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EXPERIMENTAL INVESTIGATION ON A DI DIESEL ENGINE FUELLED WITH BIO OIL (MAHUA OIL CAKE) AND DIESEL

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Abstract — *Partial or complete replacement of petroleum based fuels for diesel engines has been seriously studied in various parts of the world. Research on alternative renewable fuels has become very important worldwide due to concerns about the effects of fossil fuel usage on global warming. They can be made from renewable raw material and can offer reduction of fossil fuel consumption. Modern diesel engines require a clean burning, stable fuel that performs well under a variety of operating conditions. Bio oil has become more attractive recently because of its environmental benefits and the fact that it is made from renewable resources. Bio oil from bio waste based fuels is obtained from limited reserves. These finite reserves are highly concentrated in certain regions of the world. In the present study, the bio oil is obtained from mahua oil cake (MOC). The engine is made to run on diesel and bio oil by various blend ratios of MOCD5%, MOCD10%, MOCD15% and MOCD20% in a single cylinder, four stroke, water cooled and diesel engine at 1500 rpm. The measured performance parameters are brake thermal efficiency, specific fuel consumption and engine exhaust emission of CO, HC, NOx and smoke density. NOx emission is lower for MOCD blend.*

Keywords- Bio oil, Diesel engine, mahua oil cake, Pyrolysis.

I. INTRODUCTION

In the past few years, fuels produced through fast pyrolysis of biomass waste or bio wastes have emerged as fossil fuel alternatives for power or plants and boilers. Compared to fossil fuels, bio oil is a potential fuel that can slow rising CO2 concentrations. In addition, plant-derived biomass is the only reliable fuel source that provides bio-char [1-3]. Biomass fuels are derived from plants and a reliable source of fuels. They are also the only stable source that can provide sufficient liquid fuel. The production of biomass fuel emits less greenhouse gases compared to fossil fuels. If a more efficient biomass fuel production technique can be developed, increased use of biomass fuels will mitigate greenhouse gas emissions [4-8].
Biomass sources are converted into various types of energy using different conversion techniques such as direct combustion, anaerobic digestion, bio photolysis, pyrolysis liquefaction, gasification, hydrolysis, and solvent extraction [9]. Considering these techniques, pyrolysis has the advantages of simple procedures, low operating pressure, limited waste, and high conversion rates. In addition, for most cellulose or cellulosic biomasses, 98% of the content can be converted into usable energy sources (including liquid, char, and uncondensed gas). Regarding the conversion of biomass into energy, the pyrolysis method has the potential for large-scale production. Pyrolysis is a process involving thermal chemistry, where the cellulose, hemicelluloses, and lignin of biomass is decomposed into solids, gases, and liquid products [6-7].

In a high-temperature (300 - 600oC) hypoxic or anaerobic environment Factors such as differing biomass types, the operating temperature, and the flow rate of fluidized gas influence the distribution of converted products. Solid products can be mixed with pulverized coal and burned in boilers; the gas products are generally volatile substances with a low heating value that are recycled and burned with other fuels to recycle waste heat and reduce pyrolysis costs, and the liquid product is bio-oil, which has attracted considerable academic attention because of its many unstable chemical components and high heating value [7]. Using various procedures, two types of biomass oil can be produced from different biomass sources. Bio-diesel can be generated through transesterification. The cellulose fibers that primarily comprise bio-waste are non-edible plant waste; these fibers can yield bio-oil through the fast pyrolysis process. However, bio-oil is not easily mixed with fossil diesel. Consequently, one of the most important experiments and indices for developing biomass energy involves using the emulsification method or procedure to examine the performance of engines using such oil. Previous studies of biodiesel tested in diesel engines [8-10]. The text must be in English. Authors whose English language is not their own are certainly requested to have their manuscripts checked (or co-authored) by an English native speaker, for linguistic correctness before submission and in its final version, if changes had been made to the initial version. The submitted typeset scripts of each contribution must be in their final form and of good appearance because they will be printed directly. The document you are reading is written in the format that should be used in your paper.

II. BIO OIL PRODUCTION

The bio oil used in this investigation was obtained by the fixed bed pyrolysis. The experiments were carried out in mahua oil cake as feed stock by varying the process parameters such as temperature, particle size and nitrogen (N2) gas flow rate. The temperatures used for this study were 500 °C, 550 °C and 600 °C, particle sizes of 2 mm, 4 mm and 6 mm and N2 gas flow rates of 0.2 lit/min, 0.3 lit/min and 0.4 lit/min. The condensed liquid product is separated into bio oil and water by separator. The temperature was measured by a K-type thermocouple fixed inside the reactor. Fig. 1 shows the photographic view of the pyrolysis setup. The maximum oil was collected in the temperature at 550 °C, feed stock size of 4 mm and N2 flow rate of 0.3 lit/min.

Table 1. Properties of pyrolysis oil

Test Property	Values	Procedure
Net Calorific value kJ/kg	25139	IS: 1448 Part 6 & 7
Kinematic viscosity @ 40° C in cSt	21.71	IS: 1448 Part 25
Flash point in ° C	52	ASTM D 92
Fire point in ° C	64	ASTM D 92
Cetane number	25	ASTM D 974

Fig. 1 photo graphic view of fast pyrolysis plant

III. EXPERIMENTAL INVESTIGATION

The experiments diesel with bio oil mixture was carried out in DI diesel engine. The test engine is a single cylinder, direct injection, water cooled compression ignition engine. The experimental setup is shown in figure 2. Diesel engine was directly coupled to an eddy current dynamometer. The engine was always run at its rated speed at 1500 rpm. The governor of the engine was used to control the engine speed. The dynamometer was interfaced to a control panel. Experimental tests have been carried out to evaluate the performance, emission and combustion characteristics of a diesel engine when fuelled mahua oil cake bio oil (MOC) and its blends of MOCD5%, MOCD10%, MOCD15% and MOCD 20% of bio oil with diesel fuel separately at different load. The emission like HC, CO, and NOx, were measured in the AVL 444 Di-gas analyzer and smoke density was measured in the AVL 437 smoke meter. AVL combustion analyzer was used to analyze the combustion characteristics.

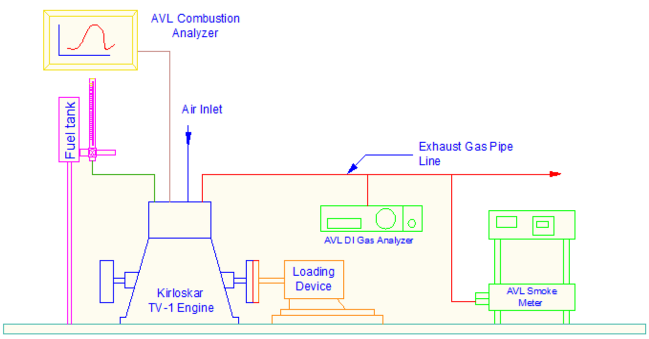

Fig 2. Test Engine

Table 2. Specifications of the Test Engine

Type	Vertical inline diesel engine ,4 stroke, water cooled
No of cylinder	Single cylinder
Bore × Stroke	87.5 mm × 110 mm
Compression ratio	17.5:1
Brake power	5.2 Kw
Speed	1500 rpm
Dynamometer	Eddy current
Ignition timing	23° bTDC (rated)

IV. RESULT AND DISCUSSION

4.1 Specific fuel consumption

The figure shows 3 specific fuel consumption with respect to brake power. The specific fuel consumption decreased when the load increases in all blends. The specific Fuel consumption is lower in maximum load for diesel compare to all bio oil blends. The MOCD 5% blend gives minimum specific fuel consumption compared to other blends.

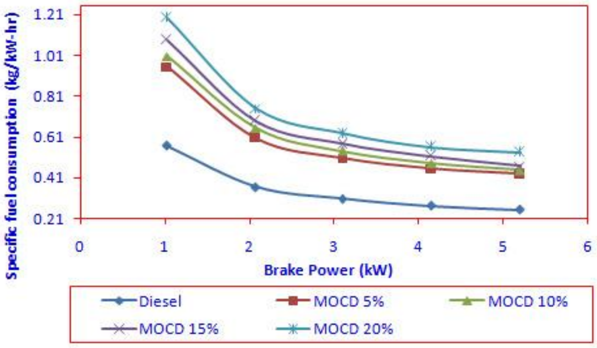

Fig. 3. Specific fuel consumption Vs brake power

4.2 Brake thermal efficiency

Fig. 4 shows the effect of brake power on brake thermal efficiency operating with different MOCD bio oil blends. MOCD 5% was showing higher brake thermal efficiency compared to other MOCD blends. At full load condition maximum brake thermal efficiency recorded was 31.68% for diesel and 29.48% for MOCD 5%. MOCD blends showed less brake thermal efficiency compared diesel due to high viscosity and low volatility.

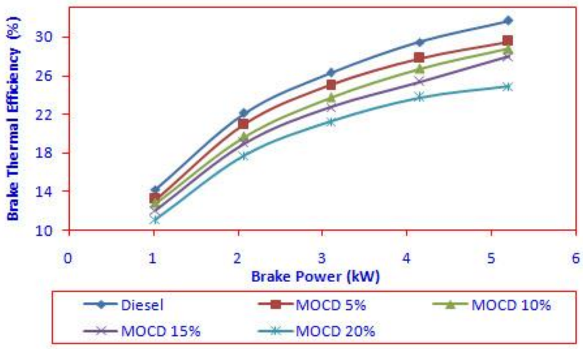

Fig.4. Break thermal efficiency Vs brake power

4.3 Exhaust Gas Temperature

The fig 5 shows the exhaust gas temperature with respect to brake power. It is observed that the exhaust gas temperature increase with load increment. More fuel is burnt at higher load. The Exhaust gas temperature is slightly higher with diesel compared to bio oil.

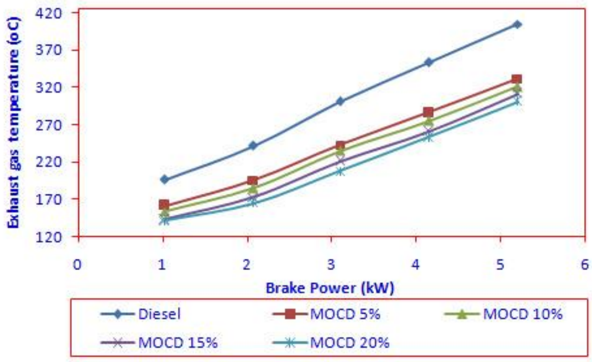

Fig.5. Exhaust gas temperature Vs brake power

4.4 *Smoke density*

From the test data shown in the Fig 6, it is observed that smoke density of diesel is lower compared to bio oil blends. It is evident from the graph that, among the bio oil blends the smoke density of MOCD 5% blend is lower compare to all other bio oil blends. Higher thermal efficiency means, better and complete combustion and lesser amount of unburnt hydrocarbon in the engine exhaust thus improving smoke density values.

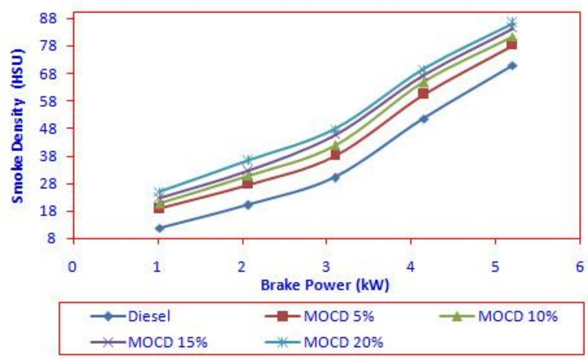

Fig.6. Smoke density Vs brake power

4.5 Oxides of Nitrogen

The comparison of the NOx concentration emitted from the engine exhaust using diesel fuel and various blends of MOCD is shown figure 7. The concentration of NOx is increased when the load is increases. It is due to conversion of elemental nitrogen to No under the condition of high gas temperature which can be easily combined with oxygen to create nitrogen dioxide (NO_2). Emission of NOx is significantly lower amount in all bio oil blends. This is due to in complete combustion in combustion chamber, hence NOx is decreased.

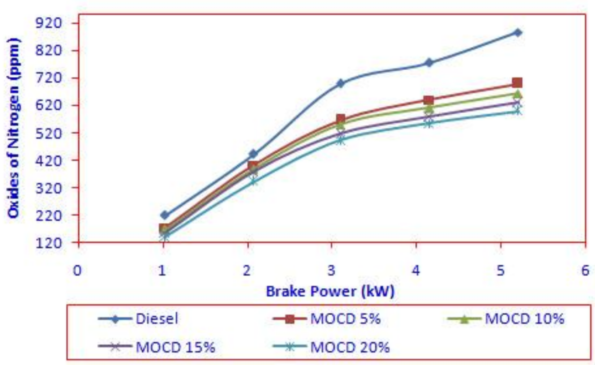

Fig.7. Oxides of nitrogen Vs brake power

4.6 Hydro Carbon

It is seen in Fig. 8 that there is a significant increase in the HC emission level with blends of MOCD as compared to diesel operation. There is increased from 63 ppm to 82 ppm at the maximum power output. These increased indicate that more incomplete combustion of the fuels and thus, HC level increases significantly. The reduction in HC was lower blends of MOCD blend.

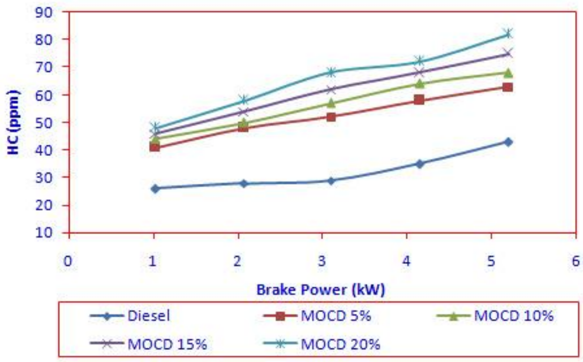

Fig.8. Hydrocarbon Vs Brake Power

4.7 Cylinder pressure

Fig 9 shows the variation of cylinder pressure with respect to crank angle. It is seen from fig that the peak pressure of 75 bar in diesel. The rate of pressure rise is always lower in the case of bio-diesel operation due to its slower burning characteristics. The pressure variation in the cycle is important in the analysis of the combustion characteristic of any fuel .In compression ignition engines the peak pressure depends on combustion rate in the initial combustion period, which in turn depends on the amount of fuel taking part in the uncontrolled combustion phase.

4.8 Heat release rate

Fig 10 shows the variation of heat release rate for bio oil blends with diesel at full load operating condition. The crank angle at which the maximum heat release rate occurs is in advance for bio oil. This is due to the start of combustion after TDC for both fuels at lower engine loads and the combustion starts later for diesel than for bio oil. As the engine load is increased, the heat release rate for diesel is higher because of the longer ignition delay, during which more fuel is accumulated in the combustion chamber to release higher heat during the premixed combustion phase, as suggested earlier.

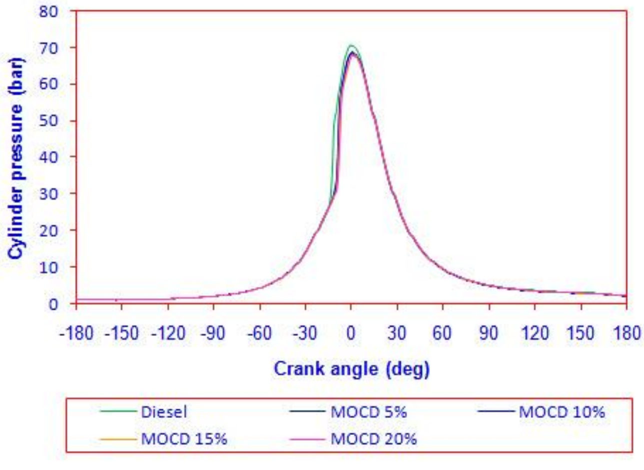

Fig.9. Cylinder pressure Vs Crank angle

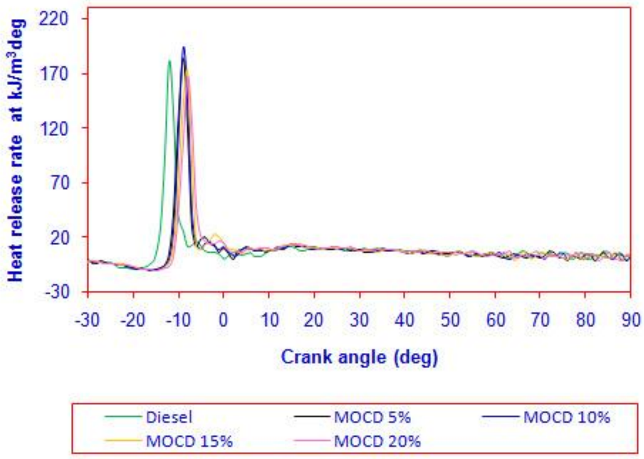

Fig.10. Heat release rate Vs crank angle

IV. CONCLUSION

Bio oil produced from mahua oil cake. Pyrolysis process is a feasible method for bio mass conversion into bio oil. The bio oil is a complex mixture of several organic compounds. Experiments were conducted on a single cylinder, four stroke, water cooled, direct injection, compression ignition engine using MOCD blends and diesel as fuel. Based on the findings the conclusions are drawn. The specific fuel consumption is found to be lower to that of diesel at full load. The thermal efficiency is found to be at lower in MOCD blends. There is a significant higher in emissions of hydrocarbon, carbon monoxide and smoke emissions. The NOx emission is lower for MOCD blends compare to diesel. At full loads, the cylinder pressure and heat release rate are slightly higher for MOCD 15%. These would attract bio oil as a suitable substitute for diesel fuel.

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