Renewable CSO-Diesel Blend: A Partial Substitute And Smoke Reduction Fuel for Di Diesel Engines

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ABSTRACT- Now-a-days, vegetable oils are becoming more promising renewable alternatives to fossil fuels for internal combustion engines; however, it is required to reduce viscosity of these by some means like preheating, blending or transesterfication etc., to use them in conventional CI engines. In this experimental study, Cottonseed oil (CSO) is chosen because of it's renewable in nature, and is available in India abundantly. It is also relatively inexpensive and non-edible. The study used CSO and its blends with diesel from 10% to 90% by volume, evaluated fuel and performance characteristics of single cylinder diesel engine. The CSO10D90 blend is found to be optimum during short-term study, since with this fuel there is 3.5% decrease in SFC, 2.0 % increase in brake thermal efficiency, 7% increase in mechanical efficiency and 20% decrease in smoke density in comparison with conventional diesel D100.

Keywords: *Cottonseed oil; Properties; Brake thermal efficiency.*

I. INTRODUCTION

Diesel fuel is mostly utilized in the transport, agriculture, commercial, domestic and industrial sectors for power generation. It has been the main source of energy for Diesel or Compression Ignition (C.I) engines. In the present energy scenario, the world has been confronted with an alarming energy crisis due to depletion of resources. A part from the problem of fast vanishing reserves creates environment pollution due to their combustion. Petroleum fueled vehicles discharge significant amount of pollutants like CO, HC, NOx, Soot, Lead compounds and Aldehydes. In view of these problems attempts must be made to search for an eco-friendly and economic alternative fuel. The vegetable oils are one of becoming a promising alternative to diesel fuel, which are produced from renewable agricultural crops that assimilate carbon dioxide from the atmosphere to become plants. Rosca Radu and Zugravel Mircea [1] were made experimental investigation with three different types of sunflower oil and mixtures containing 50% sunflower oil and 50% diesel fuel. It is noticed that vegetable oil-diesel mixtures seems to be a better alternative to pure oils. Narun Nabi et al. [2] reported that, carbon dioxide (CO2) and nitric oxide (NOx) emissions for vegetable oils were lower than diesel. P.Battacharya et al. [3] focused on the scope of Bio-fuel plantations and establishment of Bio fuel extraction units. D.Sarma et al. [4] reported the various aspects of engine performance using neem diesel blend (B-20) as fuel at different injection pressures and suggested that optimum injection pressure was 1.57kN/cm^2. Oznur Kose et al. [5] investigations shown the transesterfication of refined cotton seed oil of Turkish origin was converted to its esters with 72% to 94% of conversion in the presence of an immobilized enzyme. Fangrui [6] research included palm oil, soybean oil, cotton seed oil etc. for producing biodiesel using transesterfication process. M. Senthil Kumar et al. [7] presented various methods of using vegetable oil (Jatropha oil) such as blending, transesteri1cation and dual fuel operation. Brake thermal efficiency was better with dual fuel operation. Smoke was reduced with all methods compared to neat vegetable oil operation. Nwafor [8] reported that the performance of diesel engine has given no significant difference in BSFC between heated and unheated plant fuels at higher loading conditions. A.S. Ramadhas et al. [9] reviewed the production and characterization of vegetable oil also reported that using vegetable oils the thermal efficiency was comparable to that of diesel. The review and results of various researchers support the use of vegetable oil and its blends with diesel as a viable alternative to the diesel to use in C.I engines and it is essential to reduce viscosity of vegetable oils by methods like preheating, blending, transesterfication etc. The Cotton Seed Oil (CSO) is renewable fuel, which is available in many parts of the world and it appears to be an attractive candidate for use as a diesel engine fuel. It has been chosen due to its availability in India at cheaper price, as it is byproduct from cotton industries. The study dealt with determination of fuel characteristics of CSO and its blends with diesel; and experimentation investigation, for performance evaluation of unmodified single Cylinder, 4-stroke, water-cooled, direct injection Diesel engine.

II. PROPERTIES OF CSO-DIESEL BLENDS

The vegetable CSO is extracted from the seeds of the cotton plant after the cotton lint has been removed. The seeds will be shelled, crushed and pressed to obtain the crude oil and the oil content in the cottonseeds is about 20%. The CSO is found to be containing about 90 % of diesel fuel energy content and about 15 times more viscous than diesel. The CSO is relatively inexpensive, readily available and rare use of food oil. There are some approaches to use vegetable oils as fuels in diesel engine without being converted to biodiesel are: *Straight vegetable oil, Diesel blended oil, Organic solvent blended oil and preheated vegetable oil.*

Blending is mixing of two compatible fuels having different properties to produce an intermediate fuel. The various CSO-Diesel blends in the proportions of 10%, 20%, 30%,40%, 50%, 60%, 70%, 80%, and 90% by volume, respectively naming CSO10D90 **(**Consists10% CSO and 90% Diesel**)**. It is essential to study the various properties of any fuel for implications in engine use, storage, handling and safety [10-12]. The summery of the properties like Flash point, Kinematic viscosity (K.V) Calorific value (C.V) etc. for all the CSO blends in comparison with diesel has given in the Table1, which were determined using various conventional apparatus like Pensky Marten's, Redwood Viscometer and Bomb calorimeter etc. The CSO Diesel blends can operate in diesel engine, since the properties were similar to that of diesel. So that, CSO-Diesel blends as a substitute for diesel in diesel engine is reasonable and prospective with little or no engine modifications. The ignition quality of the fuel will be defined by its Cetane Number (CN). The Cetane Number of the diesel fuel and Cotton Seed Oil are 47 and 48.1 respectively [9]. Due to lack of facility, CN test is not carried out. The Cetane Number of the CSO-Diesel blends will be the intermediate between these two fuels is assumed. Higher the Cetane number, better ignition properties and results in higher combustion efficiency and smoother combustion. The vegetable oils (example CSO) contain very low sulfur than conventional diesel; in addition vegetable oils are oxygen contents [4-5]. The oxygen content in the vegetable blended fuel encourages the effective combustion. The low or absence of sulfur in the oils means a reduction in the formation of acid rain by sulfate emissions also decrease the levels of corrosive sulfuric acid accumulating in the engine crankcase oil over time [13, 14].

Table I: Properties of CSO-Diesel Blends

Properties	D100	CSO10 D90	CSO20 D80	CSO30 D70	CSO40 D60	CSO50 D50	CSO60 D40	CSO70 D30	CSO80 D20	CSO90 D10	CSO100
Specific Gravity	0.840	0.843	0.848	0.856	0.868	0.873	0.883	0.885	0.898	0..901	0..912
Density, kg/m^3	840	843	848	856	868	873	883	885	898	901	912
Flash point, °C	67	72	80	84	96	107	119	132	156	188	207
K.V, cSt @40 °C	3..5	4..39	6.82	7.19	7.88	10.38	19.43	27.08	32.54	46.17	55.61
C.V, MJ/kg	42.5	42.1	41.6	41.2	40.7	40.3	39.8	39.4	38.9	38.5	38.0

III. EXPERIMENTAL SETUP

The experimental tests were conducted using CSO and its blends with diesel on 5 hp Single cylinder; 4-stroke, water-cooled unmodified direct injection diesel engine (Bore: 80mm, Stroke: 110mm, Compression Ratio: 16.5: 1), the typical experimental setup is shown in the Fig.1. The short term experiments were conducted at constant speed 1500 rpm for 0%, 20%, 40%, 60%, 80% and 100% of the maximum loads to visually compare the effects of using CSO-Diesel blends with pure diesel. The engine is coupled to a rope pulley break arrangement to absorb the power produced. Necessary weights and spring balances are attached to apply load on the break drum. A fuel measuring system incorporated for measuring fuel consumption of the engine, which consisting fuel tank, burette and three-way-cock. Air intake is measured using an air box fitted with an orifice and a water manometer. The Hatridge Smoke meter is used for measurement of smoke, and is reported in Hatridge smoke units (HSU). The experimental study reveals that the performance of the engine was found to be satisfactory with all the blends without drastic reduction in performance.

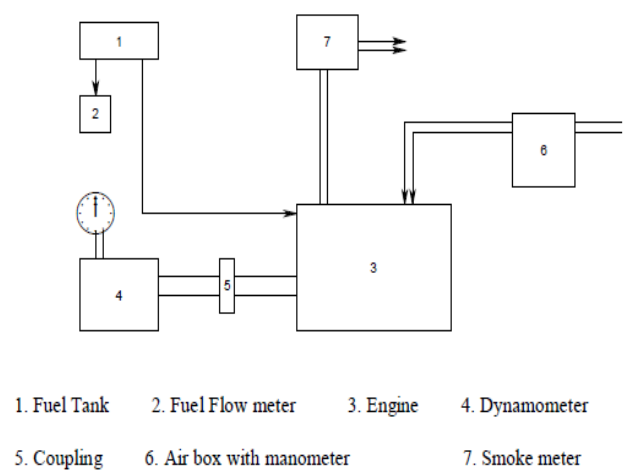

Fig1: Line diagram of experimental setup

IV. RESULTS AND DISCUSSION

The engine performance characteristics for all the fuels were presented using experimental data in Figures 2, 3, 4 and 5 for the performance parameters Specific Fuel Consumption (SFC), Brake Thermal Efficiency (B.Th.Eff.), Mechanical Efficiency(Mech.Eff.) and Smoke(HSU) against different loads respectively. *For effective visualization, it is plotted all the graphs in combined line-column graphs as there are more number of fuels considered in this study.* The experimental evaluation showing that the performance of the engine with blended fuels upto CSO50D50 gave closer performance to the D100, even though performance of all the blends found to be satisfactory. Next, it is found that performance of diesel engine is improved using CSO10D90 fuel in comparison with conventional diesel with considerable decrease in smoke. The physical observation during short-term tests is that no failure of fuel injector and fuel pump and carbon deposition the injector tip with CSO-Diesel blends were found to be approximately the same as that of found in engine operated with neat diesel.

A. Specific fuel consumption

Variation of brake SFC with loads for all the fuel is presented in figure 2 and it is found to be decrease with increase in the load. This is due to the higher percentage increase in brake power with load as compared to the increase in fuel consumption. The average SFC of CSO10D90 fuel is 3.5 % lower in comparison with conventional diesel, it may be due to some sufficient oxygen content in this blend fuel caused for effective combustion. In addition, it is obvious that the slight high viscosity of CSO10D90 fuel than neat diesel might be played favorable role in combustion process despite its adverse effect on droplet sizes, distribution and possible over penetration etc. The results from graph (Fig.2) shown upto CSO50D50, the SFC is increase but little closure to diesel and beyond CSO50D50 with an increase in the CSO percentage in the blends there is increase in SFC compared to diesel due to low energy content.

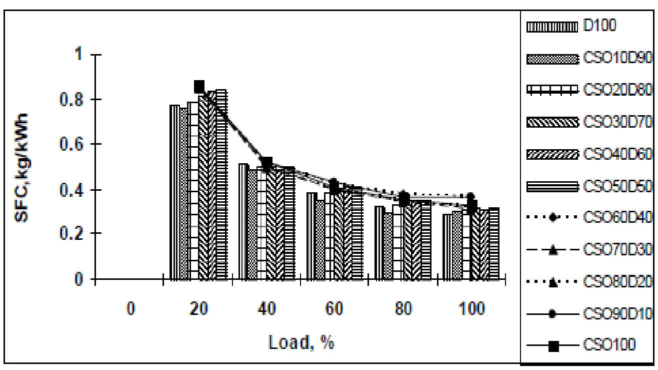

Fig 2: SFC Vs Load

B. Brake thermal efficiency

The Fig.3 compares the variation of B.Th.Eff. against load for all the fuels; and depicted B.Th.Eff. is increased with increase in load. This is due to reduction in heat loss and increase in power developed with increase in load. Higher thermal efficiency indicates better and complete combustion of fuel. It is noticed that, the average increase in B.Th.Eff is 3.8 % withCSO10D90 blend in comparison with conventional diesel. It is resulted may be due to sufficiently high fuel viscosity of CSO10D90 blend than diesel acted as a lubricant, as well as a sealant between the piston rings and cylinder wall, thus fulfilling the engine compression requirement and the oxygen content in this blend together contributed in better combustion. The Fig.2shown upto CSO50D50 the B.Th.Eff is little closure to diesel and beyond CSO50D50 there is decrease in B.Th.Eff compared to diesel.

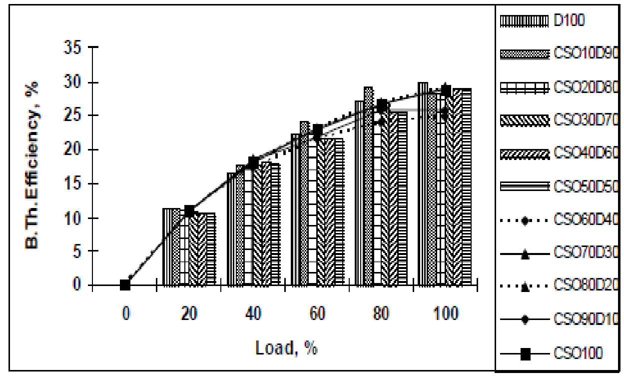

Fig 3: B.Th.Eff Vs Load

C. Mechanical efficiency

The Fig.4 shows the Mech.Eff. against load plots for all the fuels and average increase in mechanical efficiency is about 7% with CSO10D90 fuel blend due to the high viscosity in comparison with conventional diesel. The friction power was noted to decrease for all the blends, with an increase in fuel viscosity in comparison with conventional diesel, due that Mech.Eff. is increased for all the fuels at all the power outputs.

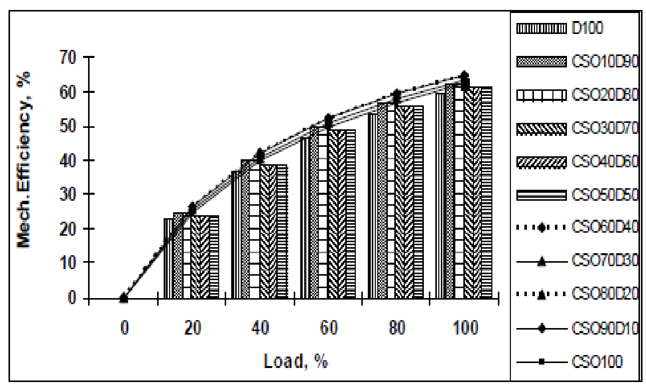

Fig 4: Mech.Eff Vs Load

D. Smoke density

Variation of smoke against load is depicted in Fig.5 and is considered only for CSO10D90, CSO50D50, CSO100 fuels in comparison with neat diesel D100. It is noticed, there is decrease in smoke density with CSO based fuels compared to diesel at any load. The smoke emitted by engine is an indicator of Particulate Patter (PM). The oxygen content in CSO may have contributed in achieving effective fuel burn and improved the smoke levels. It is found the average decrease in smoke levels is about 20% withCSO10D90 fuel in comparison with conventional diesel. It is also observed that, there is rise in exhaust gas temperature with blends as compared to diesel may be due to poor volatility and high viscosity of the fuels. The nitrogen oxides (NOx) emission is directly related to the engine combustion chamber temperatures, which in turn indicated by the prevailing exhaust gas temperature i.e. the rise in exhaust gas temperature, indicates that there is increase of NOx emissions [4]. The hydrocarbon (HC) emissions are influenced by the fuel viscosity and there is a decrease in HC emissions as the viscosity of the fuels increases [8].Due to lack of emission test facility, NOx, HC, Carbon monoxide (CO) and (PM) have not measured.

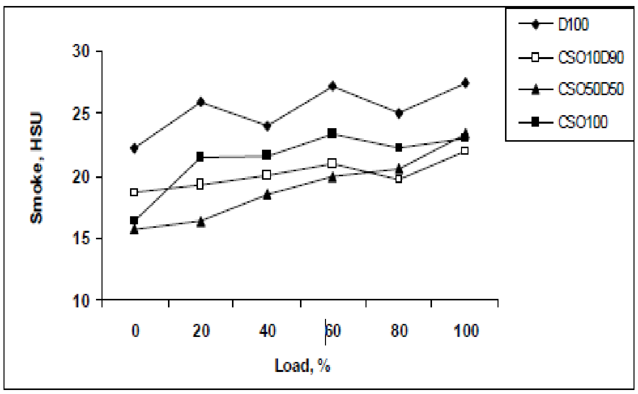

Fig 5: Smoke Vs Load

V. CONCLUSIONS

Following conclusions were drawn from this study: short-term engine testing indicates that CSO-Diesel blends can be readily used as a fuel source, since which performs in the approximately same way as that of diesel with considerable reduction in smoke.

- Properties of the CSO-Diesel blends upto CSO50D50 fuel are more comparable with conventional diesel than blends beyond CSO50D50. The flash points of blends are higher than that of diesel, led less risks of fire hazards.
- The use of CSO-Diesel blends reduce power loss against friction since which are more viscous than diesel and in turn extend the life of engine. The performance of the engine was found to be satisfactory with all the blends but only upto CSO50D50 blends gave closer performance to that of the engine using diesel fuel. It is found that on average there is 3.5% decrease in SFC, 7% increase in mechanical efficiency, 2.0 % increase in brake thermal efficiency and 20% decrease in smoke levels with CSO10D90 blend, in comparison with conventional diesel.
- Carbon deposits on the tip of the injector with CSO-Diesel blend were found to be approximately the same as that of diesel used in engine. It is noticed, during short-term tests no failure of fuel injector and fuel pump. The short-term experimental investigation on whole, suggests that CSO10D90 fuel is the practically optimal composition to replace the neat diesel fuel as it superior from the performance and environmental point of view for an unmodified diesel engine without any difficulty.
- Although short-term engine test results were promising, it is suggesting that long term engine tests are needed to determine the overall effects of using CSO and its blends as a substitute fuel for diesel engines.

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