ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

Volume 3, Special Issue 3, March 2014

2014 International Conference on Innovations in Engineering and Technology (ICIET'14)
On 21st & 22nd March Organized by

K.L.N. College of Engineering and Technology, Madurai, Tamil Nadu, India

Experimental Investigation of Variable Compression Ratio Diesel Engine using Ziziphus Jujuba oil

K.Naveen[#1], T.Parameshwaran pillai [*2], Azhagiri pon[#3]

[#1] Department of Thermal Engg. University College of Engineering (BIT Campus), Tiruchirappalli, India

*[2]Asst.Professor, Department of Mechanical Engg, University College of Engineering (BIT Campus), Tiruchirappalli, India

[#3]Asst.Professor, Department of Mechanical Engg, University College of Engineering (BIT Campus), Tiruchirappalli, India

ABSTRACT— Depleting the sources of petroleum pushes the researchers to find hopeful alternate for future. From the extensive study of many researchers results that, Biofuel having the potential used as fuel in compression ignition engine. Biofuel derived from Ziziphus jujuba (Indian jujube), which is the edible in nature, first time introduced as fuel to run single cylinder, four stroke, variable compression ratio diesel engine. Experimental investigation of diesel engine was made with 20% (B20), 40% (B40) and 60% (B60) blending of Ziziphus jujuba oil with diesel for compression ratio from 15:1 to 18:1 and the results were compared with diesel. Performance parameters such as Specific fuel consumption, Brake thermal efficiency and Exhaust gas temperature for varying compression ratio and blending has been presented.

KEYWORDS— Ziziphus jujuba, Indian jujube, Edible, Blending, Variable compression ratio (VCR) engine

I. INTRODUCTION

Developing countries like India, growth of the nation severely affected by increasing the price of petroleum products due to their demand. Since the last century, researchers were tried to find the alternate, for replacing the conventional fossil fuels. Properties of the fuel such as viscosity, flash point and fire point decide the combustion capability. Oil extracted from dry seed of vegetables, posses higher viscocity and lower combustion quality interms of flash point and fire point due to insufficient oxygen content and higher percentage of fatty acid presented. Chemical treatment namely esterification was suggested by the researchers for conversion of the extracted vegetable oil in to combustible fuel inside the engine. Esterification process popularly used method of chemical treatment, which removes the unwanted fatty acid presented in the vegetable oil and reduced the viscosity. Simultaneously, it improves the combustion qualities of the vegetable oil in terms of heating value,flashpoint, fire point nearer to diesel [1-11].Based on fatty acid content of the oil, esterification was done in single stage or two stage.When the fatty acid presented above 4% (by volume) then two stage esterification process suggested.otherwise single stage esterification recommended[3].After the esterification also the flash point and fire point of the biofuel slightly more than the diesel. Therefore, storage and transportation of fuel is not much difficult compared to diesel in safety point of view[9]. Changing the parameters of the engine such as setting higher compression ratio helped to accomplish enough temperature for buring the biodiesel inside the engine. Similarly, increase of injection timing and retard the ignition delay improve the combsution environement made suitable for biofuel.

Many researchers conducted expeirmental investigation on compression ignition engine by using biofuel prepared from Jatropha, Mahua, Pinnai oil, Cotton seed oil, Soybean oil, Rubber seed oil, Karanj oil and Putranjiva after esterification process. Performance, Combustion and Emission characteristics were studied without major modification of engine parameter[1-11].

TABLE 1:PROPERTIES OF FUEL

Properties	Diesel	Ziziphus jujuba oil
Density@30°C (kg/m^3)	0.8316	0.8777
Kinematic Viscosity @ 40°C (Cst)	3.294	4.02
Kinematic Viscosity @ 100°C (Cst)	1.269	2.03
Flash Point (^{0}C)	69	182
Pour Point (^{0}C)	-6	-2
Gross Calorific Value (kJ/kg)	44000	38233

Reference [2] evaluate the performance of compression ignition engine using Mahua oil and its blends (20%,40%,60% and 80%) with high speed diesel at varying compression ratios from 18:1 to 20:1. They concluded that Brake thermal efficiency of the engine operated with High speed diesel same as Mahua oil at injection timing setting of 20^0 or 40^0 at compression ratio of 20.

Reference [4] optimized the performance, emission and combustion characteristics of diesel engine with various blending [20%, 40%, 60% and 80%] of waste cooking oil methyl ester. Authors concluded that 40% blending with the compression ratio of 21 produces higher efficiency. Reference [5] studied the effect of injection timing on performance and emission characteristics of engine with Jatropha biodiesel blend and also revealed the combustion characteristics. It has been observed that advances in injection timing results that reduction in brake specific fuel consumption, CO, HC and Soot emission. Alternatively, Brake thermal efficiency, NO emission, Maximum pressure, Heat release rate were increased. Optimum value of injection timing found as 340 CAD. Jatropha has been register better performance than Kanjara oil and Putranjiva oil in terms of brake thermal efficiency and overall efficiency at injection timing of 45^{0}bTDC timing, and compression ratio of 20 [6]. References [7] were prepared methyl esters of rubber seed oil and carried the performance and emission evaluation on diesel engine with different blending. From the experimental results, they concluded that brake thermal efficiency of diesel increased about 3% for the 10% blended diesel at the rated load conditions. However, emission and brake specific fuel consumption is reduced. It has been observed that Higher the concentration of biodiesel blend, smoke density in exhaust gas were reduced. Reference [8] examined the potential of rapeseed methyl ester fuel for diesel engines based on emission characteristics. Experimental results showed that rapeseed methyl ester and its blends with diesel fuel emitted higher CO_2 compared with diesel fuel. However, significant reduction in emissions of hydrocarbon (HC) was recorded. HC emissions were noted that increased with raising the amount of diesel fuel in the blend. References [9] were prepared biodiesel from cottonseed oil with methanol in a green, zero waste discharge process. Glycerol was recovered by gravity separation and unutilized methanol was recycled after distillation. Authors observed that lower brake thermal efficiency and higher brake specific fuel consumption compared with diesel. Also, it has been observed that emissions of CO, CO_2, soot emissions and un-burned hydrocarbons considerably reduced by 33.3%, 8.4%, 43.4% and 29.4% respectively. However, results in higher levels of NO_X emission.

Reference [10] performed the experimental investigation of Single cylinder diesel with 20% jojoba oil blended diesel at compression ratio of 17:1 and injection timing of 24^0 bTDC. From the experimental results, they concluded that power loss is negligible and SFC increased compared with diesel due to higher viscosity and lower calorific value. NO_x and soot emission were reduced when compared with diesel for same experimental condition. Reference [11] conducted experiments for developing correlation between equivalent ratio and ignition delay for different blending of Jatropha biodiesel. They also revealed from experimental results that Brake specific fuel consumption and Brake toque increased with 50% blending of Jatropha. However it produced lesser NO_x emission.

From the research papers, the biofuel preparation by esterification process identified as suitable method for biofuel preparation. The potential of the oil finalize by comparison of properties with diesel. Instead of using pure biofuel inside the engine, blending of biofuel with diesel avoid major modification of the engine setting.

II. MATERIAL AND METHOD

A.Biofuel preparation

Raw oil extracted from the dry seed of ziziphus jujuba have higher viscosity and poor combustion quality due to the presence of fatty acid. ZJ oil undergone esterification process for reducing the viscosity and make it has combustible. Raw ZJ oil was taken in the reactor for the measured quantity. The oil was heated slowly up to 65^o C. After that, the mixture of catalyst (Sodium methoxide) and methanol was added in the reactor. The mixture was stirred continuously for three hours and the temperature maintained at 65^{o}C. During that time period the chemical reaction takes place between raw Ziziphus oil and the methanol. At the end of completion of reaction, the mixture was drained and transferred to the separating funnel. The phase separation was takes places in the funnel in two layers. Upper layer was the biodiesel and lower phase was Glycerine.Finally,washing was made with water.

TABLE 2:ENGINE SPECIFICATION

S.No	Engine part	Specification
1	Make	Kirloskar
2	Model	PS234
3	Number of cylinder	Single
4	Ignition system	Compression ignition
5	Cylinder Bore	87.5 mm
6	Stroke length	110 mm
7	Rated power	3.5 kW @ 1500 rpm
8	Cooling medium	Water cooled
9	Combustion chamber	Open chamber (DI)
10	Compression ratio	12:1 to 18:1

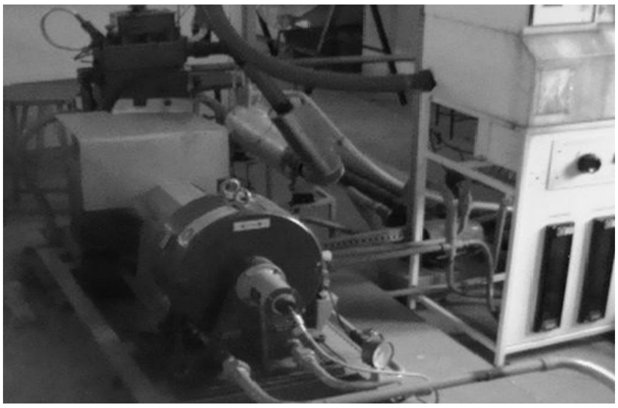

Fig 1: Experimental setup of VCR engine

B. Biofuel properties

For successful use in a diesel engine, the properties of biodiesel analysed and compared with diesel. The values shown in Table 1.

C. Experiments:

Performance of variable compression ratio engine is carried out by blending of ZJ oil with diesel. Experiment started with 20% blending of ZJ oil with diesel at the compression ratio of 18:1 and no load. All the Engine parameters such as Specific fuel consumption (SFC), Exhaust gas temperature (EGT) recorded using computerized data logger. Raise the load to 25% of full load using electrical dynamometer and again the parameters were recorded. Similarly, Engine loaded with 50%, 75% & 100% of full load and readings are recorded. Brake thermal efficiency computed from the initial measurement. After that, Compression ratio set as 17:1 by adjusting the clearance volume of the combustion chamber and the experiments conducted similar manner of 18:1 and parameters recorded using computerized data logger. Similarly, the compression ratios of 16:1 and 15:1 procedure repeated for 40% and 60% blending of ZJ oil with diesel.

D. Experimental setup

Figure 1 shows the schematic diagram of the VCR engine experimental setup. The specification of the VCR engine listed in Table 2. Engine performance analysis software package "Engine Soft" has been employed for online performance analysis. The setup consists of single-cylinder four-stroke Variable Compression Ratio diesel engine connected to eddy current dynamometer for loading. A specially designed tilting cylinder block arrangement was used for varying the compression ratio. Setup was provided with necessary instruments for combustion pressure and crank angle measurements. These signals are interfaced to computer through engine indicator for Pθ−PV diagrams. Provision was also made for interfacing airflow, fuel flow, temperatures, and load measurement. The setup has stand-alone panel box consisting of air box, two fuel tanks for duel fuel test, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, and process indicator and engine indicator. Rotameters were provided for cooling water and calorimeter water flow measurement.

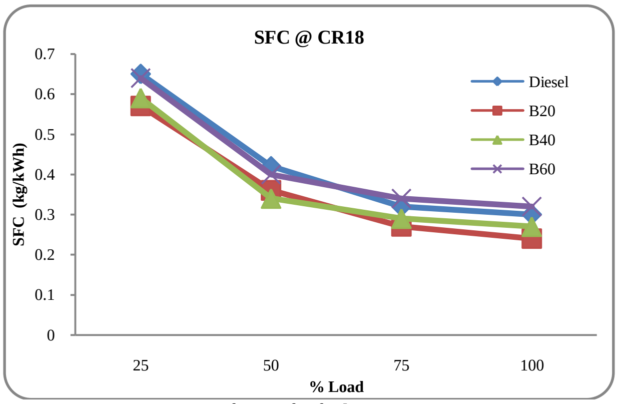

Fig 2: Variation of Specific fuel consumption at CR18

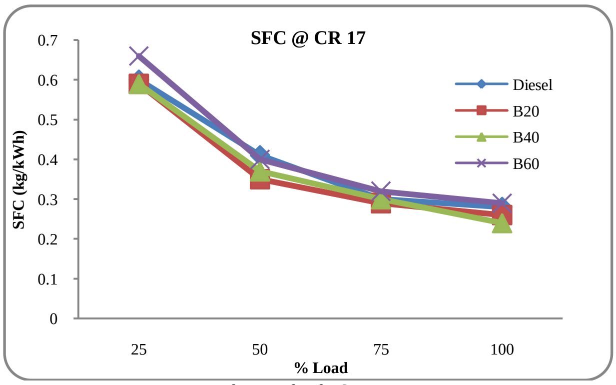

Fig 3: Variation of Specific fuel consumption at CR17

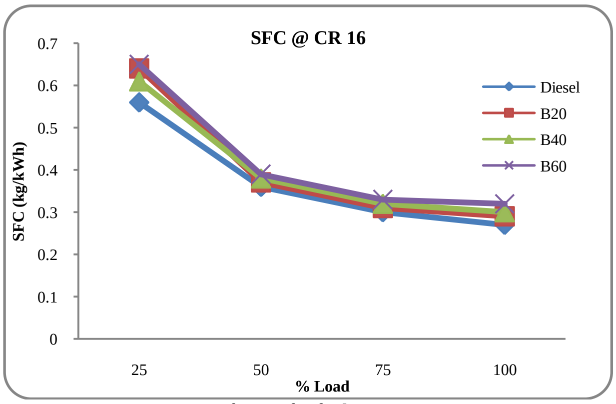

Fig 4: Variation of Specific fuel consumption at CR16

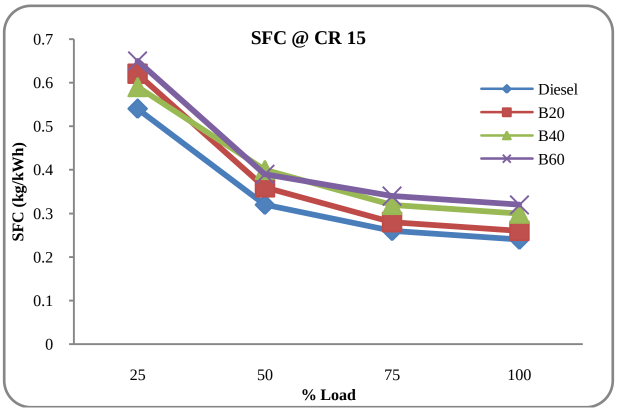

Fig 5:Variation of Specific fuel consumption at CR15

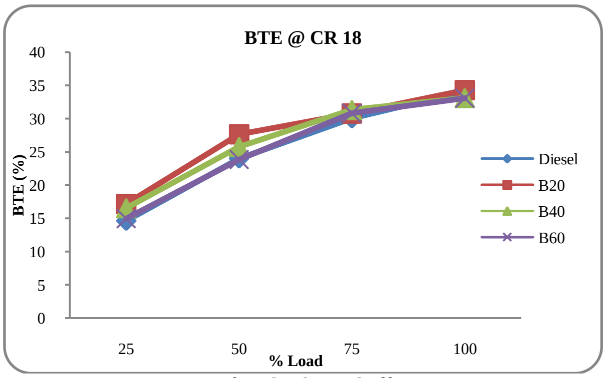

Fig 6: Variation of Brake thermal efficiency at CR18

III. RESULTS & DISCUSSION

Engine was started with no load condition and run for few minutes to reach unwavering working condition. After reached steady running condition, fuel supply source for engine changed from fuel tank to measuring burette by closing the knob availed in the setup. Data such as Specific fuel consumption, torque applied and exhaust temperature were recorded by using "IC engine" software through the data logger connected with the engine setup. Then the fuel supply retrieved to origin condition. Load changes from 0 to 100% of full load with the interval of 25% of full load. For each load condition, the parameters were stored using software. BTE for each load condition calculated from the values obtained from software. The procedure repeated for each compression ratio and variations of parameters such as SFC, BTE and EGT are presented with respect to load for compression ratio of 15,16,17,18 respectively. The graphs in each figure correspond to three different blending (B20, B40 &B60) and diesel values.

A. Specific fuel consumption:

Experimental results show that SFC was reduced with increasing the load for all the compression ratios as shown in Figs.2 to 5. Results obtained were similar to results reported by many researchers [2, 3, & 7]. The main reason for that brake power developed was higher than fuel consumption in higher load. Also, increasing the temperature at higher load condition [2].SFC increases with increasing the percentage of blend from 20% to 60%.

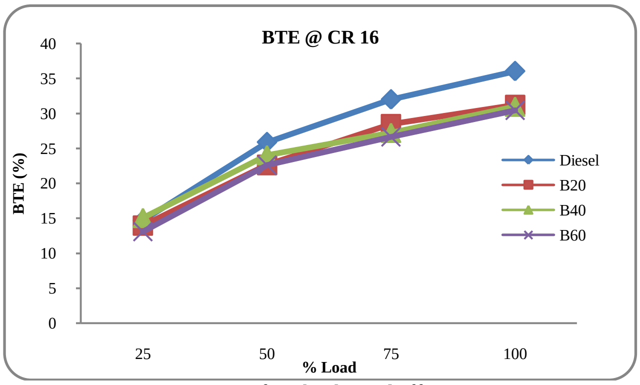

Fig 8: Variation of Brake thermal efficiency at CR16

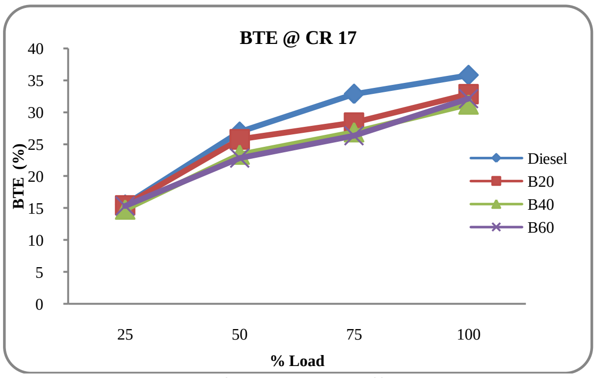

Fig 7: Variation of Brake thermal efficiency at CR17

At higher load condition B20 registered lesser fuel consumption when compared to other blending (B40 and B60) for all the compression ratios selected except the compression ratio of 17:1. B60 register higher fuel consumption for the entire compression ratio. This is due to combined effect of higher density and lower calorific value with respect to increasing the blend and also varying chemical structure. High density of the ZJ oil causes higher mass injection of fuel for the same volume at same injection pressure. Lower calorific value causes higher fuel consumption for the same power development. Also, Different chemical structure of oil have poor combustion quality increases the fuel consumption [2].SFC decreases with increasing the compression ratio in consequence of higher temperature produced at the end of compression.

B. Brake thermal efficiency:

Brake thermal efficiency (BTE) shows the capacity of mechanical energy conversion by engine from heat released by the explosion of fuel inside the cylinder volume. BTE is directly proportional to Brake power developed and inversely proportional to mass of fuel injection and calorific value. Experimental result shows that BTE increases with increase in the load for compression ratio selected from 15:1 to 18:1 as shown in Figs.6to9. Results obtained were similar to results reported by many researchers [2, 3, 7, 9 &11]. Because increasing the load on engine increase the brake power output. When the percentage of blending increased then brake thermal efficiency reduced for all the compression

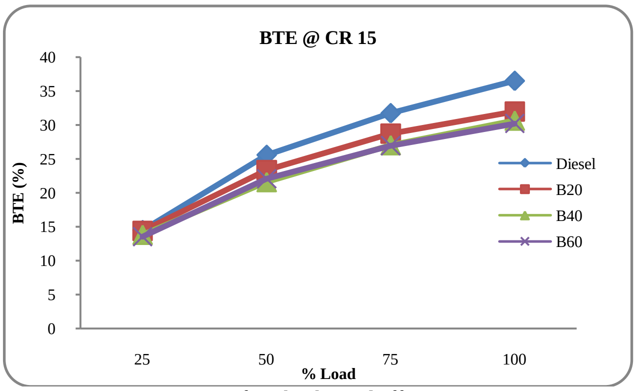

Fig 9: Variation of Brake thermal efficiency at CR15

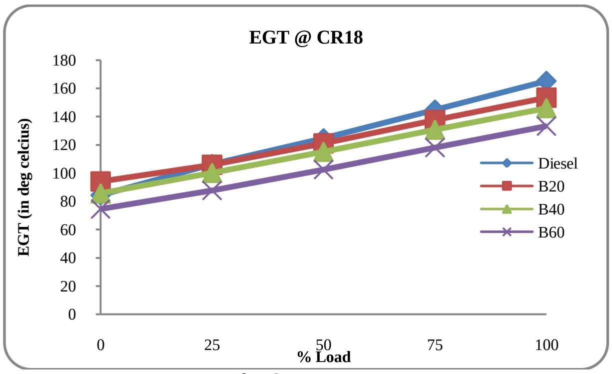

Fig 10: Variation of Exhaust gas temperature at CR18

ratios selected. This is due to increasing density and viscosity with increase of blending from 20% to 60%. High density of blending increased the mass of fuel injected for same power output. At higher load condition 20% blending of Ziziphus jujuba oil (B20) with diesel having higher BTE among the three different blending for all the compression ratios selected except CR 17. At the same time, the percentage blending of ZJ oil increased with diesel results that elevated flash point and fire point of the fuel. Increasing the compression ratio of the engine produced higher peak pressure and higher temperature at the end of compression. Such increased peak temperature helped to achieve improved combustion quality of blended diesel even it has higher viscosity. At compression ratio of 18, BTE of engine fueled with 20% blending of ZJ oil given same result as diesel.

C. Exhaust gas temperature:

Exhaust gas temperature (EGT) is the indicator of the combustion and emission characteristics of the engine. Normally, High temperature exhaust gas have higher amount of NO_x. The variation of EGT of the engine for varying the compression ratio from 15:1 to 18:1 as shown in Figs 10 to 13. With increasing the load on the engine, EGT were increased due to higher heat loss from the combustion.EGT decreased with increasing the blending percentage. Many researchers reported similar trend in results for EGT [4, 6, 7, 9 &11]. B20 register the highest EGT among the B20, B40 and B60 at full load condition. Lowest EGT register by B60 among the three different blending and diesel. Lesser EGT of biodiesel blends could be due to lower calorific value and higher viscosity led to

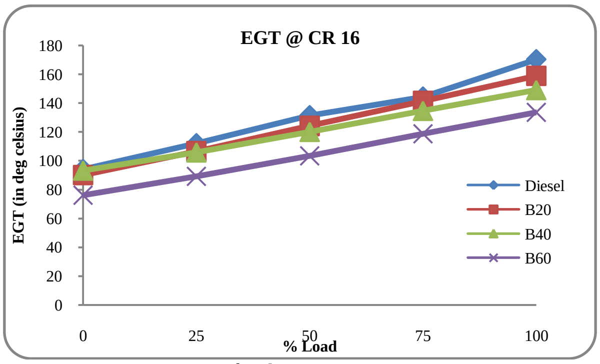

Fig 12: Variation of Exhaust gas temperature at CR16

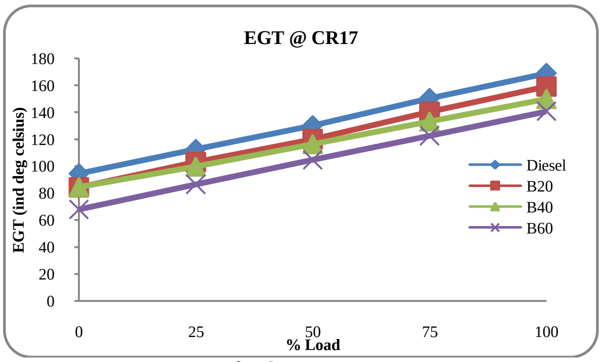

Fig 11: Variation of Exhaust gas temperature at CR17

poor atomization rate. The lower EGT suggested that the engine was not thermally overloaded but more fuel was required to maintain the same output power [9]. EGT decreased significantly for all the blending when raising the compression ratio from 15:1 to 18:1. Combustion quality increased with increasing the compression ratio because the negative effects of higher viscosity overcome by improved combustion temperature. Raising the compression ratio and blending of ZJ make the positive effect in EGT aspect.

IV.CONCLUSION

The performance parameters of single cylinder variable compression ratio engine fueled with Diesel blended Ziziphus jujuba oil have been investigated. The experimental results showed that the SFC, EGT & BTE were varied with respect to blending and compression ratios. From the experimental result, conclusion were made as follows

- SFC decreases with increasing load for the compression ratio from 15:1 to 18:1 and increases with increasing percentage blending of biofuel. B20 having lower specific fuel consumption when comparing with B40 & B60.
- BTE and EGT increases with increasing the load for all the compression ratio (18:1 to 15:1) and all the

blending (B20, B40 & B60).B20 register higher BTE when compared to B40 & B60 except the compression ratio of 17:1.

- EGT decreases with increasing the compression ratio and blending percentage. B60 register lower EGT at all compression ratio comparing with B20 & B40 as well as Diesel.

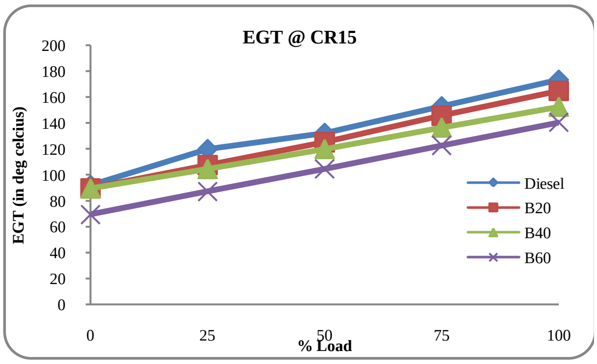

Fig 13: Variation of Exhaust gas temperature at CR15

NOMENCLATURE

ZJ Zizipus Jujuba

B20 20% ZJ oil + 80% Diesel

B40 40% ZJ oil + 60% Diesel

B60 60% ZJ oil + 40% Diesel

CR Compression Ratio

SFC Specific Fuel Consumption

BTE Brake Thermal Efficiency

EGT Exhaust Gas Temperaure

REFERENCE

[1] D.Laforgia, V.Ardito. “Biodiesel Fueled IDI Engines: Performances, Emissions and Heat Release Investigation,” Bio resource Technology, vol.51. pp.53-59, 1995.

[2] H.Raheman, S.V.Ghadge. “Performance of diesel engine with biodiesel at varying compression ratio and ignition timing,” Fuel, vol.87, pp. 2659–2666, 2008.

[3] T.Mohan Raj, Murugumohan Kumar K Kandasamy “Tamanu oil - an alternative fuel for variable compression ratio engine,” International Journal of Energy and Environmental Engineering, vol. 3, pp. 18, 2012.

[4] K.Muralidharan, D.Vasudevan. “Performance, emission and combustion characteristics of a variable compression ratio engine using methyl esters of waste cooking oil and diesel blends,” Applied Energy, vol. 88, pp.3959–3968,2011.

[5] T. Ganapathy, R.P. Gakkhar, K. Murugesan. “Influence of injection timing on performance, combustion and emission characteristics of Jatropha biodiesel engine,” Applied Energy, vol. 88, pp. 4376–4386, 2011.

[6] B.B.Ghosha, Sandip Kumar Haldar, Ahindra Nag. “Synthesis of Biodiesel from Oils of Jatropha, Karanja and Putranjiva. To Utilize in Ricardo Engine and its performance & Emission Measurement,” Proceedings of the 4th BSME-ASME International Conference on Thermal Engineering, pp. 27-29, 2008.

[7] A.S. Ramadhas, C. Muraleedharan, S. Jayaraj. “Performance and emission evaluation of a diesel engine fueled with methyl esters of rubber seed oil,” Renewable Energy, vol. 30, pp.1789–1800, 2005.

[8] O.M.I.Nwafor. “Emission characteristics of diesel engine operating on rapeseed methyl ester,” Renewable Energy, vol.29, pp.119–129, 2004.

[9] Soham Chattopadhyay, Ramkrishna Sen. “Fuel properties, engine performance and environmental benefits of biodiesel produced by a green process,” Applied Energy, vol. 105, pp.319–326, 2013.

[10] A.S. Huzayyin, A.H. Bawady, M.A. Rady, A. Dawood. “Experimental evaluation of Diesel engine performance and emission using blends of jojoba oil and Diesel fuel,” Energy Conversion and Management, vol. 45, pp.2093–2112, 2004.

[11] Mohammed EL-Kasaby, M.A. Nemit-allah. “Experimental investigations of ignition delay period and performance of a diesel engine operated with Jatropha oil biodiesel,” Alexandria Engineering Journal, vol.52, pp.141–149, 2013.