EFFECTS OF BUTANOL AS AN OXYGENETED ADDITIVE ON PERFORMANCE OF VCR ENGINE FUELLED WITH COTTONSEED METHYL ESTER-DIESEL BLENDS AT 2 COMPRESSION RATIO

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Abstract : Decreasing diesel and petrol reserves, increasing price of fossil fuel, global warming, and environmental issues and their regulation creates an international interest and vision for development in alternate and sustainable fuel for the engines. To meet the energy demand gap of transport sector, biodiesel has attracted attention due to its better combustion, renewable nature, and biodegradability and nontoxic properties. Cotton seed oil is cheap, non-edible, high viscosity, low volatility and widely availability. Additives are also used to improve combustion and ignition efficiency and to enhance performance of the engine. Present work investigate the effects of butanol as an oxygenated additive on performance of variable compression engine and compare it using blends of diesel and cotton seed methyl ester at 2 compression ratio 17, 18 on various loads. The methyl esters of cotton seed is prepared by transesterification with methanol and potassium hydroxide as catalyst. The blends of methyl ester are prepared on volume basis with butanol additive i.e. B20, B20+2%, B20+4%, B20+6%. The test results concluded that BTE is increased for all the percentage of additive in the test fuel as compared to B20 and it is 29.01% highest for B20+6% at 75% of total load at compression ratio 18. BSFC also decreased for all percentage of additives in test fuel as compared to B20 and is 0.309kJ/Kg.hr lowest for B20+6% at 75% of total load on CR18. It has been concluded that CSME with Butanol as additive has been used as biofuels thus stating that B20+6% at 18 CR is the most suitable blends and that can be used in place of pure diesel without making any changes in the conventional engine.

***IndexTerms* – Brake thermal efficiency, brake specific fuel consumption, biodiesel, additive, compression ratio.**

I. INTRODUCTION

In the present scenario, conventional energy sources like petrol, diesel, atomic energy etc. are finite in nature. These sources are also causing heavy damage to environment as well as human health. The limited fossil fuel petroleum reserves are depleting since from the cold war which waved a warning to whole of the world to think about the alternate sources of these conventional energy sources. These sources should be renewable as well as nontoxic to environment and human. Most of the transport and power sector are heavily relies on these petroleum products like diesel, petrol etc. [1]. India is also looking forward towards the alternative fuels so that it will use as an alternative for diesel fuel. Switching from non-renewable energy sources to alternative and renewable energy resources is the demand and necessity of the world. The biodiesel promotes increasing interest in recent years as it can reduce global dependence on non-renewable resources. Increased environmental awareness also gives a blow to development of biodiesels with less emission in effort to reduce global warming and environmental pollution [2]. Alternative fuels are non-petroleum-based fuels derived from either renewable. The advantages of the biomass-derived biofuels are their renewability, biodegradability, non-toxicity and low emissions. Use of bio-chemicals helps to complement chemicals from non-renewable sources.

Aim of alternative fuel is to show a wide range of technology in the era of the limited fossil fuel to make these alternative fuels more efficient and will be developed as to replace fossil fuel. Furthermore, they have been widely used in transportation, electric generation and for heavy duty. However, emitting high amount of NO, CO2 and soot emissions of diesel engines should be reduced. Trans esterified vegetable oil (biodiesel) is one of the most attractive alternative automotive fuels among several other alternatives [3]. It is one of the present favorites to be the next generation diesel fuel.

The main objective of the present work is to investigate the effects of oxygenated butanol on perform, evaluate and compare the performance of the VCR engine using blends of Cottonseed oil methyl ester and diesel with butanol as an additive at all loading condition. Performance characteristics like Brake thermal efficiency, brake specific fuel consumption, exhaust gas temperature fuelled with methyl ester of cotton seed and diesel with butanol as an additive in variable compression ratio engine [4]. These characteristics are performed, evaluate, compared at various loading condition. Performance of the multi fuel, water cooled, variable compression ratio engine was used to compare (cotton seed oil + butanol) with neat diesel.

II MATERIAL AND METHODS

A. Properties of Biodiesel

The properties of cotton seed and butanol are tabulated in the table 1 and 2.The properties of these fuels are compared with ASTM standards and tested in the Vivekananda Global University Jaipur, Rajasthan. Since straight vegetable oils cannot be used directly without bringing its properties closer to petroleum fuel as diesel. Generally viscosity is reduced to improve its flow and atomization properties. Different techniques are generally used to reduce viscosity of these oils such as heating, transesterification, emulsification and blending etc. [5]. From the various studies we can also consider that B20 is the best test mixture that used in the C.I. engine [6]. B20 (20% biodiesel + 80% diesel) gives the properties nearby to diesel as compared to other mixture i.e. B100, B80, B60 and B40. Various additive properties are also compared in the table 2. The calorific value of the butanol is higher than other additives which will used to improve properties of biodiesel [7]. These oxygenates additives are usually referred as gasoline additives to reduce CO emission and soot that is created during the burning of the fuel. As the additives have enough number of oxygen and no. of carbon. The use of additives in biodiesel also solves many technical problems which limits the acceptability of biodiesel as an alternative fuel in all conditions.

Table no. 1 Properties of Fuel

Properties	Cotton Seed Oil	Biodiesel	Diesel
Density(g/cc)	0.90	0.88	0.84
Boiling Point °C	319	262	248
Calorific Value (MJ/Kg)	41.95	38.51	45
Kinematic Viscosity at 34°C	29.215	7.2	-

Table No. 2 Properties of Additive

Additives	Kinematic viscosity at 40°C (cSt)	Density	Calorific value	Cetane number	Flash point
Ethanol	1.14	791	27.33	5-8	-
Butanol	3.00	812	34.33	25	35
Diethyl Ether	0.22	712	33.89	125	-
Methanol	0.59	790	19.62	-	11

B. Materials

The cotton seed oil used in the research was purchased from local market from Bikaner, Rajasthan, India. Methanol, Butanol and KOH was purchased from Duva chemical supplier, Jaipur, India and pure diesel was supplied from diesel filling station. Biodiesel was prepared from cotton seed oil by alkali transesterfication [8]. The triglyceride of vegetable oil is reacted with alcohol in the presence of a catalyst, generally a strong alkaline like sodium hydroxide (KOH) by the transesterification process. Mixture of 20% methanol with 1% KOH by weight was treated with cotton seed oil to prepare the methyl esters of cotton seed oil. A successful transesterification reaction is signified by the separation of the methyl ester (biodiesel) and glycerol layers after the reaction time [9]. The heavier co-product, glycerol, settles out and may be used as is or as purified form for use in other industries. Additive Butanol is used in the test fuel in percentage basis i.e. 2, 4 and 6% in the test fuel. The test fuels are diesel, B20, B20+2%, B20+4% and B20+6%.

C. TEST FUEL

D : Diesel
B20 : Biodiesel 20% + Diesel 80
B20+2% : Biodiesel 20% + Diesel 80+ 2% Butanol
B20+4% : Biodiesel 20% + Diesel 80+ 4% Butanol
B20+6% : Biodiesel 20% + Diesel 80+6% Butanol

III. EXPERIMENTAL SETUP

A four stroke, single cylinder, direct injection, multi fuel, naturally aspirated variable compression ratio with a stroke length 110mm selected for the present research work. Detailed technical specification is given in table no 3 [6] [10]

Table No. 3 Engine specification

Sr. no	Features	Specification
1	Make	Kirloskar diesel Engine
2	Type	Four Stroke, Variable Compression ratio, Multi Fuel Diesel engine
3	No of cylinder	Single cylinder
4	Maxx speed	1500
5	Compression ratio	14 to 18
6	Loading	Eddy current dynamometer
7	Maximum power	3.75Kw
8	Stroke	110mm * 80mm
9	Temperature sensor	Type K nickel chromium based thermocouples

10	Cooling	Water
11	Load sensor	Strain gauge load cell

Compression ratio of the engine is varied with the help of handle mounted on the head of the engine by rising and lowering of the bore which increases the clearance volume of the piston in the combustion chamber. Load has been varies by eddy current dynamometer. Test blend are tested on the load 0, 3, 6, 9, 12 and 15 Kg. applied load is measured by the strain gauge load cell which shown digitally in load meter sent by load sensor. High rate of water circulation is required to ensure a uniform temperature for the engine inside the head. For this water circulation is done by a centrifugal pump in a closed circuit through inlet and outlet. To measure the flow of water to engine calorimeter, Rota meter are installed at the back side. Six thermocouples are setup at different position for measuring of exhaust gas temperature and water. Burette is used to measure the amount of fuel used in the combustion of fuel.

A. Methodology

Experimental study of the performance of the variable compression ratio engine to evaluate the brake thermal efficiency and brake specific fuel consumption in the engine when run on pure diesel while a series of test has been performed and compared when run with different test fuel of cotton seed oil with butanol as an additive.

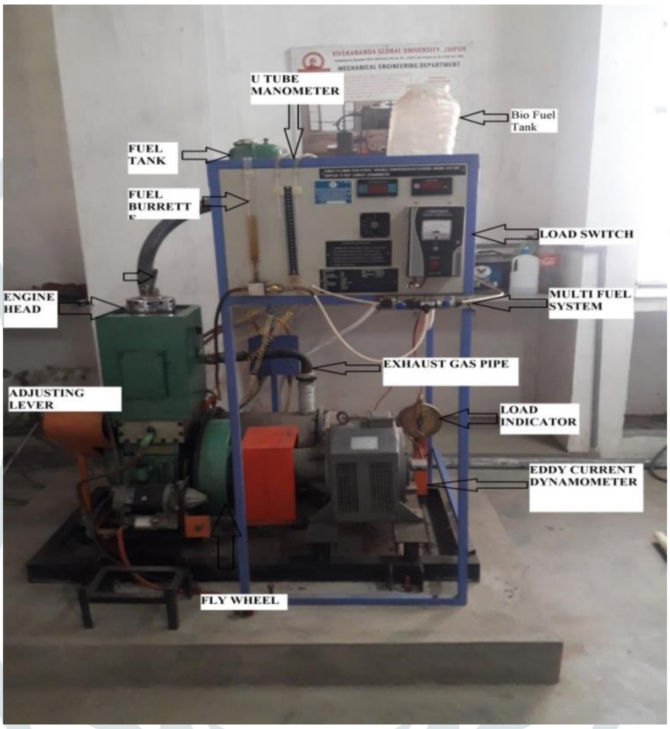

Fig 1 Overview of Variable Compression Ratio Engine

IV Result and Discussion

Analyses of different results obtained are carried out using the biodiesel with additive on the VCR engine on various loading condition and compression ratios. Detailed analysis of the effects of butanol as an additive on performance characteristics of the variable compression ratio engine are discussed by graphs in each section. These characteristics are also compared with the B20 and other test fuel.

A. Brake Thermal Efficiency

Brake thermal efficiency is the ratio of the output produced by the engine and heat supplied by the working fuel. The variations in the brake thermal efficiency depends upon the brake power which depend upon load applied. BTE increases with increasing compression ratio for all test blend because as the compression ratio increases. Increasing the compression ratio reduces the heat loss and increase power output. The BTE also increases with load for all test blends and is maximum values obtained at 75% (12kg) of the total load is due to friction losses. BTE also increases with increasing concentration of additive due to available no. of oxygen molecules in the additive increased which takes part in the combustion process.

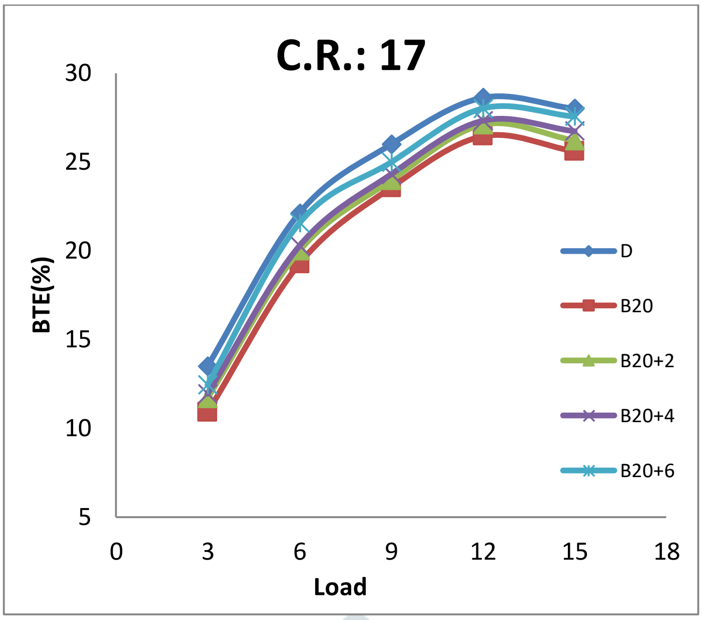

Fig 2 Graph between BTE v/s Load at CR 17

Fig 2 shows the efficiency graph between BTE and load at compression ratio 17. The result shows the maximum BTE maximum for diesel at CR17 is 28.60, while for the other blends it is 26.44%, 27.10%, 27.31% and 27.96% for B20, B20+2%, B20+4% and B20+6. It is maximum 27.96% for B20+6% as compare to other test blends at compression ratio 17. BTE also increases with increasing concentration of additive due to availability of oxygen molecules from the additive that takes part in the combustion process from 2-6%.

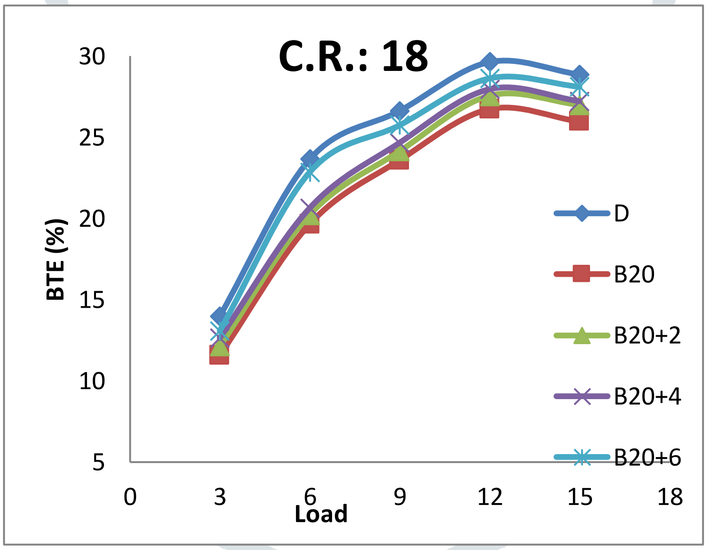

Fig 3 Graph between BTE v/s Load at CR18

Fig 3 shows the graph between BTE and load at CR 18 for the test fuel blends at various load conditions. As the result shows the maximum BTE for diesel is 29.65% while for other test fuel blends is 26.75%, 27.54%, 27.96%, 29.01%. The test result indicated that maximum efficiency is at B20+6% at compression ratio 18. With increasing no. of oxygen molecules present in the fuel improves the combustion characteristics at 75% of the full load condition. BTE also increases with increasing concentration of additive due to availability of oxygen molecules from the additive that takes part in the combustion process from 2-6%.

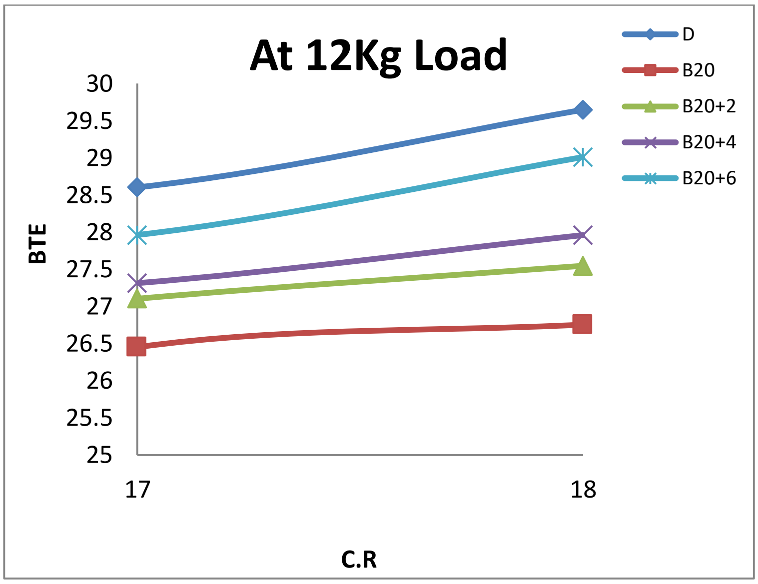

Fig 4 Graph between BTE and Compression Ratios

Fig 4 shows the graph between maximum BTE obtained at compression ratio 17 and 18 at 75% of full load condition. The graph shows the similar pattern for all the test fuels. BTE increases with increasing compression ratio for all test fuel because as the compression ratio increases, it increases the temperature of compressed air inside the combustion chamber which increases the overall heat produced by the burning of fuel. The highest BTE is obtained at B20+6 at CR18 (29.01%) from all the test fuel this is probably due to increase in the amount of available oxygen, resulting into increase in combustion efficiency and power output. The graph also indicated that BTE increases as the concentration of additive increases up to 6% (i.e. 2 to 6%)

B. Brake Specific Fuel Consumption (BSFC)

Brake specific fuel consumption is the amount of fuel used by engine to produce per unit power. Minimum value of BSFC is for diesel while compare to other test fuels for all loads and compression ratios due to its high calorific value than all test fuels. Value of BSFC is decrease with increase in load this is due to the fact that percentage increment of brake power is higher with load as compared to increment of fuel consumption at that load. BSFC is decreased with increasing compression ratio due to increase in BTE. It will increase temperature of air inside the combustion chamber. B20+6% resulted into minimum BSFC for CR 18 due to increase in the amount of percentage of additive and are very closer to diesel.

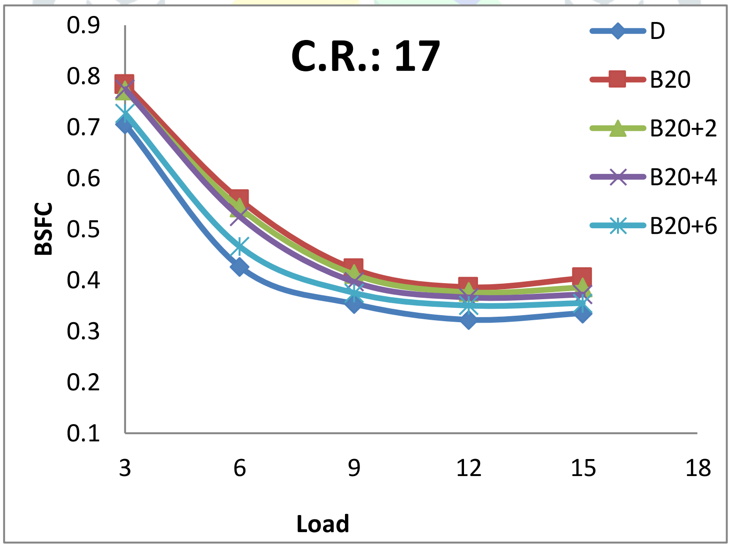

Fig 5 Graph between BSFC and Load at CR 17

In the given fig 5 shows the variation between BSFC and load applied on the engine at compression ratio 17. Fig shows the result obtained for BSFC at compression ratio 17 is 0.321, 0.385, 0.376, 0.356, 0.345 for diesel, B20, B20+2%, B20+4%, B20+6. Minimum value of BSFC at diesel at CR 17 is 0.321 Kj/kg.hr at 75% i.e.12 kg due to friction losses at full load condition. BSFC is lowest among all the test fuels is for B20+6% 0.345 Kj/kg.hr due to increase in availability of oxygen in the blends resulted into complete combustion of fuel in the combustion chamber.

In the given fig 6 shows the variation between BSFC and load applied on the engine at compression ratio 18. Fig shows the result obtained for BSFC at compression ratio 18 is 0.292, 0.345, 0.334, 0.331 and 0.309 Kj/kg.hr for diesel, B20, B20+2%, B20+4%, and B20+6% Minimum value of BSFC for diesel at CR 18 is 0.292 due to its high calorific value while it is lowest among all the test fuels at 75% i.e.12 kg due to friction losses at full load condition. BSFC is lowest among all the test fuels is for B20+6% 0.309 Kj/kg.hr due to availability of percentage of oxygen in the blends which increase the participation of oxygen , molecule for combustion.

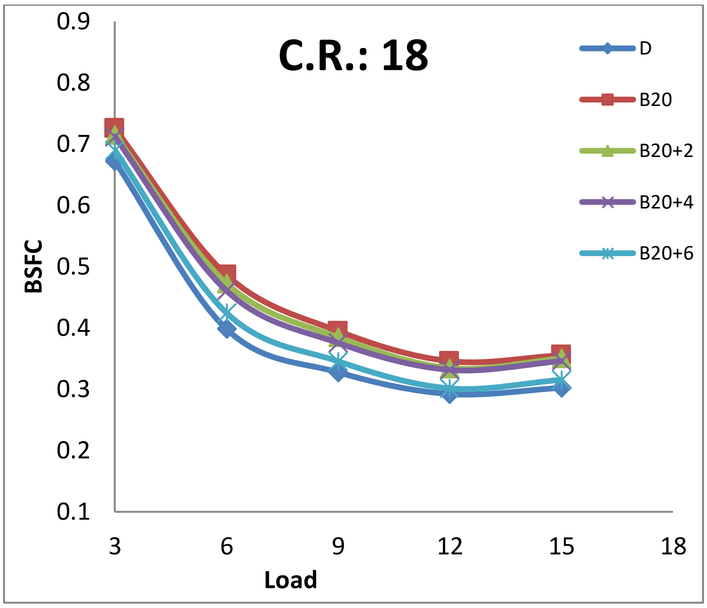

Fig 6 Graph between BSFC and Load at CR 18

Fig 7 shows the variation of minimum BSFC at various compression ratios. The graph shows similar pattern with diesel and all test fuels. BSFC is lowest for diesel while for rest of the test fuels the lowest value of BSFC is for B20+6% at CR 18 i.e. 0.309 kJ/kg.hr. Figure also shows that BSFC decreases as the compression ratio increases from 17 and 18 due to increase in BTE. BSFC decreases as the concentration of additive varies from 2-6%, may be due to increase in the availability of the oxygen hence resulting into increase in the power output, thus lesser fuel is required for producing the same power output. The figure also indicates that BSFC decrease as the percentage of additive increases in the test fuel up to 6% (i.e. from 2-6%) The decrease in the BSFC is due to the same reason as mentioned above.

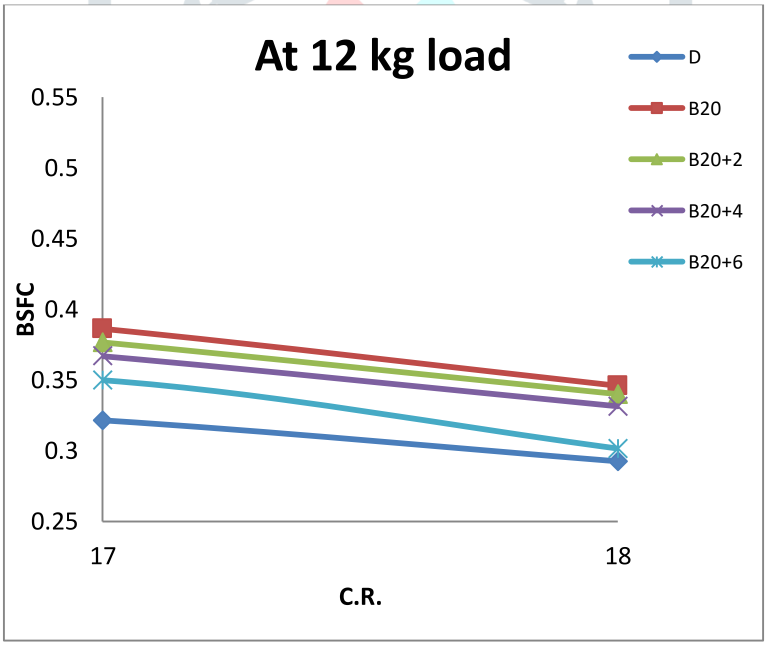

Fig 7 Graph between BSFC and Compression ratio

C. Exhaust Gas Temperature

The Exhaust gas temperature increases as load increases for all tested fuel as because more fuel is required for generating extra power for alleviated load. Mass flow rate increased in combustion of engine per unit leads to more heat required for burning of extra fuel, which increased heat available and increases the temperature of exhaust gases from the engine. The maximum exhaust temperature is obtained at full load condition for all test blends. As load increases, it will increase the load on the engine to generating same power. Fuel in the combustion chamber will leads to more combustion of fuel which produces extra heat and ultimately that will increase the temperature of exhaust gases. EGT is increasing with increase in the concentration of additive in the test fuel; temperature of exhaust gases was also increasing due to increasing amount of available oxygen content in the fuel. More no of oxygen increase the burning of fuel which produces more heat in the combustion chamber during power stroke.

So the exhaust gas temperature is highest for higher concentration of additive in the test fuel.

Fig 8 shows the temperature graph shown during the exhaust at CR 17 with different blends of exhaust gas temperature with different engine load at compression ratio of 17. Maximum exhaust gas temperature noticed at full load condition for all tested fuel and values are as 301°C for diesel, 330°C, 354°C, 356°C, 358°C for B20, B20+2, B20+4, B20+6 respectively for CR17. EGT increased with applied load for all test fuel including diesels. The test result showing EGT 358°C is highest for B20+6% due to increased concentration of additive wills increases the availability of oxygen content in the test fuel.

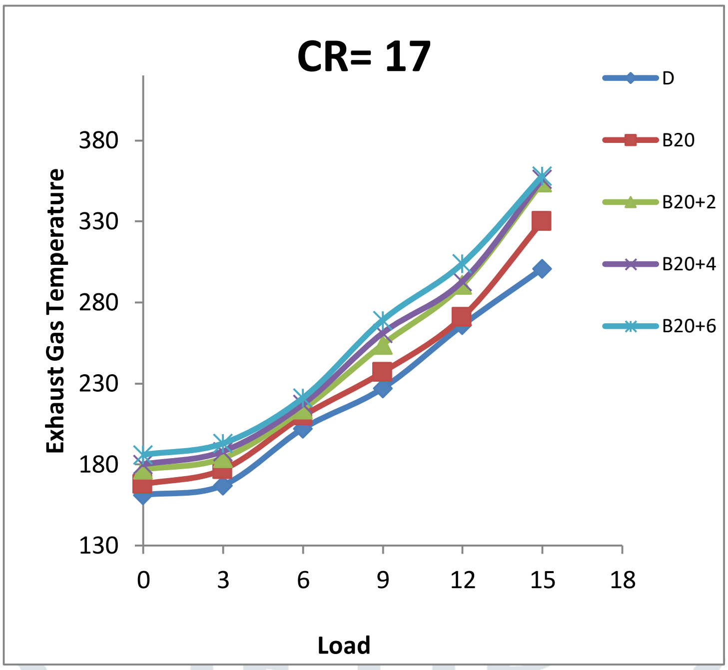

Fig 8 Graph between EGT and Load

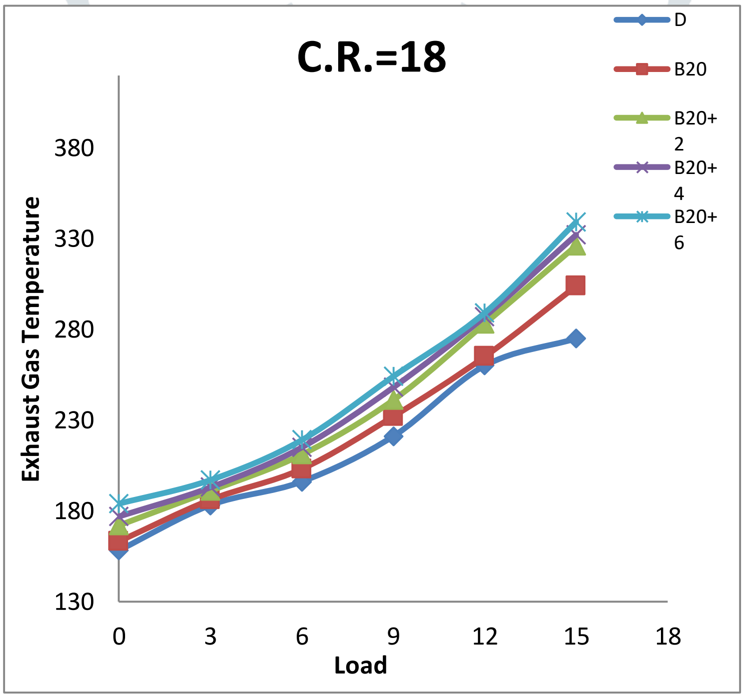

Fig.9 Graph between EGT and load

Fig 9 shows the temperature graph shown during the exhaust at CR 18 with different blends of biodiesel. Maximum exhaust gas temperature noticed at full load condition for all tested fuel and values are as 295°C, 321°C, 335°C, 339°C, 347°C for diesel B20, B20+2, B20+4, B20+6 respectively. As the load applied on engine increases the friction causes more fuel consumption resulting into more heat generation. The test result showing EGT 347°C is highest for B20+6% due to increased concentration of additive. As the additive concentration is increased, it will increase the available oxygen in the test fuel resulting into higher temperature.

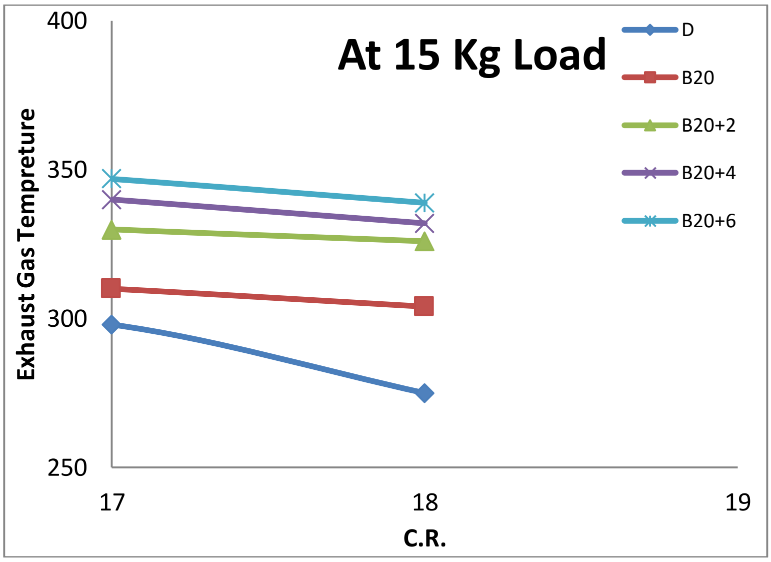

Fig no. 10 Graph between EGT and Compression ratios

Fig 10 shows the variation in exhaust gas temperature at compression ratios 17 & 18. Highest exhaust gas temperature obtained at full load condition for all test fuel are as 358℃, 368℃, 371℃, 374℃, 379℃for pure diesel, B20, B20+2%, B20+4%, B20+6. Maximum temperature for exhaust gases noticed at B20+6% at CR17 is 379℃. EGT decrease with increasing compression ratio because at higher compression ratio, the expansion of burnt gases is higher i.e. greater work done by the mixture. More energy is converted into useful work. Temperature of the exhaust gases is increased with the increase in the concentration of additive in the test fuel due to increasing amount of oxygen. More the oxygen more the heat is produced in the combustion chamber.

V CONCLUSION

The effects of butanol as an oxygenated additive on performance of single cylinder, multi fuel, direct injection, water cooled four stroke variable compression ratio engine fuelled with diesel, B20, B20+2%, B20+4% and B20+6% on 2 compression ratio 17 and 18 and compare it with diesel. The following obtained results can be drawn from the present study:

1. Highest Brake thermal efficiency for all percentage of additives in the test blends is measured at B20+6% at compression ratio 18 & it is highest i.e. 29.01% for B20+6% at 12Kg load.
2. Brake thermal efficiency increased for all the test fuel as compression ratio increases while Brake specific fuel consumption shows the decreasing trends.
3. Brake specific fuel consumption is also lowest for all percentage of additives for B20+6% i.e. 0.301 kJ/Kg.hr. on 12kg loading condition at compression ratio 18 as compared to B20 and other test fuels.
4. Highest Exhaust gas temperature 379℃ is noticed at CR 17 on full load condition
5. Exhaust gas temperature is increased with increases in concentration of additive for all test fuels

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