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Experimental Investigation on Injection pressure for MOME Blended Fuel C.I. Engine

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***Abstract*-- Energy demand increases with growth of population and industrialization in the world. Most of the energy is consumed for transportation of goods and passengers. Most of the vehicles are currently running with conventional fossil fuels and this leads to depletion of these fuels within a few years as well as the increase in environmental pollution levels. It is required to develop alternatives which save fuel for future generation and reduce environmental pollution and global warming. One of the alternatives is to produce biodiesel from renewable source to meet the energy demand. In the present work, Mahua oil methyl ester (MOME) is developed by transesterification and blends are prepared (B0, B25, B50, & B100) with diesel to investigate optimal injection pressure in four stroke C.I engine. The optimal injection pressure and blend are found to be B25 and 240 bar respectively from the experimental results.**

Keywords—MOME; Biodiesel; Injection pressure; BTE; Emissions.

I. INTRODUCTION

At present, the researchers are focusing on development of renewable alternate fuels in order to reduce consumption of fossil fuels as well as environmental pollution. One of alternatives is to produce biodiesel from renewable sources. Cultivation of non edible plants has two advantages, one of them is to produce the biodiesel from the seeds of the plants and second one is the plants absorb the CO_2 produced by burning the fuels thus forming a part of CO_2 cycle. Huang et al [1] stated that due to the increasing awareness of the depletion of fossil fuel resources and environmental issues, biodiesel became more and more attractive in the recent years. Biodiesel production is a promising and important field of research because the relevance it gains from the rising petroleum price and its environmental advantages. Their work reviewed the history and recent developments of biodiesel, including the different types of biodiesel, the characteristics, processing and economics of biodiesel industry. The application of biodiesel is in automobile industry, the challenges of biodiesel industry development and the biodiesel policy are discussed as well. Ayhan Demirbas [2] studied the performance and recent trends in biodiesel fuels, his work included with different methods for production of biodiesel such as direct use and blending, microemulsification, pyrolysis, and transesterification processes. He pointed out that transesterification process with methonal is widely accepted technique to reduce the viscosity of the oil. He also mentioned that biodiesel is future fuel, because it is renewable, biodegradable, non-toxic, free of sulfur and aromatics, environmentally friendly and can be used in any diesel engine without modification.

Ashraful et al [3] studied the Production and comparison of fuel properties, engine performance, and emission characteristics of biodiesel from various non-edible vegetable oils. They concluded that a diesel engine could be successfully run and performance of karanja, mahua, rubber seed, and tobacco biodiesel and their blends as fuel in a CI engine and their emissions are comparable with diesel. Pradhan et al [4] conducted experiments on pyrolysis of Mahua seed oil at different temperatures under nitrogen flow with constant heating for production of biofuel and its characterization. They concluded that at an optimum temperature of 525^0C, the maximum biofuel yield of 49% was obtained. They also mentioned that, it is a potentiality beneficial energy resource. Gupta et al [5] conducted experiments to evaluate the production of biogas from raw and detoxified (water treated; detoxified up to 75%) mahua oil seed cake (MC). They concluded that 50% hot water detoxified MC and 50% cow dung gave maximum biogas production with 58.5–60% methane content.

Shadangi and Mohanty [6] studied pyrolysis of non-edible oil seed powders such as mahua, karanja, niger and linseed by conducting experiments at a heating rate of 5, 10 and 15^0C/ min in the presence of nitrogen using thermo-gravimetric and differential scanning calorimetric analysis. The results show the kinetic parameters are directly proportional to temperature and heating rate. This analysis during pyrolysis of the oil seeds indicates three stages of thermal degradation whereas differential scanning calorimetric analysis shows both endothermic and exothermic pathways. Sajith et al [7] conducted experiments to study the influence of the addition of cerium oxide in the form of nano particle on the physicochemical properties and the performance of biodiesel. Their study indicates the flash point and the viscosity of biodiesel were increased with the

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inclusion of the cerium oxide nano particles. The emissions, hydrocarbon and NOx are reduced with the addition of cerium oxide nano particles. Qiao et al [8] conducted experiments with the biodiesel and dimethyl ether (DME) blends in direct injection engines with a view to keep the viscosity at required level between biodiesel and DME and also to improve atomization by initiating flash boiling. The results show that with increasing DME blend ratio, the maximum rate of pressure rise decreases linearly, the exhaust gas temperature increases for all loads and power decreases due to low heat value of DME. Banapurmath et al [9] evaluated the effect of injection pressure and injection timings on performance and emission characteristics of a single-cylinder diesel engine with fuel as Honge oil, its ester, and ester blends with diesel. Their results show that retarded injection timing of 19° BTDC, injection pressure of 260 bar gave better performance for B20 blend.

Gautam and Agarwal [10] conducted experiments with cotton seed methyl ester blends as fuel to evaluate engine performance, emissions and combustion characteristics of engine. Their results show the BTE decreased marginally and the BSFC increased at the rated power due to the lower calorific value of biodiesel. They also mentioned that the nitrogen oxide emissions increased by 8% and particulate matter emissions decreased by 32%. Jianbo et al [11] studied lubrication properties of biodiesel as fuel lubricity enhancers by addition of refined and unrefined biodiesels to diesel. The unrefined biodiesels contain monoglycerides, diglycerides, and triglycerides, and refined biodiesels not containing these glycerides. The resulting lubricity was measured using the High Frequency Reciprocating Rig (HFRR). They concluded that the unrefined biodiesels showed higher lubricity properties than refined biodiesels.

Padhi et al [12] have produced bio diesel from Mahua (Madhuca Indica) oil through esterification followed by transesterification and conducted experiments to study its characteristics. Kinetic studies were carried out to optimize the preparation of MOME by varying different parameters like methanol / oil molar ratio, of excess alcohol, reaction time, temperature and concentration of acid catalyst. The results show that 4% H_2SO_4, 0.33% v/v alcohol/oil ratio, 1 hr reaction time and 65°C temperatures are the optimum conditions for esterification. Optimum conditions for the production of biodiesel from Mahua oil are 8% Sodium Methoxide, 0.33%v/v alcohol/oil ratio, 1 hr reaction time, 65°C temperature and 150% v/v excess alcohol. The fuel properties were found to be comparable with that of diesel fuel. The study recommended that the Mahua oil is also a potential raw material for biodiesel which is cost effective and can be a viable alternative fuel in near future.

Shadangi et al [13] compared yield and fuel properties of thermal and catalytic Mahua seed pyrolytic oil. The catalytic effect of CaO, on Mahua seed pyrolysis at different catalyst ratios of 2:1, 4:1 and 8:1 was studied. They found that at optimum temperature of 525^0C and catalyst ratios of 2:1 produces maximum yield and best quality with CaO as catalyst. Adaileh et al [14] studied the combustion characteristics and emissions of compression ignition diesel engine using a biodiesel as an alternative fuel. The tests were performed in four stroke single cylinder diesel engine loaded at variable engine speed between 1200-2600 rpm without any modification to diesel engine. The emission results compared with standard diesel show that biodiesel provided significant reductions in CO, and unburned HC, but the NO_x was increased.

In the present work, MOME is produced by transesterifiction process and prepared blends with diesel (B25, B50, and B100).These blends are used as fuels in four stroke C.I engine at different injection pressures with varying load to determine better injection pressure for better performance of engine.

II PRODUCTION OF BIODIESEL

A laboratory-scale biodiesel production setup is as shown in fig.1. It consists of a motorized stirrer, straight coil electric heater and stainless steel containers. The system was designed to produce maximum 5 liter of biodiesel. Temperature of the mixture of the triglyceride, methanol and catalyst were maintained at about 60°C. The method adopted for preparation of biodiesel from madhuca indica oil for this work is, transesterification which is a process of using methanol (CH_3OH) in the presence of a catalyst, such as potassium hydroxide (KOH), to chemically break the molecule of madhuca indica oil into an ester and glycerol. This process is a reaction of the oil with an alcohol to remove the glycerine, which is a by-product of biodiesel production.

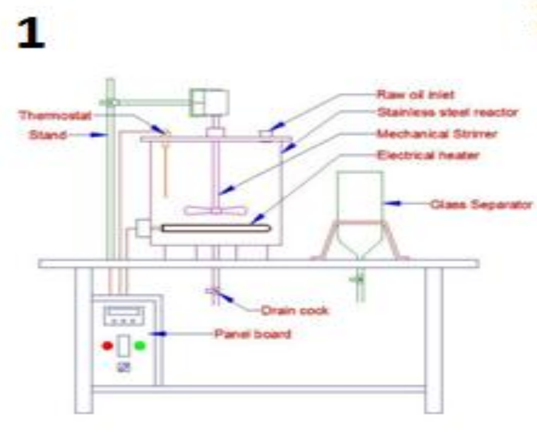

Fig.1 Transesterification biodiesel plant

Fig.2 Raw madhuca indica oil and Fig.3 Madhuca indica biodiesel

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III PREPARATION OF BLENDS

In this work, blends are prepared by addition of mahua oil methyl esters to conventional diesel with suitable percentages. The blends are used as fuel in a C.I. engine to evaluate performance and emission characteristics at different injection pressures. In the present study, B0, B25, B50, and B100 blends are prepared and used in experimentation.

IV EXPERIMENTATION

The experimental setup is shown in Fig. 4, prepared with a single cylinder, 4-stroke diesel engine test rig. The engine has specifications are 87.5mm of bore size, 110mm of stroke length, 7BHP of rated power at 1500 rpm. The engine is coupled with an eddy current dynamometer to apply different loads on the engine. The setup has a stand-alone panel box consisting of fuel tank, manometer, air box, transmitters for air and fuel flow measurements. Rotameters are provided for measuring water flow through the engine and calorimeter. As per experimental plan, experiments were conducted on single cylinder four stroke C.I engine by varying load, and blends at different injection pressures.

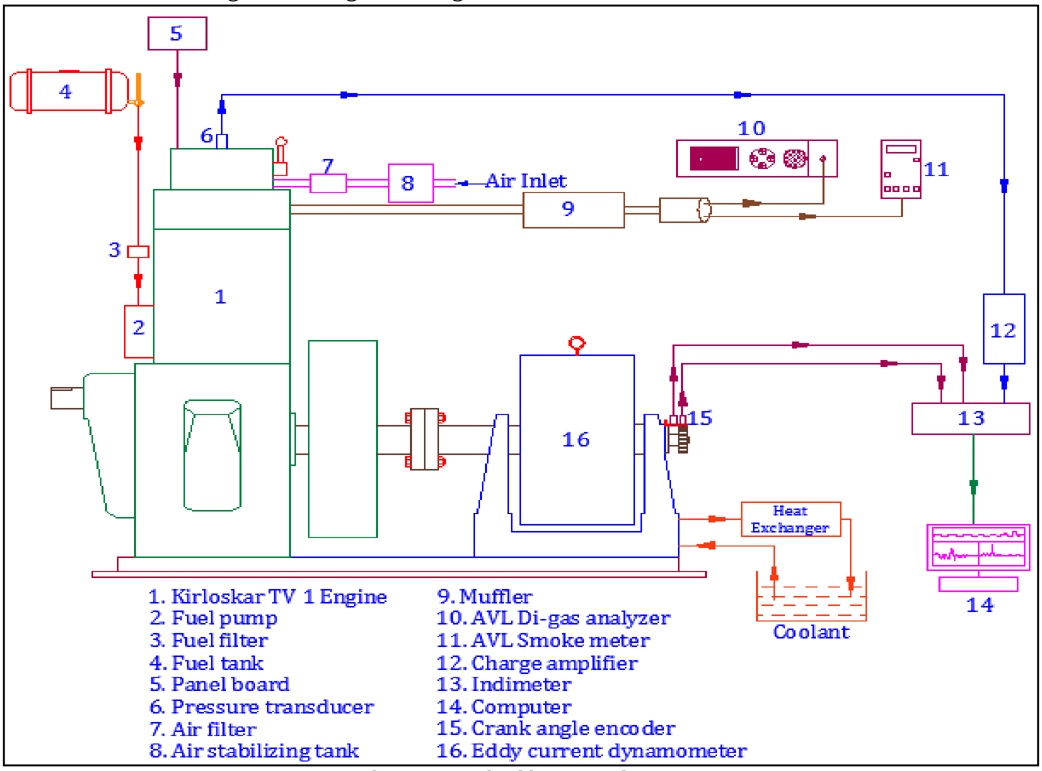

Fig.4 Four stroke engine with eddy current dynamometer test rig

V RESULTS AND DISCUSSION:

A. BTE Analysis

Fig 5. (a), (b) and (c) Show the variation of BTE with variation of B.P at different injection pressures of B25, B50, and B100 respectively. From the graph it is clearly observed that all MOME blends are investigated with various injection pressures with constant speed of 1500rpm. The blend B25 with 240 bar injection pressure shows maximum brake thermal efficiency when compared to standard (220bar) injection pressure at full load condition. The advanced injection pressures (200, 210bar) show the lower brake thermal efficiency. The brake thermal efficiency of blend B25 with 240, 230, 220 bar is 28.55%, 27.43%, 26.15% respectively Blend B25 at 240 bar injection pressure shows 2.4% of brake thermal efficiency increases when compared to that standard injection pressure and other blends. The reason is due to better atomization, and fine spraying of fuel.

B. Smoke density analysis

The variations of smoke density against brake power for MOME blends with various injection pressures are shown in the Figures 6 (a-c). From the graph it is noticed that the blend B25 with 240bar injection pressure shows lower smoke density when compared to the same fuel with standard injection pressure. The smoke density of blend B25 with 240, 230, 220, 210, 200bar injection pressure is 66.2, 70.2, 81.2, 80.5, 82.4HSU respectively. The blend B50 and B100 with the same injection pressures shows increasing trend of smoke density when compared to B25 blend. The diesel fuel at standard injection pressure is 71HSU at full load. The blend B25 with 240bar injection pressure has 6.7% lower value when compare to standard injection pressure with diesel fuel. The increasing smoke density for lower pressure due to attributed to the lengthening combustion duration. This is due to high pressure and better atomizaion as a result of improvement of fuel evaporation and diffusion combustion.

C. Smoke density analysis

The variations of smoke density against brake power for MOME blends with various injection pressures are shown in the Figures 6 (a-c). From the graph it is noticed that the blend B25 with 240bar injection pressure shows lower smoke density when compared to the same fuel with standard injection pressure. The smoke density of blend B25 with 240, 230, 220, 210, 200bar injection pressure is 66.2, 70.2, 81.2, 80.5, 82.4HSU respectively. The blend B50 and B100 with the same injection pressures shows increasing trend of smoke density when compared to B25 blend. The diesel fuel at

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standard injection pressure is 71HSU at full load. The blend B25 with 240bar injection pressure has 6.7% lower value when compare to standard injection pressure with diesel fuel. The increasing smoke density for lower pressure due to

The variations of CO against brake power for MOME blends with various injection pressures are shown in the Figures 7 (a-c). From the graph all blends with 240 bar injection pressure show lower CO emission when compared to other injection pressures. The CO emission of blend B25 with 240, 230, 220, 210, 200bar is 0.16, 0.18, 0.27, 0.28 and 0.3% respectively at full load condition. The blend B25 with 240bar shows lowest CO emission when compared to

The variations of HC emission against brake power for MOME blends with various injection pressures are shown in the Figures 8 (a-c). The blend B25 with 240 bar injection pressure shows lower HC emission when compared to all other blends and injection pressures. The HC emission of B25 blend with 240, 230, 220, 210, 200bar is 95, 104, 129, 132, 135ppm respectively and standard pressure with diesel is 119.4ppm. The HC emission of B25 with 240bar pressure has a decrease of 20.43% when compared to standard injection pressure with diesel fuel. The reason for decreased HC emission is the complete combustion of bio diesel and its blends due to rich oxygen content.

F. NOx analysis

attributed to the lengthening combustion duration. This is due to high pressure and better atomizaion as a result of improvement of fuel evaporation and diffusion combustion.

D. CO analysis

standard fuel at all the injection pressures with biodiesel blends. It has shown a decrease of 54.3% compared with standard fuel and injection pressure. The reason is biodiesel and its blends contain more oxygen which increases conversion of CO into CO_2. The high injection pressure leads to better fuel mixture in combustion chamber thereby resolving the CO emissions.

E. HC analysis

The variations of NOx against brake power for MOME blends with various injection pressures are shown in the Figures 9 (a-c). The blend B25 with 200bar injection pressure shows lower NOx emission when compared to other injection pressure and blends. The NOx emission of the blend B25 with 240, 230, 220, 210, 200bar injection pressure is 1144, 1115, 1018, 998, 981ppm respectively. The NOx emission with diesel fuel at standard injection pressure is 1118ppm. The blend B25 with 200bar injection pressure has 12.27% lower NOx emission when compared to standard diesel at standard pressure. This is because better atomization and shortened ignition delay period will enhance temperature during the combustion. At high temperatures, nitrogen (N_2) reacts with oxygen and increases NOx levels.

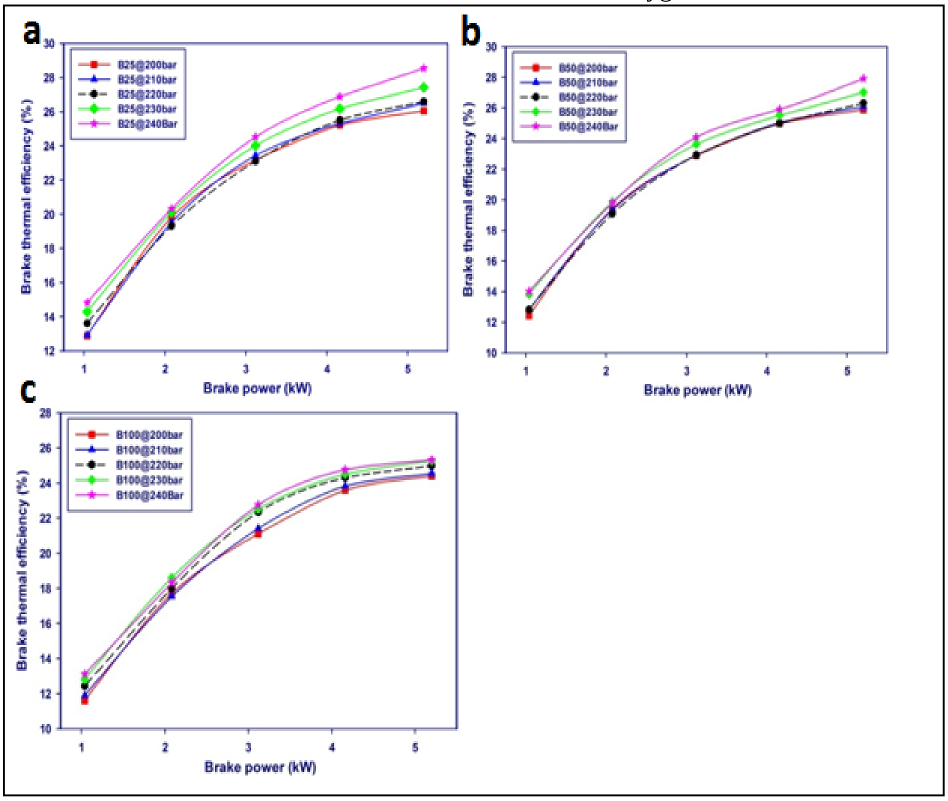

Fig. 5(a) B.P vs BTE of B25 at different injection pressures, (b) B.P vs BTE of B50 at different injection pressures, and (c) B.P vs BTE of B100 at different injection pressures.

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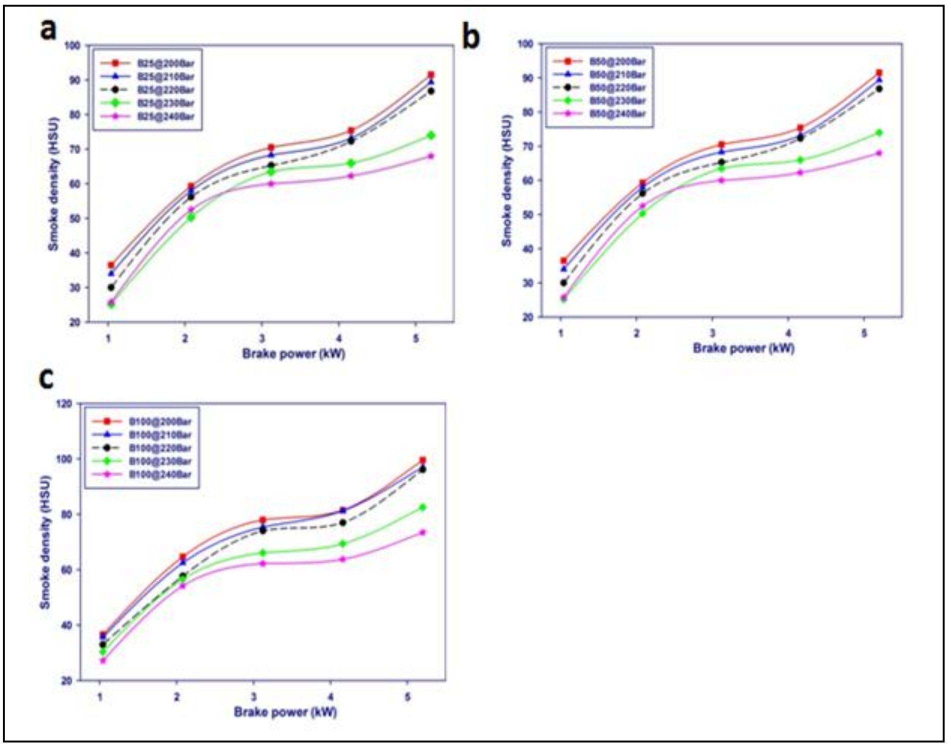

Fig. 6 (a), B.P vs smoke density of B25 at different injection pressures, (b) B.P vs smoke density of B50 at different injection pressures, and (c) B.P vs smoke density of B100 at different injection pressures

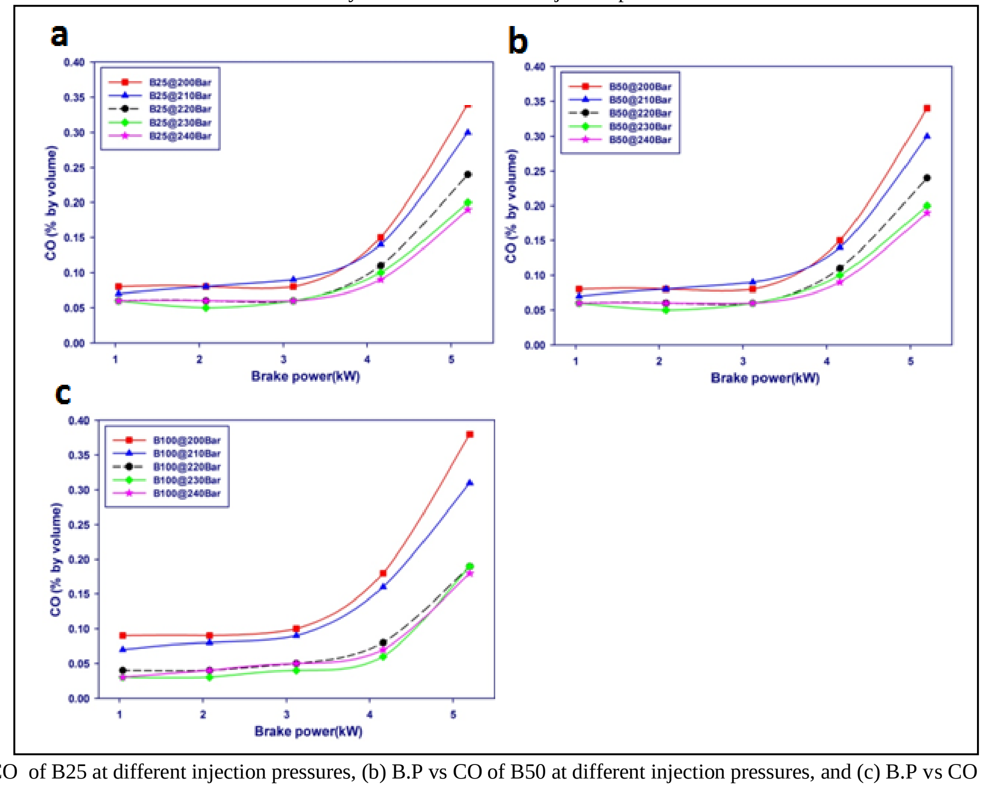

Fig 7 (a), B.P vs CO of B25 at different injection pressures, (b) B.P vs CO of B50 at different injection pressures, and (c) B.P vs CO of B100 at different injection pressures,

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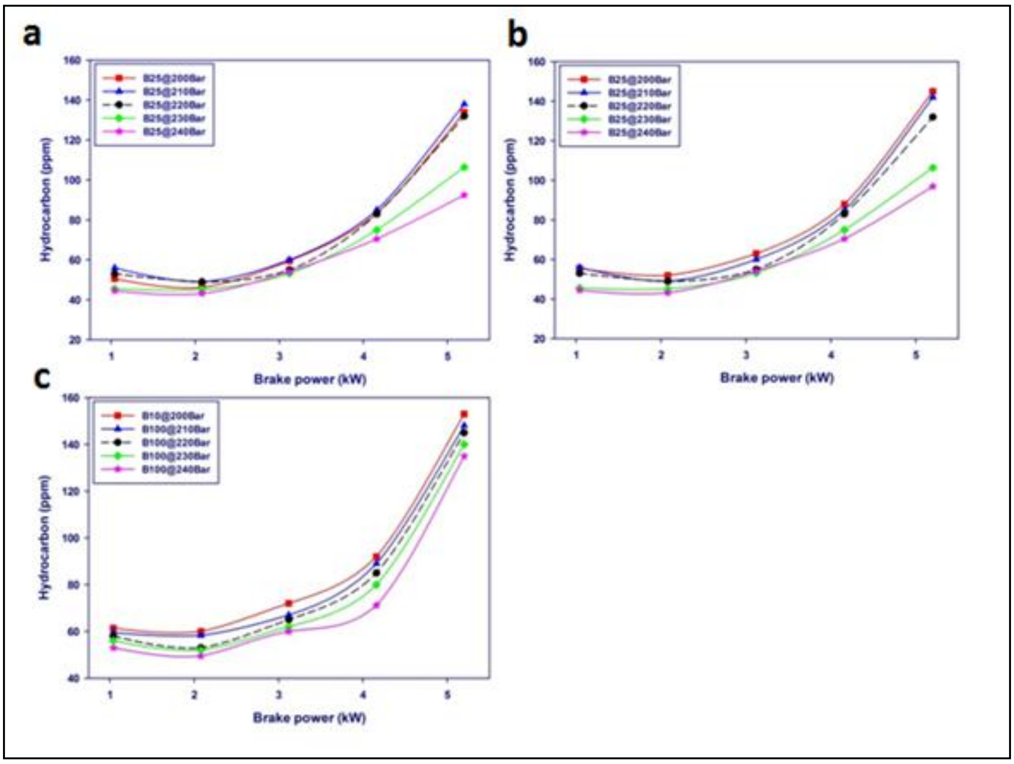

Fig 8 (a), B.P vs HC of B25 at different injection pressures, (b) B.P vs HC of B50 at different injection pressures, and (c) B.P vs HC of B100 at different injection pressures,

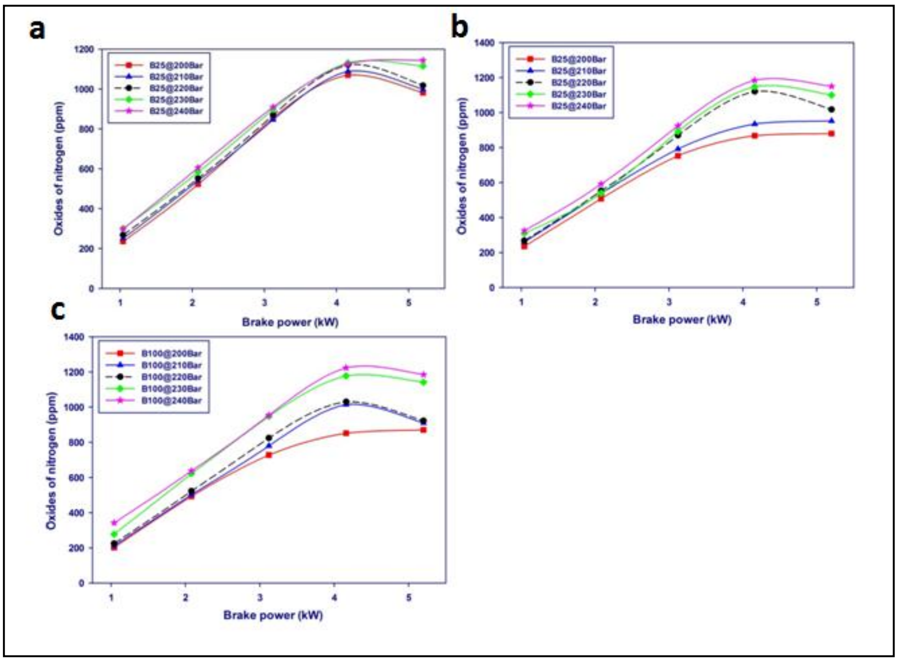

Fig 9 (a), B.P vs NOx of B25 at different injection pressures, (b) B.P vs NOx of B50 at different injection pressures, and (c) B.P vs NOx of B100 at different injection pressures,

VI CONCLUSIONS

In the present work, MOME is prepared by transesterification process and tested in single cylinder 4-stroke C.I. engine to evaluate its performance and emission characteristics at different injection pressures with varying loads.. Characteristics like BTE, smoke density, and emissions of CO, HC, NO_x, have been studied. The following conclusions can be drawn from this work:

- The B25 can be utilized as a fuel in diesel engine without modification of the engine, since its performance is almost nearer to diesel.
- As pressure increases the BTE increases for all blends.
- Injection pressure 240 bar shows better performance.
- The emissions are lower (smoke, CO, HC) with high injection pressures.

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- The NOx emissions are lower with injection pressure of 200 bars.

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