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Kusum Oil as a Fuel for Small Horse Power Diesel 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 research, experiments were designed to study the effect of reducing Kusum oil's viscosity by increasing the fuel temperature, thereby eliminating its effect on combustion of the engine. A single cylinder 5 hp, four stroke, constant speed, water cooled, direct injection diesel engine typically used in stationary operation was used for the experiments. The acquired data were analyzed for various parameters such as thermal efficiency, brake specific fuel consumption (BSFC), emission of CO,CO2,HC and NOx gases in exhaust. While operating the engine on Kusum (preheated and blends), performance were found to be very close to mineral diesel for lower blend concentrations. The preheated oil's performance was slightly inferior in efficiency due to low heating value. In pollution point of view it can perform well for the unmodified engine for a long period operation without any ignition problem. People of rural areas and undeveloped areas can use this for their agricultural engines without depending on market and without modification of whole engine, at the same time they can reduce the requirement of diesel fuel from outside market.

Index Terms— **Blending,Kusum oil, Straight vegetable oils, Viscosity.**

I. INTRODUCTION

Diesel out of different liquid fossil fuels is widely used through out the world in automobiles, pumps and other engines mostly in the agriculture related sectors. In addition to stringent environment pollution norms, diesel's ever rising demand and limited reserve becomes a hurdle in its future survival. So research is going on through out the globe for a suitable diesel substitute. In this race among different alternatives, vegetable oils are emerging as one of the strongest contender because some of their physical, chemical and combustion related properties are nearly similar to that of diesel fuel. Another important feature of vegetable oils that advocates in their favour as future diesel alternative is the carbon balance in the environment. In general vegetable oils are obtained from crops and forest resources. The crop used to make fuel has carbon content in it, which is taken by the plants absorbing the CO2 from the atmosphere. This when burnt as a fuel gives the same amount of CO2 which it has absorbed, so the net CO2 value in the atmosphere remains constant. But in diesel it is not the same as above, so the CO2 level increases causing global warming. In a developing country like India major concentration has been focused on non-edible vegetable oils as the fuel alternative to diesel because edible vegetable oils have their use in our day-to-day life. There are oils like Karanja, Neem, Jetropha and Mahua etc are being under research for partial or complete replacement of diesel in compression ignition engines. Commonly found fatty acids in vegetable oils are stearic, palmitic, oleic, linoleic and linolenic acid. Vegetable oils can be produced even on a small scale for on-farm utilization to run tractors, pumps and small engines for power generation/irrigation. Suitability of vegetable oils as fuels for diesel engines depends on their physical, chemical and combustion characteristics as well as the type of engine used and operating conditions [1]. Vegetable oils can be used directly or blended with diesel to operate compression ignition engines. Use of blends of vegetable oils with diesel has been experimented successfully by various researchers in several countries [2–6].Either it can be used directly in the engine without any previous treatment with the required engine modification or in the form of biodiesel. The later needs investment and high skill for its preparation from vegetable oils and adds extra cost of processing because of the transesterification reaction involving chemical and process heat inputs.

In rural and remote areas of developing countries like India, where grid power is not available, vegetable oils can play a vital role in decentralized power generation for irrigation and electrification. In these remote areas, different types of vegetable oils are grown/produced locally but it may not be possible to chemically process them. Hence using heated or blended vegetable oils as petroleum fuel substitutes is an alternative proposition. Keeping these facts in mind, a set of engine experiments were conducted using Kusum oil on a engine. Heating and blending were used to lower the viscosity of Kusum oil in order to eliminate various operational difficulties.

1.1 Kusum Oil: The botanical name of Kusum is Schleichera olcosa and the potential of kusum oil is 66000 tonnes per year in India, out of which 4000 to 5000tonnes are collected. It is a medium or large sized dense tree growing to 35 to 45 feet in height. It mainly occurs in sub-Himalayan

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tracts in the north, central parts of eastern India, particularly in orissa at Mayurbhanj disrict. The flowers come from February to April and yields fruit in June and July. The fruits are smooth, hard skin berries contains one or two irregularly ellipsoidal slightly compressed seeds. The brown seed coat is brittle and breaks at a slight pressure to expose a 'U' shape kernel. 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. FFA (free fatty acid) present in oil is 5-11%. Iodine value is 215-220 and total fatty acid content is 91.6%.The FFA content of Kusum oil is presented in Table 1

TABLE 1:CHARACTERISTICS OF FATTY ACIDS IN KUSUM OIL[7]

Sl.No	Fatty acids	% of compositions
1	C10	0.2
2	C12	0.3
3	C14	0.3
4	C16	8.0
5	C16:1	1.3
6	C18	2.3
7	C18:1	42.6
8	C18:2	4.5
9	C20	20.6
10	C20:1	15.2
11	C20:2	0.6
12	C22	1.5
13	C22:1	1.9

The oil is bitter in taste thus it is not considered to be edible. In India, the oil is used generally for soap making. The oil can be used as substitutes of Diesel but the greatest difference between kusum oil and diesel oil is viscosity. The high viscosity of this kusum oil may contribute to the formation of carbon deposits in the engines, incomplete combustion and results in reducing the life of engine.

The main objective of present study was to reduce the viscosity of oil by blending with diesel and preheating the kusum oil. Using oil in the above mode performance and exhaust analysis of CI engine was conducted.

II. .MATERIALS

The kusum oil used for this study was from Kusum seeds collected from different parts of Orissa and expelled in a mechanical expeller installed in the Integrated Biodiesel plant of Orissa University Agriculture and Technology,Bhubaneswar,Orissa and commercially available diesel was purchased from near by IOC petrol tank.

III. EXPERIMENTAL:

A. Extraction of kusum oil

For extraction of Kusum oil from Kernel, two methods have been identified. They are the chemical extraction with n-hexane and mechanical extraction method in two stages using screw type of expellers.

In the present study, the chemical extraction process gave the oil content about 23 to 33% from the kernel. In the two stages expellers the oil extracted were 30 to 38%.

B. Properties of Kusum oil:

From different review of literatures it is evident that dilution or blending of vegetable oil with diesel fuel would bring the viscosity close to specification range. Therefore the Kusum oil was blended with diesel oil in varying proportion to reduce its viscosity close to that of diesel fuel for engine acceptability. The physical and chemical properties of Kusum oil and its blends used for the engine testing were tested according to ASTM methods at the renewable testing laboratory of College of Agricultural Engineering Technology, OUAT, Bhubaneswar. The Table 2 shows the various procedures followed and Instrument used for the purpose.

TABLE-2:ASTM METHODS AND INSTRUMENTS USE TO MEASURE VARIOUS PROPERTIES

Property	**ASTM method**	**Instrument**
Density	D1298	Hydrometer
Kinetic viscosity	D445	Kinetic Viscometer
Flash Point	D93	Pensky-Martens closed cup tester
Calorific value	D240	Bomb calorimeter

B. Engine Performance test:

The typical engine used for stationary application has been selected for present experimental investigation. A single cylinder, four stroke, constant speed, water-cooled, direct injection diesel engine was used for the experiments. The technical specification of the engine is given in Table.3.The engine operated at constant speed of 1500 rpm. The fresh lubricating oil 20W40 was filled in oil sump before starting the experiments.

The engines is coupled with single phase 230V AC alternator with water rheostat loading. The main components of the experimental setup are two fuel tanks (Diesel and Kusum oil).The schematic layout of the experimental set up is shown in Fig.1. The exhaust gas was analyzed by multi-gas analyzer of NETEL India Pvt.Ltd make.

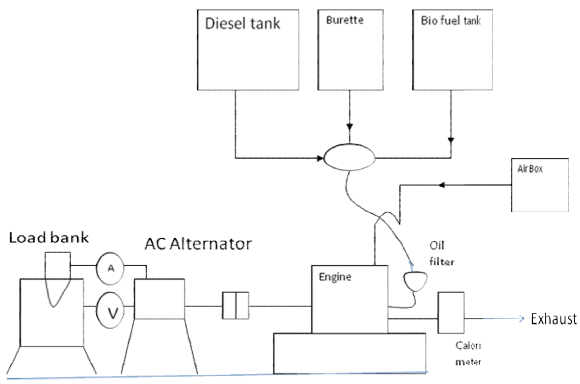

Fig.1 Schematic diagram of experimental set up

The engine tests were carried out using diesel, diesel blends with kusum oil, preheated kusum oil at 100^0C and 120^0C. Performance was evaluated in terms of specific fuel consumption, break thermal efficiency and exhaust temperature.

IV. RESULT AND DISCUSSION

A. Effect of blending Kusum oil on Physical, chemical and thermal Properties:

The properties like kinetic viscosity, specific gravity, calorific value and flash point of diesel blended with kusum oil were analyzed as per the ASTM standard and results were shown in Table.4.

Kinetic viscosity, specific gravity and flash points are higher in Kusum oil and Kusum blended diesel. The viscosity of blended kusum oil from 10% to 20 % are in the range of ASTM limits of diesel fuel use for diesel engines i.e. 6 and hence gone for engine performance testing. The energy content of Kusum oil–diesel blended fuels decreases as Kusum oil is added to the pure diesel fuel. The flashpoint temperature of Kusum oil is higher than the pure diesel fuel. The high flash point temperature of Kusum oil is a beneficial safety feature, as the fuel can be safely stored and transported at the room temperature.

TABLE-3 :ENGINE SPECIFICATIONS:

Manufacturer	Kirloskar oil Engine Ltd,India
Engine Type	Vertical,4 stroke, single cylinder, constant speed, direct injection, water cooled, compression ignition engine
Rated power	3.67 kW at 1500 rpm
Piston diameter & stroke length	0.08m and 0.11m
Compression Ratio	16.5:1

B. . Effect of temperature on viscosity in Kusum oil

From the properties studies of Kusum oil it has been observed that the viscosity is not acceptable for the diesel engines. The viscosity of this required to be reduced more, in order to make it suitable for diesel engine. From the different literatures it has been concluded that heating of the fuel makes it spray characteristics more like those of diesel oil, which is direct reduction of viscosity. Therefore an effort has been tried to find the viscosity by heating the Kusum oil in a range of 40^0C to 120^0C.The results are shown in Fig.2. The viscosity decreases considerably as the temperature increases and are close to diesel engine operation at about 120^0C.After studying this the experiment has been conducted on preheated oil from 100^0C to 120^0c for engine testing.

C. Engine test results and discussion:

Effect of brake power on brake specific fuel consumption

The specific fuel consumption of diesel, blends of Kusum oil and preheated Kusum oil up to 120^0C at varying break loads shown in the Fig.3. It was observed that specific fuel consumption of preheated kusum oil, blened oil were higher than diesel fuel at different percentage of loads. The bsfc of diesel engine depends on the relationship among the amount of fuel injected, fuel density, viscosity and heating value[8,9]. More blended fuels were needed to produce the same amount of energy produced by the pure diesel fuel due to the low heating value of Kusum oil. It was also shown that there is decrease in bsfc values at high engine loads under all operating modes.

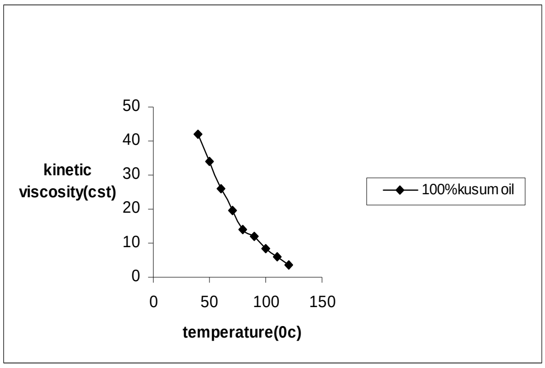

Fig.2 Effect of temperature on viscosity of Kusum oil

Table-4:Properties of Fuel

Sl. No.	Types of oil blends	Sp. gravity	Calorific value (KJ/kg)	Kinetic Viscosity (cst) at 40^0c	Flash point (^{0}C)	Fire point (^{0}C)
1	100%oil	0.904	35000	42.075	147	158
2	90%oil+10%diesel	0.89	35900	36.5	138	147
3	80%oil+20%diesel	0.882	36700	30.2	132	141
4	70%oil+30%diesel	0.875	37800	25.8	124	135
5	60%oil+40%diesel	0.866	38600	18.5	114	125
6	50%oil+50%diesel	0.858	39400	15.6	107	116
7	40%oil+60%diesel	0.850	40800	12.5	92	105
8	30%oil+70%diesel	0.842	41600	9.2	83	94
9	20%oil+80%diesel	0.838	42210	6.3	72	81
10	10%oil+90%diesel	0.834	42500	4.9	68	75
11	100%diesel	0.828	43000	3.5	55	64
12	Preheated oil at 100^0c	0.89	35000	8.4	147	158
13	Preheated oil at 110^0c	0.874	35000	5.9	147	158
14	Preheated oil at 120^0c	0.855	35000	3.6	147	158

D. Effect of break power on brake thermal efficiency

The variation of break thermal efficiency of the engine with various fuel i.e. diesel, blended diesel with kusum oil and preheated kusum oil is shown in Fig.4.In all the cases the with increases of break power the thermal efficiencies increases. The maximum thermal efficiency is achieved at 80% of load of the engine in all mode of operation. The brake thermal efficiencies of the blends and the kusum oil were lower than that with diesel fuel throughout the entire range. The drop in thermal efficiency with increase in proportion of vegetable oil must be attributed to the poor combustion

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characteristics of the vegetable oils due to their high viscosity and poor volatility.

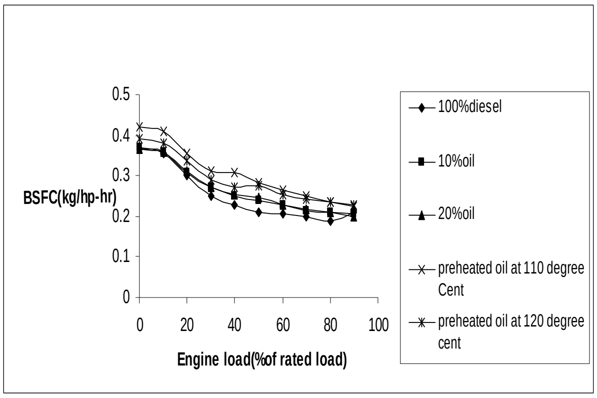

Fig.3 Effect of percentage of brake power on specific fuel consumption for diesel, various blends and preheated Kusum oil.

E. .Effect of break power on exhaust gas temperature

Fig.5 shows the variation of exhaust gas temperature with different percentage of load of the engine.The result shows that the exhaust temperature increases with increase in break power in all cases. The exhaust temperature of preheated oil and blended are lower than pure diesel fuel mode. This is due to the poor combustion characteristics of the kusum oil because of its high viscosity.

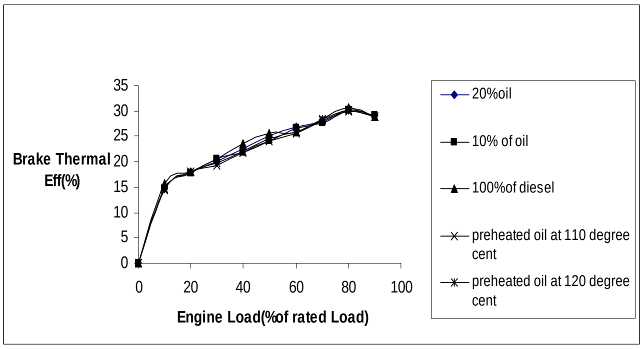

Fig.4 Variation of brake thermal efficiency with percentage of engine load for diesel, preheated kusum oil and various blends.

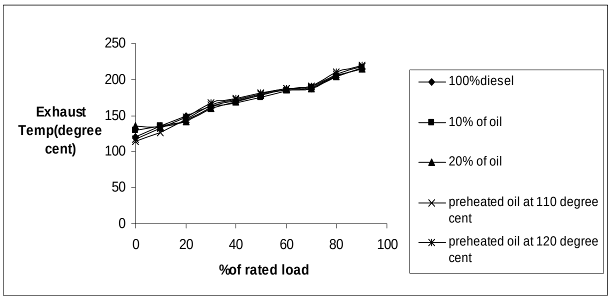

Fig.5 Effect of load on exhaust gas temperature for diesel, Kusum oil and various blends.

F. Effect of break power on engine Emission

The emission results for the pure diesel fuel as well as the Kusum–diesel blended fuels and preheated Kusum oil fuel are given in Figs. 6–9. The CO,CO_2 HC and NO_xemissions of preheated kusum oil is higher than diesel and its blended fuel. In general the poor physical properties of co-oil lead to high emissions.

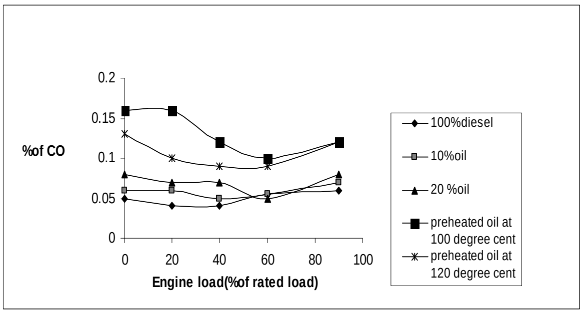

Fig.6 Carbon monoxide emissions vs. % engine load for the tested fuels.

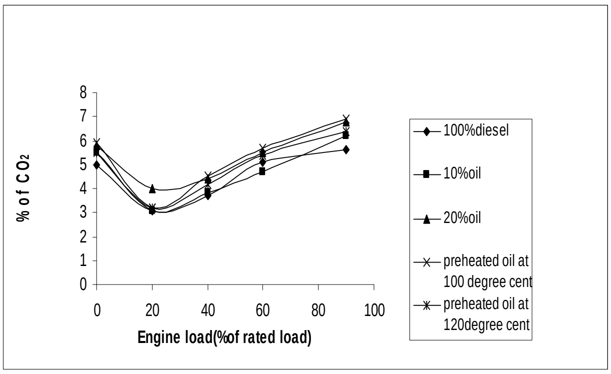

Fig.7 Carbon dioxide emissions vs. % engine load for the tested fuels.

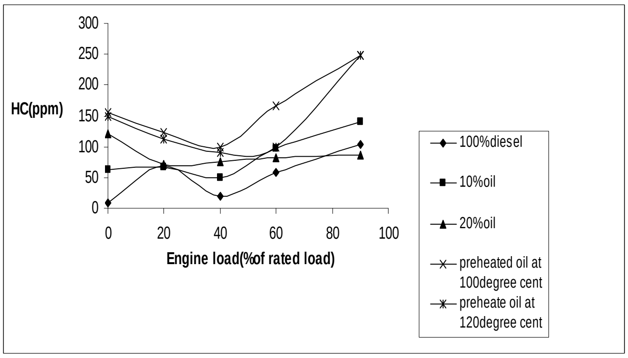

Fig.8 Hydrocarbon emissions vs. % engine load for the tested fuels.

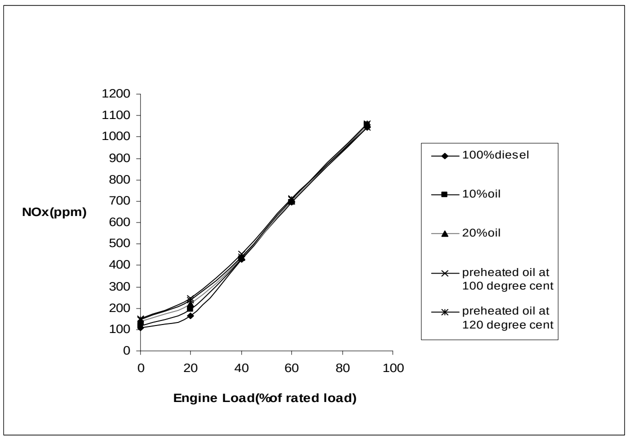

Fig.9 NOx emissions vs. % engine load for the tested fuels

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