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Investigation on the performance and Emission characteristics Of a diesel engine fuelled with vegetable oil methyl Ester blends and diesel blends

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Abstract:- The present research work involves the production of methyl ester from various vegetable oils like Karanja oil and application of with diesel blend as alternative fuel in a diesel engine to investigate on the engine performance and emission characteristics. The methyl ester is obtained by base catalyzed transesterification process which is then blended with diesel in various volume proportions. The use of additive in blended fuels reduces the ignition delay and combustion period of a diesel engine and lowers the sulfur and nitrogen oxide emissions. The investigation shows that the brake thermal efficiency increases upto 80% load and then decreases. The highest brake thermal efficiency is obtained for diesel. The brake specific fuel consumption decreases upto 80% load and then increases. The exhaust gas temperature increases linearly with load and is highest for pure biodiesel. The engine emission analysis with the above test fuels show that CO, CO2, HC and smoke emissions increase with load for all test fuels. The NOx emission increases with load and is highest for pure biodiesel. From the results obtained during the ongoing experimental investigation it may be concluded that the Karanja oil methyl ester blends with diesel can be successfully used in a compression ignition engine without degrading the engine performance and emission.

Keywords:- Vegetable oil; Biodiesel; Transesterification; Performance; Emission.

I. INTRODUCTION

The world energy demand is increasing at a very faster rate which is responsible for the world economic crisis. This present energy crisis in the world has created new challenges for scientists and researchers to find another suitable alternative to the vastly popular petroleum products as the engine fuels. This increases the global demand for exploration of the renewable energy sources through a sustainable approach [1-3]. Some common renewable energy sources are being hydropower, wind energy, solar energy, geothermal, biomass, biofuels etc. Extensive research is being carried out by most of the developed and developing countries for the development of renewable fuels for future use in engines [4, 5]. There is huge demand for non renewable energy sources and this demand is increasing day by day, where in the future the demand to supply ratio of nonrenewable energy sources is unbalanced which leads to energy crises. Work is going on for production of alternative fuels using renewable energy sources. The best alternative fuel for engines being biodiesel [5-7].

A. Transesterification Reaction

Transesterification is a process of producing a reaction in triglyceride and alcohol in presence of a catalyst to produce glycerol and ester. Molecular weight of a typical ester molecule is roughly one third that of typical oil molecule and therefore has a lower viscosity [8]. Alkalis (NaOH, KOH), acid (H_2SO_4.HCl, or enzymes (lipase) catalyzed reaction. Alkali catalyzed Transesterification is faster than acid catalyzed Transesterification is most often used commercially, because the reaction is reversible, excess alcohol is used to shift the equilibrium to product side. Alcohols are primary and secondary monohydric aliphatic alcohols (1-8 Carbon atoms) [8, 9]. In the Transesterification process, methanol and ethanol are more common. Methanol is extensively used because of its low cost and its physiochemical advantages with triglycerides and alkalis are dissolved in it. To complete Transesterification stoichiometrically 3:1 molar ratio of alcohol to triglycerides is needed [10-12]. Studies have been carried out in different oils such as soybean, sunflower, ape, coconut, palm, used frying oil, Jatropha, rubber seed and coconut seed. Mostly biodiesel is produced by Base catalyzed Transesterification of the oil as it is most economical. Here the process is reaction of triglycerides (oil/fat) with alcohol to form esters (biodiesel) and glycerol (by product) [12, 13]. During this process the triglycerides is reacted with alcohol in the presence of a catalyst, usually a strong alkaline like sodium hydroxide. The chemical reaction which describes preparation of biodiesel is:

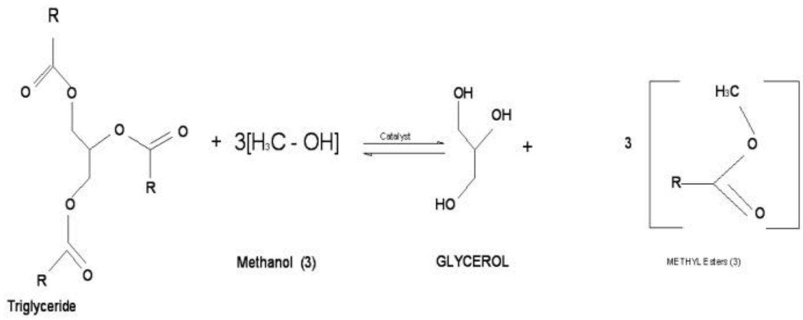

Fig. 1: Reaction scheme for transesterification

II. MATERIALS AND METHODS

B. Karanja Tree (Pongamia Pinnate)

Karanja (Pongamia pinnate) is a tree which plentily grows in forest lands of western ghats of India. The average life of Karanja tree is 80-100 years and it grows upto a height of 40 ft. It can grow in humid and sub tropical environment within suitable temperature range between 5-50 ^{0}C and an average annual rainfall of 600-2500 mm. The average yield of kernel per tree is about 9-90 kg per year and the oil production potential is approximately 1,35,000 metric tons per year in India [8].

C. Methodology

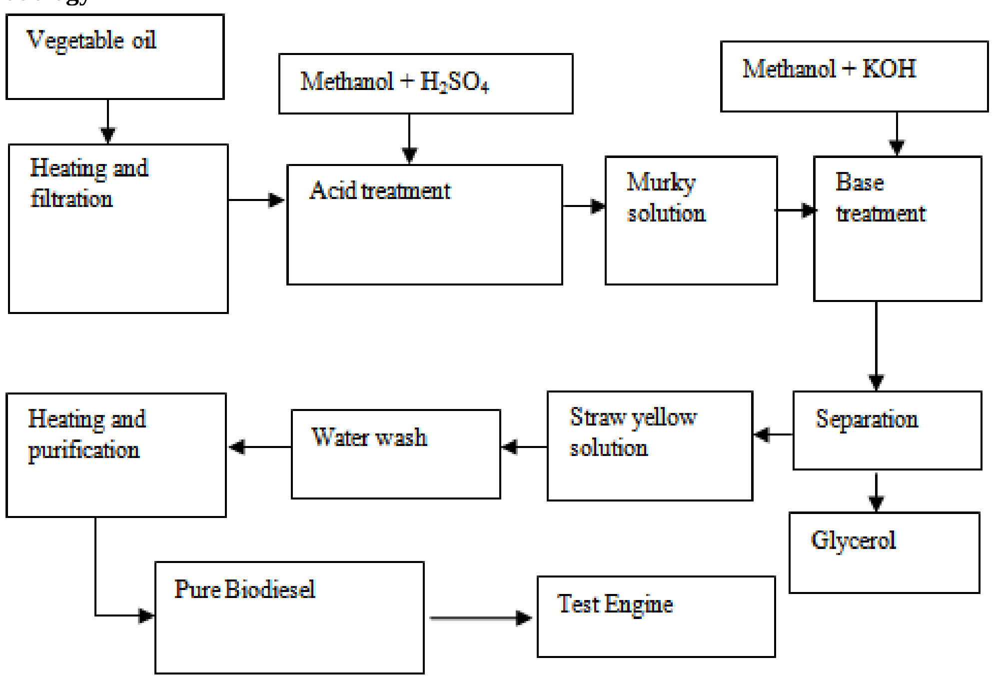

Fig. 2: Flow chart for vegetable oil methyl ester preparation.

Table 1 Parameters of the processes

Sl.No	Process parameters	Description
1	Process selected	Alkali catalyzed transesterification
2	Volume of oil being used	1000 ml of raw mahua oil
3	Reaction temperature	50-55^{0}C
4	Methanol used	120 ml/kg of oil
5	Catalyst used	KOH , 0.5-1 % per kg of oil
6	Stirring speed	500 rpm
7	Reaction time	1.5-2 hours
8	Settling time	8-10 hours
9	Water wash	4-5 times (40 min.)

Fig. 3: Separation of biodiesel and glycerol.

D. Characteristics of test fuels

Table II: Comparison of fuel properties for diesel and biodiesel

Sl.No	Properties of fuel	Unit	Diesel	Biodiesel
1	Kinematic viscosity at 40 ^{0}C	cSt.	4.57	5.39
2	Specific gravity at 15 ^{0}C	-	0.8668	0.8712
3	Flash point	^{0}C	42	157
4	Fire point	^{0}C	68	183
5	Pour point	^{0}C	-18	2
6	Cloud point	^{0}C	-3	16
7	Cetane index	-	50.6	51.2
8	Calorific value	KJ/Kg-K	42850	42293

E. Experimentation

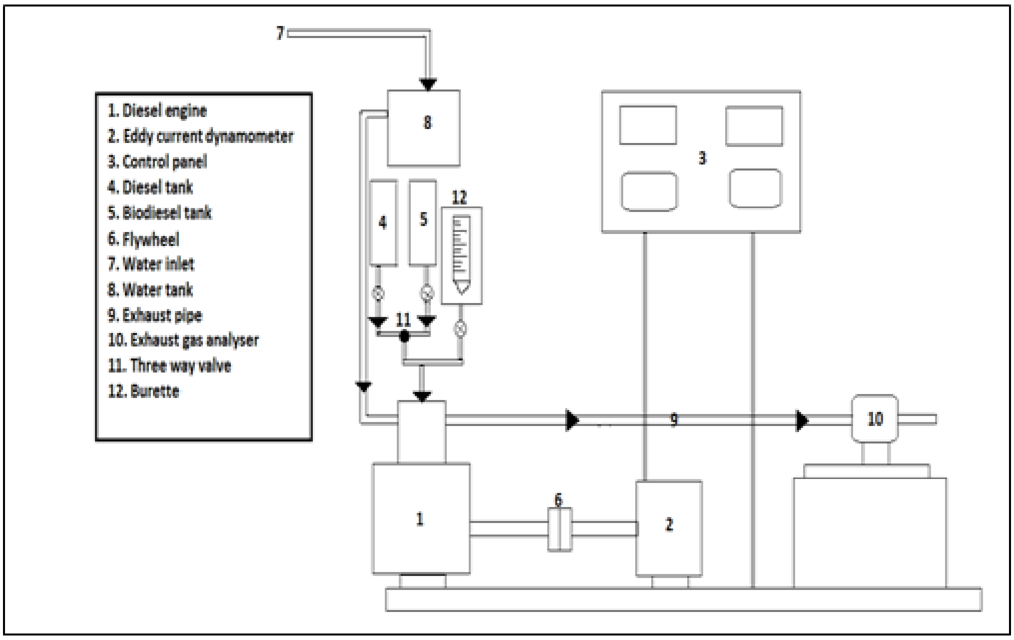

Fig. 4: Picture of the test rig.

F. The Test Engine

The experimental setup consist of single cylinder, four stroke, vertical water cooled, direct injection diesel engine. The test bed comprises of eddy current dynamometer, orifice meter in conjunction with U-tube manometer. The specification of the test engine is provided in Table 3. The fuel consumption rate is estimated with the help of a measuring burette and the engine emission analysis is carried out with a NETEL exhaust gas analyzer and an AVL 437 smoke meter.

Table III: Engine Specification

Sl.No	Particulars	Description
1	Engine type	Single cylinder, 4-stroke. vertical water cooled diesel engine
2	Bore diameter	80 mm
3	Stroke length	110 mm
4	Compression ratio	16:1
5	Rated power	3.67 KW
6	Rated speed	1500 rpm
7	Dynamometer	Eddy current dynamometer

III. RESULT AND DISCUSSION

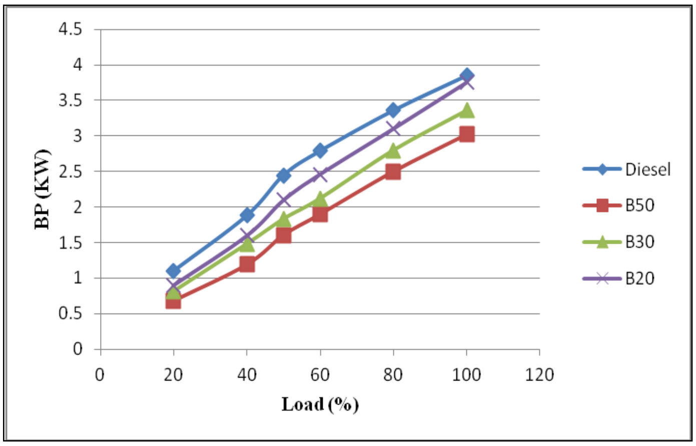

Fig. 5: BP with Load (%)

Figure 5 shows the variation of brake power with respect to percentage of load. The above result shows that diesel has highest BP for varying loads when compared with other test fuels. Brake power developed with B20 blend is somewhat close enough to that of diesel [8, 10].

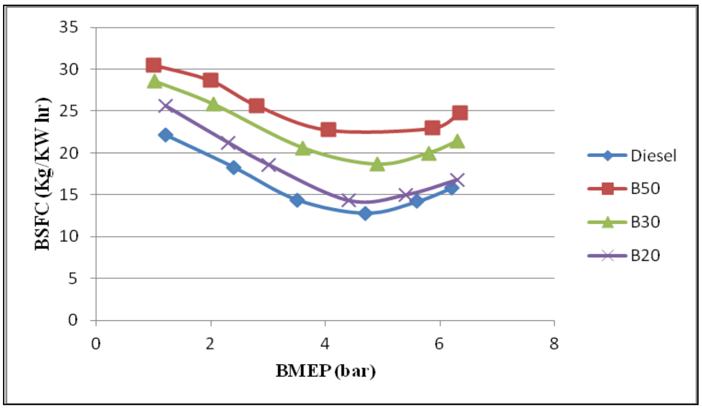

Fig. 6: BSFC with BMEP

Figure 6 shows the variation of BSFC with respect to BMEP. The above result shows that BSFC reduces with increase in BMEP. It is highest for pure biodiesel and lowest for diesel because the heating value is very low and high viscosity of the biodiesel blends [4, 8].

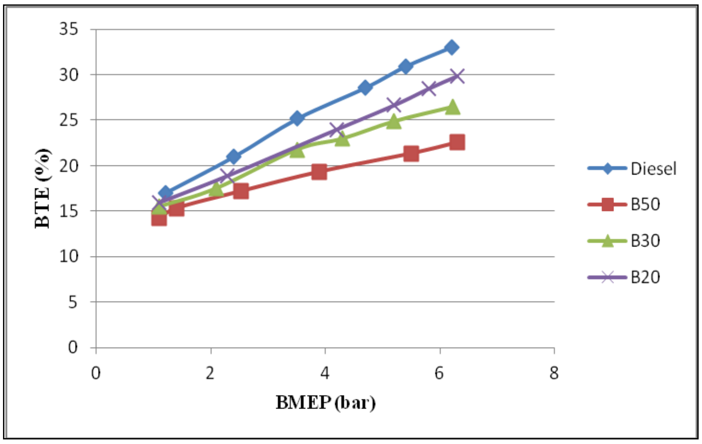

Fig. 7: BTE with BMEP

Figure 7 shows the variation of BTE with respect to BMEP. The above result shows that BTE increases as BMEP increase. It was observed that BTE was higher for diesel when compared with biodiesel and its blends. When there is increase in blending of biodiesel, there is a decrease in BTE because of high viscosity of biodiesel. Therefore the test fuels are more viscous for which they have a low heating value [4, 8].

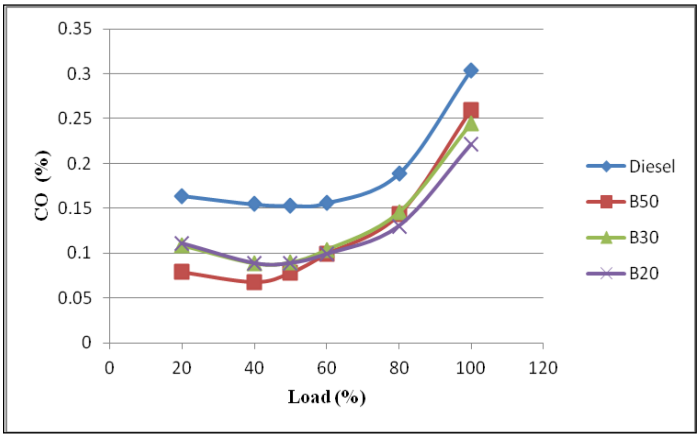

Fig. 8: CO with load (%)

Figure 8 shows the variation of CO with respect to load. The above result shows that at lower load there is decrease in CO emissions but at higher loads CO emission increases. The lowest and highest CO emission was obtained for B50 and B20 at low and full load conditions. This may be due to the reason that at low load total power output is low which complete combustion. Similarly at higher load total power output is high which causes incomplete combustion [14, 15].

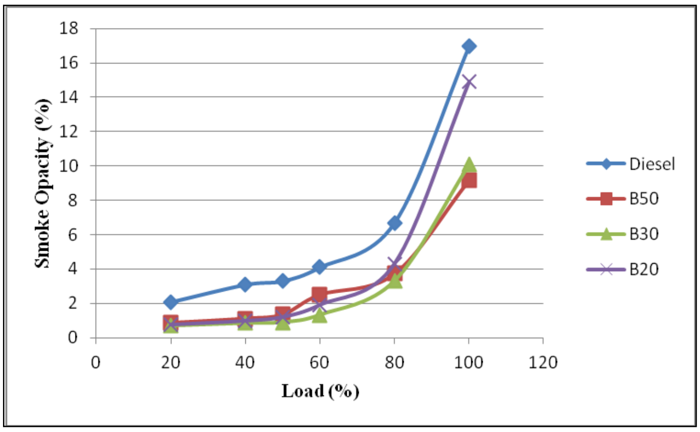

Fig. 9: Smoke Opacity with load (%)

Figure 9 shows the variation of smoke opacity with respect to load. The above result shows that smoke emission increases with increase in load for all test fuels. B50 blend produce less smoke incomparision with other test fuels because of better combustion as there is sufficient avaliability of oxygen in biodiesel [8, 16]].

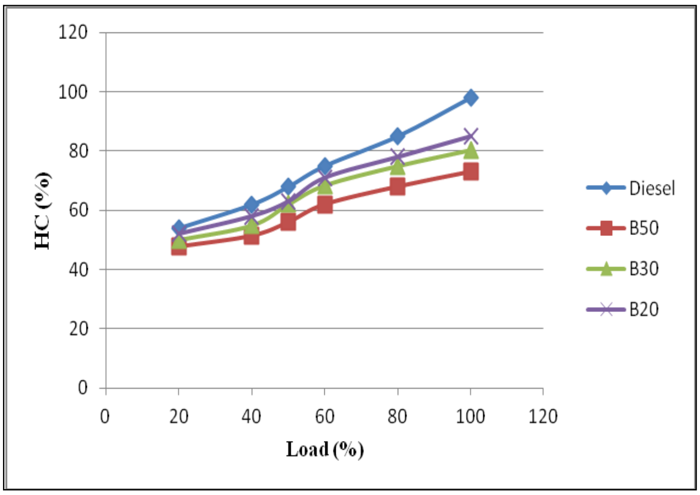

Fig. 10: HC with load (%)

Figure 10 shows the variation of HC with respect to load. The above result shows that HC emission increases with increase in load and is highest for diesel when compared with other test fuels. B50 blend has lowest HC emission at high load of all the test fuels [4, 8].

IV. CONCLUSIONS

From the above experimental data we may conclude that:

1. The BP was found to be increasing with increase in load (%). BP was highest for diesel and lowest for B50 blend. B20 blend curve was somewhat close to that of diesel curve.
2. The CO emission decreases with increase in load, but at 60% CO emission increases with increase in lo ad and was lowest for B20 blend at full load condition.
3. The smoke emission increases with increase in load, B50 blend have the lowest smoke emission at full load when compared with all other test fuels.
4. The HC emission gradually increases with increase in load, B50 blend have the lowest HC emission of all the test fuels.

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