Performance and Emission Nature of IC Engine using Biodiesel Obtained from Castor Oil

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Abstract: **Due to the restrained reserves of fossil fuel come together with global environmental pollution have induced the find for other way of fossil fuel for diesel engine. In the current case, non-eatable vegetable oil like Castor methyl ester were generated and mixed with diesel fuel in various ratio. An experimental research was conducted out to figure out the performance and emission characteristics of a compression ignition engine fuelled with mixture of Castor biodiesel and diesel fuel. It was observed that performance characteristics like brake thermal efficiency (BTE), brake specific fuel consumptions (BSFC) with 30% Castor methyl ester was close to diesel fuel. The emission characteristics like CO, HC and smoke were lower compared to diesel fuel. Engine performance and emission test were carried through using biodiesel mixture (10%, 20% and 30%) in 4.4 kW single cylinder air cooled four stroke compression ignition engine at different loads. Anyhow the emissions such as NOx was observed to be higher for Castor biodiesel mixture.**

Keywords: Non-eatable vegetable oils, Castor methyl ester, biodiesel mixture, performance, emission

I. INTRODUCTION

Petroleum is the mostly used source of energy consumed by world's population exceeding coal, natural gas, nuclear, hydro and renewable. The crude oil price has been oscillating in the world market and has increased much in recent past, reaching a level of more than $ 140 per barrel. Such abrupt increase of crude oil prices is severely twisting various economies of the world over, particularly those of developing countries. Petro-based oil meets about 95% of the need for transportation fuels, and the demand has been steadily rising [1]. The concept of making liquid fuel from vegetable oil is not a new. When Rudolf Diesel first invented the diesel engine, about century ago, he explained the assumption by employing Peanut oil and hinted that vegetable oil would be future fuel for diesel engine. However with the development of cheap petroleum products the uses of vegetable oil got declined. After 1973 oil disaster coupled with environmental pollutions uses of vegetable oils get momentum.

Most of the developed countries used edible vegetable oils based biodiesel such as Sunflower, Rapeseed, Soya bean and Palm oil as a replacement of diesel fuel; but these edible vegetable oils are costly in developing countries. So stresses are on non-edible vegetable oils based biodiesel as a diesel replacement to meet their energy requirements and socio-economic evolution [2,3]. The use of straight vegetable oils is restrained by some unfavourable physical properties, particularly their adhesiveness. Due to higher adhesiveness, the straight vegetable oil causes poor fuel disintegration, incomplete combustion and carbon removal on the injector and valve seats resulting in serious engine choking. It has been announced that when direction injection engines are run with neat vegetable oil as fuel, injectors get blocked up after few hours and lead to poor fuel disintegration, less profitable combustion and dilution of lubricating oil by moderately burnt vegetable oil [4]. In the present experimental analysis, non-edible vegetable oil from Castor oil have been selected for its consumption in diesel engine. From the literature, it was observed that the performance and emissions studies in diesel engine using Castor oil and its methyl ester specially at lower mixture of biodiesel with high speed diesel has scantly been reported. Castor *(ricinus communis)* is a species that belongs to the Euphorbiaceae family and it is commonly known as Castor oil plant. This plant originates in Africa but it is found in both primitive and cultivated states in all the tropical and subtropical countries of the world.

In wild conditions this plant is well-adapted to desert conditions and is able to stand long periods of dryness. The plant starts flowering about 45 days after planting. Seeds are approximately 46% oil. This oil is highly adhesive, its coloration ranges from a pale yellow to colourless. It has a soft and delicate smell and a highly unpleasant taste. The present studies was carried out with aim to understand the effect of various biodiesel mixture of obtained from Castor oil. The performance and emissions part were analyzed to ensure minimum power drop and emission remained within the limits. The oxygenated nature of biodiesel contribute to improve the combustion efficiency at the same time it is also a factor contributing to increase of NOx. The experiments helped in determining the optimum biodiesel blend suitable for operation in an unmodified stationary diesel engine.

II. BIODIESEL PRODUCTION

a. Production of Castor Methyl Esters

The Castor biodiesel was produced using both acid and based transesterification technique which exhibits the properties related to that of diesel, essentially lowering the adhesiveness to recommended limit for usage in engines.

Methyl esters (biodiesel) from Castor oil was produced in 1 litre capacity biodiesel reactor as shown in Figure 1.

The major components of biodiesel reactor are mechanical stirrer, condenser and inlet for reactant as well as for placing thermocouple to observe the reaction temperature. The flask has a nozzle at bottom for collection of the final product. Initially the required amount of raw oils, alcohol and catalyst were added to the reactor. The mixtures were heated to about 2-3 hours at a constant temperature of 65°C. It was then mixed using electric stirrer at the speed of 350-400 rpm. After the completion of reaction, the mixture mainly consisted of two products, namely, biodiesel and glycerol. The

light layer on the top is the biodiesel while the darker layer is glycerol. After
taking the glycerol layer using separating funnel, the methyl ester was mixed with hot distilled water, shakes gently and allowed to settle for 10-15 minutes. The procedure was repeated for 3 to 4 times till the water appears clear. After water washing the methyl esters was heated in oven for about temperature of 100-105◦c to remove the water particles. The final product obtained was the methyl esters (biodiesel).

b. Engine selection and test procedure

Diesel engines have been widely used for decentralized distributed power generation for automobiles and also rural agricultural region over the last few decades. At the same time, diesel engines are major contributors of various types of air pollutants such as oxides of nitrogen (NOx), particulate matter (PM), sulphur dioxide (SO2) and other harmful compounds. With the increasing concern of environmental protection and more inflexible government regulations on exhaust emission, decrease in engine emissions has become a major research work in engine development. In study of some typical characteristics such as power produced, specific fuel consumption and endurance etc, diesel engine would continue to lead our agricultural region. In the present study a Kirlosker made single cylinder, air cooled, direct injection, TAF1 model diesel engine was
choosed for current observation (Table 1). The engine was connected to a dynamometer to check the power obtained by engine. Examine were show over entire scope of engine action deal with the genset utilisation at same speed of 1500 rpm under different load conditions.

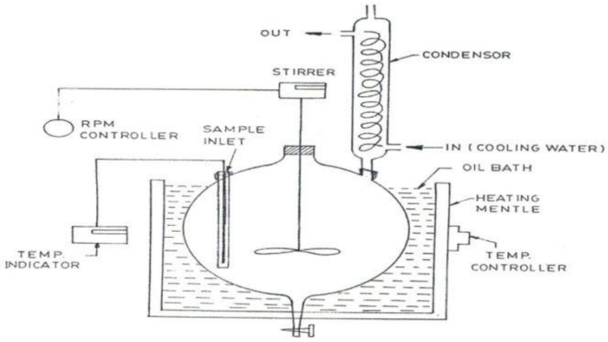

Figure 1. Schematic Diagram of Transesterification activator

The emission quality were regular using AVL 5 gas reviewer and AVL 437 Smoke cadency. The analysis setup is as given in Figure 2.First the grovelling boundary data of diesel fuel were achieved. After that the biodiesel and its mixture were examined in engine and noted. The engine achievement and exhaust data were organised triplicate for each mixture of biodiesel in the examine engine.

III. RESULTS AND DISCUSSION

a. Formulation of Castor Methyl Ester:

The methyl ester of Castor was obtained by proving acid and based catalyst transesterification technique. The kinematic viscosity of oil acutely minimised later transesterification technique. It was checked that the kick back limitation acting as catalyst combination, alcohol/oil (molar ratio), reaction time, temperature and stirring speed play enhance role mean while conversion technique .

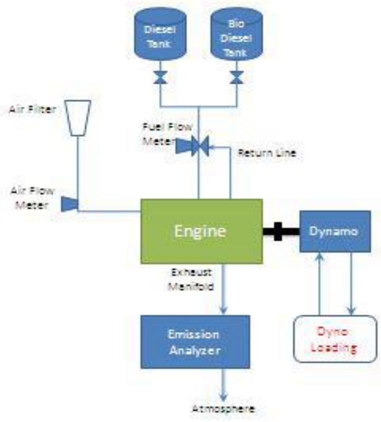

Figure 1. Schematic Diagram of Experimental Set up for Engine Test Rig.

b. Attainment and Emission concentration of Castor Methyl ester:

Figure 3 shows the different of brake thermal efficiency of Castor methyl ester and its mixture with corresponding to loads. It is noticed that, brake thermal efficiency of biodiesel mixture increases with increased in the load. This may be as a result of contraction in heat loss and increased in the power developed with increasing load [5].Admist the biodiesel mixture, the maximum efficiency was obtained for biodiesel mixture CB30 (30% Castor biodiesel and 70% diesel). The deviation of brake specific fuel consumption (BSFC) with corresponding to loads is given in Figure 4. It is seen that the brake specific fuel consumption contracted with increased in load . When minimum load , brake power generated is small , so BSFC is enormous on that load for all the examine fuels. Anyhow with [6] increased in biodiesel percentage in the mixture , the calorific value of fuel contracted and hence BSFC increases (Table 2). Figure 5 given verify the alteration of CO with corresponding to loads. It is examine that CO emission increases with increasing loads for all test fuels. This may be as a result of evidence that air fuel associating ratio was distressed by complication in atomization of heavy fusion. The examining locally wealthy mixture conclusion in inadequate ignition effects more CO to be generated during ignition period due to inadequate of oxygen. Figure 6 shows the similarity of unburned hydrocarbon (UBHC) at surpassing load for diesel, biodiesel and its mixture. The UBHC of all the examined fuels increases at sirpassing load. This may be as a result of the fact fuel portion injected is increased hereby contributing to increases in HC exhaust. The minimum UBHC was obtaining for CB30 biodiesel due to enormous oxygen content mature to better combustion. NOx emission for Castor methyl ester is higher in similarity diesel fuel as shown in given Figure 7. This may be as a result higher combustion chamber temperature as with increased in combustion chamber temperature, NOx emission increases. Figure 8, shows the similarity of smoke for various test mixture at various loads. The smoke levels of Castor methyl ester and their mixture is extremely subordinate than that of diesel fuel.

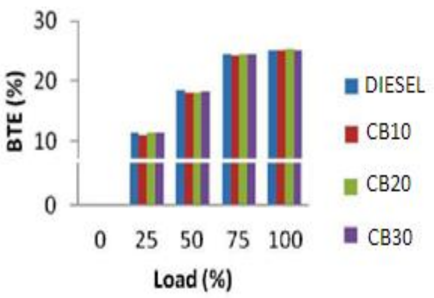

FIG3 (Vartion of BTE with loads)

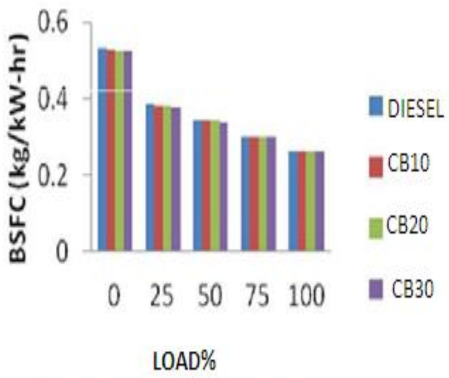

fig4 (Variation of BSFC with loads)

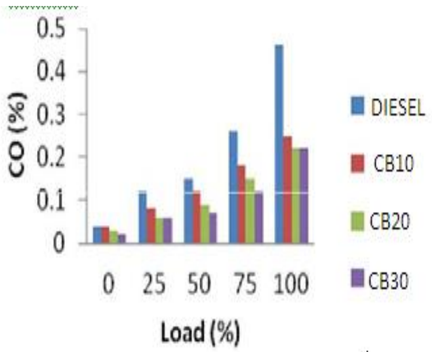

fig5(Variation CO with loads)

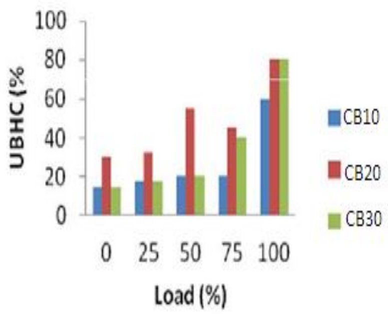

fig6(variation of hydrocarbons with loads)

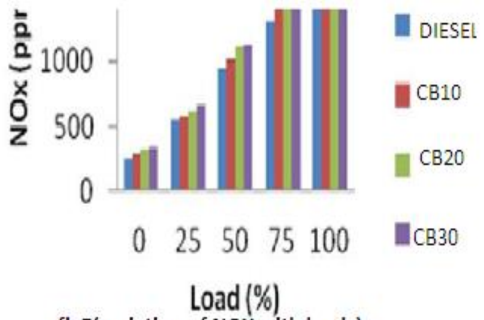

fig7(variation of NOX with loads)

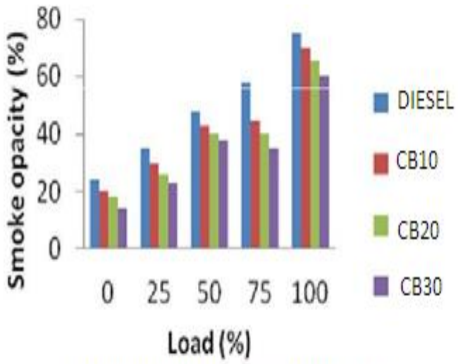

fig8(variation of smoke with loads)

Table 1
Properties of Biodiesel Blends of Castor

Fuel Name	Properties					
	Viscosity @ 40°C (mm²)	Density (g/ml)	Heating Value (MJ/kg)	Cloud Point (°C)	Flash Point (°C)	Pour Point (°C)
Diesel	2.87	0.851	44	6.5	76	3.1
CB30	3.42	0.883	41.59	-2.2	82	-6.9
CB20	3.22	0.857	41.70	-1.5	71	-6.3
CB10	3.04	0.854	42	-1.3	68	-6.1

oil (ASTMD6751 standard)
Note: CB Castor biodiesel

IV.CONCLUSIONS

In the present study Castor oil was converted to mono-esters using acid and based catalyst transesterification technique. The kinematic viscosity of Castor oil decraesed significantly after transesterification process.

Among the various mixtures studied it was found that 30% mixtures of Castor biodiesel yields the best result in terms of performance and emission.

The biodiesel mixtures of Castor methyl ester shows higher NOx compared to diesel fuel during full range of operation.

The BSFC Castor biodiesel mixtures decreases at increasing loads but further increased of ratio of biodiesel mixtures increased the fuel consumptions due to lower calorific value and higher viscosity.

In general the emission characteristics like CO, HC and smoke were lower at all engine load conditions compared to diesel fuel.

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