Performance and Emission Analysis of an Unmodified Four Stroke Diesel Engine Operating with Extracted Mahua Longifolia Biodiesel and Its Blends

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Abstract*—The increased demand for renewable energy sources and developing countries like India's need to secure its energy supply has spurred interest in development of bio fuel production whereas the exhaust emission of the biodiesel is deteriorating the environment also. The aim of the research is analyze the emission characteristics of Mahua Longofolia oil and its blends. Mahua Longofolia butyl ester is derived through transesterification process. A single cylinder, water cooled, four stroke diesel engine was used for this work. The following fuels were tested such as diesel, B10, B20, B30, and observe the exhaust emission characteristics in terms of concentration of NOX, CO, HC, particulate matter and smoke density. Observe results of diesel, Mahua Longofolia oil butyl esters and their blends with diesel by volume were compared. As load applied to the engine increases brake thermal efficiency of the fuel blends also increases. The maximum brake thermal efficiency is 32.47% for B30 at full load, which is 4.2% higher than standard diesel. As the load increases specific fuel consumption of the engine decreases gradually. At full load conditions the specific fuel consumption for the blends B20 and B30 is 0.363 kg/ kWh, 0.355 kg/ kWh respectively whereas for standard diesel it is 0.38 kg/ kWh. As load applied increases exhaust gas temperature get decreased. Lower calorific value of the blended fuel than standard diesel and lower temperature at the end of compression leads to reduction in exhaust gas temperature. As load increases mechanical efficiency of the blended fuel shows steady increase. At full load condition the maximum mechanical efficiency obtained from blend B10 and B20 is 61.7% and 58.96 % respectively. From the analysis of exhaust emission of the blends, it has found that at higher load condition B30 blends having higher hydrocarbon emission. At lower loads B30 blended fuel having higher NOx emission than standard diesel. The carbon monoxide emission is also higher than the standard diesel and B10 & b20 blends.

Keywords*— *Mahua Longofolia, butyl ester, unmodified CI engine, performance, emission characteristics

I. INTRODUCTION

Energy consumption increases rapidly due to increase in population. Today, the energy crisis becomes one of the global issues confronting us. It is impossible to satisfy the needs in forthcoming years with fossil fuels itself. So, there is an urgent need for suitable alternative fuels for use in diesel engines. The non-edible vegetable oils like Jatropa oil, Karanja or Pongamia oil, Neem oil, Jojoba oil, Mahua oil, Cottonseed oil, Linseed oil are considered as alternate fuels to diesel. Mahua oil which is promising alternative because they have advantages like they are renewable, Eco-friendly and produced easily in rural areas, where there is an acute need for modern forms of energy [1]. Out of all alternative fuel options for diesel, plant/vegetable oils in the form of blends or trans esterified form emerged as a promising source as a fuel extender. There exists numbers of vegetable/ plant which produce oil and hydrocarbon substances a part of the natural metabolism. These vegetable oils from oil seed crops like soya bean, sunflower, groundnut, mustard etc. and oil seed from tree origin have got 90 to 95% energy value of diesel on volume basis, comparable cetane number and can be substituted between 20-100 percent. It seems that vegetable/plant oil are better proposition as alternative fuel for diesel engine as they are liquid in nature and have many advantage over other alternative fuel option. The review of literature revealed that the use of vegetable oil ester as a fuel in diesel engines, a comparable engine performance with diesel was achieved. Also, harmful exhaust emissions, particularly hydrocarbon, smoke and carbon monoxide are considerably reduced as compared to diesel with the use of vegetable oils as a fuel. The major problems associated with direct use of vegetable oils, as a fuel for compression ignition engine is their high viscosity. It interferes with the fuel injection and atomization and contributes to incomplete combustion, nozzle choking, excessive engine deposits, ring sticking, contamination of lubricating oil etc. One possible method to overcome the problem of higher viscosity is trans esterification of potential oils. The investigators reported that with the use of vegetable ester as a fuel for diesel engines, comparable performance with diesel was achieved [2-6].

II. Materials And Methods

A. *An Overview of Madhuca Longifolia*

Mahua longifolia, commonly known as mahwa or Mahua, is an Indian tropical tree found largely in the central and north Indian plains and forests. It is a fast-growing tree that grows to approximately 20 meters in height, possesses evergreen or semi evergreen foliage, and belongs to the family Sapotaceae. It is adapted to arid environments, being a prominent tree in tropical mixed deciduous forests in India in the states of Jharkhand, Uttar Pradesh, Bihar, Madhya Pradesh, Kerala, Gujarat and Orissa.

B. *Transesterification*

Transesterification is the most common method to produce biodiesel, which refers to a catalyzed chemical reaction involving Vegetable oil, and an alcohol to yield fatty acid alkyl esters and glycerol i.e. crude glycerin. The process of 'transesterification' is sometimes named methanol sis or alcoholysis. This method is used to convert the Mustarded oil in to Mustarded oil BME ester. After transesterification, viscosity of MOBME is reduced by 75-85%. It is also called fatty acid BME esters, are therefore products of transesterification of Mustarded oil and fats with butyl alcohol in the presence of a NAOH catalyst. During the reaction, high viscosity oil reacts with BME in the presence of a catalyst NAOH to form an ester by replacing glycerol of triglycerides with a short chain alcohol. [Triglycerides (Mustarded oil) + BME ester + Glycerol].

C. *Engine Specification*

Type	: Water cooled, constant speed
Speed	: 1500 rpm
Power	: 3.73 KW
Fuel	: H.S. Diesel
Lubricating Oil	: SAE30/SAE 40
Loading	: Electrical Loading

Fig. 1. Tested Engine.

III. Results And Discussions

A. *Total Fuel Consumption (TFC)*

The variation of the total fuel consumption for with load for different blends is shown in Fig. 3. B10, B20, B30 were comparatively higher than that of diesel fuel due to high specific gravity.

Fig. 2. Blender.

Fig. 3. Separation process.

TABLE I. Fatty Acid And Composition Of Mahua Oil

Fatty acid	Structure	Formula	Weight (%)
Palmitic	16.0	C16H32O2	24.5
Stearic	18.0	C18H36O2	22.5
Arachidic	20.0	C20H40O2	1.5
Oleic	18.1	C18H34O2	37.5
linoleic	18.2	C18H32O2	14.3

B. Brake Thermal Efficiency (BTE)

The variation of the total fuel consumption for with load for different blends is shown in Fig. 4. Thermal efficiency purely depends on engine design, type of fuel used and area of application. Vegetable oil based fuel contains oxygen (10-12 %), which causes better combustion in case of esters compared to diesel. However, heat release does not only depend upon oxygen content but also heating value of the fuel. Here, vegetable oil based fuel have less heating value (10-12%) compared to diesel fuel. So the oxygen content and heating value of the fuel is purely responsible for thermal efficiency, which (Fig. 5) for methyl ester is high than for diesel.

C. Emission Analyses

The exhaust emission is most important of the making of bio fuel why because the vegetable oil having a fatty acid content that fatty acid is a acting on the major role of making bio fuel. Then the vegetable oil having oxygen content in naturally. So, the bio fuels are having more emission compare the diesel fuel. The variation of hydrocarbon emission with load for different blends is shown in Fig.7. At higher load condition the hydrocarbon emission of various blends are higher except the blend B10. In vegetable oil fuels, the effect of fuel viscosity and the fuel spray quality has been expected to produce some increase in hydrocarbon content in emission.

The variation of nitrogen oxide (NOx) emission with load for different blends is shown in Fig.6. The nitrogen oxide emission for standard diesel is lower than that of biodiesel and its blends except B30 at lower loads. Usually vegetable based fuel contains a small amount of nitrogen. This leads to the nitrogen oxide production. From the graph it is concluded that for 50% load, nitrogen oxide emission from the Mahua oil blend B30 is higher than that of standard diesel. But in case of 100% load condition the nitrogen oxide emission from the B30 blend is higher than that of standard diesel, while the other blends close follows the standard diesel. The variation of carbon monoxide emission of the blends and diesel for various loads is shown Fig. 7.

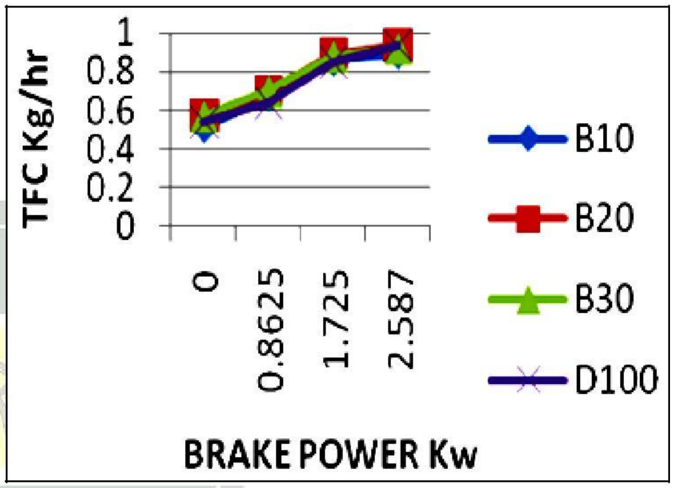

Fig. 4. Effect of Total Fuel Consumption for various blends.

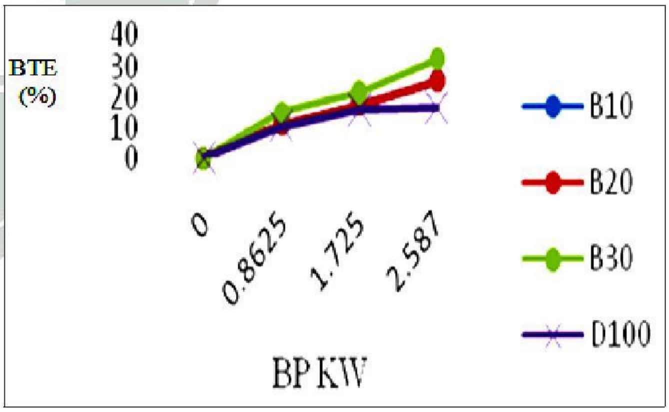

Fig. 5. Effect of brake thermal efficiency for various blends.

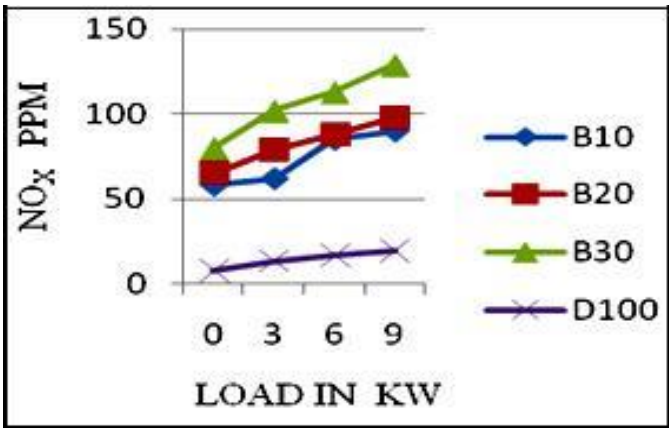

Fig. 6. Variation of nitrogen oxide (NOx) emission.

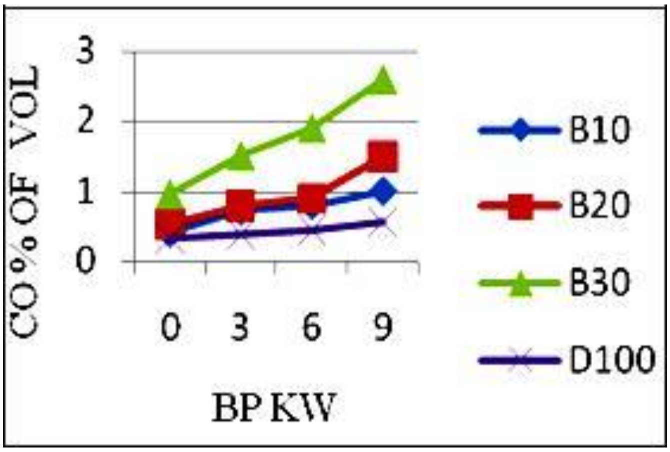

Fig. 7. Variation of carbon monoxide oxide (CO) emission.

The carbon monoxide emission of the blend B30 is found to be higher for light and medium loads. B10 B20 are closer than the standard diesel Due to rising temperature in the combustion chamber, air fuel ratio, lack of oxygen at high speed, physical and chemical properties of fuel and smaller amount of time available for complete combustion, the proportion of carbon monoxide emission increases. The carbon monoxide emission increases for vegetable oil fuels due to the effect of fuel viscosity on the fuel spray quality. Fig.8 shows that the variation of carbon dioxide emission with different loads. The complete combustion of fuel in the combustion chamber leads to increased emission of carbon dioxide. The carbon dioxide emission changes with exhaust gas temperature. Due to incomplete combustion and inadequate supply of oxygen carbon dioxide emission of the fuel blends B30 at full load increases compare with other blends B10 & B20. The increased emission of carbon dioxide in the atmosphere leads to several environmental problems like global warming and ozone layer depletion. The carbon dioxide emission from the combustion of bio fuel blends can be intake by the plants and so the carbon dioxide level is kept constant in the atmosphere.

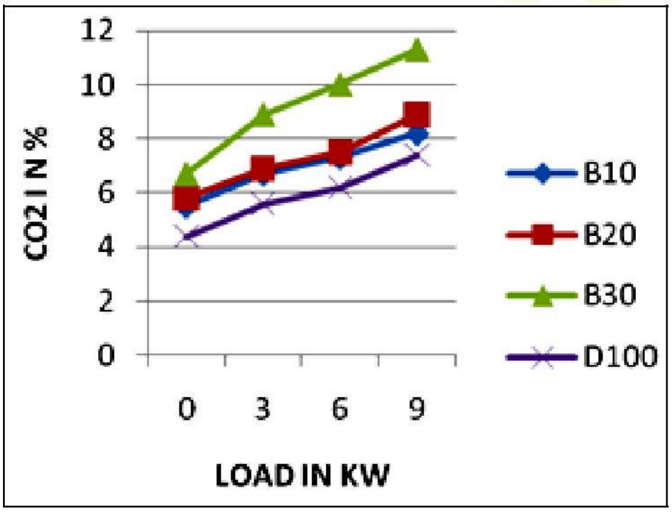

Fig. 8. Variation of carbon-di-oxide (CO2) emission.

Summary

A single cylinder, water cooled, four stroke diesel engine was used for this work. The following fuels were tested such as diesel, B10, B20, B30, and observe the exhaust emission characteristics in terms of concentration of NOX, CO, HC, and CO2. Observe results of diesel, Mahua Longifolia oil butyl esters and their blends with diesel by volume were compared. A detailed experimental study was conducted to evaluate and analyze the performance, exhaust emission level and combustion of Mahua oil biodiesel and diesel blends in a fully instrumented single cylinder multi fuel engine. The conclusions are summarized as follow; as load applied to the engine increases brake thermal efficiency of the fuel blends also increases. The maximum brake thermal efficiency is 32.47% for B30 at full load, which is 4.2% higher than standard diesel. As the load increases specific fuel consumption of the engine decreases gradually. At full load conditions the specific fuel consumption for the blends B20 and B30 is 0.363 kg/ kWh, 0.355 kg/ kWh respectively whereas for standard diesel it is 0.38 kg/ kWh. As load applied increases exhaust gas temperature get decreased. Lower calorific value of the blended fuel than standard diesel and lower temperature at the end of compression leads to reduction in exhaust gas temperature. As load increases mechanical efficiency of the blended fuel shows steady increase. At full load condition the maximum mechanical efficiency obtained from blend B10 and B20 is 61.7% and 58.96 % respectively. From the analysis of exhaust emission of the blends, it has found that at higher load condition B30 blends having higher hydrocarbon emission. At lower loads B30 blended fuel having higher NOx emission than standard diesel. The carbon monoxide emission is also higher than the standard diesel and B10 & B20 blends.

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