EFFECT OF INJECTION PRESSURE ON ENGINE PERFORMANCE AND EMISSION CHARACTERISTICS OF DIESEL ENGINE USING MANGO SEED OIL METHYL ESTER

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Abstract
In this study, the affect of injection pressure on the performance and emission characteristics of a single cylinder, four stroke, direct injection, naturally aspirated diesel engine has been experimentally investigated when using mango seed oil methyl esters (MSME) and its blends(B20, B100) with diesel fuel(B00). The tests were conducted for three different injection pressures (210, 220 and 230 bar) at constant engine speed and different loads. The experimental results showed that the fuels exhibit different performance and emission characteristics for different engine loads and injection pressure (IP). Analysis on the injection pressure of the fuels showed that the brake thermal efficiency (BTHE) of B20 increasing with injection pressure when compare to the B00, B100. The maximum BTHE attain for B20 at IP 230. The brake specific fuel consumption (BSFC) for B20 MSME is shown lower value at IP 230 bar. There is considerable reduction of emissions of MSME and its blends.

Key words: mango seed oil methyl ester, injection pressure, performance, emission, diesel engine.

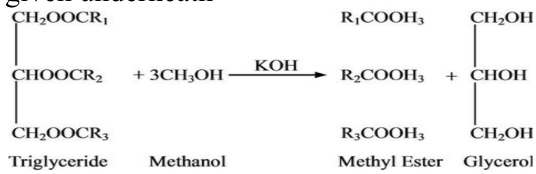
Introduction

Diesel engines usage in broad area like transportation, industrial, agriculture and power generation are increasing because of its excellent fuel economy, reliable, durable and toughness. The increasing requirement of energy in the form of fossil fuels may increase the demand that leads continues rise in global prices of crude oil and scarcity. There is another trouble also come into picture is due to high usage, the engine emissions that may increase the air pollution and global warming. Consequently need to search the alternative for fulfill the demand. At present there are more alternative sources for power generation such as solar, wind, biomass, tidal and wave energy, biodiesel from vegetable seeds and animal fats [1-4]. All of the above, biodiesel is fulfill the certain percentage of global demand. It can be use in the engines without any modifications upto some percentage blend with conventional diesel. Therefore, it is of curiosity to investigate the use of biodiesel in the diesel engine, intended to increase efficiency of operation and to decrease the emissions of pollutants [5-9]. Many researchers doing their research in different biodiesels extracted from different seed oils like pongamia, jatropa, cotton seed, sesame, linseed, honge, rubber seed etc. Combustion of the fuel inside the cylinder sequentially depends on different factors like, fuel injection timing, fuel injection pressure, engine design such as shape of combustion chamber and position of injector, fuel properties, number and size of injection nozzle hole, fuel spray pattern, air swirl, fuel quantity injected, etc[10-14]. However biodiesel having high viscosity, surface tension and density then diesel, so as to affects the atomization of fuel by increasing fuel droplet size. When fuel injection pressure increases, the droplet size decreases, so that minimizes the problem of atomization. Some researches, compression ratio was varied, the performance and emission parameters varies[15-17]. Matin gumus et al. done research on impact of injection pressure of biodiesel blends at different injection pressures (12.5, 25, 37.5, and 50 kPa) and concluded that upto some increase in injection pressure the performance and emission parameters improved. In this present research, study the impact of injection pressure on engine performance and emission characteristics for MSME blends and compare with diesel.

II. MATERIALS AND METHODS

A) Biodiesel

For this study, trade diesel was brought from local petroleum station, mango seed oil was extracted from mango seeds by mechanical crushers and biodiesel was formed by transesterification process, the different processes of mango seed to biodiesel are shown in Fig.1 At first, mango seed oil was responded with a monohydric alcohol (methanol (CH_3OH)) within the presence of catalyst (potassium hydroxide (KOH)). The procedure of transesterification was influenced by the method of response condition, molar proportion of alcohol to oil, sort of alcohol, sort and measure of catalysts, response time, temperature and virtue of reactants. After transesterification, water wash was done by purified water took after by warming for virtue. The various processes associated with transesterification process are given underneath



The physical and thermal properties of the Diesel fuel, biodiesel and biodiesel blend B20% are summarized in Table 1. The representative values like fire point, density, flash point, viscosity, cetane index and gross calorific value are measured for biodiesel and its blends. The fig.1 shows the different stages of biodiesel production

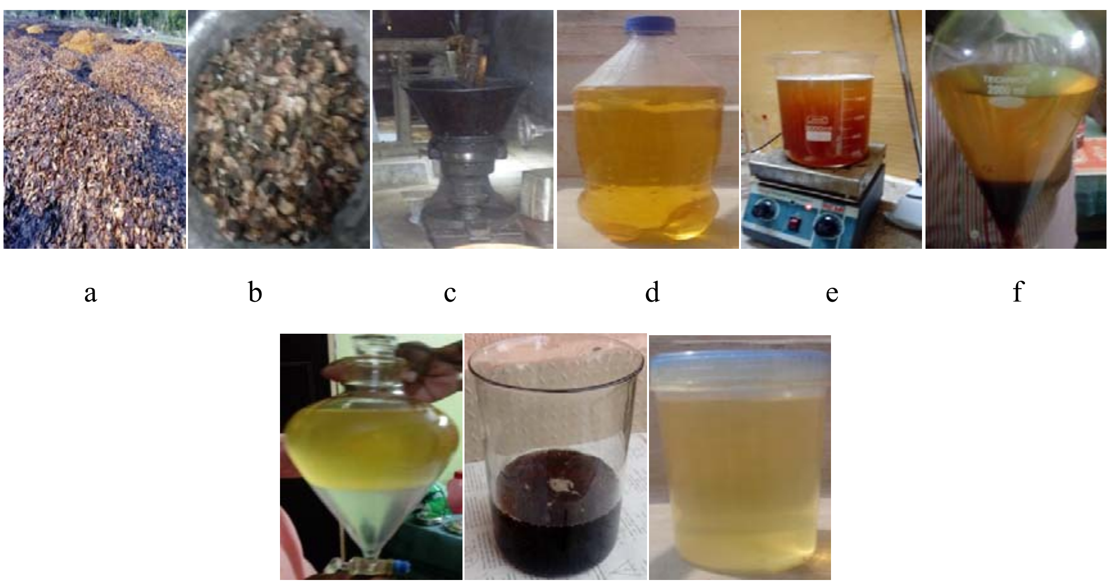


Fig.1 Different stages of mango seed oil methyl ester

a) Mango fruit wastage from juice factory, b)dry mango seed, c)oil extracting machine, d)mango seed oil, e)transesterification, f)settling after transesterification, g)water wash after separating the biodiesel, h) glycerol, i) pure mango seed oil methyl ester.

TABLE 1
Fuel properties of diesel and biodiesel blends

Properties	Diesel (D100)	B20	Biodiesel (B100)
Flash point in ^{0} C	60	78	160
Fire point in ^{0} C	63	82	170
Density kg/m^3	830	849	929
Kinematic viscosity in cst at 40^{0}C	3.26	3.51	4.66
Calorific value in kJ/kg	42500	41888	39442
Cetane number	51	----	48

III. EXPERIMENTAL SETUP

A 5HP (3.5 kW) 4-Stroke direct injection research diesel engine (shown in Fig.2) was chosen to investigate the performance and emission characteristics. The air flow rate into the engine was measured by mass flow sensor and the fuel consumption was measured by burette method. Loading was applied on the engine with the help of eddy current dynamometer. The experiment was carried at different loads (0, 25, 50, 75% and full load). Various sensors were utilized during the experiment to collect, store and analyze the data by computerized data acquisition system(IC enginesoft). An exhaust gas analyzer (AIRREX HG-540, 4Gas analyzer) was employed to measure HC, CO, CO_2 and NO_X emissions. The performance, combustion and emission results obtained were tabulated. The specifications of Research engine are shown in Table 2.

IV. RESULTS AND DISCUSSIONS

A. Performance Characteristics

The major performance parameters such as Brake power (BP), Brake thermal efficiency (BTHE) and BSFC are evaluated for B20, B100 of MSME and diesel (B00)

TABLE 2
Specifications of the Research engine

Engine parameters	Specifications
Make	Kirloskar
Model/Type	TV1/Four stroke
Number of cylinders	Single
Bore/Stroke	87.5 mm/110 mm
Rated power	5 HP(3.5 kW) @ 1500 rpm
Capacity(cc)	661
Type of cooling	Water cooled
Compression Ratio range	12–18
Injection timing range	0- 25^0 BTDC
Loading	Eddy current dynamometer
Data acquisition device	NI USB-6210, 16-bit, 250kS/s.
Temperature sensors	Type RTD, PT100 and Thermocouple, K-Type
Load sensor	Load cell, type strain gauge, range 0-50 Kg
Fuel flow transmitter	DP transmitter, Range 0-500 mm WC
Air flow transmitter	Pressure transmitter, Range (-) 250 mm WC
Software	“Engine soft” Engine performance analysis software
Rotameter	Engine cooling 40-400 LPH; Calorimeter 25-250 LPH

Fig.2 Experimental setup

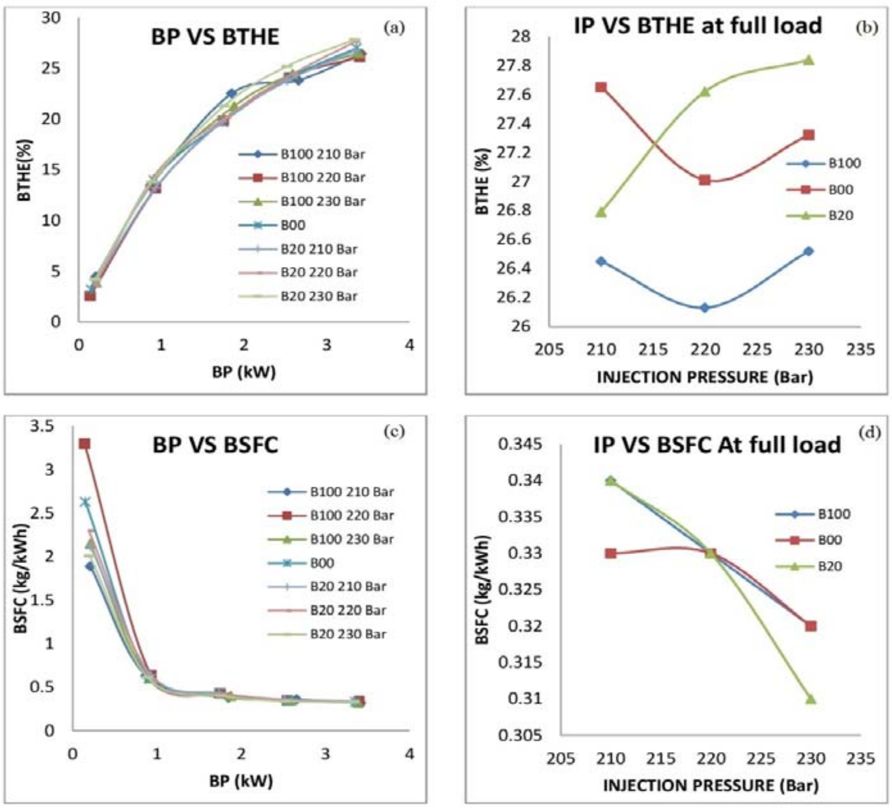


Fig.3 a-d represents the variation of BTHE and BSFC with BP and injection pressure.

1) Brake power and Brake thermal efficiency: Fig.3a shows the variation of BTHE with BP for B20, B100 of MSME and diesel. The BTHE is gradually increasing with BP. BTHE for blend B20 is increasing with injection pressure where as B100 and B00 it is decreases upto 220 bar then increases shown in Fig.3b.For B20 blend have higher BTHE at 230 bar(27.84%), This may be due to enhanced atomization and smaller droplet. For B100 and B00 highest values are 26.52% at 230 bar and 27.65% at 210 bar ,normal pressure for diesel is 200 bar for this engine. The results show that efficiency at full load for B20 blend is closer to diesel fuel because of improved atomization and better mixing process at higher injection pressures. It can be seen that at 230 bar injection pressure the efficiency is marginally higher than diesel. This may be due to the better combustion of MSME. It is to be noted that the oxygen (12%) contained in the MSME take part in combustion which in turn enhance the combustion process.

2) Brake power and Brake specific fuel consumption: Fig.3c shows the variation of BSFC with BP for B20, B100 of MSME and diesel. BSFC decreases while increasing the BP for all combinations of MSME and for diesel. It is clearly shows in the fig 3d BSFC is decreases while increasing the injection pressure corresponding to BP, BSFC is decreasing while increasing the BP. At full load, BSFC is higher for B20 (0.31 kg/kWh) and for B100 (0.32kg/kWh). It can be observed that at all loads and injection pressures; the fuel consumption is nearly equal in the case of B100 of MSME compared to diesel at 230bar pressure. This is due to higher density and lower heating value of MSME compared to diesel.

B. Emission Characteristics: The major emissions of engine are unburned hydro carbons (HC), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x) and particulate matter from internal combustion engines. The effects of additives and nano additives on emissions of B20 blend of MSME are discussed here.

1) Hydro carbons (HC): The Fig.4a-b shows the variation of hydro carbons emissions with injection pressure for B20, B100 of MSME and diesel at 50% and full load conditions. In fig 4a the HC decreases while increasing the pressure for B20 and B100 of MSME but for diesel it is slightly decreased upto 220 bar and then increases. For blend B20 shows lower value at pressure 230 bar. In fig.4b shows the HC variation with injection pressure at full load condition, the B100 shows lower values then B20 and B00. Fundamentally, the oxygen content of fuel is the main reason for hydro carbon emissions reduction. May be biodiesel having some oxygen content that improves the combustion.

2) Carbon monoxide (CO): Fig.4c-d shows the variation of carbon monoxide emissions with injection pressure for B20, B100 of MSME and diesel at 50% and full load conditions. In fig 4c the CO emission is decreasing while increasing the IP for blend B20 at 50% load the B100 and B00 is varies differently where as at full load for B20 blend decreases when increasing the injection pressure. It is also observed that CO increases with load. Hence CO emissions shows lower values for B20 blend at 230 bar pressure. This may be combustion improvement due increase in pressure gets good atomization of fuel. Because of incomplete combustion causes CO emissions.

3) Carbon dioxide (CO_2): Fig.4e-f shows the variation of carbon dioxide emissions with injection pressure for B20, B100 of MSME and diesel at 50% and full load conditions. It is clearly disclose that conventional diesel having higher CO_2 emissions at 50% load than biodiesel blends where as at full load B100 shows lower values. The load increases CO2 emissions deceases for B100 and B00 where as B20 shows slightly higher values at full load.

4) Nitrogen oxides (NOx): Fig.4g-h shows the variation of nitrogen oxides emissions with injection pressure for B20, B100 of MSME and diesel at 50% and full load conditions. Nitrogen oxides are mainly formed due to high temperatures. NO_X is increasing with load and injection pressure however diesel values are higher than B100 at 50% load. B20 blend shows nearly same values at both the conditions.

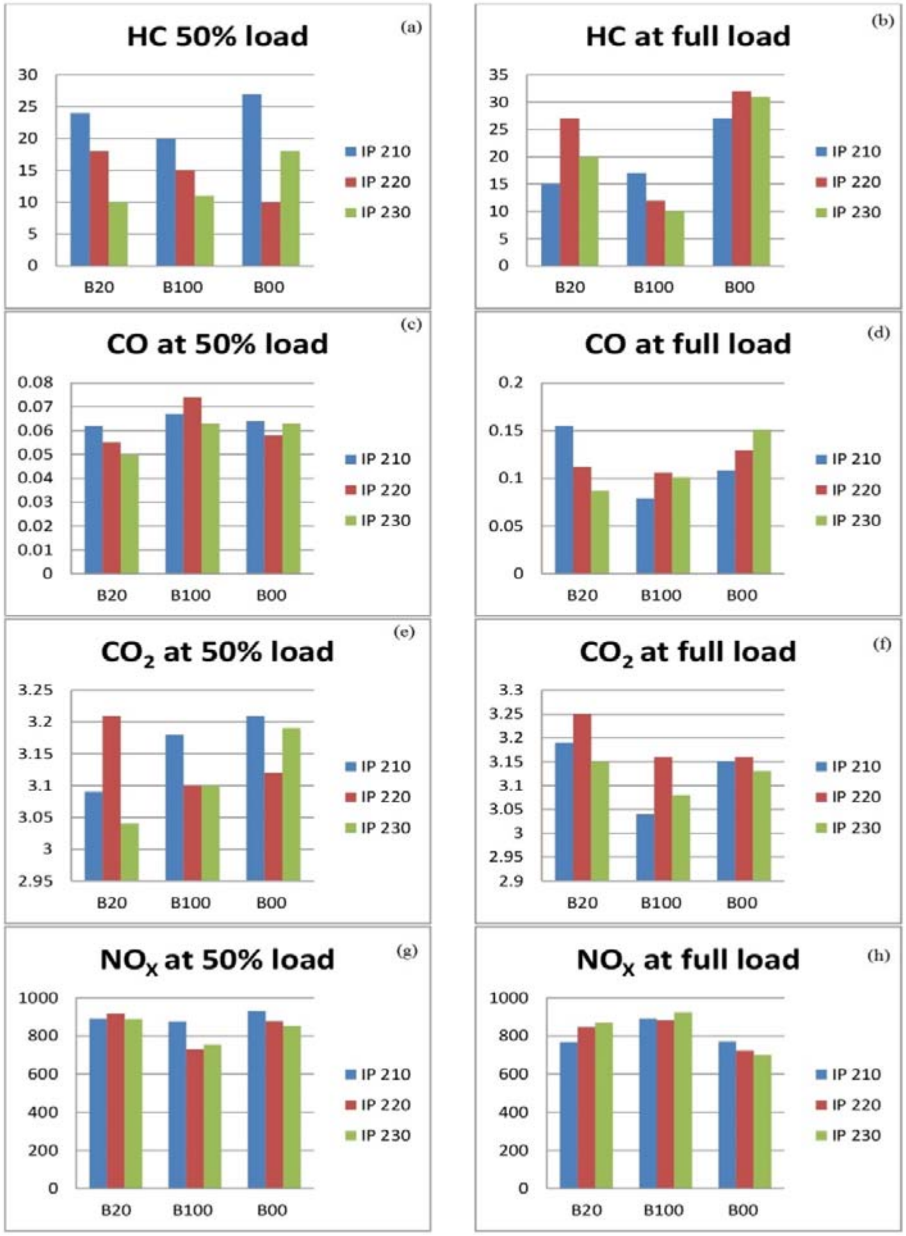


Fig.4 Variation of HC, CO, CO_2, and NO_X with Brake power and IP

V.Conclusions

From the present experimentation, the following conclusions are drawn:

1. Mango seed oil having high viscosity and low volatility makes the oil unsuitable for a diesel engine.
2. By transesterification process the fuel properties are closer to diesel fuel.
3. MSME, derived from non-edible oil, which is an oxygenated fuel, used in a diesel engine reduces HC, CO, CO2 and NOx emissions while increasing IP
4. At 230 bar injection pressure, the thermal efficiency improved for B20 blend with decreased emissions. This may probably be due to the changes in the fuel spray structure which affects combustion.

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