INVESTIGATIONS OF KARANJA OIL BLENDS ON CI ENGINE BY ENRICHED HYDROGEN

Ranjit Pawar[1], Atul Londhekar[2], Suhas C.Kongre[3]

[1,2] Department of Mechanical Engineering, Rajiv Gandhi Institute of Technology, Mumbai, INDIA
[3] Department of Mechanical Engineering, ASP Pipri, Wardha, INDIA

ABSTRACT

Strict emission norms and available fossil fuel depletion make karanja oil a leading candidate of non-edible vegetable oils. In this investigation, biodiesel KO (karanja oil), Pure Hydrogen has been selected for the combustion process in CI (compression ignition) engine. Small amount of hydrogen when added to a diesel engine shorten the diesel ignition lag and decrease the rate of pressure rise. This paper presents the results of experimentations carried out in studying the fuel properties of KO, its blend with diesel fuel and constant flow rate 5l/min of hydrogen as additive. The engine was run at a constant speed and variable load. It reduces diesel fuel consumption. By using hydrogen as an additive and blends of KO as fuel to CI engine, the efficiency of CI engine could be improve upto 2%-3.5%. It is clear from this experimentation that, there is 0.01%-0.02% reduction in exhaust emissions (Carbon monoxide (CO), Carbon dioxide (CO_2) and Hydro carbon (HC)) together with increase in brake power, brake thermal efficiency and reduction in brake specific fuel consumption make the blends of KO (B30 and B40) a suitable alternative fuel for diesel and could help in controlling emission, but still there is slight increase in Nitric oxide (NOx), which is has to be reduced.

Keywords: Blending, Hydrogen, KO (Karanja Oil), Preheating.

I. INTRODUCTION

Research is being carried out throughout the world to evaluate the performance, exhaust emission and combustion characteristics of the existing engines using several alternative fuels such as hydrogen,biofuels, liquefied petroleum gas (LPG), biogas, producer gas,and others.

Many researchers to investigate the possibility of using alternative sources of energy instead of oil and its derivatives.The concept of biodiesel as an alternative diesel fuel has been gaining great importance worldwide for its good quality exhaust, sustainability, biodegradability and has minimal toxicity.Biodiesel can be used in its pure form or can be blended with diesel to form different blends.

According to the review and recent trends in biodiesel fuels [1], blends of up to 20% KO mixed with diesel fuels can be used in nearly all diesel engines. It has been identified that neat KO and its blends reduces Particulate matter (PM), HC and CO emissions but slightly increased in the NOx emissions compared with diesel fuel used in an unmodified diesel engine.The increase in NOx emissions with biodiesel fuel operation is found to be in the range of 10-14% [2]. Because of some great combustion properties of the hydrogen, it is one of the appreciate alternative for internal combustion engine. Hydrogen fuel is safe. It's colorless, odorless and nontoxic. Hydrogen due to its high self ignition temperature (858k) compare to neat diesel (535k) cannot be used in diesel engine directly, therefore mixed with air [3], But hydrogen's potential has not been realized even partially mainly because of storage and commercial production difficulties One of the good solutions to this storage problem is to generate hydrogen non-board through electrolysis of water [4].

II. FUEL PROPERTIES OF KARANJA BIODIESEL AND HYDROGEN

The other main property of biodiesel fuel is its lubricating properties. It has much better lubricating and a higher cetane ratings than today's lower sulfur diesel fuels [5].

India is a tropical country and offers most suitable climate for the growth of karanja tree. It is found in abundance in rural areas and forests of entire India, especially in eastern India and Western Ghats [6]. Fig.1 shows the close view of seeds of karanja. The seeds are crushed in expeller to get the oil. A view of raw oil obtained by crushing the seeds has been given in Fig.2. As the tree of karanja is naturally found in forests, there are so far no reports on adverse effects of karanja on fauna, flora, and humans but that is a different area of research and hence further encourages its application for biodiesel production.

Fig. 1: Karanja seeds

Fig.2: oil expelled from seeds of karanja

The general properties of KOas fuel shown in table1.It is found that Karanja has the similar fuel properties as per diesel fuel.

Table 1: General properties of diesel and karanja oil [7, 8, 9,].

Properties	Diesel	Karanja biodiesel	Hydrogen
Color	yellow	Yellowish Red	Colorless
Density (gm/cc)	0.824	0.924	0.00008376
Kinematic viscosity at 40 °c	2.0-2.7	27.84	9.15
Calorific Value (Kcal/Kg)	4285	8742	28900.35
Flash Point (°c)	52	205	
Cetane number	49	42	130

Observing the physical properties of KO has a high boiling point and low vapour pressure. The flash point of KO is considerably higher than that of diesel. Studying the chemical properties of KO, its calorific value is about 8742 Kcal/Kg, which is 9% lower than regular diesel. The disadvantages to the use of this oil is the high viscosity (about 20 times higher than that of diesel), lower volatilities causes the formation of deposits in the engine due to incomplete combustion. A high viscosity may lead to poor atomization of the fuel, incomplete combustion, choking of the injectors, ring carbonization and accumulation of the fuel in the lubricating oils. These problems are associated with large triglyceride molecules and its high molecular mass; hence it can be avoided by the various methods like transesterification, dilution, and micro-emulsion, blending and preheating. In this investigation, preheating method is used to reduce the viscosity of KO. This is the most suitable and economical method as compare to other methods [10, 11].

The high auto ignition temperature of hydrogen allows larger compression ratio. Hydrogen is a nearly ideal fuel in terms of smog reduction when combusted. Hydrogen contains no carbon or sulfur, so no CO, CO2 or SOx or soot is produced during combustion (although the combustion of lubricating oil may result in trace amounts). Hydrogen allows for leaner combustion, resulting in lower combustion temperatures and very low NOx emissions [12, 13, 14, 15, and 16]. Hydrogen is non-toxic so uncombusted hydrogen does not pose a direct health risk.

III. EXPERIMENTAL SET UP AND PROCEDURE

A single cylinder four-stroke, air-cooled diesel, constant speed (1500 rpm) and direct injection engine is used for the work. Engine specification is given (see Table 2). An electric dynamometer is used for loading the engine. The major pollutants in the exhaust of a diesel engine are smoke. AVL 437 smoke meter was used to measure the smoke density of the exhaust from the diesel engine. An exhaust gas analyser was attached after the smoke meter for measurement of CO & HC emissions. (See Fig. 3). Actual complete set up shown in Fig. 4

1) Engine 2) Dynamometer 3) Fuel Tank (Bio-diesel) 4) Diesel Tank 5) Burettes6) Three way valve 7) Air box 8) Manometer9) Air flow direction 9) Air flow direction10) Smoke meter11) Exhaust Analyzer (CO & HC) 12) Exhaust flow

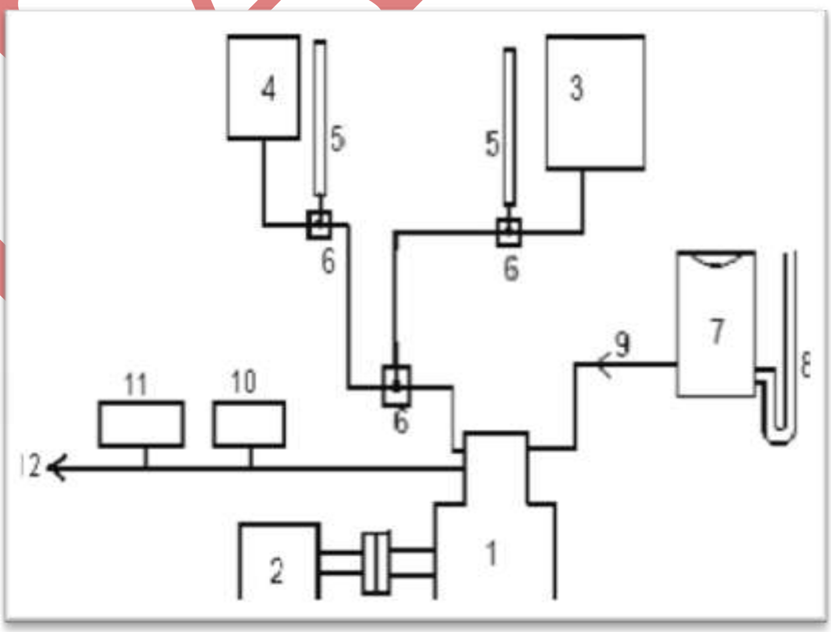

Fig.3: layout of Experimental set-up

The engine specifications of the engine shown in the **Table 2**

ENGINE TYPE	Vertical 1 cylinder 4 stroke, constant speed(1500 rpm), direct injection C.I Engine
POWER (RATED)	5 BHP
BORE / STROKE	85 / 110 (mm)
LUBRICATING OIL	SAE 30/40
COMPRESSION RATIO	16:1
METHOD OF COOLING	Water

Fig.4: actual set up of experimentation

In this investigation the raw KO is heated at 65-75 degree Celsius for 40-45 minutes. The hot oil was kept for cooling upto 15-20 hr and then it was mixed with diesel in varying proportions to prepare the various blends which shown in Fig. 5. Thus these mixtures were kept to be cooled for a day and then the mixtures were ready for testing in the engine. This procedure was done to reduce the viscosity of the raw oil as we observed that the raw Karanja had a high viscosity.

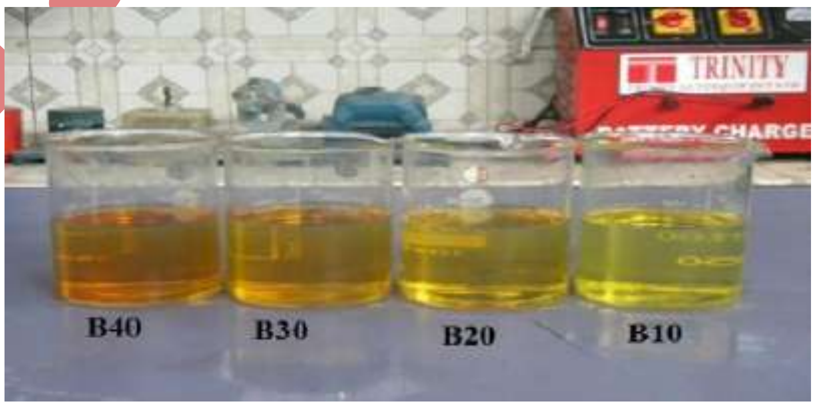

Fig. 5: Various blends of fuel

The fuel properties of different blends as fuel has been tested in lab and these values are shown in table 3.

Table 3: General properties of various blends fuel

Properties	**B 10**	**B 20**	**B 30**	**B 40**
Color	Light yellow	Light yellow	yellow	Little dark yellow
Density (gm/cc)	0.816	0.822	0.825	0.829
Kinematic viscosity at 40 °c	2.89	3.39	3.98	4.63
Calorific Value (Kcal/Kg)	4173.8	3980.4	3828	3785
Flash Point (°c)	78.6	79	80	81
Cetane number	51	52	53	56

The performance data were then analyzed from the graphs regarding thermal efficiency, brake specific fuel consumption and emission performance of all fuels.

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IV. RESULT AND DISCUSSION

4.1 Engine Performance

4.1.1 Brake Power (BP)

The variations of brake power output of the engine with load for different fuels are presented in Fig. 6. The brake power linearly increased with increase in load. Due to complete combustion of fuels, the brake power produced in case of all blends was higher than that of diesel respectively. The KO has low calorific value and by increasing the percentage of biodiesel in the blends the brake power also gets increased at different load.

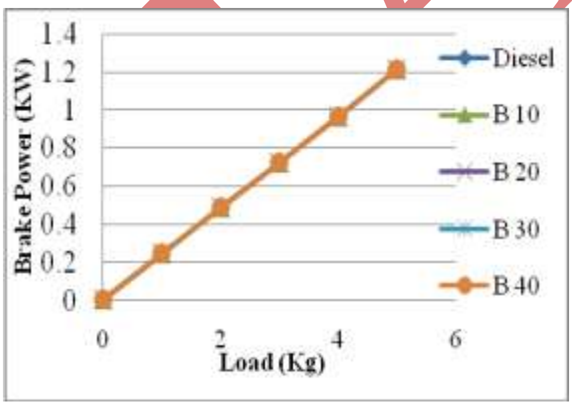

Fig. 6: Variations of Brake Power with load

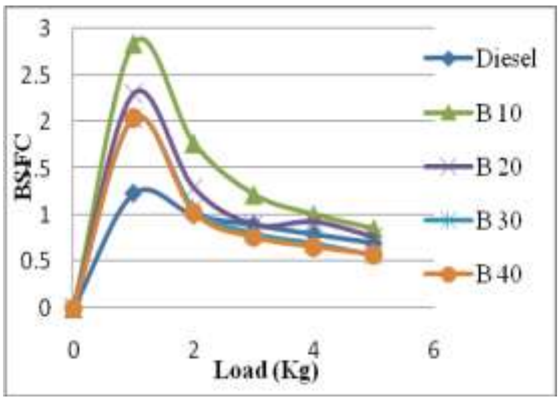

Fig.7: Variation of BSFC with load

4.1.2 Brake Specific Fuel Consumption (BSFC)

Brake-specific fuel consumption (BSFC) is the ratio of mass fuel consumption to break power. The results for the variation in the BSFC with increasing load on the engine studied are presented in Fig.7.As the load increases BSFC decreases [17,18], it has high value at minimum load (0.5 Kg to 1.2 Kg) but it decreases as load increases on the engine, and then reaches the value to that of diesel fuel operation. The BSFC becomes equal at maximum load for both KO and diesel. In case of all blends of the fuel, the BSFC value for B 30 and B 40 was 0.5668 and 0.5787respectively, which is loweras compared to diesel fuel at maximum load. The BSFC value for B 10 and B 20 was slightly lower than diesel fuel.

4.1.3 Brake Thermal Efficiency (BTE)

The variation of brake thermal efficiency with load for different blends of fuels is presented in Fig. 8. It is increases with load. In case of B 30 and B 40, the brake thermal efficiency improves upto 2.2%-2.5% as compared to diesel. The lower brake thermal efficiency obtained for B10 and B20.

4.1.4 Mass Flow Rate

The variation of mass flow rate with load for different blends of fuels is presented in Fig.9. The mass flow rate increases with increase in load [19]. The mass flow rate for B 30 and B 40 fuel slightly more than that of diesel fuel.

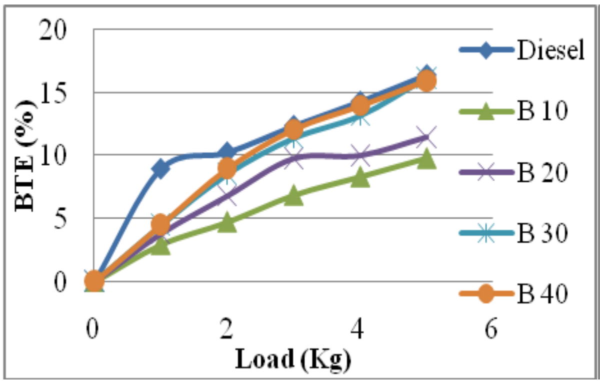

Fig. 8: Variations of BTE with load

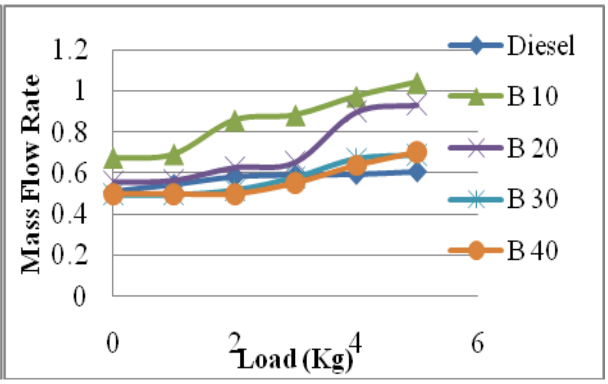

Fig.9: Variation of mass flow rate with load

4.2 Emission studies

4.2.1 HC Emission

The variation of HC with load for different blends of fuels is presented in Fig. 10. The value of HC slightly increases for all fuels with increase in load [20]. The value of HC for diesel, B 10 and B 20 shows similar variation with different loads, but for B 30 and B 40, the performance of HC emission shows better result as compare to diesel and other blends, which reduces almost 0.01-0.02%. Hence reduction in HC emission was obtained for B 30 and B 40.

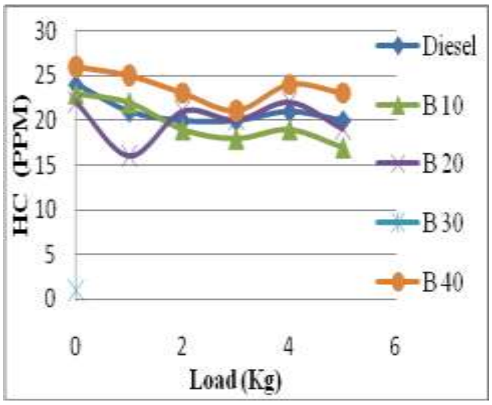

Fig. 10: Load Vs HC emission

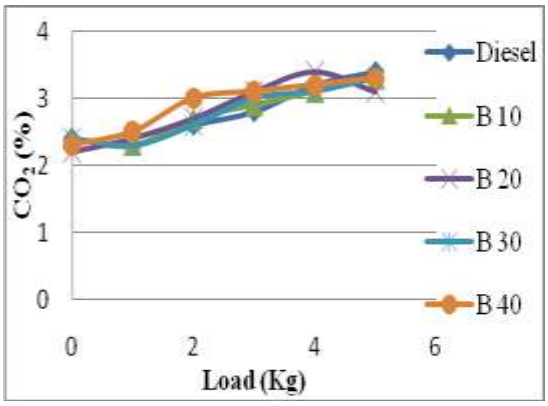

Fig.11: Load Vs CO_2 emission

4.2.2 CO_2 emission

The variation of CO_2 with load for different blends of fuels is presented in Fig. 11. The value of CO_2 slightly increases for all fuels with increase in load and then linearly increases at different loads. The value of $CO_2$for diesel, B 10 and B 20 shows similar variation with different loads, but for B 30 and B 40, the performance of CO_2 emission shows better result as compare to diesel and other blends.

4.2.3 CO emission

The variation of CO with load for different blends of fuels is presented in Fig. 12. The value of CO emission increases for all fuels with increase in load. Initially the value of CO emission for all fuels increases upto certain load and then decreases.The reduction in CO emission has found upto 0.01%.

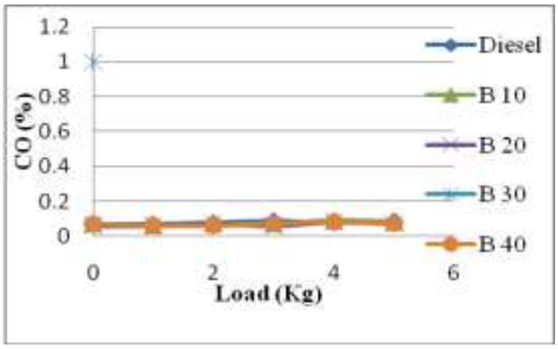

Fig. 12: Load Vs CO emission

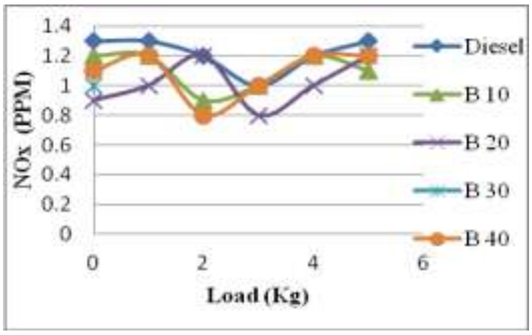

Fig. 13: Load Vs NOx emission

4.2.4 NOx emission

The variation of NOx with load for different blends offuels is presented in Fig. 13. The value of NOx emission increases for all fuels with increase in load. Initially the value of NOx emission for all fuels decreases upto certain load and then increases.On an average 2-3% increase in NOx was obtained for all blends as compared to diesel.

V. CONCLUSION

Hydrogen enriched KO blends can be use as alternative to a diesel. It is observed that, the performance parameters of KO with enriching of hydrogen proved to surpass that of diesel fuel and its application requires no engine modification. As per the experimentation, blends of KO with diesel and hydrogen as an additives improves the brake thermal efficiency of CI engine upto 2-3.5 %, BSFC also decreases as the load increases but the performance of emission in terms of NOx which reduces initially, then suddenly it slightly increases that has to be reduced. It is found that the CO, HC and CO_2 emissions were low.

It is clear that from this study, by boosting of $H_{2,}$ as enriched to blends of KO with diesel gives better improvement in the performance characteristics of diesel engine with no modification in the CI engine.

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