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Performance and Emission Characteristics in a Diesel Engine Using Cotton Seed Oil and Diesel Blend

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ABSTRACT

Diesel engines are mostly promoted for transportation since they are highly efficient and durable in the long run. Environmental concerns and energy crisis of the world has led to the search of viable alternatives to the fossil fuel. The present work describes the performance and emission characteristics of a diesel engine using cotton seed oil and diesel blend in different proportions by volume. The results revealed significant enhancement in Brake thermal efficiency (BTE) with B20, B40 and B60 proportions of blend resulted in 3.75%, 10.47% and 3.30% respectively rise in BTE at full load of engine. Significant reduction in fuel consumption and emissions were also noticed.

Keywords: Brake Thermal Efficiency (BTE), Cotton seed oil, Internal combustion engine.

1. INTRODUCTION

Energy comes in a variety of renewable forms like wood, biomass, wind and sunlight. It also comes in non-renewable form of fossil fuels like oil, coal etc. and their use is a major source of pollution throughout the world. The increasing rate at which the changes in human lives are occurring has important consequences for the environment and carrying capacity of earth. Pollution and accelerating energy consumption has already affected equilibrium of earths land masses, oceans and atmosphere. Fortunately, the last 25 years has seen growing awareness of some of these consequences. Since the dawn of oil age man has burnt about 800 million barrels of petroleum. About 71 barrels are burnt everyday throughout the world. And this consumption rate goes on increasing by 2% every year. The 2% doubles the quantity every 34 years. Somewhere between 1000 to 1600 billion barrels of fuel consumption are assumed to be in formation where economic recovery is possible. With recent price rise and scarcity of these fuels there has been a trend towards use of alternative energy sources like solar, wind, geothermal etc. (Rajvanshi, 1978).

However these energy resources have not been able to provide an economically viable solution for agricultural applications (Dutta, 1981). Since the energy crisis in 1970s, the energy utilization from biomass resources (called biomass energy) has received much attention. The energy obtained from agricultural wastes or agricultural residues is a form of renewable energy and, in principle, utilizing this energy does not add carbon dioxide (CO2), which is a greenhouse gas, to the atmospheric environmental pollution and health risk than fossil fuel combustion. The main advantages of using these bio-fuel are its renewability, as it gives a better quality exhaust gas emission, its biodegradability and, it does not contribute to a net rise in the level of CO2 in the atmosphere, and consequently to the greenhouse effect. The main objective of this work is to examine performance and emission characteristics of a diesel engine using cotton seed oil and diesel blend in different proportions by volume. An attempt has been made to enhance brake thermal efficiency (BTE) of diesel engine with different proportions of cotton seed oil and diesel blend. In 1885, Dr. Rudolf Diesel built the first diesel engine with intention of running it on vegetative oils.

Scott et al (1984) investigated that through flash pyrolysis, high liquid yields from biomass can be produced. An organic liquid yield of 65-70 wt. % of dry wood is feasible. Solantausta et al (1993) studied the feasibility and economics of using wood pyrolysis oil in a diesel power plant. It has been estimated that Pyrolysis oil suffers from ignition problems which could be reduced by adding cetane improver like (nitrated alcohol) to wood pyrolysis oil. Best emission results were obtained with 5% ignition improver. Raja et al (2011) have studied the production and characterization of biodiesel produced from jatropha oil. Transesterification process was used in which alcohol (methanol) reacts with triglycerides present in jatropha oil to convert it to jatropha methyl ester in the presence of NaOH catalyst. Oil was extracted from jatropha seeds by crushing them with a yield of 25-30%.

The optimum parameters for biodiesel production were found out to be 6:1 methanol to oil molar ratio with catalyst-NaOH 0.92% and reaction temperature of 60^{0}C. MichioIkura et al (2003) have conducted tests on emulsions of pyrolysis oil and diesel fuel. It has been found that stable emulsions are formed with 0.8 to 1.5 wt% surfactant concentrations. The costs of surfactants used were high and could be reduced by using a new CANMET surfactant. The heating value of emulsion was in between the bio-oil and diesel. Many researchers have been reported that pyrolysis oil quality can be improved by the addition of alcohol which improves storage stability and reduces its viscosity. This process improves stability and decreases viscosity. The main aim is to facilitate the use of pyrolysis oil in already existing equipment for heat and power generation and also the emulsions have improved ignition characteristics compared to pure pyrolysis oil. The pyrolysis oil cannot be used directly for engine operation because of high viscosity, low calorific value, high acidity, low stability, poor lubrication. So, blending with diesel or biodiesel is most suitable alternative to utilize a major fraction of it.

2. METHODOLOGY

The present work is an attempt to investigate the evolution of cotton seed oil with diesel. Experiments were carried out at constant speed of 1500 rpm and at different loads with different blends. Cotton seed oil is cooking oil extracted from the seeds of cotton plants of various species, mainly Gossypiumhirsutum and Gossypiumherbaceum that are grown from cotton fibre, animal feed, and oil. Cotton seed has a similar structure to other oil seeds such as sunflower seed, having an oil-bearing kernel surrounded by a hard outer hull; in processing, the oil is extracted from the kernel. Cotton seed oil is used for salad oil, mayonnaise, salad dressing, and similar products because of its flavour stability. Its fatty acid profile generally consists of 70% unsaturated fatty acids (18% monounsaturated, and 52% polyunsaturated), 26% saturated fatty acids. When it is fully hydrogenated, its profile is 94% saturated fat and 2% unsaturated fatty acids (1.5% monounsaturated, and 0.5% polyunsaturated). Different properties of diesel and cotton seed oil is shown in table1.

Table 1: Different Properties of diesel and cotton seed oil

Sr. No.	Properties	Diesel	Cotton seed oil
1.	Calorific Value	43,000 KJ/Kg	39,648 KJ/Kg
2.	Flash Point	44^{0}C	234^{0}C
3.	Fire Point	49^{0}C	192^{0}C
4.	Viscosity	0.278 poise	2.52 poise
5.	Density	835 Kg/m^3	850 Kg/m^3

Transesterification process has been adopted for the preparation of biodiesel. The basic reaction used in this process is shown in figure 1. A catalyst is usually used to speed up the reaction that may be basic, acid or enzymatic in nature. Transesterification is a method of transforming of an ester into another when a vegetable oil is reacted with methanol in the presence of catalyst to give methyl ester also biodiesel and amount of glycerine. The different schematic experimental set up for transesterification process is shown in figure 2.

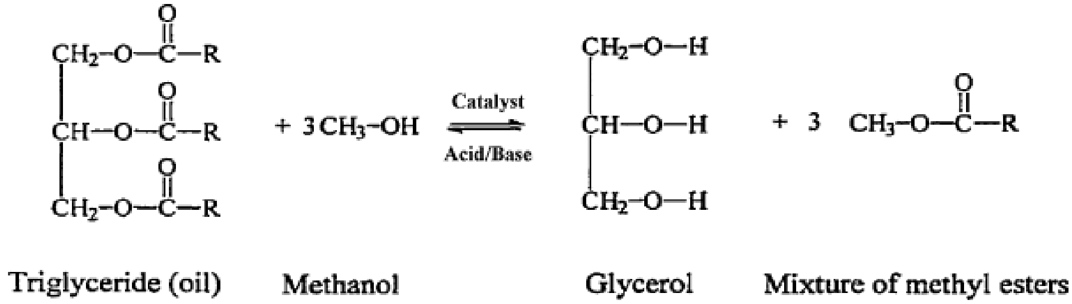

Figure 1: Transesterification reaction

Figure 2: Experimental Set up for transesterification process

For the present analysis, a Field Marshal make, single cylinder, water cooled, direct injection, Model No. BF2 diesel engine was taken, which is primarily used for agriculture activities and household electricity generation. The engine was directly coupled to alternator and loaded by electrical resistance. The separate fuel measurement unit was connected with engine. A resistive load panel was attached with the output of the generator. The detail specification of the selected engine has been given in table 2. The schematic diagram and photographic view of experimental set up is shown in figure 3 and figure 4 respectively.

Table 2: Engine Specification

Parameter	Value
Engine No.	HX 28036
Model No	BF2
Type	DI
Output	4.8/6.5 KW/bhp
Speed	1500 r.p.m
SFC	240g/kwh
Bore of Engine (D)	85 mm
Stroke Length of Engine (L)	110 mm
Outer diameter	20 mm
Cross Section Area of Orifice	0.0031416 (M)
Coefficient of Discharge	0.62

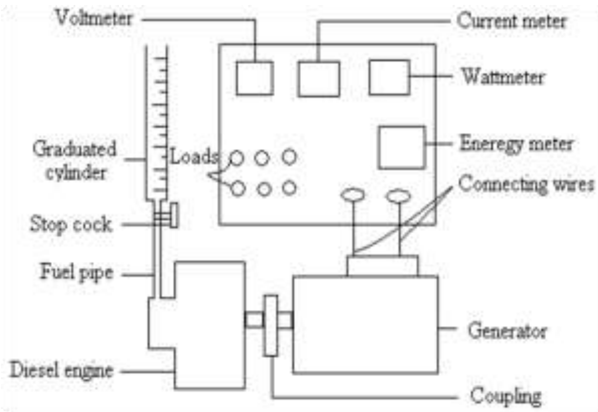

Figure 3: Schematic of Experimental set up

Figure 4: Photographic view of Experimental set up

3. RESULTS AND DISCUSSION

Engine performance and emission characteristics have been investigated with different proportions of cotton seed oil and diesel blend. Firstly the performance on pure diesel has been checked at 20 ml diesel with different load and then different parameter values i.e. current, voltage and time for fuel consumption has been noted. The results obtained through diesel are shown in table 3. After that, cotton seed oil and diesel blend is prepared and then performance was measured with B20, B40 and B60 blend. Brake specific fuel consumption (BSFC) and brake thermal efficiency (BTE) has been calculated at different load of engine. The results of B20 Blend are shown in table 4. Table 5 showed the results of B40 blend and results obtained through B60 blend and B100 are shown in table 6 and table 7 respectively.

Table 3: Results of Diesel

Diesel					
S. No.	**Load (W)**	**m_F (Kg/hr)**	**Brake Horse Power (B.H.P.) (KW)**	**Brake Specific Fuel Consumption (B.S.F.C.) (Kg/KW-hr)**	**Brake Thermal Efficiency (B.T.E) (%)**
1	20	0.5966	1.3643	0.4372	19.28
2	40	0.7323	2.02	0.3638	23.164
3	60	0.9182	2.94	0.3123	26.995
4	80	1.0945	3.659	0.2991	28.185
5	100	1.268	4.59	0.2762	29.92

Table 4: Results of B20 Blend

B20					
S. No.	**Load (W)**	**m_F (Kg/hr)**	**Brake Horse Power (B.H.P.) (KW)**	**Brake Specific Fuel Consumption (B.S.F.C.) (Kg/KW-hr)**	**Brake Thermal Efficiency (B.T.E) (%)**
1	20	0.5016	0.5227	0.9596	8.826
2	40	0.5773	1.5893	0.3632	23.31
3	60	0.7034	2.725	0.2981	32.81
4	80	0.8869	3.3568	0.2842	32.06
5	100	1.222	4.486	0.2728	31.04

Table 5: Results of B40 Blend

B40					
S. No.	**Load (W)**	**m_F (Kg/hr)**	**Brake Horse Power (B.H.P.) (KW)**	**Brake Specific Fuel Consumption (B.S.F.C.) (Kg/KW-hr)**	**Brake Thermal Efficiency (B.T.E) (%)**
1	20	0.523	0.5227	1.0005	8.46
2	40	0.5884	2.045	0.2827	29.43
3	60	0.7463	2.7375	0.2726	31.09
4	80	0.9562	3.476	0.27	30.79
5	100	1.53	5.97	0.2559	33.05

Table 6: Results of B60 Blend

B60					
S. No.	**Load (W)**	**m_F (Kg/hr)**	**Brake Horse Power (B.H.P.) (KW)**	**Brake Specific Fuel Consumption (B.S.F.C.) (Kg/KW-hr)**	**Brake Thermal Efficiency (B.T.E) (%)**
1	20	0.5884	0.5113	1.1507	7.36
2	40	0.765	2.009	0.3807	22.24
3	60	0.9562	2.7375	0.3492	24.25
4	80	1.127	3.46	0.3257	30.65
5	100	1.224	4.393	0.2786	30.90

Table 7: Results of B100 Blend

B60					
S. No.	**Load (W)**	**m_F (Kg/hr)**	**Brake Horse Power (B.H.P.) (KW)**	**Brake Specific Fuel Consumption (B.S.F.C.) (Kg/KW-hr)**	**Brake Thermal Efficiency (B.T.E) (%)**
1	20	0.6244	0.5	1.2488	6.78
2	40	0.9272	1.9545	0.4743	17.85
3	60	1.092	2.51	0.435	19.46
4	80	1.224	3.26	0.3754	22.56
5	100	1.3304	3.818	0.3484	24.30

Variation of brake specific fuel consumption with load has been shown in figure 5. A significant reduction in brake specific fuel consumption has been found with increase in engine load. Also the variation of brake thermal efficiency and emission characteristics of engine at different load has been shown in figure 6 and figure 7 respectively.

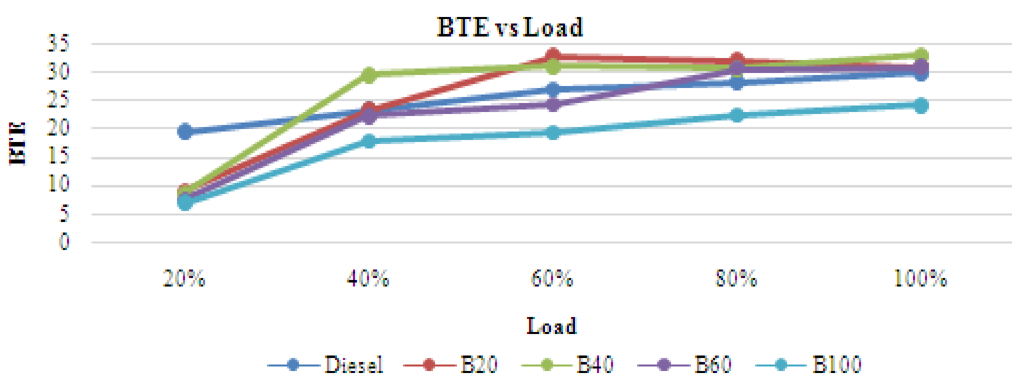

Figure 5: Variation of BSFC with Load

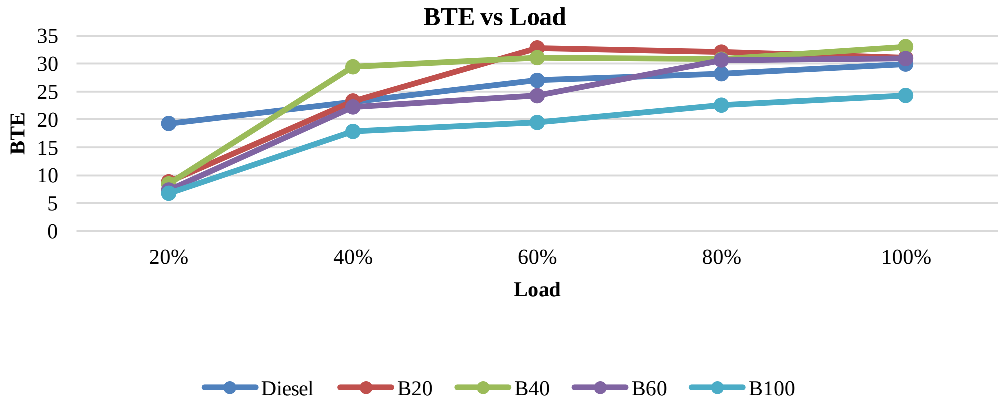

Figure 6: Variation of BTE with Load

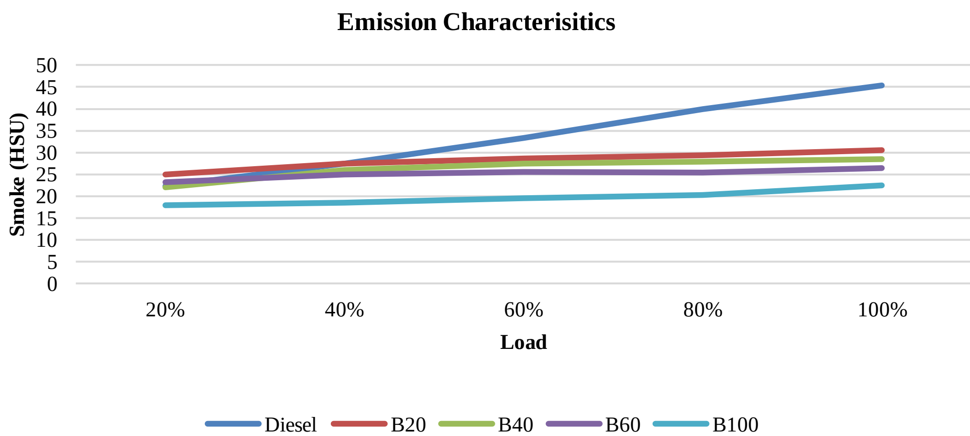

Figure 7: Emission characteristics

CONCLUSIONS

Cotton seed oil methyl ester COME was produced by means of transesterification process using cottonseed oil, which can be described as a biomass based and renewable energy source. The viscosity of COME was reduced by preheating it before supplied to the test engine.

1. A higher BTE was found with the preheated with B20, B40 and B60 that 3.75%, 10.47%, 3.30% at full load more than that for diesel.
2. Smoke was reduced with considerable factor when quantity of biodiesel is increased in pure diesel.

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