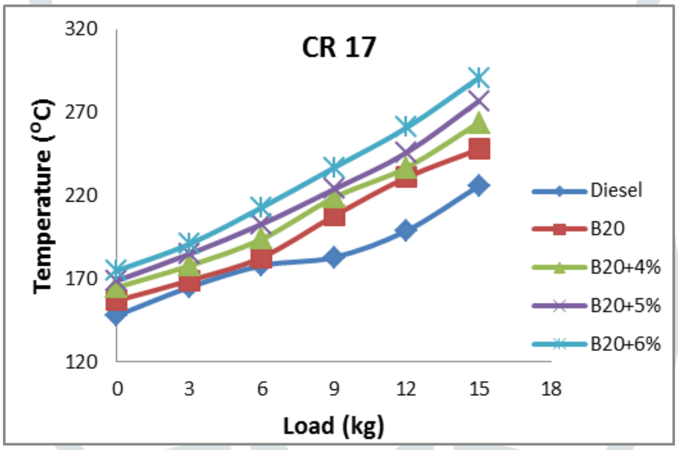

Figure 9: Temperature vs Load at CR 17

Figure 9, shows the graph plotted between temperature of exhaust gasses and load at compression ratio 17 for different samples of fuel. The temperature of exhaust gases increased with increase in applied load for all test fuels including diesel. The result depicts that higher exhaust gas temperature 298°C is for B20+6% because of the same reason discussed above.

Figure 10, shows graph between EGT and load at CR 18 with different blends of biodiesel. EGT increases with increase in applied load and it was observed that EGT is higher for B20+6% % test fuel for the reason discussed above.

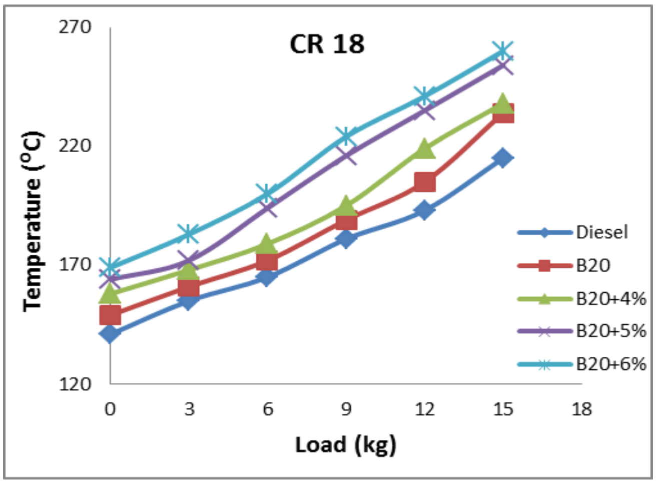

Figure 10: Temperature vs Load at CR 18

CONCLUSION

Different fuel samples of cottonseed oil methyl ester with variable percentage of diethyl ether as an additive were tested on a VCR engine for the optimization of engine parameters. The conclusions of the investigation are:

i. BTE and BSFC both were improved by the addition of DEE in the blend B20.
ii. BTE increased with increased compression ratio from 16-18.
iii. BTE is highest for fuel sample B20+6% at CR 18.
iv. BSFC decreases with increasing compression ratio from 16-18.
v. BSFC is lowest for fuel sample B20+6% at CR 18.
vi. EGT decreases with increase in compression ratio i.e. 16-18 for all the test fuels.
vii. EGT in maximum for fuel sample B20+10% at full load) at compression ratio 16.

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