Effect of additives on the performance characteristics of VCR engine fuelled with Karanja oil and blends by varying injection pressure

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ABSTRACT

An experimental study is accomplished to assess the influences of methanol, ethanol and diethyl ether as additives to Karanja oil blends on the performance analysis of a four-stroke VCR-CI single cylinder diesel engine. The fuels considered for testing is denoted as B20 (20% karanja oil and 80% petrodiesel by volume), B20+5%DEE (5% diethyl ether, 20% karanja oil and 80% petrodiesel by volume), B20+5%E (5% ethanol, 20% karanja oil and 80% petrodiesel by volume), B20+5%M (5% methanol, 20% karanja oil and 80% petrodiesel fuel by volume), B20+10%DEE (10% diethyl ether, 20% karanja oil and 80% petrodiesel by volume), B20+10%E (10% ethanol, 20% karanja oil and 80% petrodiesel by volume) and B20+10%M (10% methanol, 20% karanja oil and 80% petrodiesel by volume) respectively. The fuel injection pressure is retarding 20 bar and advancing 20 bar and 40 bar from the standard injection pressure (fuel) of 200 bar which gives the injection pressures of 180, 220 and 240 bar. Analysis of performance parameters is investigated by the IC Engine analysis software which has been coupled with the VCR Engine. The outcome of data of these blends is to be associated with the petrodiesel. At higher engine load, performances of all tested fuels are almost same and comparatively diethyl either is more competent than standard diesel at 220 bar fuel injection pressure. As higher injection pressure (240 bar) and lower injection pressure (180bar) is giving a lower performance when related to standard diesel fuels. The experimental results depicted that the lower contents of diethyl ether and methanol along with karanja oil blend is more efficient when compared to petrodiesel ant it can be a substitute for the petrodiesel without any alteration in diesel engines.

Keywords: *Karanja oil, Transesterification process, Diethyl ether, Ethanol, Methanol, VCR Engine, performance characteristics, Injection pressure.*

I. Introduction

Biodiesel is renewable petroleum created from vegetable and mammal fats, which can be operated in diesel engines with small changes or not any alteration. The increasing worldwide concern has focused on the blends of oxygenated diesel fuels due to the natural hazards from engines[1]. Vegetable oil has a less amount of heating (calorific) value than the diesel oil and this is due to oxygen present in the molecules of vegetable oils. Vegetable oil encompasses a cetane number of a span about 35 - 40 and diesel fuel encompass a cetane number value of 45 [2].The biodiesel is a more attractive replacement for engines are operated by petroleum diesel. Since, it is a sustainable and non- adulterated fuel that can be formed from shrub and mammal fats. Biodiesels are releasing a smaller amount of pollutants (except NOx) than petroleum diesel. But the extensive complication emerges for the commercialization of biodiesel is its cost[3, 4].The divergent vegetable oil used for the invention of biodiesel categorized as jatropha oil, mahua oil, karanja oil, palm oil, soyabean oil, sunflower oil, soyabean oil etc. Soya oil, Palm oil, Sunflower oil is palatable oils therefore it cannot be implemented for biodiesel manufacture. Alternatively karanja oil are in-edible oil and are efficient because of easy availability and little production cost[5]. The pongamia pinnata (L.) Pierre is a tremendous growing tree with the proficiency for large oil seed manufacture and the additional advantage of the capability to grow up on poor soiled land. This charateristics promote the appropriate vegetable oil manufacturing through large scale industry. Pongamia pinnata is identified as a sustainable biofuel feedstock of the forthcoming days inspite of its enormous making of oil-rich seeds, tolerance to abiotic stress, and capacity to endure biological nitrogen fixation (diminishing nitrogen inputs) [6, 7]. It is renewable, harmless and non polluting resource of energy[8].The combination of 20% biofuel (B20) and lesser can be applied in diesel apparatus without any alteration in diesel engine. Biodiesel is gaining further and additional significance as a substitute fuel because of the reduction of petroleum components and the cost scramble of petroleum products [9-11].

The pongamia pinnata trees are implanted aside the highways, roads, trenches to block soil erosion. The large voluminous numbers of trees grow all over India. If the seeds grown besides road side are gathered and oil is expelled at rural level, some million tons of oil will be obtained for igniting the lamps in rural area. It is the excellent alternative to kerosene [12]. The non edible cleaned Karanja, jatropha and polanga oil are produced as biodiesel and mixed with diesel are analyzed in diesel engines. The ignition delays were measured through investigation is minimum for neat Polanga and Karanja biodiesel when measured with diesel. [13]. The elevated viscosity of vegetable oil and small calorific value affects the atomization and squirt creation of fuel, leading to unfinished combustion, carbon authentication, injector harsh and piston ring downhill. Transesterification is the method to change the vegetable oil into creating fresh, low viscosity and green fuel [14]. The performance elements such as mechanical efficiency, thermal efficiency, BSFC, brake power and indicated power. These performance parameters are arrived by the IC Engine analysis software which has been coupled with the VCR Engine. The analysis depicts that different parameters ranging from the thermal efficiency, CO and NO_X emissions are very nearer to mineral diesel for lower blend concentrations. But, it is detected that for higher blend concentrations, emissions and performance were comparatively much lower than diesel [15]. The Railways system in India is now planning to impart in biodiesel up to 5% of the entire fuel consumption of over 4000 diesel locomotives and to obtain the emissions and performance of this different biofuels are analyzed. In this analysis, a dual biodiesel blend, particularly palms (Elaeis guineensis) and jatropha (Jatropha curcas) in diesel is examined for investigation in a DI diesel engine (single cylinder). Experimental results confirmed that the engine outlet gas temperature for the majority of the biodiesel blends was decreased [16]. The fuel composition encompasses characteristics of karanja oil (KME) and its combination with diesel range of 20% - 80% and applying these fuels in a diesel engine are studied. Engine analysis was conducted with the scope of getting comparative measures of torque, power, Brake-specific fuel consumption (BSFC) and emissions likely CO, smoke density and NOx to measure and calculate the characteristics of the diesel engine tested on the above specified fuels. The exhaust emissions decrease along with rise in torque, thermal efficiency, brake power and decreases in BSFC made the mixture of karanja oil blends of B20 and B40 was best proxy fuel for diesel [17]. The influence of dimethyl carbonate(DMC) as additive in calophyllum inophyllum oil (CIME) is integrated with diesel blends on an engine emission norms and performance characteristics. By varying the compression ratios (CR) for 20% and 40% biodiesel using a VCR engine are investigated. Based on the results, it seems that the DMC added with CIME -diesel blends have improved the thermal efficiency up to 3% and an increase in BSFC of about 2.7% and 5.3% of higher CR [18]. An experiment was conducted to study the influences of ethanol and diethyl-ether as additives to diesel/biodiesel blends on the performance, emissions and combustion study of a DI diesel engine. Based on the experiment's findings, there is a marginal increase of BSFC to 5% when compared with 30% biodiesel. Radical decrease in smoke is inferred with 5% ethanol (E) and 5% diethyl ether (DEE) at maximum engine loads. The estimated values of oxides of nitrogen emission with 5% E are superior to other additives. HC emissions are comparatively superior for 5% E and 5% DEE, but CO is slightly inferior. HC emissions are noticeably greater for 5% E and 5% DEE, but CO_2 is considerably inferior. The rate of peak pressure rise and the maximum heat release rate of 5% DEE is nearly analogous to blend of B30, and better than those of 5% E at minimal engine loads [19]. An experiment is conducted to interpret the influences of pressure of fuel injection on the combustion process and emissions of a DI diesel engine run by a diesel solution which contains orange skin powder (OSPDS). The diverse fuel pressures of 255, 235 and 215 bar are analyzed. The outcome shows that the pressure of engine cylinder at 235 bar pressure of fuel injection with 30% OSPDS are soaring when compared with diesel fuel, further at other injection pressures. The HC, CO, BTE and NOx emission are improved at 235 bar when measured with other fuel injection pressures and also it is comparatively low when measured with diesel fuel [20]. The experiment was done with a diesel engine (single cylinder) with high linolenic-flax oil operated at a uniform speed by varying the fuel injection of 240, 220 and 220 bar respectively. The main objective is to interrogate the outcome of injection pressures on performance analysis, combustion and emission norms of the engine. The analysis shows that the optimal fuel injection pressure is 240 bar with linseed oil and thermal efficiency is analogous to standard diesel. The reduction in CO, UHCs and emissions of smoke with a raise in the NO_x was noticed [21-23].

II. Experimental setup

The engine unit contains a single cylinder with 4-stroke research engines with adjustable compression ratios associated to eddy current dynamometer. It is attached with necessary devices for crank-angle, fuel flow, combustion pressure, airflow, load measurements and temperatures. These signals are incorporated to computer through data acquisition device. This arrangement has a separate controlling unit which contains air box, twin fuel tank, manometer, measuring unit of fuel, transmitters for flow measurement air of fules, process indicator and the piezo powering unit.

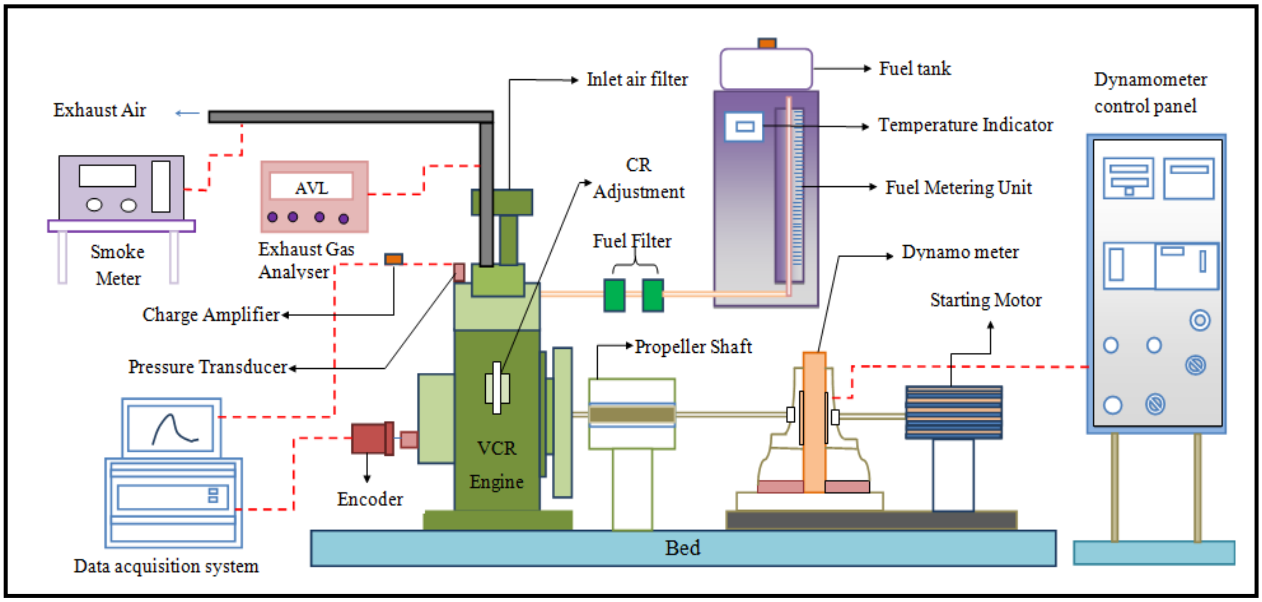

Fig.1 Experimental Setup

The flow of calorimeter water and cooling water are measured by rotameters. The setup permits the performance study of both diesel/petrol mode with VCR engine and revision of ECU programming. The engine performance analysis includes BHP, IP, FP, BMEP, IMEP, thermal efficiency, A/F ratio, and volumetric efficiency, mechanical efficiency, SFC, heat balance and ignition behaviours.

Table 1: Configuration of the VCR Engine

Make	Kirloskar
General details	4S- Water cooled, Adjustable Compression Ratio Engine
Rated power	3.5kW at 1500 rev/min
Speed	1500 rev/min (constant)
No of cylinder	One
Compression Ratio Range	12 - 18
Bore x Stroke length	87.5 x110 millimeter
Ignition	Compression ignition

The blends used in these experiments are diesel, B20, B20+5%DEE, B20+10% DEE, B20+5%E, B20+10%E, B20+5%M and B20+10%M. The performance of the engine under different engine load conditions (No load, 25%, 50%, 75% and full load) is studied for various blends.

III. Results and Discussion

The outcomes of performance characteristics of the different injection pressure of engine fuelled by karanja oil and various additives (Diethyl ether, Ethanol, Methanol) at various injection pressures of 180bar, 220bar and 240bar have been explained with the figures below.

A. Brake Thermal Efficiency

Fig.2 evaluates the BTE using karanja oil with additives in diesel. It can be noticed that the BTE of an engine with all blends of karanja oil follows a comparable trend as that of diesel and increases with the engine load. Further, BTE with karanja oil with ethanol as additive is lower than that of diesel at all engine loads. This may be attributed the lower heating (calorific) value, higher values of viscosity and density of blends compared to that of standard diesel. The maximum BTE for blend containing 5% diethyl ether and 5% ethanol is 31.93% and 33.20% of injection pressure at 180bar. At ultimate load operation, brake power of karanja oil and additives of B20, B20+10%DEE, B20+10%E and B20+10%M are 29.50%, 31.35%, 28.91% and 31.12%, respectively, and its value is a comparatively nearby value to the diesel is 30.62%. Fig.3 shows the engine operates at 220 bar, the maximum BTE was observed for blend containing diethyl ether is 32.24%. The engine operates at full load, the brake power of karanja oil and additives of B20, B20+5%M, B20+10%E and B20+10%M are 31.58%, 31.52%, 32.15%, 30.73% and 29.58% respectively. The BTE of blends is a comparatively nearby value to the diesel fuel, measuring BTE value of 29.84%.

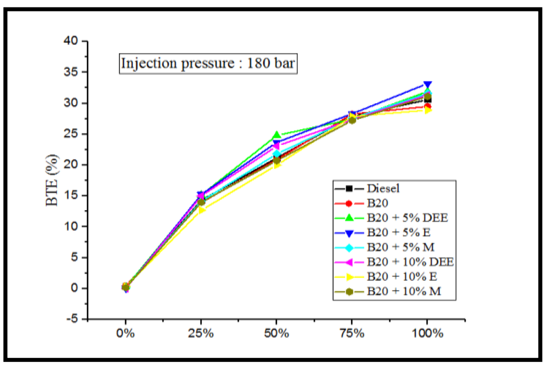

Fig. 2: Assessment of Thermal efficiency (Brake) with load at 180bar

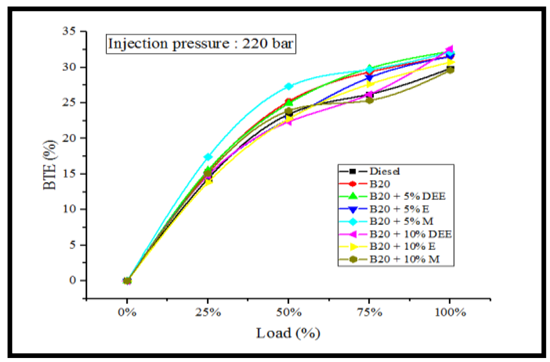

Fig.3: Assessment of Thermal efficiency (Brake) with load at 220bar

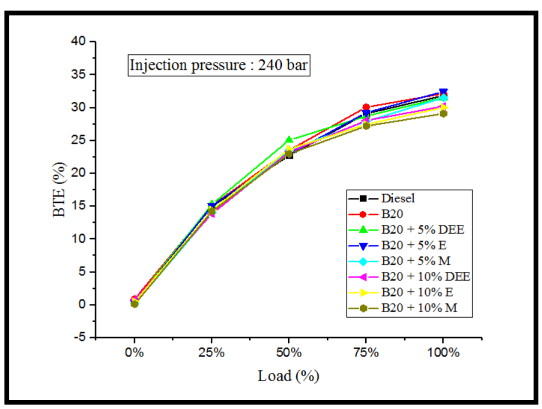

Fig. 4: Assessment of Thermal efficiency (Brake) with load at 240bar

Fig.3 depicts the engine operates at 240bar, the maximum BTE for blend containing ethanol is 32.46%. At full load operation, BTE of Karanja oil and additives of B20, B20+5%DEE, B20+10%M, B20+10%DEE, B20+10%E and B20+10%M are 32.15%, 31.54%, 31.52%kW, 30.22%, 30.04% and 29.11% respectively. This is finalized that the BTE was elevated by the addition of additives with karanja oil. The BTE of all blends is very close to injection pressure (fuel) of 220bar compared to other injection pressures and 5% diethyl ether is more competent than other additives.

B. Indicated Thermal Efficiency

Fig.5 evaluates indicated thermal Efficiency (ITE) at diverse loads at an injection pressure (fuel) of 180 bar. At full load, ITE of engine operated with karanja oil of B20+5%DEE, B20+5%E, B20+5%M, B20+10%DEE, B20+10%E and B20+10%M is calculated as 68.28%, 65.23%, 67.82%, 68.48%, 66.64% and 67.16% respectively. The ITE values of blends obtained are slightly nearer to diesel fuel.

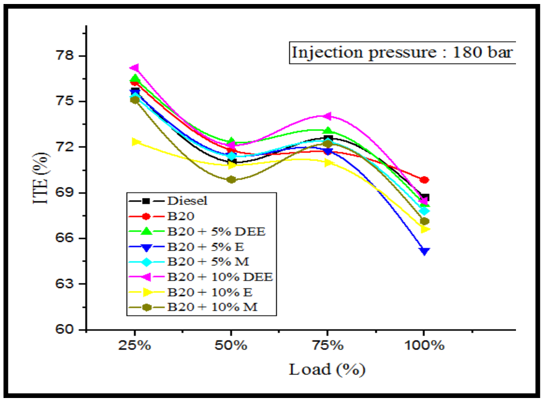

Fig. 5: Assessment of Thermal efficiency (Indicated) with load at 180ba

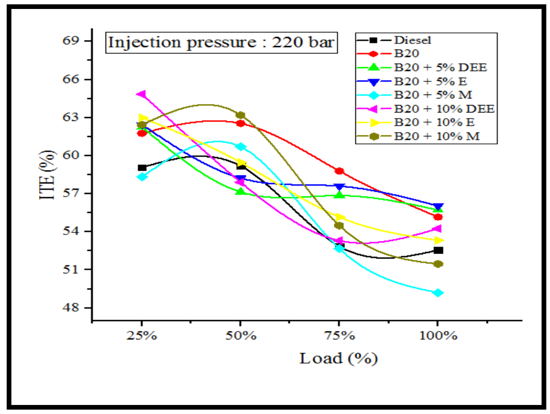

Fig. 6: Assessment of Thermal efficiency (Indicated) with load

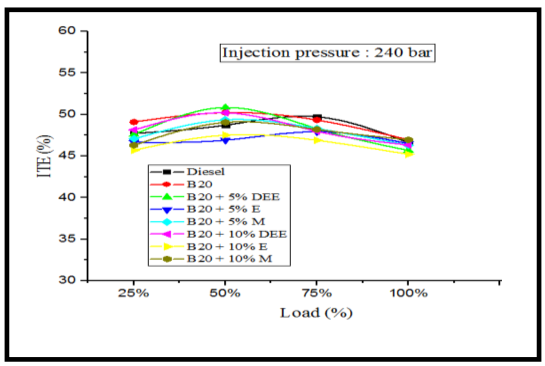

Fig. 7: Assessment of Thermal efficiency (Indicated) with load at 240bar

Fig.6 illustrate the ITE of engine under different loads at an injection pressure (fuel) of 220 bar. At full load, ITE of engine operated with karanja oil blends of B20+5%DEE, B20+5%E, B20+5%M, B20+10%DEE, B20+10%E and B20+10%M is estimated as 55.72%, 56.04%, 49.22%, 54.26%, 53.33% and 51.48% respectively. When elevated with diesel, the ITE of blend results is relatively closer at an injection pressure (fuel) of 220 bar. Fig.7 shows the ITE under different loads at an injection pressure (fuel) of 240 bar. The engine runs at full load, ITE of the engine for Karanja oil blends of B20+5%DEE, B20+5%E, B20+5%M, B20+10%DEE, B20+10%E and B20+10%M is estimated as 45.67%, 46.51%, 46.32%, 46.34%, 45.21% and 46.95% respectively. It is revealed that ITE slightly decreases as an increased injection pressure (fuel) due to the soaring viscosity of the blends and poor penetration of fuel during the combustion process.

C. Mechanical Efficiency

Fig. 8 portrays the Mechanical efficiency under different loads at an injection pressure (fuel) of 180 bar. The engine operates at full load, maximum mechanical efficiency of engine was obtained with blends of B20+5%M and B20+10%M is estimated as 68.98% and 69.54% respectively. The estimated Mechanical efficiency of blends are analogous to diesel fuel. Fig.9 shows the mechanical efficiency of engine under different loads at an injection pressure (fuel) of 180 bar. At full load, maximum mechanical efficiency of the test engine with blends of B20+5%DEE and B20+10%DEE is estimated as 58.65% and 60.04% respectively.

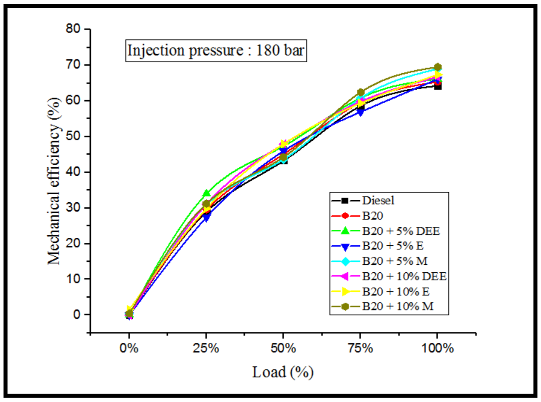

Fig. 8: Assessment of mechanical efficiency with load at 220bar

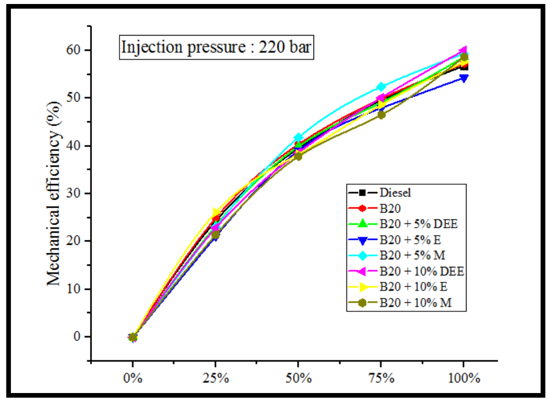

Fig. 9: Assessment of mechanical efficiency with load at 180bar

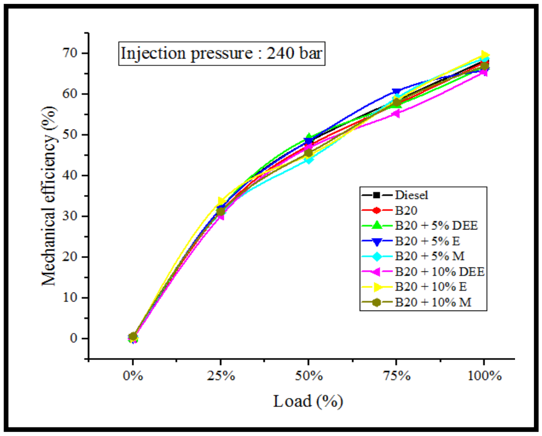

Fig. 10: Assessment of mechanical efficiency with load at 240bar

Fig.10 portrays the Mechanical efficiency of the test engine under different loads at an injection pressure (fuel) of 220 bar. At ultimate load operation, maximum mechanical efficiency was obtained with blends of B20+5% M and B20+10%E is estimated as 68.86% and 69.73% respectively. The estimated mechanical efficiency of blends is comparable to the diesel fuel and there is a uniform increase in mechanical efficiency for karanja oil blends with respect to increasing load. The above findings are dependent on better mixing process and improved atomization at higher injection pressure (fuel).

D. Brake-Specific Fuel Consumption

Fig.11 depicts the effect of Brake-specific fuel consumption (BSFC) for various blends of karanja oil with additives and diesel fuel at an injection pressure of 180 bar. Fuel consumption is to assess the quantitative fuel consumption of given blends and depends on a number of parameters, namely the calorific value, air-fuel ratio and performance of the engine process. At full load, minimum BSFC is observed with blends of B20+5% DEE, B20+5%M and B20+10% DEE is estimated as 0.27, 0.27 and 0.26 kg/kW-hr correspondingly. The value of BSFC for remaining blends is increased as compared to standard diesel. The findings are dependent on collective effects of the minimal heating value, poor atomization and high density of the fuel.

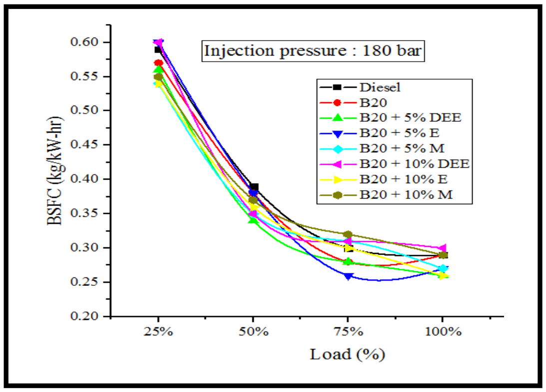

Fig. 11: Assessment of BSFC with load at 180bar

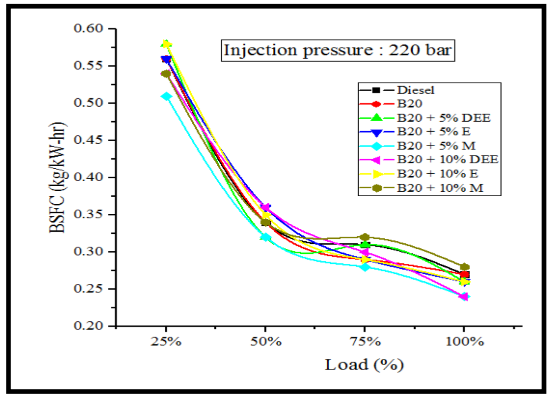

Fig. 12: Assessment of BSFC with load at 220bar

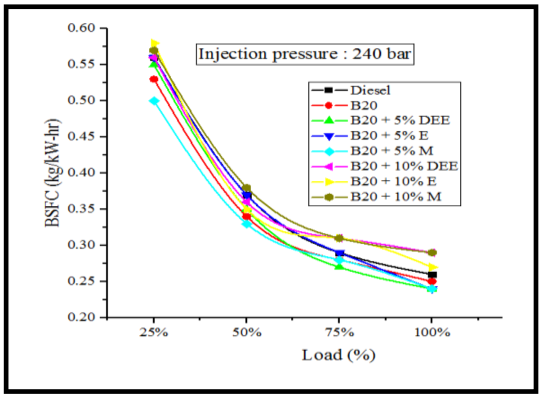

Fig. 13: Assessment of BSFC with load at 240bar

Fig.12 depicts the effect of BSFC for various blends of karanja oil with additives and diesel fuel at an injection pressure (fuel) of 220 bar. The engine works under full load operation, the minimum BSFC with blends of B20+5% DEE, B20+5%E, B20+5%M and B20+10% DEE is estimated as 0.26, 0.26, 0.24 and 0.24 kg/kW-hr respectively. Fig.13 depicts the effect of BSFC for various blends of karanja oil with additives and diesel fuel at an injection pressure (fuel) of 220bar. The engine operates under full load operation, the minimum BSFC with blens of B20+5% DEE, B20+5%E and B20+5%M is estimated as 0.24, 0.25 and 0.24 kg/kW-hr respectively.

IV. Conclusion

The paper experimentally studies the performance analysis of four-stroke VCR-CI diesel engine operates under 20% karanja oil (B20) with 5% and 10% of diethyl ether, methanol and ethanol as an additive by varying the injection pressures of 180 bar, 220bar and 240bar. The engine works under full load, blends of B20+5%DEE was achieved the maximum indicated thermal efficiency at 68.41% at 180bar. The ITE gradually decreased with increasing the injection pressures due to improved penetration of biodiesel during combustion. The blends of B20+5%M and B20+10%M attain maximum mechanical efficiency as 68.98% and 69.54% respectively at 180bar when considered with other blends. The engine operated under full load, maximum mechanical efficiency is obtained with blends of B20+5%M and B20+10%E are predicted as 68.86% and 69.73% respectively at 220 bar. These blends are identical to diesel fuel because of better atomization and improved mixing process at higher injection pressures. The blends of B20 + 5% DEE and B20+5%E are achieved minimum BFSC as 0.24 kg/kW-hr and 0.24 kg/kW-hr at 240bar when measured with other blends and it is comparatively equal to diesel. Then the increase in injection pressure may lead to low specific fuel consumption. The experimental results proved that the lower percentages of diethyl ether, ethanol and methanol can be substituted for the diesel fuel without any modifications in standard diesel engines.

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