Research Paper Engineering

Performance Testing of Preheated Waste Cooking oil on An Agricultural Diesel Engine

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ABSTRACT

Present work is focused on the performance testing of a water cooled diesel engine using preheated (800C) waste cooking oil as a fuel. In this experiment, two Preheated Waste Cooking Oil blends; PH WCO-20(80 % diesel and 20% preheated waste cooking oil) and PH WCO-40 (60 % diesel and 40% preheated waste cooking oil) are tested without any modification of the diesel engine. It has been observed that performance of blended fuels is very much similar with lower emissions compared to that of diesel. Some of the important conclusions are (i) the sfc is slightly higher (average about 5%) than that of diesel for blends (ii) at all brake power conditions the opacity of all PH WCO blends decreases than diesel. Maximum percentage decrements of opacity obtained are 22.52% at 3.5 kW brake power for PH WCO-20 and for PH WCO-40, 21% at 2 kW brake power.

Keywords : Preheated Waste Cooking Oil, Specific Fuel Consumption, Break Thermal Efficiency, Smoke Opacity.

1. Introduction

Although India is the largest producer of oil seeds in the world, it is also the second biggest buyer of vegetable oil in the world [Debdeep, 2011]. Also every year million tons of waste cooking oil from hotels and restaurants have been illegally dumped into rivers and landfills, creating environmental pollution. Whereas this waste cooking oil can be effectively used as a diesel engine fuel after reducing of its viscosity by preheating it, blending or by tranesterification.

India's energy demand is expected to grow at an annual rate of 4.8 per cent over the next couple of decades. Most of the energy requirements are currently satisfied by fossil fuels – coal, petroleum based products and natural gas. Domestic production of crude oil can only fulfil 25-30 per cent of national consumption rest is met by importing crude oil from other countries. In these circumstances bio-fuels seems to play an important role in meeting India's growing energy needs. Since the demand for diesel is five times higher than the demand for petrol in India, Bio-diesel is a promising alternative for our Diesel needs. Being agriculture rich country, certainly bio-diesel is a viable source of fuel for Indian conditions. Recent studies and research have proved the feasibility to extract bio-diesel at economical costs and quantities but large biodiesel production plants are yet to be made at a affordable cost.

1.1 History of vegetable oils

The idea of using vegetable oil as fuel has been around as long as the diesel engine. Rudolph Diesel, the inventor of the engine that bears his name, experimented with fuels ranging from powdered coal to peanut oil. In the early 20th century, however, diesel engines were adapted to burn petroleum distillate, which was cheap and plentiful. In the late 20th century, however, the cost of petroleum distillate rose, and by the late 1970s there was renewed interest in biodiesel.

2. Literature Overview

Studies have shown that various problems are associated with vegetable oils being used in compression ignition engines are mainly caused by their high viscosity, ring sticking, gum deposits and low volatility. The high viscosity is due to the large molecular mass and chemical structure of vegetable oils which in turn lead to problems in pumping, combustion and atomization in the injector systems of diesel engine. Therefore reduction in viscosity is of prime importance to make vegetable oils suitable alternate fuel for diesel engines [1].

The oils that are extensively studied are Sunflower, Soya bean, Peanut, Rapeseed, Rice bran, Karanja etc [Niehaus et al.,1985, Schlick et al.,1988 and Pal et al.,2010]. One of the major disadvantages of using these oils in diesel engines is nozzle deposits, which affects the engine performance and emissions. Tranesterification and blending processes of vegetable oil gives better performance compared to crude vegetable oil [Goering et al.,1982, Cigizoglu et al.,1997, Machacon et al.,2001 and Sapvan, 1996].

Pramanik et al., 2003 conducted performance tests using jatropha oil and diesel blends in a single cylinder C. I. engine and compared with the performance obtained with diesel and found that the blend up to 50%vof Jatropha oil and diesel was proved to be the best suitable oil without modification of engine.

3. Experimental Work

This engine experiment has been performed with different blends of PH WCO and diesel (diesel, PH WCO-20, and PH WCO-40). These blends are prepared on weight basis in quantity of 1 liter each by mixing required quantity of WCO in petroleum diesel.

Calorific value of diesel = 44300 kJ/kg.
Calorific value of WCO = 39450 kJ/kg.
Density of petroleum diesel = 830 kg/m3.
Density of WCO = 890 kg/m3.

3.1 Engine Test Setup

The setup consists of single cylinder, four strokes, diesel engine connected to eddy current type dynamometer for loading, as shown in Fig.1. The setup enables the study of engine performance for brake power, indicated power, frictional power, brake thermal efficiency, indicated thermal efficiency, mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio and heat balance. Main specifications of the test setup are given in Table 1.

S. No.	Component	Specifications
1.	Engine Make	Kirloskar
2.	Engine Type	1cylinder, 4stroke,
3.	Rated Power	3.5 kW @ 1500 rpm
4.	Cylinder volume	661 cc
5.	Compression ratio	18
6.	Dynamometer	Type eddy current
7.	Software	"Enginesoft"

Figure 1 Experimental setup. Table 1 Specifications of engine test setup

3.2 Results and Discussions

Figure 2 shows the variation of torque with brake power for diesel and blends of PHWCO. Variation of torque for different blends and diesel at a particular engine speed is within a very narrow range. The torque developed for diesel is little more than PHWCO blends for 3.0 kW. For rest of the brake power it is almost same for both.

The variation of brake specific fuel consumption v/s. brake power is shown in Figure 3 for blends and diesel. For all cases the sfc initially decreases sharply with increase in brake power and afterward remains stable. In case of blends sfc values are higher at the beginning but significantly lower as compared to diesel for a wide range of brake power. This is due to complete combustion as additional oxygen is available from fuel itself.

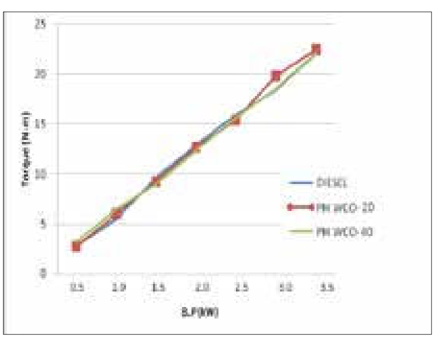

Fig.2 Comparison of brake power v/s. Torque for diesel and blends

Figure 4 shows comparison of Brake thermal efficiency v/s. brake power for different blends of waste cooking oil and diesel. For PH WCO-20blend brake thermal efficiency values are higher as compared to diesel, initially. The maximum thermal efficiency achieved by diesel is around 34.12 %. For PH WCO-40 blend brake thermal efficiency values are lower beyond 1.5 kW as compared to diesel.

Figure 5 shows comparison of mechanical efficiency and vs. brake power for different blends of waste cooking oil in comparison to diesel.Blends have higher values as compared to diesel because of better heat release rate. P-Ɵ diagrams of blends and pure diesel are shown in figures 6(a) and (b). Figures show that P-Ɵ curve of blends are almost resemble to the P-Ɵ curve of pure diesel. At various crank angle pressure observed for ph wco-20, ph wco-40 and diesel are 62.31724 at 370o, 67.179459 at 367o, and 66.350155 at 366o. As the pressure increases maximum Ɵ value 367o is observed and after this point pressure starts declining. Blends follow the similar pattern of pressure rise to that of diesel at all brake power conditions.

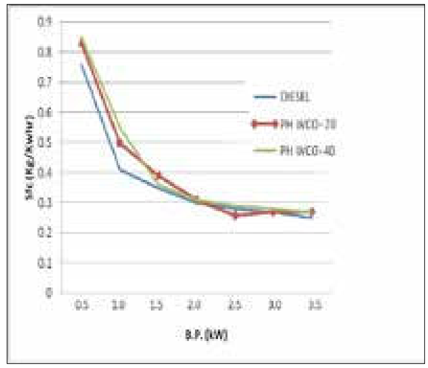

Fig.3 Comparison of brake power v/s. sfc for diesel and blends,

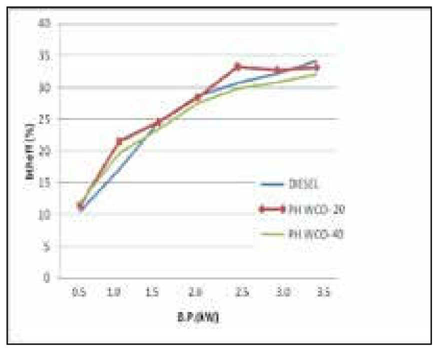

Fig. 4 Comparison of break power v/s. btheff for diesel and blends

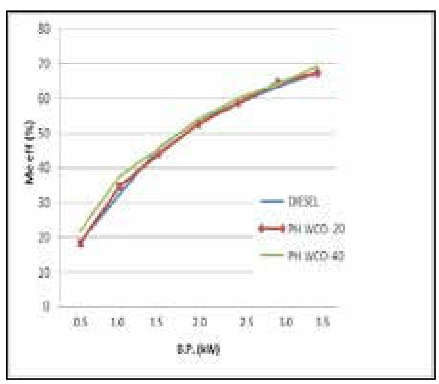

Fig. 5 Comparison of break power v/s. Me eff for diesel and blends

4. Conclusions

Some of the important conclusions made are:

1. The sfc is slightly higher than that of diesel for blends.
2. The sfc curves obtained by PH WCO-20, PH WCO-40 are very similar to the diesel performed on the same engine.
3. At all brake power conditions the opacity of all blends has less value than diesel oil. Maximum value of opacity has

obtained at 54.6 at 3.5 KW Brake power for diesel and for blends 43.7 at 3.5 kW for PH WCO-40.

4. At various crank angle pressure observed for B20, B40 and diesel are 62.31 at 370o, 67.18 at 367o, and 66.35 at 366o

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