Volume : 3 | Issue : 5 | May 2014 • ISSN No 2277 - 8160

Research Paper | Energy

Studies on Performance and Emission Characteristics of an IDI CI Engine by Using 40% SVO Diesel Blend Under Different Preheating Conditions

P. S. Ranjit	Faculty, University of Petroleum & Energy Studies, (UPES), Dehradun
Narayan Khatri	Faculty, University of Petroleum & Energy Studies, (UPES), Dehradun
Mukesh Saxena	Pro-Vice Chancellor ,University of Technology & Management(UTM), Shillong
Avanish K Tiwari	Sr. Principal Scientist- Center for Alternative Energy Research
Harshad Pandey	Pre Final year B. Tech ADE, University of Petroleum & Energy Studies, (UPES), Dehradun.
Abhishek Mishra	Pre Final year B. Tech ADE, University of Petroleum & Energy Studies, (UPES), Dehradun.
Harpreet Singh	Pre Final year B. Tech ADE, University of Petroleum & Energy Studies, (UPES), Dehradun.
Prateek Rathor	Pre Final year B. Tech ADE, University of Petroleum & Energy Studies, (UPES), Dehradun.

ABSTRACT

The purpose of this paper is to study the performance and emission characteristics of an IDI CI Engine by using SVO (Jatropha) - Diesel blend in 40:60 proportions by volume under different preheating conditions and comparing the results with Diesel. As the viscosity of SVO is high,so blending with diesel makes the prepared fuel more viscous than diesel thus SVO Diesel blend is heated under different conditions (40 ° C, 60 °C, 80 °C & 100 °C) which were developedusing counter flow heat exchanger using engine's exhaust as the hot working fluid in order to decrease the viscosity of fuel. The results were taken on different loads using eddy current dynamometer as the loading unit. The performance of SVO Diesel blend like brake specific fuel consumption (bsfc),brake specific energy consumption(bsec) and thermal efficiency were calculated. The Emission characteristics were measured with the help of Smoke meter and 5-Gas Analyzer set up.Emissions were lowered except for that of NOx for the heated SVO Diesel blend in comparison to baseline diesel at room temperature.

KEYWORDS : IDI CI Engine, Alternate Fuel, SVO, Blendbrake Specific Fuel Consumption, Brake Specific Energy Consumption, Brake Thermal Efficiency, Dynamometer

1. Introduction

The conventional fuels are depleting day by day so there is a need of alternative fuels which can meet transport sector's demands without creating negative impact on environment. Straight Vegetable Oil can solve the problem to some extent. These vegetable oils have high viscosity[1] because of large molecular mass and chemical composition of fuel, so SVO- Diesel blend becomes more viscous than diesel. The viscosity of the blend can lead to problems in pumping, combustion and atomization in injector system of a diesel engine because of gumming, the formation of injector deposits, ring sticking, as well as incompatibility with conventional lubricating oils[2-6]. The high viscous property of blend can reduce the life of an engine. The jet does not break properly and remains as a solid stream instead of spray of small droplets due to which fuel is not mixed properly with air and results in poor combustion. These problems can be solved by heating of the fuel to decrease the viscosity so as to make an alternative to that of diesel.The researchers [10–14] saw that the preheating method is effective and practicable without any modifications on the diesel engines

According to the test results in [7-8] blend containing 40% SVO & 60% diesel by volume was selected as fuel for this test. The aim is to understand different performance and emission characteristics and to compare the results obtained at different heating conditions(40 ° C, 60 ° C, 80 ° C & 100 ° C) and to conclude the best heating condition that makes the blend best suitable for use. The main objective of heating the 40% SVO-Diesel blend is to decrease the viscosity. The heating of the fuel is done with the help of counter flow heat exchanger which uses heat of engine exhaust.

2. Experimental Setup

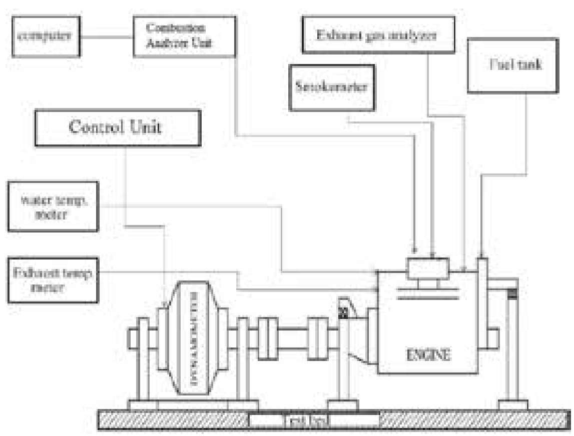

Figure 1

Fig. 1 shown is the layout for setup of the experimental study. The setup shows an engine and a dynamometer coupled together and mounted over a test bed, a fuel tank, a smoke meter, exhaust gas analyzer and a control unit. In addition to this various sensors are installed at different positions in order to obtain temperature and pressure through an advanced combustion analyzer to record the data with the help of high speed data acquisition system.

a) Engine

Engine Specifications	
Model	Lister FMS-10 Type IDI
No. of Cylinders	1
Swept Volume	1580cc
Compression Ratio	17:1
Bore	120mm
Stroke	139.7mm
Aspiration	Naturally Aspirated
Speed	1000rpm
Power Output	7.35kw/10 HP

b) Dynamometer:
To apply different loads on the IDI compression ignition engine an eddy current dynamometer has been selected which is controlled by a controlling unit and provides an option to run the engine at either constantspeed, constant load or varying load & speed.

c) Smoke meter:
AVL 437 smoke meter is used to determine the smoke opacity of exhaust gases. Its range of measurement is 0-100% smoke opacity. It has an accuracy of ±1% of full scale and a resolution of 0.1%. Smoke opacity is measured in Hartridge smoke units.

d) Exhaust gas analyzer:
AVL 5-Gas analyzer is used to measure exhaust characteristics. It can calculate the amount of HC, NO_x, CO_2, CO and O_2 in the exhaust gases. Further, it can measure the stoichiometric ratio.

e) Data pursuit system:
The AVL Indicom advanced combustion analyzer is a Complete combustion analysis platform covering pressure and optical signal measurement and conditioning, data acquisition and online and offline data evaluation - all crank angle based and cycle per cycle. Due to its high performance data acquisition this system is optimal for development and calibration at the test bed.

3. Parameters Tested
3.1 PerformanceCharacteristics

3.1.aBrake Specific Fuel Consumption
It is fuel flow rate per unit brake power. The amount of fuel consumed by the engine increases with the increase in load. But bsfc is initially high and then drops, levels at medium loads and again increases at higher loads. At lower loads the bsfc is high because the combustion efficiency is poor and the amount of heat loss to the combustion chamber walls is greater. At higher load the frictional power is increasing at a faster rate, causing slower increase in brake power than in fuel consumption. It's unit is kg/kwhr

3.1.bBrake Specific Energy Consumption
It is used to compare two different fuels in terms of the amount of energy released with the amount of fuel. It can be calculated by the product of Brake specific fuel consumption to it's calorific value. It's unit is KJ/kwhr.

3.1.c Brake Thermal Efficiency
The Brake Thermal Efficiency depends on the brake power of the engine. Brake Thermal Efficiency provides with the energy generated by the engine with respect to the heat supplied in the form of fuel given to the engine.

3.2 Emission Parameters:

3.2.a Smoke opacity measurement is the only relatively low-cost and widely available method to measure optical properties of fuel which means indirectly measuring of diesel particulate emissions. It is also used in most inspection and maintenance programs for diesel engines [16].

3.2.b Hydrocarbon emission(HC) is because of incomplete combustiondue to insufficient amount of air in air-fuel mixture or improper mixing of air with fuel. With time due to wear clearance between the pistons and cylinder wall increases which results into more oil consumption, thus leading to an increase in HC emissions.

3.2.c Nitrogen oxides (NOx) are produced by the reactionof nitrogen and oxygen under the high pressure and temperature conditions in the engine cylinder. NOx consist mostly of nitric oxide (NO) and a small fraction of nitrogen dioxide (NO_2). Nitrogen dioxide is very toxic. NOx emissions are also a serious environmental concern because of their role in the smog formation. [16]

3.2.d Carbon Monoxide(CO) is also a product of incomplete combustion due to insufficient amount of air in the air-fuel mixture or insufficient time in the cycle for complete combustion, resulting into partial oxidation of HC in the Exhaust Manifold.

4. Experimental Procedure
A plan was designed for the experimental investigation. Our experimental studies included comparing the performance and emission characteristics of preheated(40°,60°, 80°, 100°)40% SVO-Diesel blends to that of Diesel and 40%SVO-Diesel blend at room temperature. The engine is started with supply of diesel as fuel, to ensure no clogging is there in filter & then the engine is run at idling condition for at least 15-20 min. to attain the run-in conditions. Then blend supply is switched ON and Diesel supply is cut OFF. Exhaust gases which are at a high temperature of around 250°C are diverted through a heat exchanger to preheat the blend. The temperature of the blend is controlled by the valve that controls the amount of flow of exhaust gases through the heat exchanger. The temperature is noted by the temperature sensor installed in the blend fuel line. When the temperature of blend reaches to the desired level the exchanger valve is closed for heat exchanger and is directed towards the conventional exhaust line for emission measurement. The engine rpm is governed at 1000 rpm. Gradual increase in load (20 to 100%) with 20% difference is applied and reading of performanceand emissions characteristics are recorded as per the standard test procedures of the measurement devices.

5. Results and Discussions
5.1 Brake Specific Fuel Consumption (Bsfc)

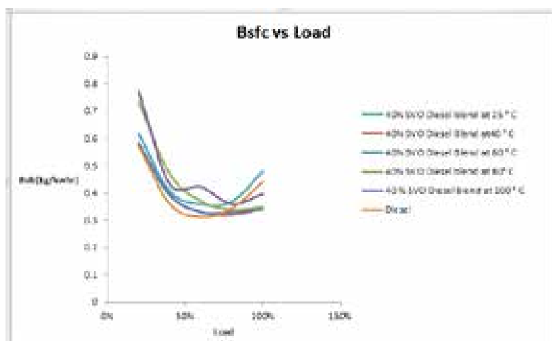

Figure 2 Bsfc vs Load
Figure 2 shows that 40% SVO- Diesel blend preheated at 100° C consumes more fuel than Diesel or any other blends. If we see closely we will come to know that Bsfc of Diesel will be less as compared to other blends. This is because of the combine effect of higher viscosity and specific gravity of blends.

5.2 Brake Specific Energy Consumption (Bsec)

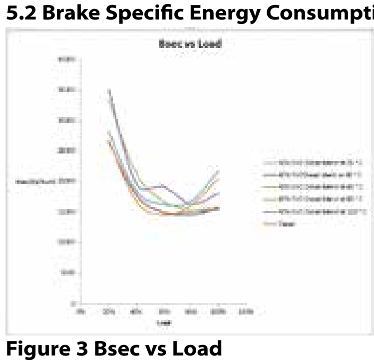

Figure 3 Bsec vs Load
Figure 3 shows that Bsec for SVO- Diesel blend is higher than that of

Diesel below 70% load. As load increases the Bsec of preheated SVO-Diesel blend decreases as compared to Diesel and results in lower fuel consumption. Also 60 °C preheated SVO-Diesel blend is comparable to Diesel.

5.3 BrakeThermal Efficiency (BTE)

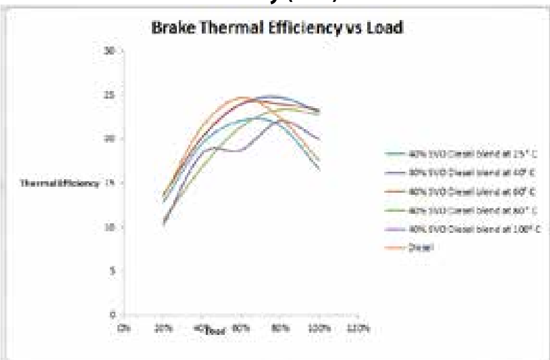

Figure 4 BTE vs Load

Figure 4 shows that Diesel has higher thermal efficiency upto 60% load as compared to other blends . At higher loads(above 60%) the blends have higher thermal efficiency as compared to Diesel.

5.4 Smoke Opacity

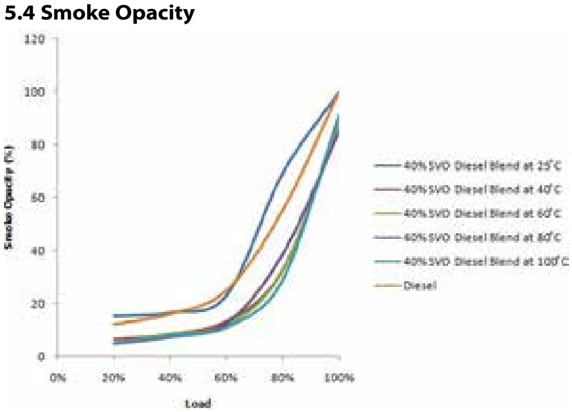

Figure 5 Smoke Opacity vs Load

Smoke Opacity increases as load increases because more fuel is being consumed at higher loads. Figure 5 shows that Smoke Opacity of preheated SVO-Diesel blend in 40:60 proportion by volume is much lowerthan that of Diesel at all loads. The least smoke opacity is obtained at 100°C SVO-Diesel blend in 40:60 proportion by volume

5.5 Hydrocarbon (HC)

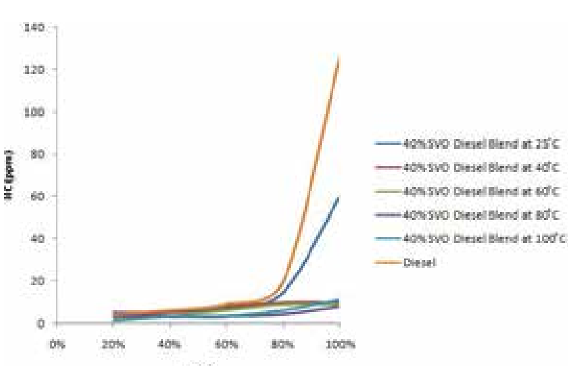

Figure 6 HC vs Load

Figure 6 shows that Diesel emits hydrocarbons more than SVO-Diesel blends in 40:60 proportions by volume.HC emission at all heating conditions of the blend is less as compared to diesel and blend at room temperature. As load increases HC emissions increases , this is due to the fact that at higher loads oxygen availability gets reduced as more amount of fuel gets injected resulting in improper combustion.40% SVO Diesel blend at 80°C gives least HC emissions. SVO molecular structure consists of straight chain alkyl groups and free fatty acids. So their blend with diesel has extra oxygen molecule as compared to diesel because of this fatty acid. Preheating of blend reduces viscosity which further results in more proper atomization of fuel, thus more free oxygen is available which results in more clean and efficient combustion and hence results in lower HC emissions.

5.6 No_x Emissions

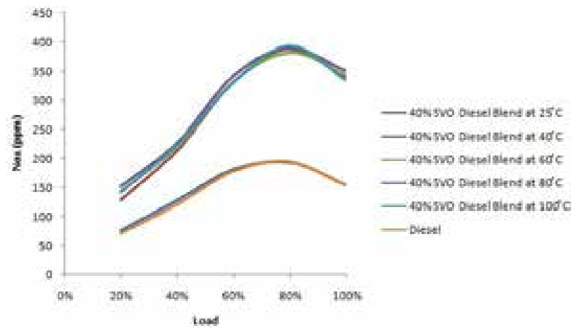

Figure 7 NO_x(ppm)vs Load

NO_x formation depends on temperature and availability of oxygen in engine. When there is a sufficient amount of oxygen present it results in proper combustion which increases the temperature of combustion temperature which icreases the formation of NO_x. Figure 7 shows that NO_x emissions by preheated 40%SVO-Diesel blends are much higher than that of Diesel and 40% SVO-Diesel blend at room temperature.NOx emissions are also a serious environmental concern because of their role in the smog formation. [10]

5.7 Carbon Monoxide

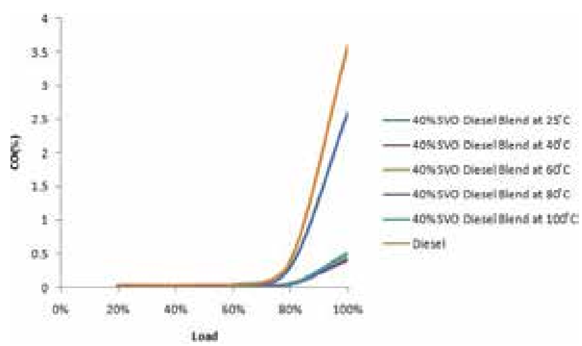

Figure 8 CO vs Load

Figure 8shows that Diesel emits Unburned hydrocarbons than SVO-Diesel blends. Preheated 40%SVO-60%Diesel by volume blends emits much lower unburned hydrocarbons.

6. Conclusion

The performance characteristics of preheated 40%SVO-Diesel blends were found comparable and sometimes improved at particular loads to that of Diesel and 40%SVO–Diesel blend at room temperature.The emission characteristics were also better for the blend at all heating conditions as compared to the diesel fuel and the blend at room temperature except for that of NOx. NO_x emissions by preheated40%SVO- Diesel blends are much more than Diesel and SVO-Diesel blend at room temperature which can cause serious environmental issues. Techniques like Exhaust Gas Recirculation(EGR) can be used to minimize NO_xemissions .Based on careful evaluation and analysis of experimental data obtained, it can be concluded that, 40% SVO Diesel blend at 80°C has both performance and emission characteristics of highest degree as compared to it's other preheated blends. It has comparable qualities as that of Diesel and 40% SVO- Diesel blend at room temperature except in NO_xemissions.

REFERENCES

[1] IOCL Test Results | [2] Ryan TW, Dodge LG, Callahan TJ. The effects of vegetable oil properties on injection and combustion in two different diesel engines. J. Am. Oil Chem. Soc. 1984;61(10):1610–9. | [3] Korus RA, Jaiduk J, Peterson CL. A rapid engine test to measure injector fouling in diesel engines using vegetable oil fuels. J. Am. Oil Chem. Soc. 1985;62(11):1563–4. | [4] Rewolinski C, Shaffer DL. Sunflower oil diesel fuel: lubrication system contamination. J. Am. Oil Chem. Soc. 1985;61(7):1120–4. | [5] Ziejewski M, Kaufman KR. Laboratory endurance test of a sunflower oil blend in a diesel engine. J. Am. Oil Chem. Soc. 1983;60(8):1567–73. | [6] Pryde EH. Vegetable oil as diesel fuels: overview. Papers from the symposium on vegetable oils as diesel fuels, presented at the 73rd AOCS annual meeting, Toronto, Canada. J. Am. Oil Chem. Soc. 1983;60(8). | [7] P.S. Ranjit, Narayan Khatri, et.al., ―Studies on Hydrogen supplemented 40% SVO- Diesel blend operated IDI CI engine for its performance improvement and reduction in Emissions‖, National Conference on Environmental Challenges & Control Measures, organized bt GIET Rajahmundry, E.G. Dist, Andhra Pradesh, Jan 24-25th, 2014. | [8] P.S. Ranjit, Narayan Khatri, et.al., ―Studies on Performance and Exhaust Emissions of Diesel Engine using different blends of SVO with Diesel, National Conference on Environmental Challenges & Control Measures, organized bt GIET Rajahmundry, E.G. Dist, Andhra Pradesh, Jan 24-25th, 2014. | [9] Senthil Kumar M, Kerihuel A, Bellettre J, Tazerout M. Experimental investigations on the use of preheated animal fat as fuel in a compression ignition engine. Renewable Energy 2005;30(9):1443–56. | [10] Agarwal D, Agarwal AK: Performance and emissions characteristics of Jatropha oil (preheated and blends) in a direct injection compression ignition engine. Applied Thermal Engineering 2007;27(13):2314–23. | [11] Nwafor OMI. The effect of elevated fuel inlet temperature on performance of diesel engine running on neat vegetable oil at constant speed conditions. Renewable Energy 2003;28(2): 171–81. | [12] Bari S, Lim TH, Yu CW. Effects of preheating of crude palm oil (CPO) on injection system, performance and emission of a diesel engine. Renewable Energy 2002;27(3):339–51. | [13] Kalam MA, Masjuki HH. Emissions and deposit characteristics of a small diesel engine when operated on preheated crude palm oil. Biomass and Bioenergy 2004;27(3): 289–97. | [14] Pugazhvadiu M, Jeyachandran K. Investigations on the performance and exhaust emissions of a diesel engine using preheated waste frying oil as fuel. Renewable Energy 2005; 30(14):2189–202. |