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Performance and Emission Analysis of Diesel Engine (DI) Using Cotton Seed Oil Methyl Ester

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ABSTRACT

Biodiesel production is a modern and technological area for researchers due to constant increase in the prices of petroleum diesel and environmental advantages. Increased environmental awareness and depletion of resources are driving industry to develop viable alternative fuels from renewable resources that are environmentally more acceptable. Vegetable oil is a potential alternative fuel. The most detrimental properties of vegetable oils are its high viscosity and low volatility, and these cause several problems during their long duration usage in compression ignition (CI) engines. The most common method to make vegetable oil suitable for use in CI engines is to convert it into biodiesel, i.e. vegetable oil esters using process of transesterification. In the present work, experimental investigations of the performance and emissions of the diesel engine was conducted for different proportions of blends of cotton seed oil methyl ester biodiesel (CSOME) with ordinary diesel at different engine loads.

Keywords- Diesel engine, Cotton seed oil methyl ester, Biodiesel, Engine performance, Emissions.

I. Introduction

Diesel engines offer higher efficiency, better fuel economy and lower emission of green house gases than conventional gasoline engines [1]. However, swooning oil resources, global warming, environmental pollution and above all meeting the stringent requirements of the upcoming automotive emissions regulations, have resulted in a worldwide interest in exploring environmentally friendly renewable energy resources and their efficient

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utilization [2].

Biodiesel is one of the most promising alternative fuels to meet the above problems [3]. It is derived from the transesterification of fats and oils, and has similar properties to that of diesel produced from crude oil and can be used directly to run existing diesel engines or as a mixture with crude oil diesel. The main advantages of using biodiesel are renewable, biodegradable, non toxic, can be used without modifying existing engines [4], and produces less harmful gas emissions such as sulphur oxide [5]. Chemically, biodiesel is a mixture of methyl esters with long-chain fatty acids and is typically made from nontoxic, biological resources such as animal fats, vegetable oils [6-9], or even used cooking oils [10].the use of this alternative fuel may also provide economic benefits in meeting the energy needs of industry. It has significantly lower emissions than petroleum-based diesel and in addition, biodiesel is better than diesel fuel in terms of sulfur content, flash point, aromatic content and biodegradability [11, 12].

Table 1. Specifications of Test Fuels

Properties	CSOME	Diesel Indian oil
Density at 15 °C kg/m^3	830	822
Viscosity at 40 °C mm/s^2	6.0	2.5
Flash point °C	110	66
Pour point °C	4	12
Calorific value kJ/kg	39600	43400
Cetane number	52	43

Biofuels are proved to be very good substitutes for the existing petro fuels. The essential minimum requirements for biofuels to be a more sustainable alternative for fossil fuels are that they should be produced from renewable raw material and that their use has a lower negative environmental impact. Plant oils are renewable and have low sulfur in nature. As biofuels are more expensive than fossil fuels, the wide spread use of biofuel was restrained from its use in C.I.engines[13,14]. In recent years, systematic efforts were undertaken by many researchers to determine the suitability of vegetable oil and its derivatives or additives to the diesel [15-19]. Various oils such as soybean oil, jatropha oil rapeseed oil[20-24] , Cotton seed oil methyl ester sunflower oil, tobacco seed oil ,karanja oil, poon

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oil, orange oil, and waste cooking oils[25,26] have been tried successfully to run a diesel engine. But the problems associated with vegetable oil are the high viscosity and low volatility. All vegetable oils are extremely viscous, with viscosities ranging from 10 to 17 times greater than diesel fuel [27]. These properties have an adverse effect on fuel injection system and may lead to heavy carbon deposits in the engine combustion chamber carbon deposition on the injector and the valve seats causing serious engine fouling[28, 29]. But there is still a lot of work that has to be done to make vegetable oil really suitable to diesel engines in place of the petroleum diesel fuel[30,31]. In the present work feasibility of blending Cotton seed oil methyl ester with ordinary diesel and utilization in a direct injection diesel engine has been evaluated. It may not always be convenient to make experimentation every time while switching over from one blend to another.

II. Experimental Setup and Test Procedure

The engine used in the present study is the computerized Kirloskar-make, 4 stroke, water cooled, single cylinder diesel engine of 5.2 kW rated power. The schematic diagram of the experimental setup is shown in Figure. 2. The engine was directly coupled to an eddy-current dynamometer equipped with a load controller. The fuel flow rate, speed, load, exhaust gas temperature and gas flow rate were displayed on a personal computer.

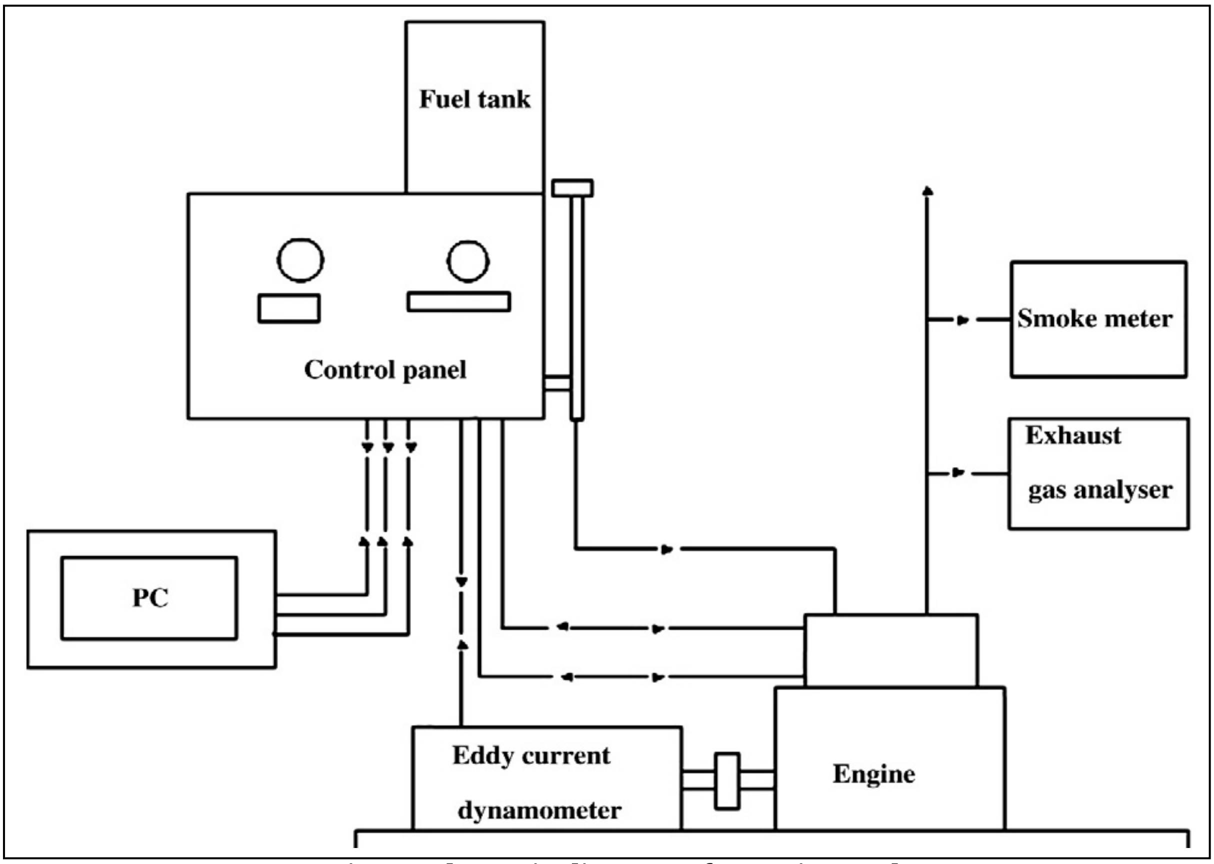

Fig 2. Schematic diagram of experimental setup

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The transesterification reaction was carried out 15% of methanol, 5% of NAOH and Cotton seed oil are required on basis of this process. It is an equilibrium reaction in which excess alcohol is required to expedite the reaction very close to completion. The Cotton seed oil was chemically reacted with methanol or ethanol in the presence of catalyst to produce methyl ester. At the end of reaction glycerol was produced as a by-product. First of all produced the mixture was stirred continuously and then allowed to settle under gravity in a separating funnel. After 24 hours the Cotton seed oil was separated as two distinct layers produced from gravity settle. The upper layer was separated out it is called ester. Lower layer is called glycerol. The separated ester is mixed with warm water around 10% volume of ester to remove the catalyst present in the ester which was allowed to settle under gravity for another 24 hours the catalyst dissolved in water, which was separated and removed the moisture. The methyl ester was blended with mineral diesel. Methyl ester from transesterification process is mixed with diesel with respect to our requirement such as C10, C20, C30, C40 and C50.

Tests were conducted at a single cylinder, four stroke, water cooled diesel engine. Exhaust gases were determined by QROTECH QRO-402 type emission analyzer. In addition engine load can be changed by 20% segments to increase and decrease engine load. The test engine was allowed to run for sufficient time to consume the remaining fuel from the previous experiment before starting the new experiment.

III. Results and Discussion

The brake specific fuel consumption (BSFC), Brake thermal efficiency(BTE), emission against engine load are presented in Figures.2&3.The Brake-specific fuel consumption (BSFC) is the ratio between mass flow of the tested fuel and effective power. Fig 2 represents the BSFC variation with power output at engine speed of 1500 r/min for diesel, biodiesel, and their blends. In general, the BSFC is found to increase with raising the biodiesel quantity with the blends under all ranges of engine load. The BSFC of a diesel engine depends on the relationship among volumetric fuel injection system, fuel specific gravity, viscosity, and heating value. When increasing biodiesel proportion in blends, calorific value decreases and leads to increase the flow rate of the blends for maintaining the same operating conditions. As expected, load increases, the BSFC decreases for all fuels. At brake power (5.2 kW), C10 and C20 are found to be the blends that give lower BSFC.

The brake thermal efficiency of Fig.3 show an increase with engine load as the amount of the Cotton seed oil in the blends increases. It can be seen from Fig.3 that the 90% diesel to 10% Cotton seed oil fuel blend incidentally gives higher efficiencies at all loads. The diesel fuel produced the lowest thermal efficiency at all loads. The higher thermal efficiency of the vegetable oil fuels may be due to their low heat input requirement for a given engine load. The BTE of C10 and C20 blends is increased around 6% at brake power of 5.2 kw when compared to diesel.

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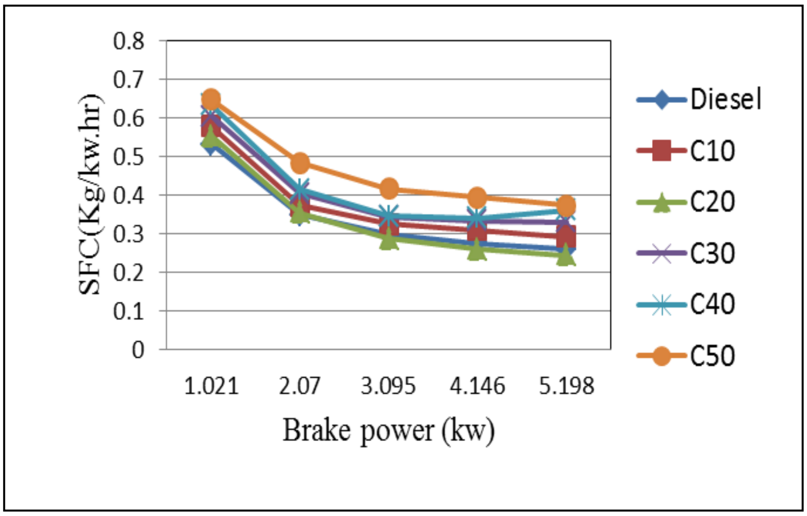

Fig 2. Effect of brake power on specific fuel consumption

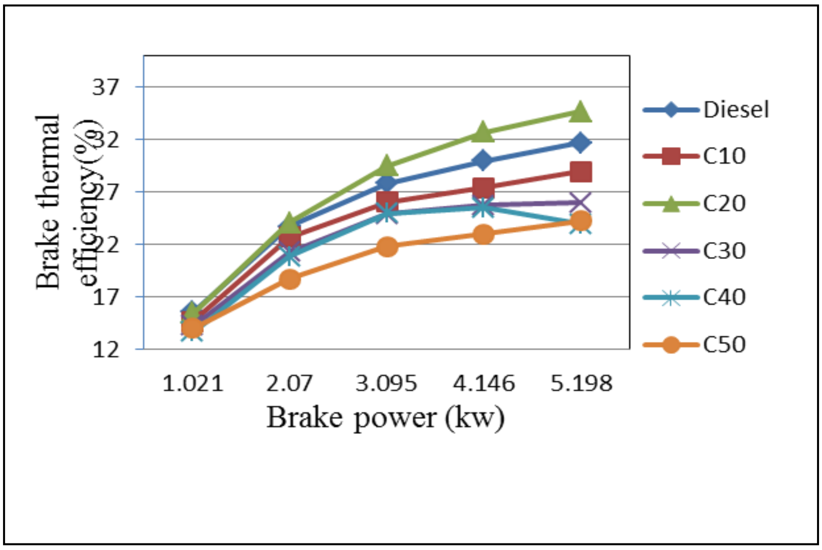

Fig 3. Effect of brake power on brake thermal efficiency

It is an important parameter for determining the emission behavior of the engine. The variation of unburned hydrocarbon (HC) with load for the tested fuels is given in Fig.3 It is shown that increasing biodiesel in the blends reduces significantly HC emissions comparatively to ordinary diesel. This is due to the increase in oxygen content in the blend which improves the combustion quality in the combustion chamber. It can be noticed that at

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high power levels for C20 (e.g.,5.2kw), the reduction in HC emissions can reach 50% in comparison with neat diesel fuel.

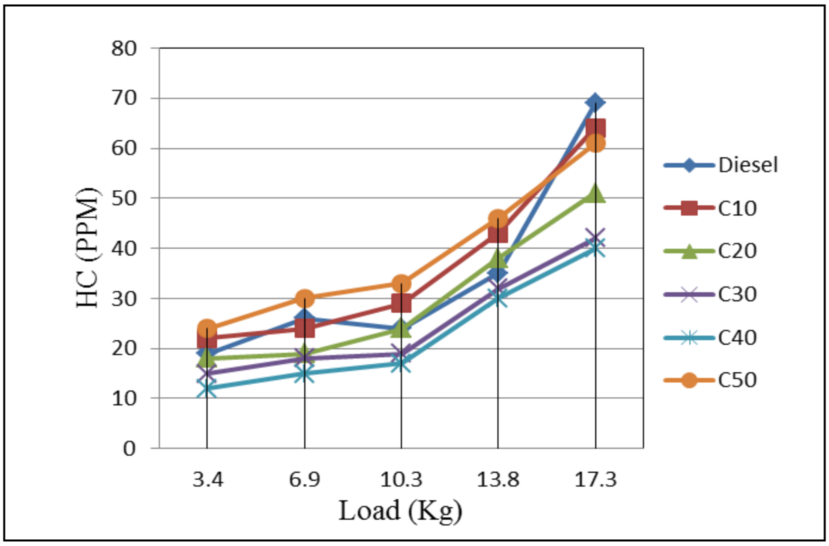

Fig 4. Effect of load on Hydrocarbon emission

The plot of Fig.4 shows the variation of carbon monoxide (CO) emission of Cotton seed oil bio diesel with ordinary diesel at various load conditions. It is shown that increasing biodiesel in the blends at low and middle engine loads has only a slight effect on the CO emissions due to the dominant premixed lean combustion with excess air.

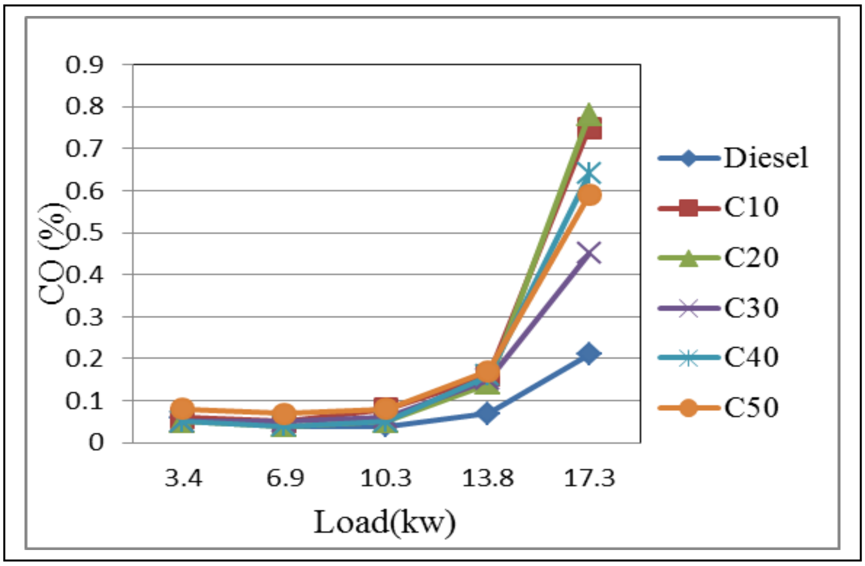

Fig 5. Effect of load on CO emission

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The CO emissions of C20 at loads 3.4,6.9,10.3 kw are evidently lower than those of diesel fuel. This is due to the fact that biodiesel which contains more number of oxygen atoms leads to more complete combustion.

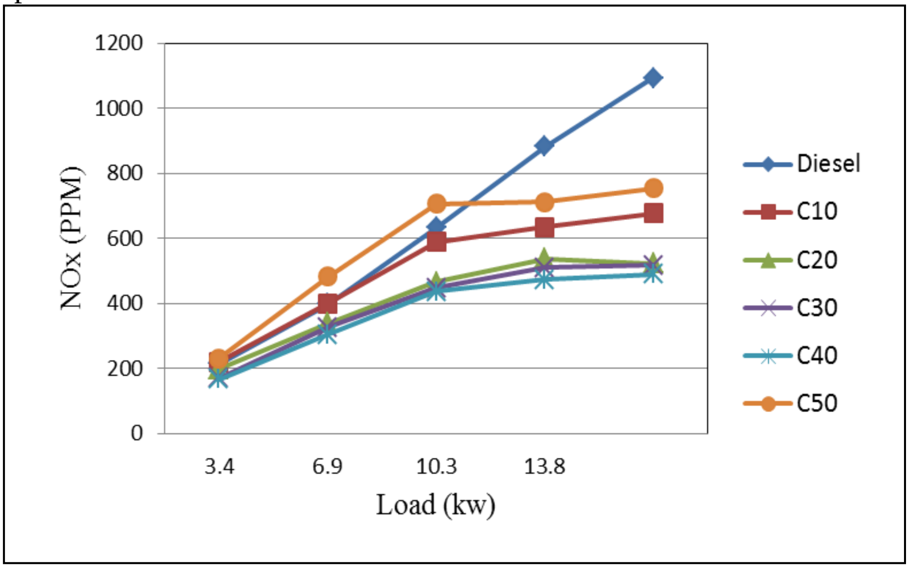

Fig 6. Effect of load on NOx emission

Fig.5 points out the variation of nitrogen oxides (NOx) emission with power output for the different fuels tested. There are mainly three factors, oxygen concentration, combustion temperature, and time, affecting the NOx emission. As the load increases, the concentration of NOx is also increasing. The graph clearly shows the diesel NOx is always higher than the biodiesel. Comparing the overall results the C30 blend exhibits lower NOx emission but its BTE is low when compared to C20 blend. However, the NOx emission was decreased for C10, C20, C30 and C40 when compared to neat diesel. At partial loads NOx emissions of neat biodiesel and its blends are higher than those of diesel fuel. Higher values of combustion temperature and presence of oxygen with biodiesel result in an increase in NOx generation.

IV. Conclusion

The first phase was the preparation of Bio-Diesel from cotton seed oil. This phase was a success as the preparation was done by simple process. The second phase is comparing the physical properties of Biodiesel with that of Diesel. The third and vital phase was the performance and emission testing of the Manufactured Biodiesel. This experiment was conducted on kirloskar, single cylinder, 4 stroke, vertical inline engine. Here, first the readings were taken by using base diesel and then with biodiesel. The results showed that the Brake Thermal Efficiency and Brake Power obtained by using Biodiesel were higher than that used from conventional diesel by 6 % and 3% at 60% and at full load conditions respectively. Also, the total fuel consumptions per load of biodiesel was lower than conventional diesel as 1.282Kg/hr at maximum load and specific fuel consumption is 0.286 Kg/kwhr . Hence, the third phase was also a successful one and it stated that this fluid obtained from Cotton seed oil can be used successfully as an alternate for diesel. The emission of the fuel is a very significant factor. According to references, there are a lot of reductions in emissions. The unburned hydrocarbons are reduced by 9%. And Carbon di oxides are reduced by 15% . However, the NO_X is increased by 13% by emission standards. Overall, when we look at the emissions of Biodiesel, it is very lower than diesel. The only hindrance is that the NO_X is high by a small amount for the market expansion.

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