Performance and Emissions Analysis of Kusum Oil Methyl Esters with Air Pre Heating on C.I Engine

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Abstract*: Due to the increase in cost and scarcity of petroleum resources have promoted research in alternative fuels for internal combustion engines. Among various possible options, fuels derived from triglycerides (vegetable oils/animal fats) are promising for substitutes of fossil diesel fuels. Vegetable oil poses some problems when subjected to prolonged usage in compression ignition engines because of high viscosity as reported by different researchers. In the present paper, the research efforts directed towards improving the performance of C.I. engine using vegetable oil (Methyl ester kusum oil) as a fuel. The paper deals with results of performance of a single cylinder, four stroke, C.I. engine using kusum oil methyl ester and its blends with diesel. The performance of engine was studied at constant speed, with the engine operated at various loading conditions*

Keywords: Blends, Efficiency, Kusum Oil, Methyl Ester, Emissions

1. Introduction

The world is presently confronted with the twin crisis of fossil fuel depletion and environmental degradation. Indiscriminate extraction and lavish consumption of fossil fuels have led to reduction in underground-based carbon resources. The search for an alternative fuel, which promises a harmonious correlation with sustainable development, energy conservation management, efficiency and environmental preservation, has become highly pronounced in the present context.

In most of the developed countries, biodiesel is produced from soybean, rapeseed, sunflower, peanut, etc., which are essentially edible in Indian context. Among the various vegetable oil sources, non-edible oils are suitable for biodiesel production. Because edible oils are already in demand and too expensive than diesel fuel. Among the non-edible oil sources, Jatropha, karanjan, Mahua, Neems, sal, Kusum, Nahar, Rice bran and Tumba is identified as potential biodiesel source and comparing with other sources, which has added advantages as rapid growth, higher seed productivity, suitable for tropical and subtropical regions of the world.

The methyl ester of vegetable oils, known as biodiesel are becoming increasingly popular because of their low environmental impact and potential as a green alternative fuel for diesel engine and they would not require significant modification of existing engine hardware. Biodiesel cannot be used purely for combustion because of their high viscosity and low calorific value. Transesterification is a most attractive method to reduce viscosityof raw vegetable oil . Biodiesel is non-toxic and biodegradable. The combustion of biodiesel contributes less CO2 to the atmosphere.

2. Characterization of Kusum Seed Oil

In India, Kusum is one of the forest-based tree-borne non-edible oil. The botanical name of Kusum is kusum is widely found in the sub-Himalayan region, Chattishgarh, throughout central and southern India. The estimated availability of kusum seed is about 25,000 oil potential per tones per annum. In the past kusum seed oil was exported from India to Germany. This market has now fallen away. From current production potential 4000 to 5000 tons are collected. kusum seed kernels (0.45 lacks of tones of seed) contain 40.3% of yellowish brown colored oil. The one or two almost round seeds some 1.5cm in diameter and weighing between 0.5 and 1.0g. The oil content is 51-62% but the yields are 25-27% in village ghanis and about 36%oil in expellers. It contains only 3.6 to 3.9% of glycerin while normal vegetable oil contain 9-10% glycerine. The viscosity of kusum oil was found to be higher than that of diesel fuel. The high viscosity of kusum oil may be due to its larger molecular weight compared to diesel. The flash point of kusum oil was higher than diesel and hence it is safer to store. It is seen that the kinematic viscosity of kusum oil is 40 cSt at 400 C and after blending decreases gradually closer to that of diesel. In the present investigation the kusum seed oil, a non-edible type vegetable oil is chosen as a potential alternative for producing biodiesel and use as fuel in compression ignition engines. kusum is widely in the sub-Himalayan region, Chattishgarh, throughout central and southern India, Burma, Ceylon, Java and Timor.

Figure 1: Kusum Tree and seeds

Figure 2: Kusum Oil

3. Transesterification Processes

Bio-diesel is produced by transesterification which is a process of using either ethanol or methanol, in the presence of a catalyst, such as potassium hydroxide or NaOH, to chemically break the molecule of an oil or fat into an ester and glycerol. This process is a reaction of the oil with an alcohol to remove the glycerine, which is a by product of bio-diesel production. **Figure** shows the transesterification reaction.

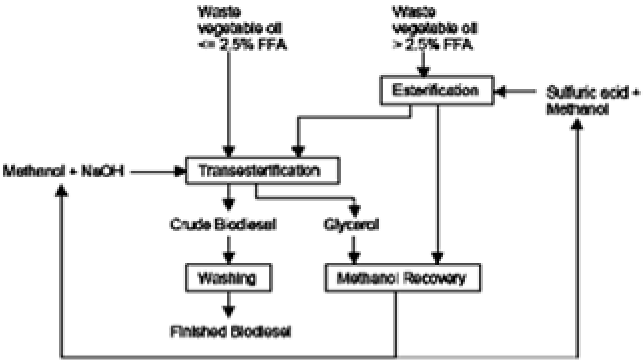


Figure 3: Transesterfication process

Figure 4: Transesterfication process set up

The reactor for producing biodiesel from kusum oil is a small batch type reactor. The first we are taken pretreatment oil temperature is 50-55oC. The products of the first stage pretreatment oil are used as the input of the alkaline Transesterification process. A molar ratio of 6:1 and 10grms by weight of potassium hydroxide (KOH) is found to give the maximum ester yield. The reaction time is maintains 2hr at 60oC. After the reaction is completed, the products are allowed to separate into two layers. The lower layer contains impurities and glycerol. This top layer (ester) is separated and purified using distilled water.

Properties

Properties	Diesel	Kusum Oil	B10	B20	B30	B40
Specific Gravity	0.83	0.876	0.834	0.84	0.848	0.85
Viscosity @40oC (cSt)	4.3	4.5	5.3	6.1	7.0	7.3
Flash point (oC)	54	172	78	90	98	105
Fire point (oC)	65	198	93	121	135	144
Calorific Value(kj/kg	42500	37710	42250	41638	41015	40500

4. Experimental Setup & Procedure

Figure 9: Experimental setup of four stroke, single cylinder, water cooled diesel engine

The engine used was a single cylinder, naturally aspirated four stroke, and direct injection diesel engine with a bowl in piston combustion chamber. The specifications of the engine used are given in Table III. With the liquid fuel injection, a high-pressure fuel pump was used, a three hole injector nozzle. Engine was directly coupled to a dynamometer. exhaust gas temperatures measured by thermocouple which indicates reading on digital display, loads are applied by rope brake dynamometer at constant rpm 1500 which is measured by contact type tachometer. Smoke was measured by a opax 2000 II smoke meter Before running the engine to a new fuel, it was allowed to run for sufficient time to consume the remaining fuel from the previous experiment. The smoke meter was also allowed to adjust its zero point before each measurement. To evaluate performance, some operating parameters like speed, power output and fuel consumption were measured.

Engine Specifications

Make	Kirloskar
Power	5hp
Speed	1500rpm
no. of cylinders	1
compression ratio	16.5:1
Bore	80mm
orifice dia	20mm
type ignition	compression ignition
method of loading	rope brake
method of starting	crank shaft
method of cooling	Water

5. Experimental Set Up For Air-Preheating

An air-preheater (APH) is a general term to describe any device designed to heat air before another process (for example, combustion in a boiler) with the primary objective of increasing the thermal efficiency of the process.

The object of the intake system is to deliver the proper amount ofair and fuel accurately and equally to all cylinders at the proper time in the engine cycle. Flow into an engine is pulsed as the intake valves open and close, but can generallybe modeled as quasi-steady state flow.The intake system consists of an intake manifold, a throttle, intake valves, andeither fuel injectors or a carburetor to add fuel.

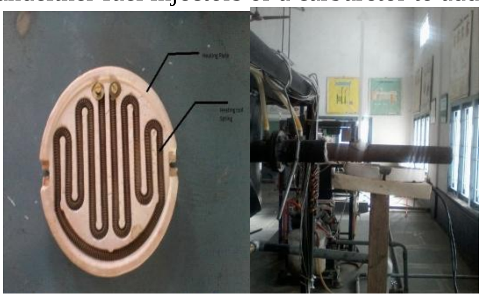
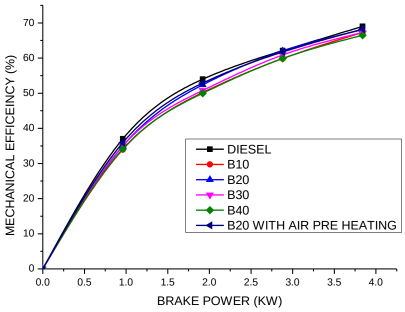


Figure 10: Experimental Set up for Air Pre heating

6. Results & Discussions

Mechanical Efficiency:

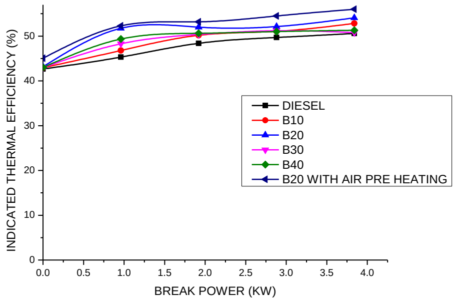
The variation of mechanical efficiency with brake power is shown in figure. The plot it is reveals that as the brake power increases mechanical efficiency increases . The mechanical efficiency of Kusum oil blend B20 and the B20 blend with air pre heating increased when compared to the diesel at full brake power condition.



Graph 1: Mechanical Efficiency vs Brake Power

Indicated Thermal Efficiency

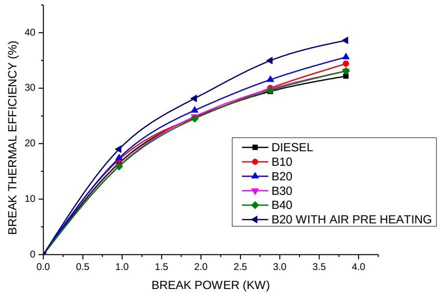
The variation of indicated thermal efficiency with brake power is shown in figure. The plot it is reveals that as the brake power increases indicated thermal efficiency increases . The indicated thermal efficiency of kusum oil blend B20 increased when compared to the diesel at full brake power condition.



Graph 2: Indicated Thermal Efficiency vs Brake Power

Brake Thermal Efficiency:

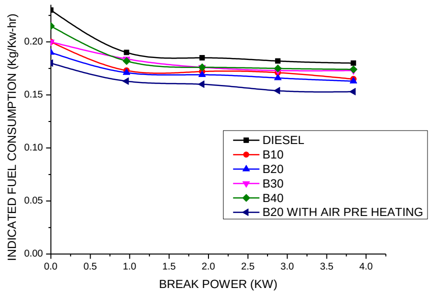
The variation of brake thermal efficiency with brake power for different fuels is presented in Fig.6.1. In all cases, it increased with increase with brake power. This was due to reduction in heat loss and increase in power with increase in load. The maximum thermal efficiency for Kusum oil blend B20 and the B20 blend with air pre heating was nearer to diesel.



Graph 3: Brake Thermal Efficiency vs Brake power

Indicated Specific Fuel Consumption:

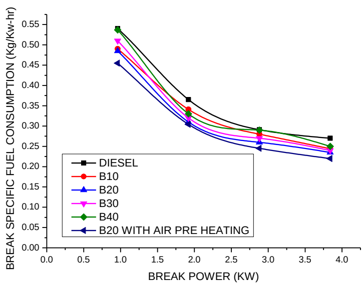
The variation of indicated specific fuel consumption with brake power is shown in figure.The plot it is reveals that as the brake power increases indicated specific fuel consumption decreases . The indicated specific fuel consumption of Kusum oil blend B20 and the B20 blend with air pre heating slightly decreased when compared to the diesel at full brake power condition.



Graph 5: Indicated Specific Fuel Consumption

Brake Specific Fuel Consumption:

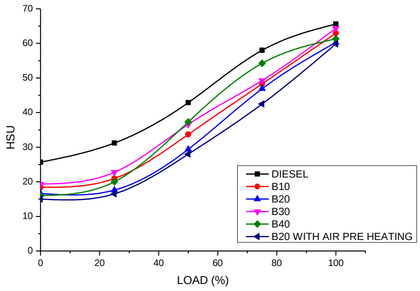
The variation of brake specific fuel consumption with brake power is shown in figure.The plot it is reveals that as the brake power increases brake specific fuel consumption decreases . The brake specific fuel consumption Kusum oil blend B20 and the B20 blend with air pre heating slightly decreased when compared to the diesel at full brake power condition



Graph 6: Brake Specific Fuel Consumption vs Brake Power

Smoke Density (H.S.U):

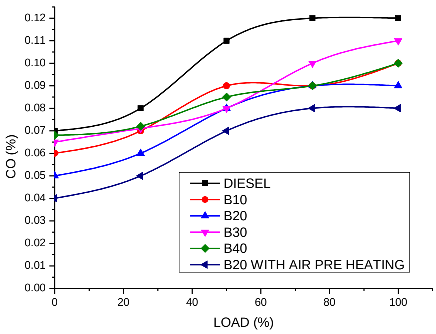
The variation of smoke density with load is shown in figure. The plot it is reveals that as the load increases smoke density decreases . The smoke density of palmyra oil Kusum oil blend B20 and the B20 blend with air pre heating slightly decreased when compared to the diesel at full load condition



Graph 7: Smoke Density vs Load

CARBON MONOXIDE (CO):

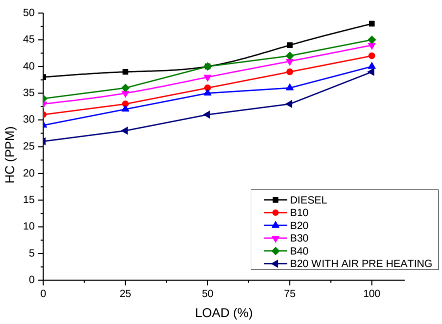
The variation of carbon monoxide with load is shown in figure. The plot it is reveals that as the load increases carbon monoxide decreases .. The carbon monoxide of Kusum oil blend B20 and the B20 blend with air pre heating slightly decreased when compared to the diesel at full load condition.



Graph 8: Carbon Monoxide vs Load

HYDRO CARBONS (HC):

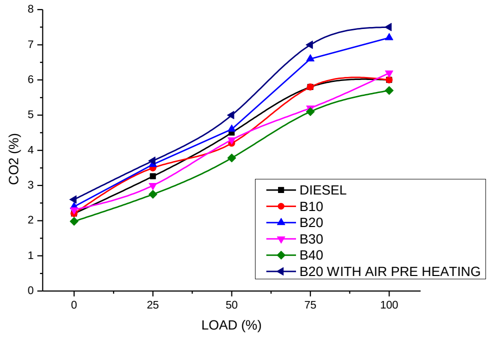
The variation of hydro carbons with load is shown in figure. The plot it is reveals that as the load increases hydro carbons decreases . The hydro carbons of Kusum oil blend B20 and the B20 blend with air pre heating slightly decreased when compared to the diesel at full load condition.



Graph 9: Hydro Carbons vs Load

CARBON DIOXIDE (CO2):

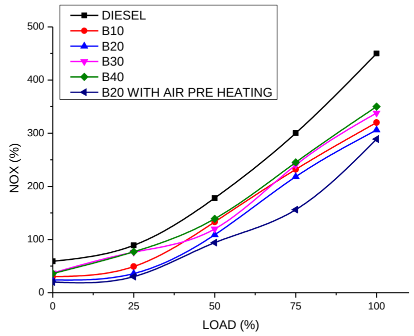
The variation of carbon dioxide with load is shown in figure. The plot it is reveals that as the load increases carbon dioxide decreases . The carbon dioxide of Kusum oil blend B20 and the B20 blend with air pre heating slightly decreased when compared to the diesel at full load condition



Graph 10: Carbon Dioxide vs Load

Nitrogen Oxide (NOx):

The variation of N0x with load is shown in figure. The plot it is reveals that as the load increases N0x decreases . The N0x of Kusum oil blend B20 and the B20 blend with air pre heating slightly decreased when compared to the diesel at full load condition.



Graph: 11 Nitrogen Oxide vs Load

7. Conclusion

- The experiments are conducted on the four stroke single cylinder water cooled diesel engine at constant speed (1500rpm) with varying 0% to 100% loads with diesel and different blends of kusum oil like B10,B20 B30. and B40.
- The performance parameters such as ηMECH, ηBTE, ηITE, ηVOL, BSFC and ISFC were calculated from the observed parameters and shown in the graphs.
- The emissions characteristics such as carbon monoxide(CO),hydro carbons(HC), carbondioxide(CO2), oxygen(O2), nitrogen oxide (NOx), smoke density(H.S.U) are also decreased, will compared to diesel and other blends.
- It is observed that having 20% kusum oil blend and with air pre heating B20 blend with diesel CI engine gives energetic results for as performance parameters.
- And emissions characteristics also decreases will compared to diesel at 20% kusum oil blend with diesel.

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