Biodiesel from Citrullus Colosynthis Oil: Performance Testing and Combustion Characteristics In I.C. Engine

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Abstract - *Since last many centuries world is using fossil fuels for fulfilling energy demands, as these sources are very limited for next few years researchers are in search of alternative fuels. Biodiesel is the one of the most economic and less polluting alternative fuel. Keeping this in view, an attempt has been made through the experiment of Thumba blended biodiesel prepared in laboratory and analyses its properties on CI engine and characteristics compare with other biodiesel blends of Thumba oil with variation in compression ratio and load. From the comparison of results, it is inferred that the engine performance is improved with significant reduction in emissions for the chosen oils without any engine modification.*

***Key Words*: Biodiesel, Citrullus Colosynthis Oil, Transesterification, Fuel Blends, Compression Ratio, Engine Load, Performance and Emissions, VCR CI Engine.**

1 .INTRODUCTION

The constant increase in the rate of consumption of fossil fuels, consequent upon the ever increasing population and the urbanization. In the present day world has made the depletion of these conventional fuel resources in the near future a quite inevitable fact. Also the greenhouse gas emissions from these fossil fuels are constantly degrading the planet and causing global warming and other pollutant emissions related problem. In this search biodiesel- diesel blends as alternative fuels has become a popular option and is gaining the attention of many researchers. This is because biodiesel being renewable, biodegradable and green fuel can reduce our dependence on non-renewable fossil fuels as well as improve environmental quality in metro cities, urban and rural sectors by reducing automotive emissions. At present the amount of biodiesel available is less than that of diesel. The biodiesel blended with diesel by volume as B10 (10% Thumba biodiesel & 90% diesel fuel) is prepared as-first 90% (900ml) of diesel fuel was taken in reactor vessel then 10 % (100ml) biodiesel was introduced in the same vessel. The mixture is then stirred (550rpm) at 40oC for 15min.Other blends was prepared as same method B20 (20% thumba biodiesel & 80% diesel fuel), B30 (30% thumba biodiesel & 70% diesel fuel), B40 (40% thumba biodiesel & 60% diesel fuel), B50 (50% thumba biodiesel & 50% diesel fuel), B100 (100% thumba biodiesel & 00% diesel fuel).The main objective of present work is to analyse the engine Performance and Combustion characteristics of diesel engines fuelled with biodiesel produced from Thumba oil and its blends with diesel fuel, which will help in both the direction of reducing emission problems and search of alternative fuel for CI engines.

1.1 Thumba

Citrullus colocynthis, commonly known as the colocynth, desert gourd, wild guardh Citrullus colocynthis closely related to watermelon, is a member of the Cucurbitaceous family. Cucurbitaceous is a large family which consists of nearly 100 genera and 750 species. This plant family is known for its great genetic diversity and widespread adaptation which includes tropical and subtropical regions, arid deserts and temperate locations. Cucurbits are known for their high protein and oil content. The seeds of cucurbits are sources of oils and protein with about 50% oil and up to 35% protein. This plant is a drought-tolerant species with a deep root system, widely distributed in the Sahara-Arabian deserts in Africa and the Mediterranean region. It is native to the Mediterranean Basin and Asia and is distributed among the west coast of northern Africa, eastward through the Sahara, Egypt until India and reaches also the north coast of the Mediterranean and the Caspian seas. It can tolerate annual precipitation of 250 to 1500 mm and an annual temperature of 14.8 to 27.8 °C. It grows from sea level up to 1500 meter above sea level on sandy loam, sub-desert soils, and sandy sea costs with a pH range between 5.0 and 7.8 and the annual temperature required for growing these plants should ideally range between 14.8°C and 27.8°C.

The main objective of present work is to analyse the engine Performance and Emission characteristics of diesel engines fuelled with biodiesel produced from Thumba oil and its blends with diesel fuel, which will help in both the direction of reducing emission problems and search of alternative fuel for CI engines.

2. MATERIAL AND METHOD

2.1 Seed Material

The fresh seeds are collected from wild region of Jodhpur and Jaipur of Rajasthan state, India. The seeds are selected according to their conditions where damaged seeds are discarded and the good conditioned seeds are cleaned. De-shelled and dried at higher temperature at 100-105oC for 30min in oven. Then seeds are processed for oil extraction through mechanical expeller at room temperature.

2.2 Pre-treatment

Filtered Thumba oil is first taken to remove moisture. As water content of the feedstock is major parameter and should be kept below 0.06% w/w for better conversion of oil to esters. Hence the raw oil is kept in an oven at 1050 C for 2-3hrs to remove the water content from the oil. After de-moisture, the oil was filtered to remove suspended particles. The parameters present in trace quantity like carbon residue, un-saponificable material and fibre etc. are removed. The free fatty acid content of raw oil and products after reactions were determined by standard titrimetric methods (ASTM-664). To determine exact molecular weight of Thumba oil, it was analysed by Gas chromatography that gives available fatty acid. As the acid value of Thumba oil was found to be 2.30 mg KOH/gm. So there was no need to go for esterification process. We directly carry out base catalysed transesterification reaction.

2.3 Transesterification reaction

Transesterification or alcoholysis is the displacement of alcohol from an ester by another in a process similar to hydrolysis, except an alcohol is used instead of water. This process has been widely used to reduce the high viscosity of triglycerides. The major components of vegetable oils and animal fats are Triglycerides. To obtain biodiesel, the vegetable oil or animal fat is subjected to a chemical reaction termed transesterification.

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CH2OCOR'"                                CH2OH      R'"COOR
     |                  Catalyst           |
CH2OCOR"  +  3ROH    ------------>       CH2OH  +   R"COOR
     |                                     |
CH2OCOR'                                 CH2OH      R'COOR

Oil or Fat    Alcohol                 Glycerine    Biodiesel
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Fig -1: Transesterification Reaction

Some feedstock must be pre-treated before they can go through the transesterification process. Feedstock with less than 5 % Free Fatty Acid, may not require pre-treatment. When an alkali catalyst is added to the feedstock's (With FFA > 5 %), the Free Fatty Acid react with the catalyst to form soap and water. If methane is used in this process it is called methanolysis.

3. EXPERIMENTAL SET UP

A 2000 ml three necked round –bottom flask was used as a reactor. The flask was placed in heating mantle whose temperature could be controlled within +20C. One of the two side necks was equipped with a condenser and the other was used as a thermos-well. A thermometer was placed in the thermos-well containing little glycerol for temperature measurement inside the reactor. A blade stirrer was passed through the central neck, which was connected to a motor along with speed regulator for adjusting and controlling the stirrer speed. The experimental set up is shown in figure3.1 1000 ml of Thumba oil was measured and poured into a 2000 ml three necked round bottom flask. This oil was heated up to 600C. In 250ml beaker a solution of potassium methoxide was prepared using 0.5, 0.75 and 1.25 wt. % potassium hydroxide pellets with the molar ratio 1:6, 1:8 and 1:10 of oil to methanol were studied. The solution was stirred until the potassium hydroxide pellet was completely dissolved (the mixture was called potassium methoxide solution). The solution was then heated up to 600C and slowly poured into preheated oil. The mixture was stirred (650rpm) vigorously for 10, 20, 30, 40, 50, 60, 70, 80 and 90 min. Finally FFA was checked and mixture was allowed to settle for 24 hours in a separating funnel. Thereafter, upper layer biodiesel was decanted into a separate beaker while the lower layer which comprised glycerol and soap was collected from the bottom of separating funnel. To remove any excess glycerol and soap from the biodiesel, hot water was used to wash it then allowed it to remain in separating funnel until clear water was seen below the biodiesel in the separating funnel. The PH of biodiesel was then tested. The washed biodiesel sample was then dried by placing it on a hot plate and excess water still in the biodiesel removed. These batches were taken to achieve highest yield and to study the effect of these parameters on yield of methyl ester.

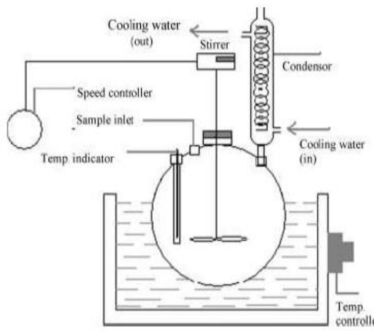

Fig -2: Experimental Set Up For Transesterification of Thumba Oil

4. METHODOLOGY

At present the amount of biodiesel available is less than that of diesel. The biodiesel blended with diesel by volume as B10 (10% thumba oil biodiesel & 90% diesel fuel), B20 (20% thumba oil biodiesel & 80% diesel fuel), B30 (30% thumba oil biodiesel & 70% diesel fuel), B40 (40% thumba veg oil biodiesel & 60% diesel fuel), B50 (50% thumba oil biodiesel

& 50% diesel fuel), B100 (100% thumba oil biodiesel & 00% diesel fuel).
Then the samples were proceed for their property testing's.

Fig -3: Pure biodiesel & Blends of Biodiesel

4.1 Seed characterization

Fresh seeds contain 8-10% of moisture.

4.2 Oil Percentage

The available oil percentage in Thumba seeds is 12-20%. As per our practical trial, we recorded 14% of oil.

4.3 Physicochemical Properties

The fresh extracted crude oil is yellowish brown in colour & it gets darkened during the storage. The oil having slightly sweet odour & bitter taste. All properties were carried out as per American Standards' For Testing & Material (ASTM)-6751.The compressibility effect of the vegetable oil causes an earlier injection of fuel into the engine cylinder as compared to diesel fuel. This earlier injection does not play an important role, as the injection advance difference is at maximum 100C even for the neat vegetable oil. The major difference occurs in atomization process, i.e. the mean droplet size of vegetable oil is much higher than diesel fuel. This is because high viscosity (38.17Cst) and low volatility of vegetable oils lead to difficulty in atomizing the fuel and in mixing it with air.

Table -1: Properties of Thumba biodiesel blend

Test Description		Density	Calorific value	Moisture
Reference Std. ASTM 6751		D1448	D6751	D2709
Reference	Unit	gm/cc	MJ/kg	%
	Limit	.800-.900	34-45	0.05%
B00		0.830	42.50	NA
B05		0.832	42.36	NA
B10		.835	42.09	NA
B15		0.837	42.00	NA
B20		0.840	41.50	NA
B25		0.842	41.10	NA
B50		0.856	40.25	NA
B100		0.872	39.00	NA

A single cylinder, four strokes, water cooled, constant speed, computer controlled, variable compression ratio engine was selected for the tests. Technical specifications of the test engine are given below.

Engine Details:

IC Engine set up under test is Kirloskar TV1 having power 5.20 kW @ 1500 rpm which is 1 Cylinder, Four stroke , Constant Speed, Water Cooled, Diesel Engine, with Cylinder Bore 87.50(mm), Stroke Length 110.00(mm), Connecting Rod length 234.00(mm), Compression Ratio 18.00, Swept volume 661.45 (cc)

Combustion Parameters:

Specific Gas Const (kJ/kgK): 1.00, Air Density (kg/m^3) : 1.17, Adiabatic Index : 1.41, Polytrophic Index : 1.26, Number Of Cycles : 10, Cylinder Pressure Reference : 7, Smoothing 2, TDC Reference : 0

Performance Parameters:

Orifice Diameter (mm): 20.00, Orifice Coeff. Of Discharge: 0.60, Dynamometer Arm Legnth (mm): 185, Fuel Pipe dia (mm): 12.40, Ambient Temp. (oC) : 27, Pulses Per revolution : 360, Fuel Type : Diesel, Fuel Density (Kg/m3) : 830, Calorific Value Of Fuel (kJ/kg) : 42000

RESULT AND DISCUSSION –

Performance parameters

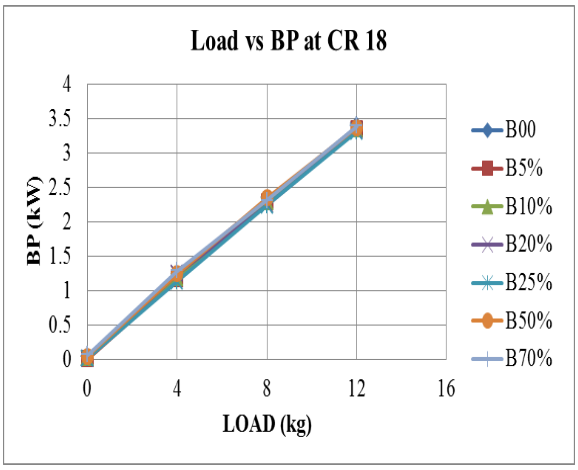

Chart-1: Load vs BP at CR 18

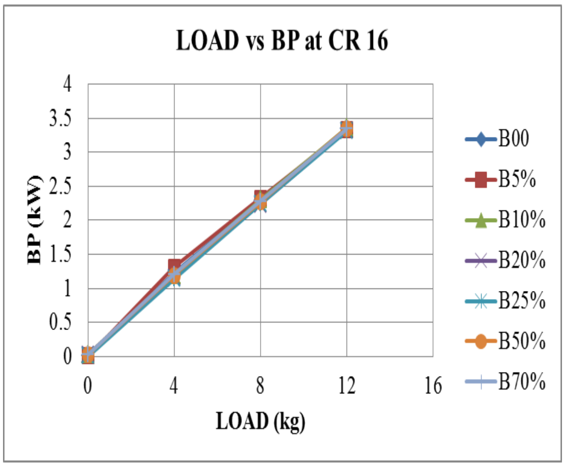

Chart-2: Load vs BP at CR 16

From the above graph plotted load vs BP at CR 16 we get that B00 i.e. pure diesel shows lowest BP. All other blends of Thumba biodiesel compared with diesel shows higher BP.BP increases with increase in load. Considering above graphs at various loads we can select B50 as principle blend for replacing diesel fuel at CR 18 and 16.

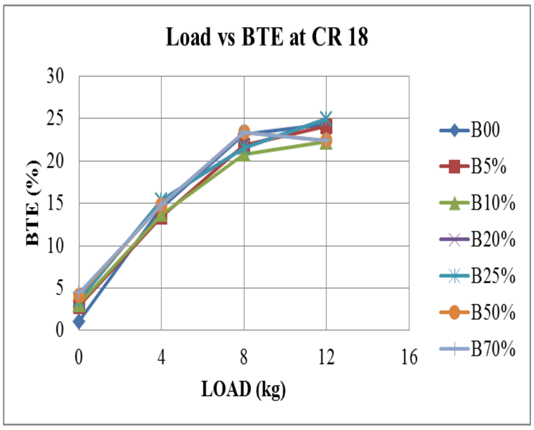

Chart- 3: Load vs BTE at CR 18

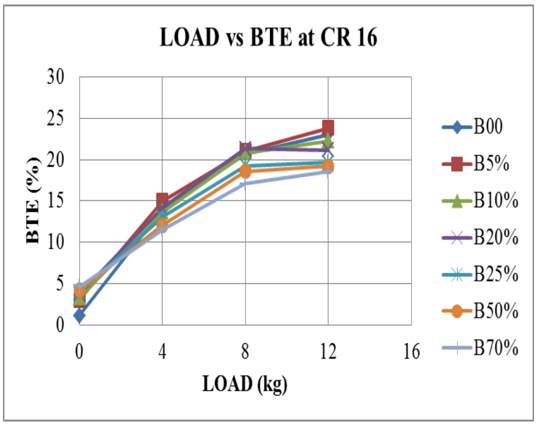

Chart- 4: Load vs BTE at CR 16

From the above graph plotted load vs BTE at CR 16 we get that B00 i.e. pure diesel shows lowest BTE. All other blends of Thumba biodiesel compared with diesel shows higher BTE.BTE increases with increase in load. Considering above graph at various loads we can select B25 as principle blend replacing diesel fuel at CR 18 and 16.

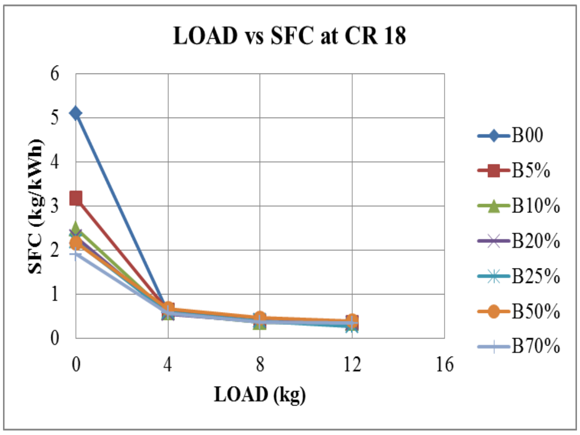

Chart- 5: Load vs SFC at CR 18

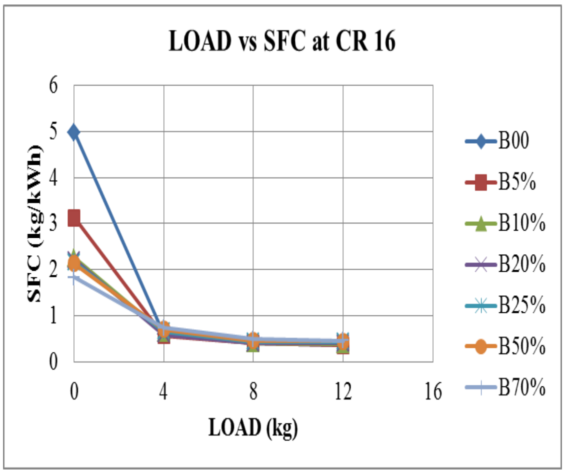

Chart- 6: Load vs SFC at CR 16

From the above graph plotted load vs SFC at CR 16 we get that B00 i.e. pure diesel shows highest SFC. All other blends of Thumba biodiesel compared with diesel shows lower SFC. SFC decreases with increase in load. Considering above graph at various loads we can select B70 as principle blend replacing diesel fuel at CR 18 and 16.

Combustion Parameters

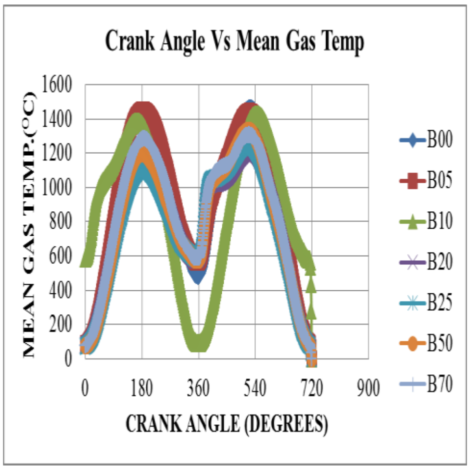

Chart- 7: Crank angle vs Mean gas temperature at CR16 L0

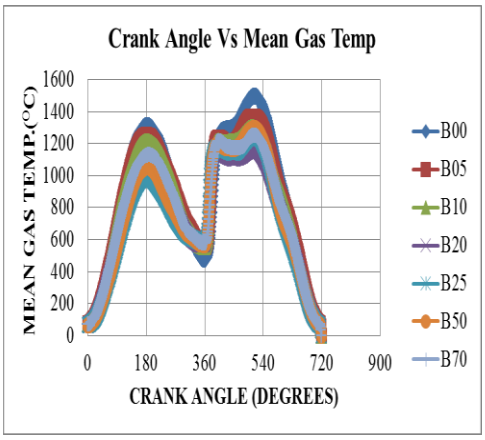

Chart- 8: Crank angle vs Mean gas temperature at CR16 L4

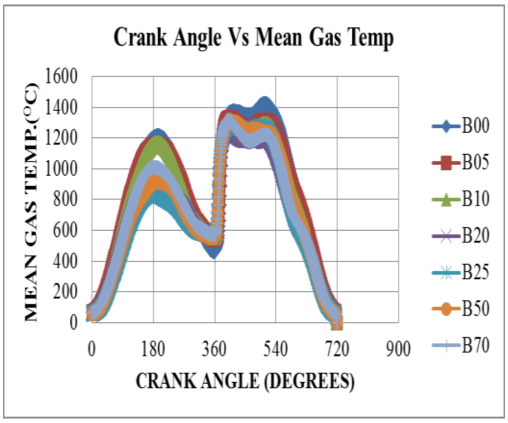

Chart- 9: Crank angle vs Mean gas temperature at CR16 L8

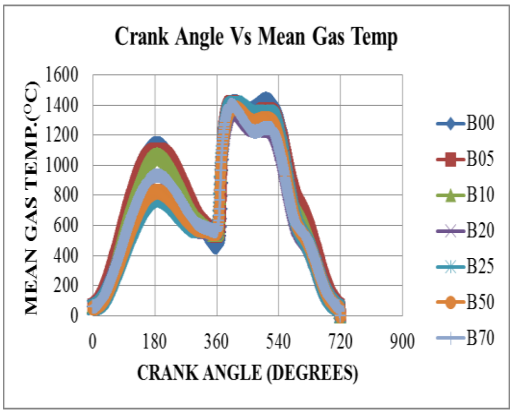

Chart- 10: Crank angle vs Mean gas temperature at CR16 L12

From the above graph Crank Angle Vs Mean Gas Temperature at CR 16 and at load 12 kg we get that B00 i.e. pure diesel shows highest mean gas temperature. All other blends of Thumba biodiesel compared with diesel shows lower mean gas temperature.At 180 degrees & 540 degrees all blends shows highest mean gas temp. While at 0 degrees, 360 degrees, 720 degrees they show lower mean gas temperature.Considering the above graphs we can select B70 as principle blend for replacing diesel fuel at CR16 and all load conditions

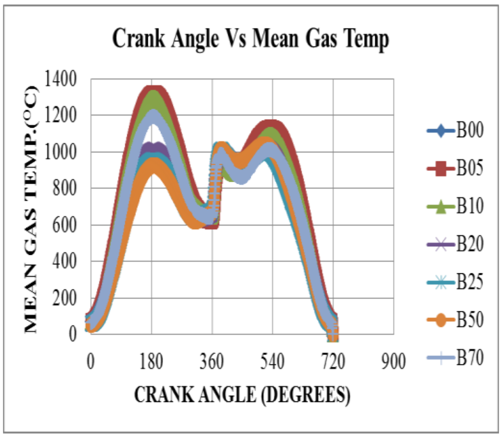

Chart- 11: Crank angle vs Mean gas temperature at CR18 L0

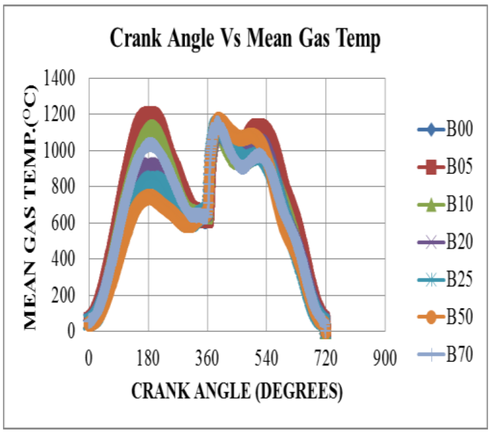

Chart- 12: Crank angle vs Mean gas temperature at CR18 L4

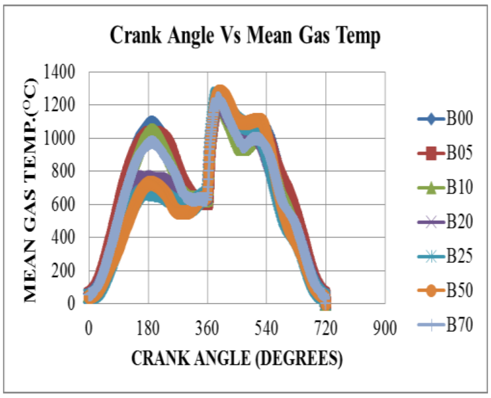

Chart- 13: Crank angle vs Mean gas temperature at CR18 L8

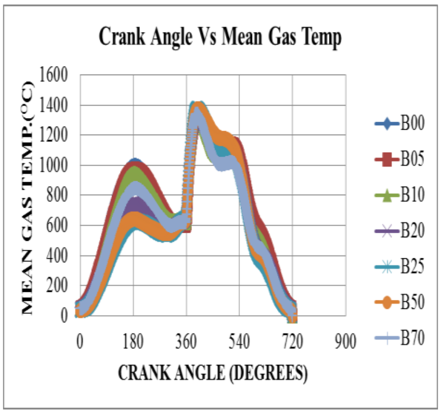

Chart- 14: Crank angle vs Mean gas temperature at CR18 L12

From the above graph Crank Angle Vs Mean Gas Temperature at CR 18 and at load 12 kg we get that B50 shows highest mean gas temperature. All other blends of Thumba biodiesel compared with B50 shows lower mean gas temperature. At 180 degrees & 540 degrees all blends shows highest mean gas temp. While at 0 degrees, 360 degrees, 720 degrees they show lower mean gas temperature. Considering the above graphs we can select B70 as principle blend for replacing diesel fuel at CR16 and all load conditions.

3. CONCLUSIONS

Performance

The biodiesel blends of B50% (combination of Diesel 50% by volume, biodiesel 50% by volume) gave better brake power at all CR. Hence we would suggest B50 as alternate fuel to diesel for better brake power compared to diesel and CR 18 as fundamental CR for optimum output. The biodiesel blends of B25% (combination of Diesel 75% by volume, biodiesel 25% by volume) gave better brake thermal efficiency at all CR. Hence we would suggest B25 as alternate fuel to diesel for better brake thermal efficiency compared to diesel and CR 18 as fundamental CR for optimum output. The biodiesel blends of B70% (combination of Diesel 30% by volume, biodiesel 70% by volume) gave lesser brake specific fuel consumption at all CR. This is due to lower heating value of biodiesel, lower the power generation for the same fuel consumption rate as compared to diesel. Hence we would suggest B25 as alternate fuel to diesel for lesser brake specific fuel consumption compared to diesel and CR 18 as fundamental CR for optimum output.

Combustion

The biodiesel blends of B50% (combination of Diesel 50% by volume, biodiesel 50% by volume) have optimum mean gas temperature compared to diesel at all load and at CR 14.The biodiesel blends of B70% (combination of Diesel 30% by volume, biodiesel 70% by volume) have optimum mean gas temperature compared to diesel at all load and at CR 16.The biodiesel blends of B70% (combination of Diesel 30% by volume, biodiesel 70% by volume) have optimum mean gas temperature compared to diesel at all load and at CR 18.
From the above conclusions, it is proved that the biodiesel could be used as an alternative fuel in VCR engine without any engine modifications.

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