IMPACT ON PERFORMANCE, COMBUSTION AND EXHAUST EMISSION CHARACTERISTICS USING MAHUA OIL AND DIESEL BLENDS IN DIESEL ENGINE

Subramanyam Pavuluri[1,a)], Dr.B.Sidda Reddy[2], Dr.B.Durga Prasad[3]

[1]Research Scholar, Department of Mechanical Engineering, Jawaharlal Nehru Technological University Anantapur, Ananthapuramu, Andhra Pradesh, India-515002
[2]Professor, School of Mechanical Engineering, RGMCET, Nandyala, Affiliated to Jawaharlal Nehru Technological University Anantapur, Ananthapuramu. Andhra Pradesh, India.
[3]Professor, Department of Mechanical Engineering, JNTUA College of Engineering, Ananthapuramu, Andhra Pradesh, India-515002

Abstract: Today's energy scenario has propagated and enhanced the research in the non-conventional, renewable and environmentally friendly fuels. The increasing cost of conventional fuels has motivated researchers to look at renewable alternatives for use in internal combustion engines. When compared to other seed fuels like ethanol and essential oils, mahua oil has comparable low viscosity, boiling temperature, and flash point. The present paper discuss on the experimental investigations carried out using the blends of Mahua oil and diesel. The blends are prepared on a volume basis and designated as MO10, MO 20, MO 30 and MO 40. It is observed that BTE increases for MO10 and MO20 blends by 2.7 and 5.8% respectively. Whereas there is a decrease in CO, HC and smoke emission compared to diesel. The NOx Emission levels for all Mahua oil blends increased due to rise In-cylinder pressure.

Key words: Mahua Oil blends, DI Diesel Engine, Performance, Combustion, and Exhaust Emissions;

1.INTRODUCTION

The world is now experiencing serious issues such as a global energy crisis, environmental degradation, and global warming as a direct result of the over usage of petroleum based fuels for industrial and car purposes. As a result, there has been a rise in awareness throughout the world about the need of finding and developing alternate fuel sources to avoid a fuel crisis. There are several projects looking into acceptable alternatives to diesel fuel, such as biodiesel.

Scientists are investigating non-food sources for biodiesel. Mahua, Karanja, Neem, Jatropha, Simarouba, and other plant oils belong here. Most non-edible oils include all six fatty acids—stearic, palmitic, oleic, linoleic, and linolenic. Many foreign scientists have investigated diesel-infused vegetable oils. Non-edible vegetable oils are plentiful in impoverished countries like India, but chemical conversion to methyl esters is costly [2-3]. Diesel is testing warmed oils as engine fuel. Many Indian state government officials [4-6] agree that non-edible plant cultivation has potential. SrinivasRao et al. tried non-edible oil to substitute diesel fuel. Non-edible oil affects brake thermal efficiency [7]. Bhanodaya Reddy et al. examined PongamiaPinnata as a fossil fuel replacement. 20% mixtures outperform fossil fuel [8]. Basavaraj et al. [9] found B20 had lower brake specific fuel consumption than other blends but worse brake thermal efficiency than fossil diesel with Honge oil. Demirbas studied biodiesel synthesis, properties, and experiments. Most studies transesterify triglyceride with methanol or ethanol. Advised

Transesterification increases conversion to 96% [10]. Karmee and Chala's methanol-KOH Pongamia oil transesterification converted 92% at 600 C [11]. Burnwall and Sharma discovered that diesel engines may consume non-edible oil using base catalysed fuel improvement. Supercritical transesterification with alcohol produces mono-alkyl ester and biodiesel [12]. Olive oil methyl ester lowered BSFC, CO, CO2, NO, and NOx in a four-stroke diesel engine, according to Dorado et al. [13]. Mahua oil methyl ester improved four-stroke diesel engine BSFC and BTE for Puhan et al. CO2, NOx, CO, HC, and smoke opacity are somewhat better than diesel [14]. Non-edible oils lowered NOx, particle pollution, and power [15]. Bhatt et al. discovered that diesel engines may operate on oil methyl ester and 20% Mahua biodiesel without altering BP, BSFC, or power output. He suggested 20:1 compression improves performance. Wang et al. [17] showed diesel engines using non-edible oils exhibited high EGT and modest CO and NOx reductions compared to fossil fuel. Mahua biodiesel-additive blends are used to study diesel engine performance and emissions (Dimethyl carbonate). Biodiesel may cut emissions and enhance combustion.

2.EXPERIMENTAL SETUP

Diesel and mahua oil methyl ester-fueled DI Diesel engine performance, combustion, and emissions evaluation. The DI Diesel engine tests mahua oil methyl ester in the first experiment. Figures 1 and 2 illustrate the experimental test engine. Kirloskar single-cylinder water-cooled DI diesel engines include eddy-current dynamometers and monitoring and control systems. DI includes common rail, pressure sensor, and fuel injector. Rail pressure maintains injection settings and common rail pressure. 7.4 kW 1500 rpm. Table.1 provides engine specifications. K-type thermocouples detect exhaust gas temperature during this experiment. An encoder measures crank angle, while a cylinder head piezoelectric pressure transducer detects cylinder pressure. Burette and stopwatch measure volumetric fuel flow. AVL 444 DI gas analyzer and smoke metre monitor exhaust emissions.

Figure.1 : Photographic View of the Experimental Setup

Table.1: Technical Specifications of the DI Diesel Engine

TECHNICAL SPECIFICATION	
Make and model	Kirloskar DM10
No. of Cylinders	01
Bore x Stroke	102 x 116mm
Cubic Capacity (CC)	0.948Ltr.
Crank Shaft Center Height	203mm
Compression Ratio (CR)	17.5:1
Torque at Full Load	0.048 kN-m
Rated Output	7.4 kW
Rated Speed	1500rpm

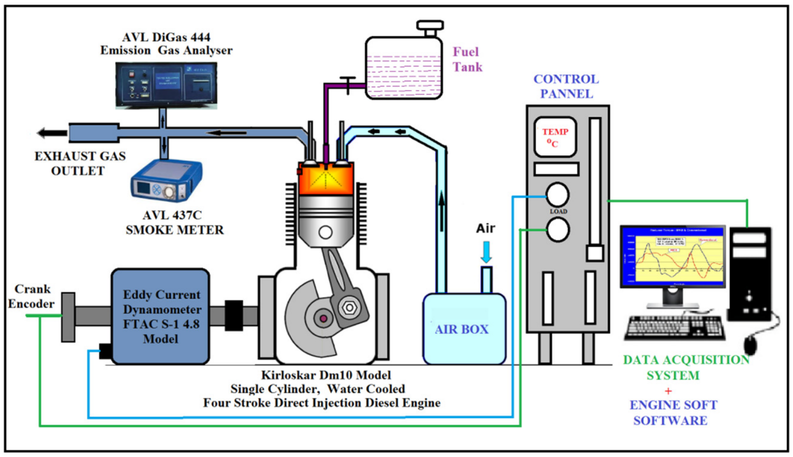

Figure.2 Schematics Layout of Experimental Setup

3. RESULT AND DISCUSSION
3.1 Combustion
3.1.1 Impact of In-Cylinder Pressure

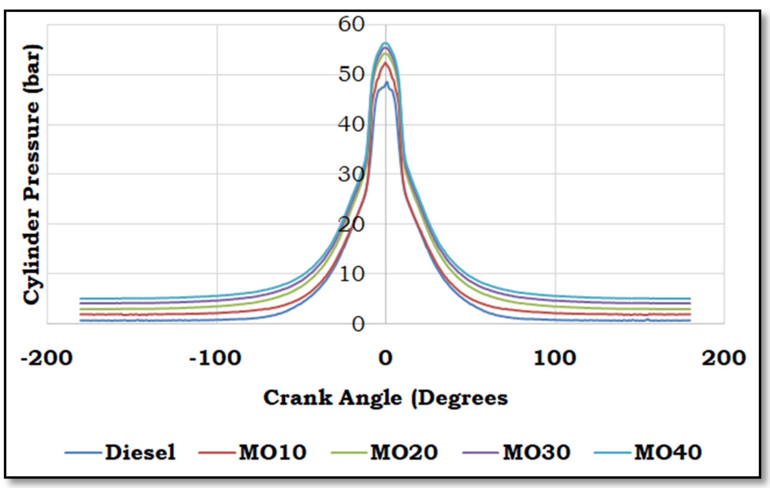

Figure.3 Variation of Cylinder Pressure with Crank Angle for Mahua Oil Diesel Blends

The cylinder pressure diagram depicts the impact of fuel burning within the engine cylinder. The engine's cylinder pressure varies according to the volatility of the fuel, the duration of combustion, the rate of heat release, and the calorific value of the fuel utilised.

The ratio of fuel to air that is burned during the DI diesel engine's premixed burning phase determines the engine's maximum cylinder pressure. Cylinder pressure is found to be greater in blends containing MO40, and lower in diesel. Combustion quality is enhanced by blending MO10, whereas it is dampened by blending MO40. This is the primary explanation for why MO10 and MO40 have different cylinder pressures. MO40 has a higher peak pressure than any other mix by 4% compared to diesel fuel and MO40.

In addition to peak pressure, the ignition delay of the blend changes with respect to change in blend fraction. MO40 blends offer higher peak pressure and the longer ignition delay compared to that of lower other blends. This is primarily due to the suppression of combustion characteristics of the blend by ethanol. Blend peak pressure decreases with fraction. MO40 peak pressure retard is 4º longer than diesel fuel operation. Ethanol also alters ignition delay. Ethanol mixtures affect ignition delay.

3.1.2 Impact of Heat Release Rate

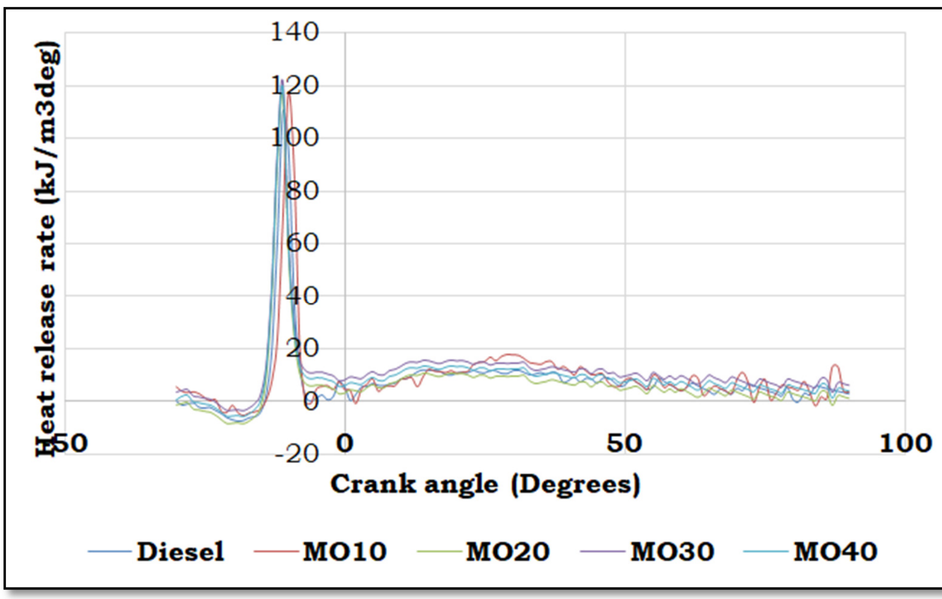

Figure.4: Variation of Heat Release Rate with Crank Angle for Mahua Oil Diesel Blends

The rate of heat release is an important determinant of combustion efficiency. This parameter contributes to the changes in BTE, Emission Parameters, and Cylinder Pressure. Figure.4 depicts a comparison of HRR variations for mahua oil blends and diesel fuel at full load. According to the graph, MO40 has a greater HRR than other blends and diesel fuel. The MO40 blend's HRR meets diesel fuel's at maximum load. Due to delayed combustion, lower cetane fuels emit more heat. The combination burns better. Overmixing decreases the blend's combustion characteristics.

3.1.3 Impact of Ignition Delay Period

The delay which occurs between when fuel injection begins and when combustion eventually starts is called as the ignition delay. In the time preceding ignition, the fuel and air are fully mixed and made ready to ignite. Figure.5 clearly shows the change in ignition delay for all gasoline blends under varied load circumstances. It is assumed that as load increases, ignition delay reduces. High-load cylinder temperatures may accelerate fuel evaporation and reduce ignition delay. Due to the decreased cetane number, the ignition delay increases with mahua oil mix amount.

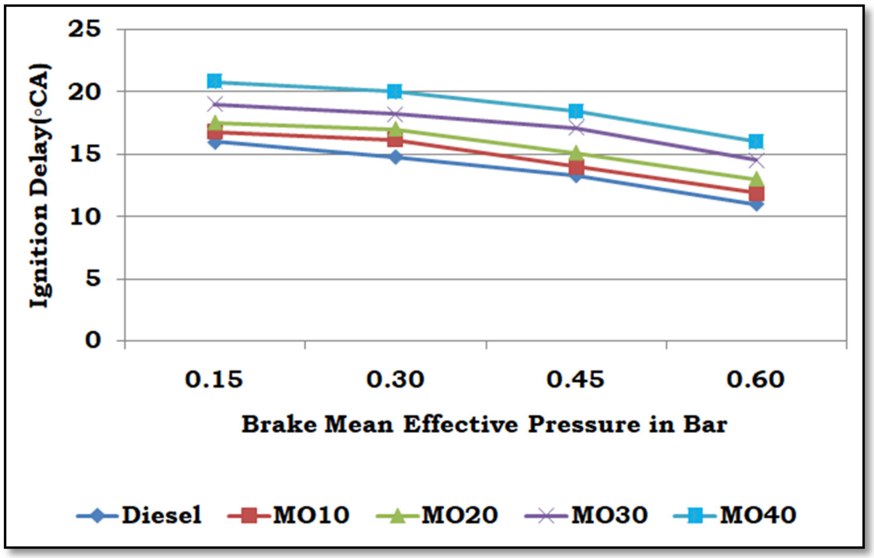

Figure.5 Variation of Ignition Delay period with BMEP for Mahua Oil Diesel Blends

3.2 Performance

3.2.1 Impact of Exhaust Gas Temperature

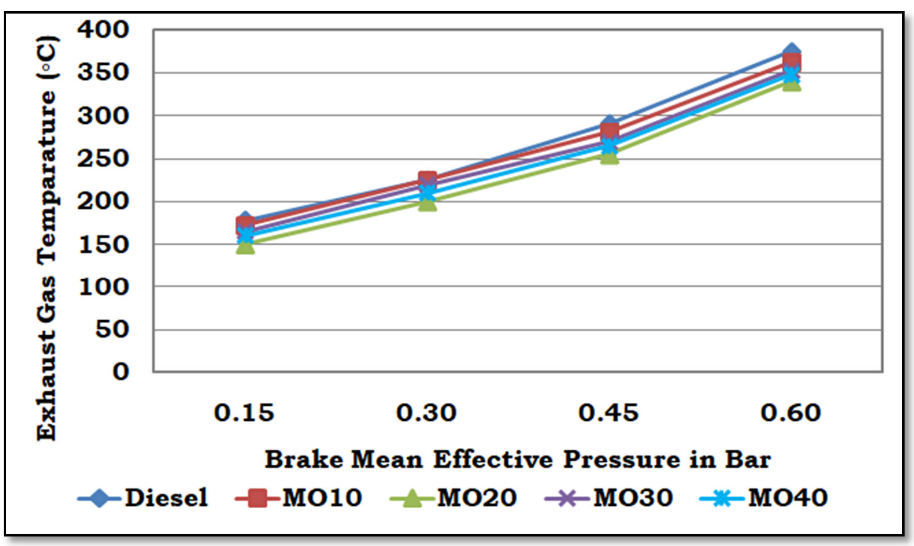

Figure.6 Variation of Exhaust Gas Temperature with BMEP for Mahua Oil Diesel Blends

The results indicate that adding mahua oil component to fuel blends causes a decrease in exhaust gas temperature. Maha oil's high volatility improves combustion quality. The fuel blend's ignition delay time extends because of the mahua oil's lower cetane number.

3.2.2 Impact of Brake Specific Energy Consumption

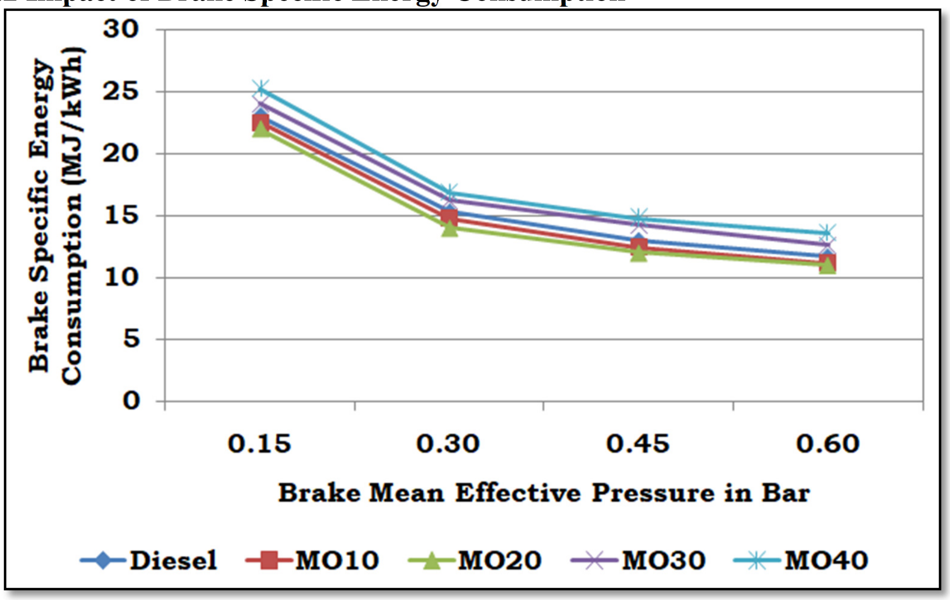

Figure.7 Variation of Brake Specific Energy Consumption with BMEP for Mahua Oil Diesel Blends

BSEC correlates fuel use well. Diesel and mahua oil mix BSECs are 11.7, 11.2, 11.5, 12.6, and 12.8 MJ/kWh at greater loads. Biodiesel mix viscosity and density increase BSEC. Data shows that blends with lower mahua oil contents have lower BSECs than diesel for all load conditions. Mahua oil's oxygen molecular content accelerates burning and decreases MO10 and MO20 blends' BSEC. MO30 and MO40 mahua oil blends have higher BSEC over the load range.

3.2.3 Impact of Brake Thermal Efficiency

At higher BMEP conditions, the BTE is found to be 30.14, 30.96, 31.89, 29.28, and 28.4% for diesel, MO10, MO20, MO30, and MO40 blends, respectively. BTE is primarily determined by the heating value of the fuel and the amount of fuel used. Increased oxygen intake in MO10 and MO20 mixes helps optimise the combustion process, leading to excellent brake thermal efficiency. In the cases of MO30 and MO40 mixes, the brake thermal efficiency drops because of the reduced energy input.

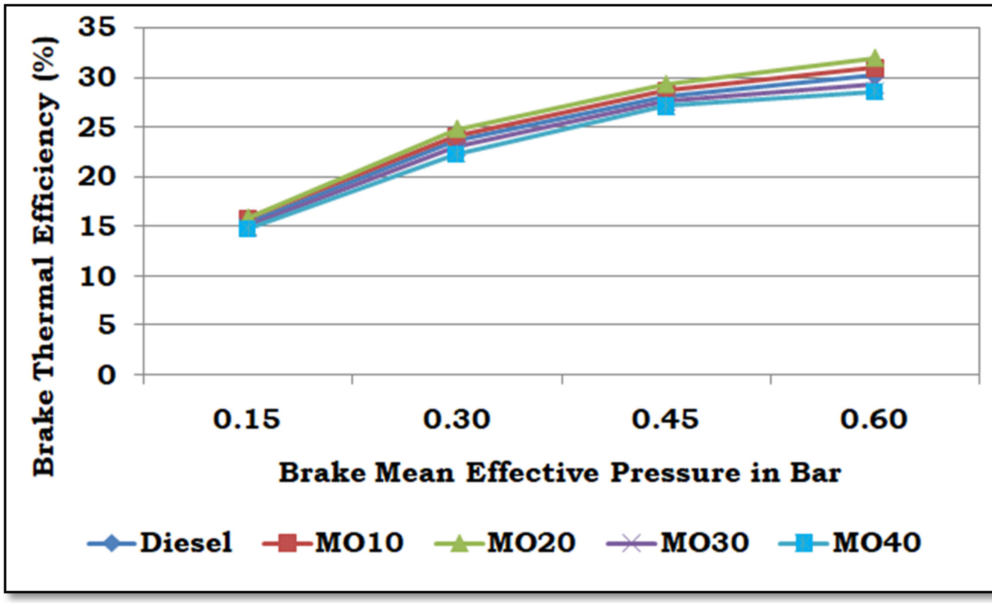

Figure.8 Variation of Brake thermal efficiency with BMEP for Mahua Oil Diesel Blends

3.3 Exhaust Emissions

3.3.1 Impact of Carbon Monoxide Emissions

Carbon dioxide (CO) emissions are sensitive to factors such as fuel-air ratio, compression ratio, delay time, fuel quality, and injection time. Diesel and mahua oil blends emit 4.1, 3.7, 3.1, 2.6, and 2.4 g/kWh and 2.4 g/kWh and 3.7 g/kWh of carbon monoxide, respectively, under higher BMEP conditions. The graph demonstrates that, in comparison to conventional diesel, CO emissions are greater at lower BMEP values and lower at higher BMEP levels. This is because the fuel air ratio is no longer effective at greater loads owing to an increase in cylinder temperature and the oxidation nature of mahua oil blends.

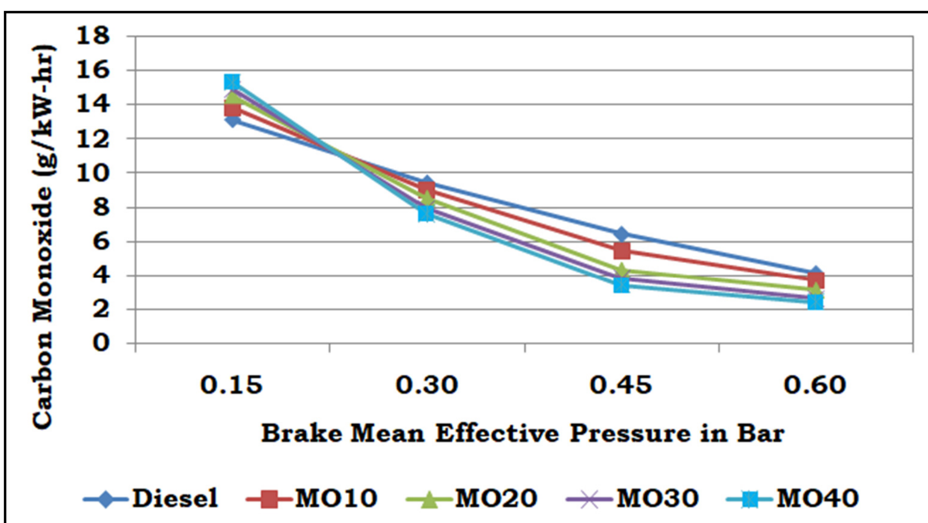

Figure.9 Variation of Carbon Monoxide Emissions with BMEP for Mahua Oil Diesel Blends

3.3.2 Impact of Hydrocarbon Emissions

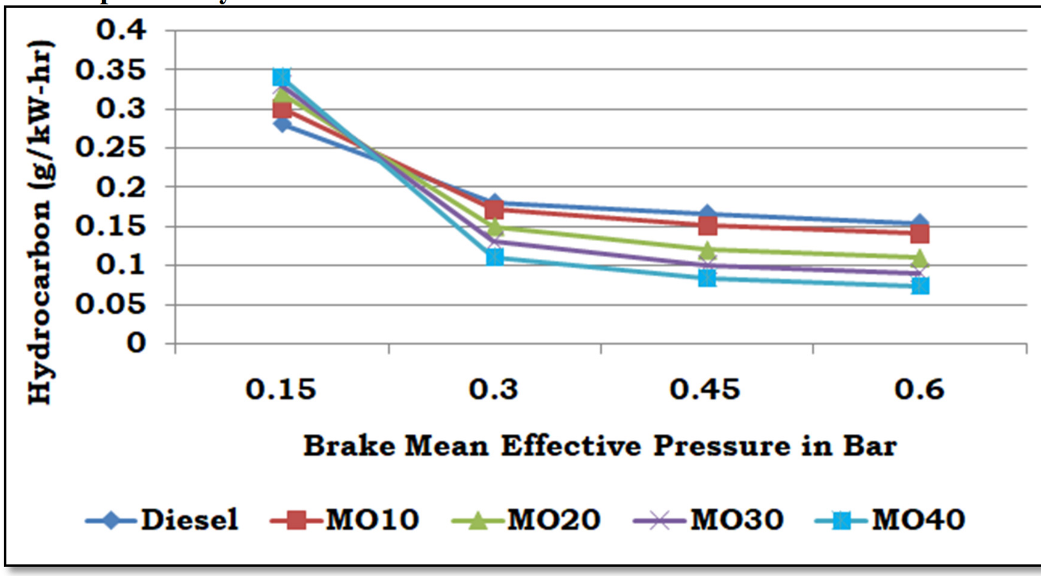

Figure.10 Variation of Hydrocarbon Emissions with BMEP for Mahua Oil Diesel Blends

Hydrocarbon (HC) emissions of mahua oil blends differ from those of diesel under varying loads, as seen in Figure.10. As a result of improper fuel combustion, HC emissions are produced. The generation of HC, particularly near the cylinder border, is influenced by the temperature of the In cylinder. When comparing MO10, MO20, MO30, and MO40 blends to conventional diesel fuel, HC emissions are decreased by 14.89, 24.47, 30.85, and 37.27%, respectively, under 100% load condition.

3.3.3 Impact of Nitrogen Oxide Emissions

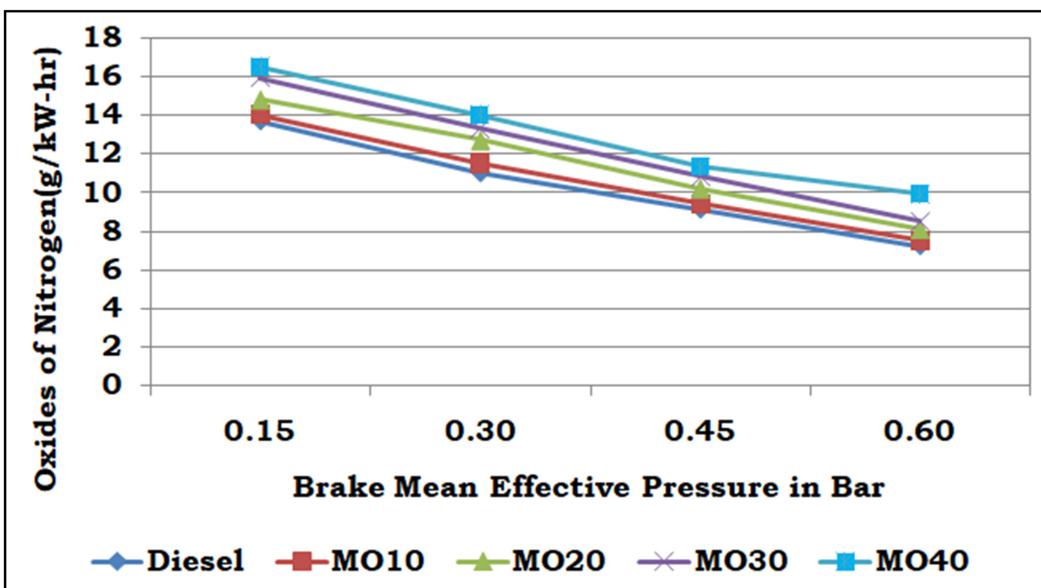

Figure.11 Variation of Oxides of Nitrogen Emissions with BMEP for Mahua Oil Diesel Blends

Figure.11 shows the range of nitrogen oxides (NO_X) produced by a diesel engine using the tested fuels with the BMEP. Nitrogen oxides are highly reactive to changes in oxygen concentration, combustion temperature, and fuel quality, making them one of the most harmful byproducts of diesel engine exhaust. Higher in-cylinder temperatures cause oxygen to react with nitrogen in the air, producing NOx. One of the causes of NOx generation is a low cetane number. The graph shows that more mahua oil results in higher NOx emissions. This is because of the enhanced premixed combustion that occurs as a result of a greater air-fuel combination in the combustion chamber.

According to the graph, the NOx emissions for diesel and MO10, MO20, MO30, and MO40 blends at high BMEP are 7.2, 7.5, 8.1, 8.5, and 9.9g/kWh, respectively. The increased temperature in the engine cylinder will be greater due to the prolonged premixed state. Another expected source of increased NOx emissions is a rise in cylinder pressure, which leads to a greater peak combustion temperature.

3.3.4 Impact of Smoke Emissions

Accumulation of mahua oil helps reduce smoke emissions. Because of the increasing mahua oil content, a leaner mixture is being formed in the engine cylinder, leading to more rapid diffusion combustion. Mahua oil's oxygen content is destroyed during diffusion combustion, which improves combustion and results in less smoke.

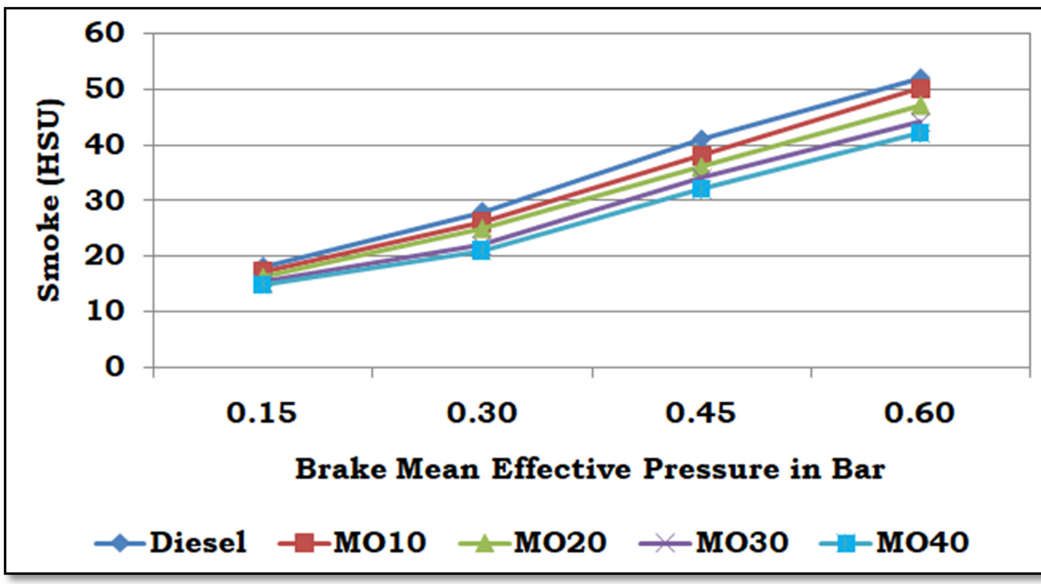

Figure.12 Variation of Smoke Opacity with BMEP for Mahua Oil Diesel Blends

Conclusions:

The experiment is carried out to determine the possibility of utilising mahua oil blends in the DI diesel engine with no modifications. According to the experimental results,

- Brake Thermal Efficiency of MO10 and MO20 blends is boosted by 2.7% and 5.8%, respectively, when compared to diesel fuel under higher BMEP conditions.
- At higher BMEP conditions, the smoke emissions of mahua oil blends MO10, MO20, MO30, and MO40 are found to be 3.4%, 7%, 17.4%, and 20.6% lower than diesel.

- At higher BMEP conditions, the CO Emissions of mahua oil blends MO10, MO20, MO30, and MO40 are found to be 7%, 28.5%, 35.7%, and 46% lower than diesel.

Compared to diesel fuel, NOx levels in all mahua oil blends rise constantly. Mahua oil and its mixes have increased heat release, peak pressure, and ignition delay due to the premixed combustion phase.

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