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Construction Material Experimental Investigations of Rubber Seed Oil Methyl Ester–Diesel and Butanol-Diesel Blend by Using Diesel Engine

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Abstract- **In this present study, the Performance, combustion and emission characteristics of rubber seed methyl ester-diesel blend (rubber seed oil methyl ester (20%) + diesel (80%)) were investigated by using diesel engine. Experiment trials were conducted at compression ratio 18:1. Experiments were conducted at constant speed of 1500 rpm and with minimum to maximum load conditions (0%, 25%, 50%, 75% and 100%). The characteristics of rubber seed oil methyl ester diesel blend were compared with the characteristics of diesel-butanol blend and diesel. Performance characteristics of rubber seed oil methyl ester-diesel blend like Mechanical efficiency, volumetric efficiency, brake thermal efficiency, and brake specific fuel consumption, combustion characteristics like cylinder pressure with crank angle, gross heat release rate and mass of fuel burned, and emission characteristics like nitrogen oxide, carbon monoxide unburned hydrocarbon and carbon dioxide were investigated.**

***Keywords*— Rubber seed oil methyl ester, Butanol, Diesel**

I. INTRODUCTION

Rubber seed oil methyl ester (RME) is chemically modified alternative fuel for diesel engine. Rubber seed oil is one of the non edible type of biofuel. The annual rubber seed production potential in India is about 150 kg/hectare. The probable availability of rubber seed production is 30,000 MT per annum and properties of rubber seed methyl ester are comparable with other esters and properties of diesel [1]. Rubber seed oil –diesel blend is more suitable for rural power energy [2]. Engine performance characteristics are inferior in fully renewable fueled engine. Electric power generation from biomass source has also received attention all over the world [3]. Butanol is renewable type of bio fuel, it is less hydrophilic, higher heating value, lower vapor pressure and miscibility than ethanol [4]. Butanol can be used as promising additives to diesel-microalgae biodiesel blends [5]. Alcohols fuels can be used as an oxygenated fuel addictives with fossil based fuels for diesel engine [6]. Butanol can be blended with diesel fuel without phase change [7]. India is in the top ten rubber seed producing countries in the world and Kerala state is the top leading rubber seed plantation state of India [8].

Literature review reveals that, blends of rubber seed oil formed with diesel [ROME (20%) + diesel (80%)] and [Diesel (80%) + butanol (20%) were not tested. Hence current work focus to investigate the effects of adding diesel in the esterified rubber seed oil and to compare its performance, combustion and emission characteristics with the characteristics of diesel-butanol blend [diesel (80%) + butanol (20%)] and only diesel (100%).

II. EXPERIMENTAL INVESTIGATION

Experimental Set up

The engine set up (schematic diagram) consists of single cylinder, four stroke diesel engine. The diesel engine connected to water cooled eddy current dynamometer for the addition of the load from no load condition (0%) to full load condition (100%). Experimental setup was provided with essential instruments for combustion pressure and top dead center pulse crank-angle measurements. Experimental set-up is also prepared for interfacing parameters measurement like air flow rate, fuel flow rate, temperatures, and load. Experiment set-up consists of mild steel fabricated air box with air flow transmitter was used for measurement of air supplied to engine and fuel tank with glass fuel metering column for fuel flow rate measurement. DP type fuel flow transmitter was used for measurement of fuel flow. Digital load indicator was used for indication of load. Strain gauge type load cell sensor was used for load sensation and two water rotameters were used for water flow measurement to engine cooling and calorimeter. These enable the experimental setup to study different performance and combustion characteristics of fuels. Lab view based engine performance and combustion analysis software package “Engine soft LV” was used.

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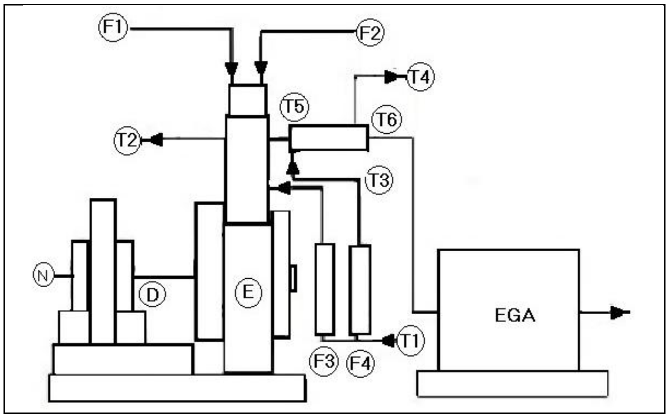

Fig. 1. Schematic diagram

Table1 Schematic diagram symbols (Fig. 1)

Symbols	Meaning
F1	Fuel flow
F2	Inlet air flow rate
F3	Water flow rate to jackets
F4	Water flow rate to calorimeter
T1	Inlet water temperature of jacket
T2	Out let water temperature of jacket
T3	Calorimeter inlet water temperature
T4	Calorimeter outlet water temperature
T5	Exhaust gas temperature
T6	Exhaust gas temperature after calorimeter
D	Eddy current dynamometer system
E	Diesel engine cylinder
N	Speed of engine
EGA	Exhaust gas analyzer

Table 2 Engine specifications.

Engine part	Specifications
Make	Kirloskar Private Limited
Number of cylinder	1
Number of stroke	4
Bore diameter	87.5 mm
Stroke length	110 mm
Rated power	3.5 kW
Product	234
Combustion chamber shape	Hemispherical bowl

Table 3 Properties of fuels.

Name of fuel	Density of fuel (kg/m3) –	Lower heating value (kJ/kg)
RME (B20)	846	40500
Butanol (20%) - Diesel (80%)	814	34500
Diesel	829	42000

III. EXPERIMENTAL METHODOLOGY

Performance, combustion and emission characteristics analysis were carried out for RME (20%) + diesel (80%). Performance, combustion and emission characteristics of RME- diesel blend were compared with the characteristics of diesel-butanol blend and diesel by varying the load on engine from no load condition to full load condition at compression ratio 18:1. Experiments were conducted by using single cylinder four stroke variable compression ratio diesel engine at constant speed.

For every operating conditions, different performance characteristics (like mechanical efficiency, brake thermal efficiency, volumetric efficiency, and brake specific fuel consumption), combustion characteristics (like cylinder pressure with crank angle, mean gas temperature mass fraction inside the cylinder, and cumulative heat release with crank angle), and emission characteristics(like carbon monoxide, carbon dioxide, HC, and NO_x) were investigated.

IV. RESULT AND DISCUSSIONS

Performance characteristics of Rubber seed oil methyl ester diesel blend (B20) and Diesel butanol blend

Fig. 2. Shows the effect of mechanical efficiency with load, brake power value after using rubber seed oil methyl ester (RME) - diesel, butanol-diesel and, diesel slightly same for compression ratio-18:1 and brake power increases with increase in load on the engine. Brake power is function of torque and speed of engine. Torque values of all blends increases from no load condition to full condition, then mechanical efficiency increases with increases in load percentage from no load condition to full condition.

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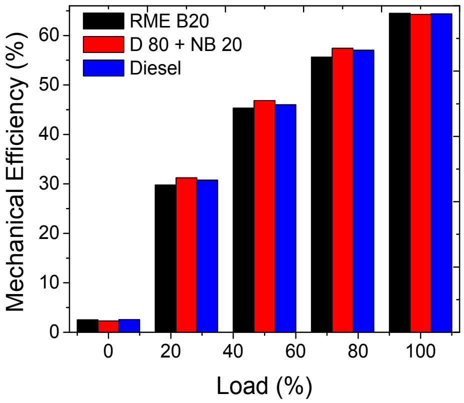

Fig. 2 Mechanical efficiency with load

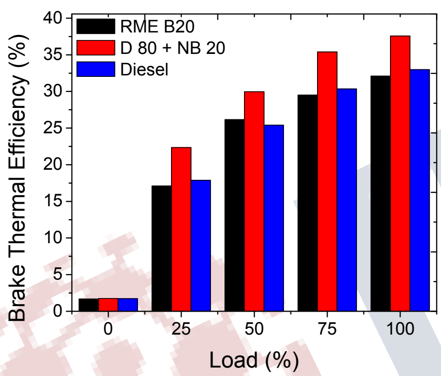

Fig. 3 Brake thermal efficiency with load

Variation of brake thermal efficiency with load on the engine for RME-diesel blend, butanol-diesel, and diesel is as shown in Fig. 3. Brake thermal efficiency of each fuel was increasing with increase in load because for given value of calorific value (Table 3), the brake thermal efficiency is the function of ratio of brake power and mass fuel flow rate of fuel and this ratio was increasing with increase in load. Brake thermal efficiency of diesel-butanol blend was more than RME-diesel blend and diesel.

The brake specific fuel consumption variation with load for RME-diesel, butanol-diesel, and diesel was shown in Fig. 4. Brake specific fuel consumption is the functional ratio of fuel flow rate (kg/hr) to the brake power. The brake specific fuel consumption of diesel decreases with increases in load percentage from no load condition to full conditions.

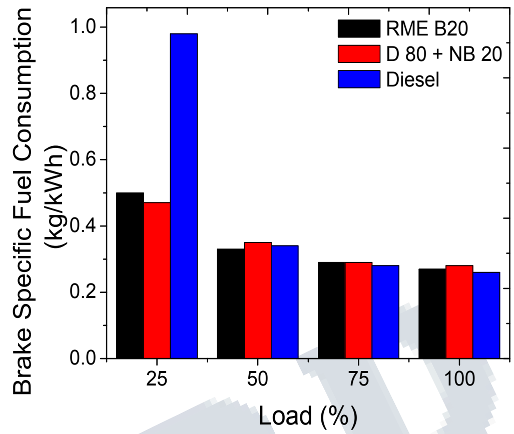

Fig. 4 Brake specific fuel consumption with load

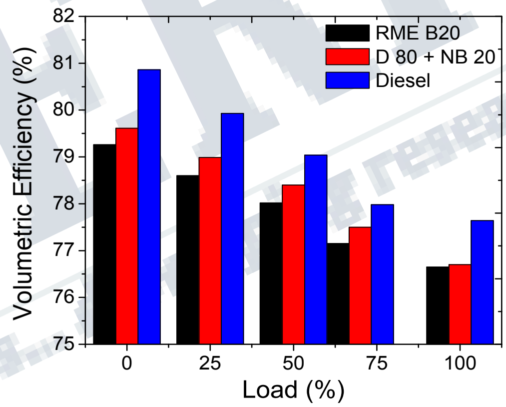

Fig. 5. Volumetric efficiency with load

Fig. 5 shows the variation of volumetric efficiency with load percentage. Volumetric efficiency means it is the breathing capacity of engine. The volumetric efficiency decreases at higher load conditions and volumetric efficiency of diesel was more than diesel-butanol and RME-diesel blend. The volumetric efficiency of diesel-butanol is slightly more than RME-diesel blend.

Combustion characteristics of Rubber seed oil methyl ester diesel blend (B20) and Diesel butanol blend

Fig. 6. Shows the comparison of cylinder pressure for RME-diesel blend, butanol-diesel blend, and diesel with crank angle. For all the fuels peak pressure occurs suddenly after 10° top dead center (TDC) position. The peak pressure for

diesel (73 bar) was more than RME-diesel (53bar) and butanol-diesel (53bar) blend. It is observed that pressure in the cylinder rises rapidly after start of combustion (SOC) with movement of piston from bottom dead center (BDC) to TDC. Combustion process occurs in form of uncontrolled, controlled and after combustion stages.

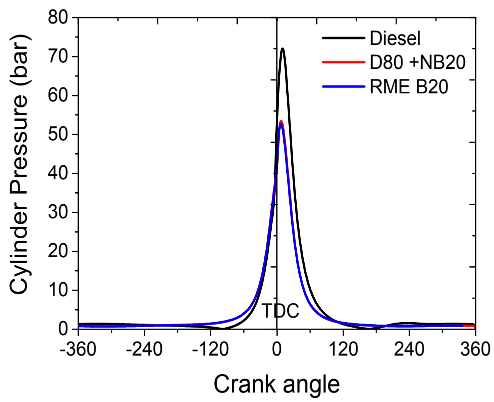

Fig. 6. Cylinder pressure with crank angle

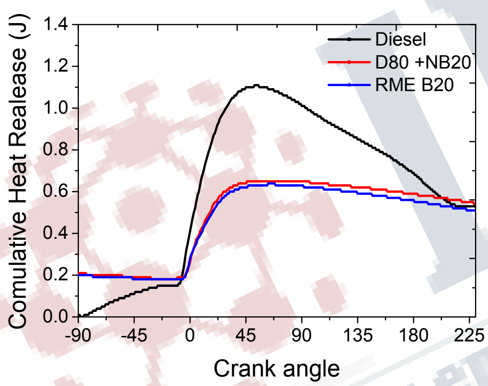

Fig. 7. Cumulative heat release with crank angle

Fig. 7. Shows the effect of cumulative heat releases rate with crank angle. Cumulative heat release rate was more for diesel than RME-diesel and diesel-butanol blends. The lower heating value of diesel was more than other selected fuels. Maximum cumulative heat release rate was occurs at 45° after TDC position for all the selected fuels.

Fig. 8 shows the variation effect of mass fraction burned with crank angle. Mass fraction burned increases rapidly with start of combustion at 20° before TDC. End of combustion occurs after TDC 30°. Mass fraction burned for diesel was more than RME-diesel and butanol-diesel blend.

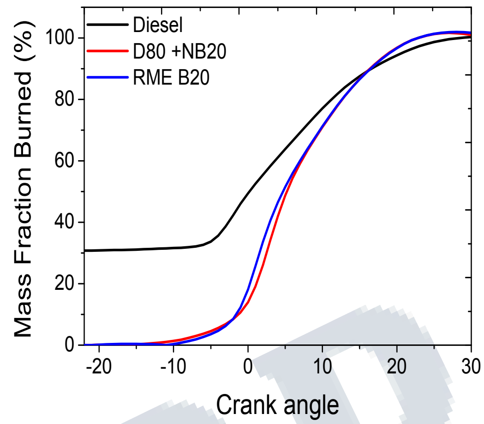

Fig. 8. Mass fraction burned with crank angle

Emission characteristics of Rubber seed oil methyl ester diesel blend (B20) and Diesel butanol blend

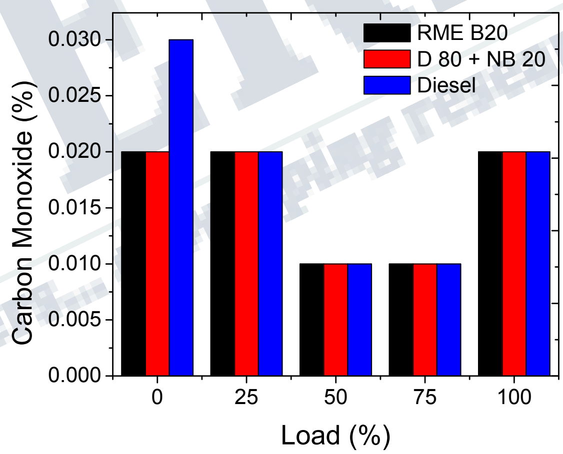

Fig. 9. Carbon monoxide with load

As shown in Fig. 9, carbon monoxide content was almost nil (maximum 0.03%).. This is being justified by percent content of carbon monoxide present in the exhaust gas shows the complete combustion of blends in combustion process. It clearly indicates that there was complete combustion of all the fuels.

Fig. 10 shows the comparison of carbon dioxide emissions of RME-diesel blend, butanol-diesel, and diesel. It is observed that, carbon dioxide content in the exhaust gas was not more than 2.1% at full load condition. Carbon dioxide emissions increase with increases in load percentage. Carbon dioxide emissions of diesel was more than RME-diesel and diesel-butanol blend.

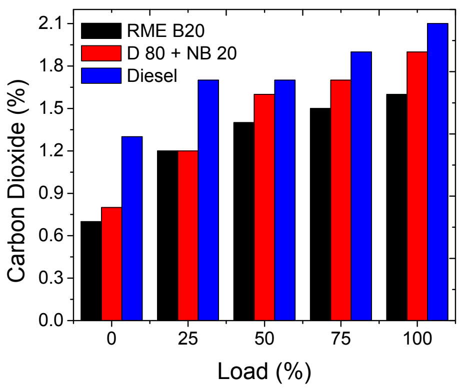

Fig. 10 Carbon dioxide with load

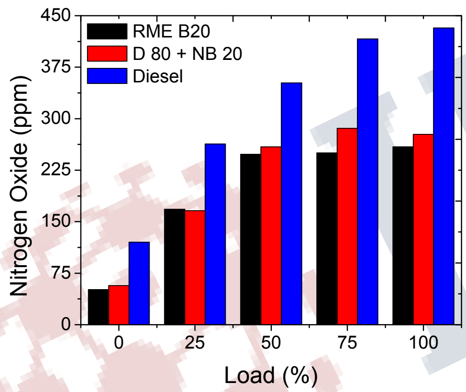

Fig. 11. Nitrogen oxide with load

Fig. 11 shows the variation of nitrogen oxide with load on the engine. NOx emission increases with increase in load percentage. This is because exhaust gas temperature increases with increase in load because of increase in fuel combusted at higher load conditions. NOx emissions of diesel were much higher than RME-diesel and diesel-butanol blends.

Fig. 12. Shows the variation of hydrocarbon with the load percentage. HC emissions were more for diesel than RME-diesel blend and diesel-butanol blend. HC emissions are increases with increase in load percentage from no load to full load condition. HC emissions content in the exhaust gas was not more than 16 (ppm) at full load condition,

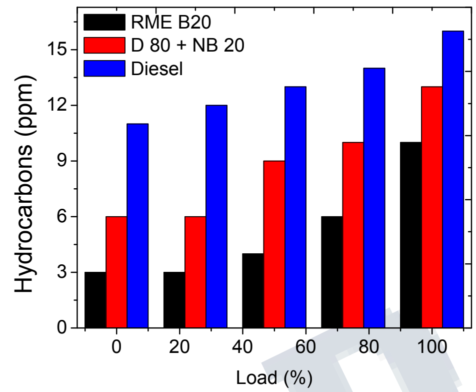

Fig. 12. Hydrocarbons with load

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V. CONCLUSION

Conclusions regarding comparisons of characteristics of RME-diesel with diesel-butanol and diesel at compression ratio 18:1 are listed below.

- Mechanical efficiency increases with increases in load percentage from no load condition to full condition.
- Brake thermal efficiency of diesel-butanol blend was more than RME-diesel blend and diesel.
- The brake specific fuel consumption of diesel decreases with increases in load percentage from no load condition to full conditions.
- The volumetric efficiency decreases at higher load conditions and volumetric efficiency of diesel was more than diesel-butanol and RME-diesel blend. The volumetric efficiency of diesel-butanol is slightly more than RME-diesel blend.
- Carbon dioxide emissions of diesel was more than RME-diesel and diesel-butanol blend.
- NOx emissions of diesel were much higher than RME-diesel and diesel-butanol blends.
- HC emissions were more for diesel than RME-diesel blend and diesel-butanol blend.

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Abbreviations

BDC	Bottom dead center
CO	Carbon monoxide
CO_2	Carbon dioxide
HC	Hydrocarbons
NO_x	Nitrogen oxides
RME	Rubber seed oil methyl ester
TDC	Top dead center