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Preheating of Biodiesel for the Improvement of the Performance Characteristics of Di Engine

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Abstract This paper mainly reviews about the usage of preheated bio diesel added with 25% Sunflower fuel and evaluates its performance for selected blend with different loads. Bio diesel is added with sunflower oil for rapid combustion as for the bio diesel, the cetane number is high that results in shorter delay of ignition and the mixture is preheated to raise its temperature to improve the combustion process. Analysis of the parameters required to define the combustion characteristics such as BSFC, BSEC, BT, Exhaust Gas Temperature, NO_X, Unborn Hydrocarbons, and Carbon Monoxide, Smoke are the performance of engine and its emissions of preheated bio diesel.

Keywords: *bio diesel, alternative fuel, sunflower oil, loads, preheated, performance, emissions*

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1. Introduction

The idea of using vegetable oil began in the year 1893 itself when diesel engines came into existence. In the year 1911, Rudolf Diesel operated his first engine using straight vegetable oil (peanut oil). The physical and combustion properties of vegetable oils are closer to that of diesel and in this context; vegetable oils can stand as an immediate candidate to substitute for fossil fuels. The greatest advantages of vegetable oils are that they are obtained from seeds of various plants. In view of this, researchers have started showing renewed interest towards vegetable oils because of its advantages as a potential alternate fuel. Vegetable oils are renewable and eco friendly in nature and at the same time, it can be easily produced in rural areas.

Sustainable development of a country depends on the extent that it is managing and generating its own resources. This also helps in conservation of depletion of non-renewable petro-products. However due to inherent high viscosity and low volatility, vegetable oils would pose problems such as fuel flow and poor atomization and constrain their direct use in engine without any modifications.

Vegetable oils are either edible or non edible. Some of the edible oils are sunflower oil, palm oil, rice bran oil, and cottonseed oil. The non-edible oils are mahua oil, jatropha oil, rubber seed oil, etc. As rice bran cottonseed oil (CSO) and sunflower oil are not very much in use for cooking purpose, these can be used as substitute for diesel in CI engines. sunflower oil has several properties closer to that of diesel but certain properties such as high viscosity and low volatility pose problem when used as an alternate fuel for C.I engines.

The potential of using vegetable oil for diesel engines was studied by Recep Altin et al. [1], Yoshomotoy et al. [2] and Kensuke Nishi et al. [3]. The engine performance was very much similar to that for diesel with little power loss and slight increase in the emission level. Karaosmanoglu. F et al [4] studied long-term utilization of vegetable oil and no significant increase or loss in power was noticed. Nwafor O.M.I et al. [5] carried out combustion studies on both diesel fuel and vegetable oil fuel with standard and advanced injection timings. Advanced injection timing compensates the effects of the longer delay period and slower burning rate that is exhibited by vegetable oils.

The problems related to low volatility and high viscosities are offset by subjecting the oil into the process of transesterification, and the high viscosity can be reduced. Methyl and ethyl esters of vegetable oil (called as biodiesel) have the physical and chemical properties closer to that of diesel. The performance and emission characteristics of the diesel engine using methyl ester are comparable with that of diesel as per Dilip Kumar Bora et al. [6]. Babu A.k et al. [7] also has reported problems related to high viscosity. Blending vegetable oil with diesel decreases the viscosity and improves the volatility. This improved properties results in better mixture formation and spray penetration. A number of investigators tried the vegetable oils in varying proportions with diesel. Results obtained from experiments shows that vegetable oil and diesel blends showed improvement in engine performance [8,9]. Pre heating the vegetable oil reduces the viscosity and improves combustion characteristics (Pramanik. K [10]).

This paper examines the use of preheated sunflower oil diesel blends on the performance of a single cylinder diesel engine. Preheating the vegetable oil decreases the viscosity and improves the atomization and mixing process, which results in better combustion.

2. Materials and Methods

The engine performance and emission studies were conducted on a Kirloskar make, single cylinder, direct injection diesel engine. The engine specifications are presented in Table 1.

Table 1. Engine Specifications

S.no	Type	Four-stroke Direct Injection Diesel Engine
1	Engine	Kirloskar-AV 1
2	Type of Cooling	Water Cooling
3	Bore	80 mm
4	Stroke	110 mm
5	Displacement Volume	553 cc
6	Piston (Standard)	Hemispherical
7	Compression ratio	1:16.5
8	Rated power	4.4 kW at 1500 rpm
9	Nozzle opening pressure	250 bar
10	Injection timing	23° before TDC (static)
11	Fuel Oil	Commercial High Speed Diesel
12	Type of Governor	Mechanical Centrifugal type
13	Lubrication System	Forced Feed

Figure 1. Experimental setup

The engine was coupled to an electrical dynamometer and a resistance load bank to operate it under various loads. A separate tank of 5 liter capacity was used for storing biodiesel blends with diesel. The fuel was fed to the injector pump under gravity and the volumetric fuel flow rate was measured by using a burette and stop watch. The exhaust gas temperature was measured using thermocouple connected to a temperature indicator. The exhaust emissions were measured by a smoke meter and NO_X analyzer. The unrefined sunflower oil has a free fatty acid (FFA) content of 15%. A two step process was used to convert the high FFA oil into biodiesel (Canakci& VanGerpen, 2001, Ghadge&Raheman, 2005, Ramadhaset al., 2005). In the first step,1% (v/v) sulfuric acid, an acid catalyst was used to esterify the FFA to methyl esters, thereby reducing the FFA level. In the second step, the low-FFA oil was transesterified with 0.6%(w/w) potassium hydroxide,an alkali catalyst to convert the triglycerides to biodiesel. The reactions were carried out in a 5 liter batch reactor for 1 hour at a temperature of 60℃.The engine experiments were conducted with diesel fuel, biodiesel- diesel blends containing 25%, 50%, 75% (v/v) biodiesel (B25, B50 and B75 respectively) and biodiesel (B100). THF was added to all the biodiesel fuels in proportions of 2%, 3%, 4% and 5% (v/v) and the impact on engine performance and emissions were measured. The fuel consumption and emission measurements (NOx and smoke) were taken under various loads and at constant speed.

3. Results and Discussion

The experiments are conducted with pre heated Sunflower Bio Diesel 25% blend at different loads.

3.1. Brake Specific Fuel Consumption

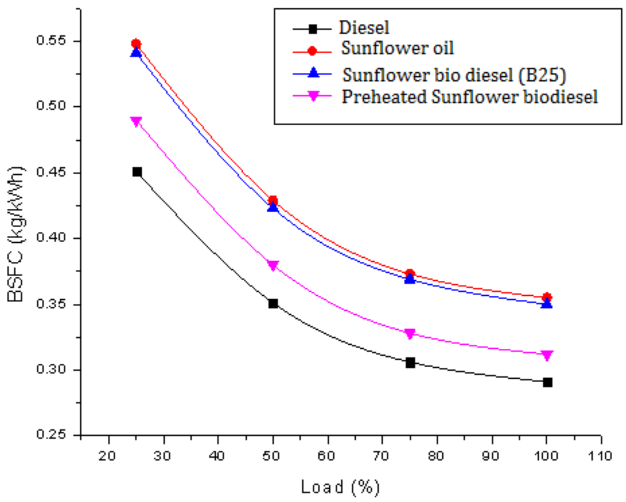

Figure 2. Variation of Brake Specific Fuel Consumption with load

The BSFC for base engine running with Diesel is 0.291 kg/kwh It can be noted from the graph that it is increased to 0.355 kg/kwh as expected. When the Sunflower Bio Diesel blend B25 is used slight improvement in BSFC is noted i.e., 0.35. But with preheating even when total Sunflower Bio Diesel is used the BSFC has come down to 0.335 kg/khw. This is due to the improvement in viscosity that leads to better atomization which obviously improves the combustion

3.2. Brake Specific Energy Consumption

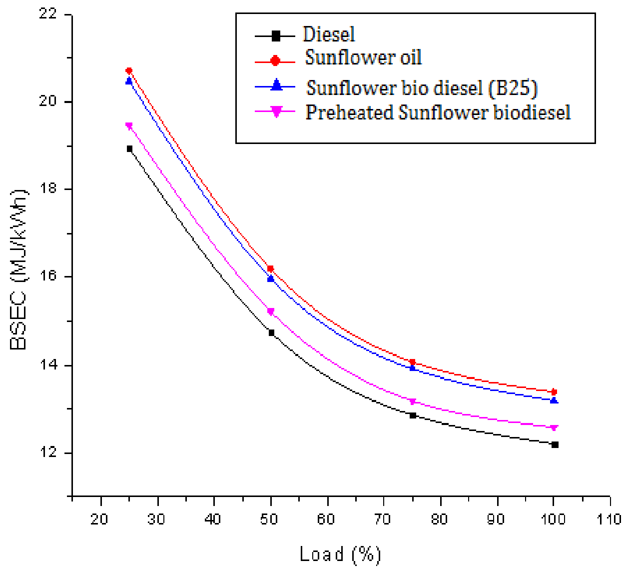

Figure 3. Variation of Brake Specific Energy Consumption with load

The above Graph gives the information about the variations of BSFC when these fuels are used on the test engine. It is noted that BSFC for Sunflower Bio Diesel is higher by 1.18 MJ/KWHr compared to Diesel which is decreased by 0.1 MJ/KWHr Sunflower BioDiesel is used. It is further reduced by 0.04 MJ/KWHr with pre heating of the fuel. For Diesel the BSFC is 12.2 MJ/KWHr and for Sunflower Bio Diesel with pre heating is 13.14 MJ/KWHr.

3.3. Brake Thermal Efficiency

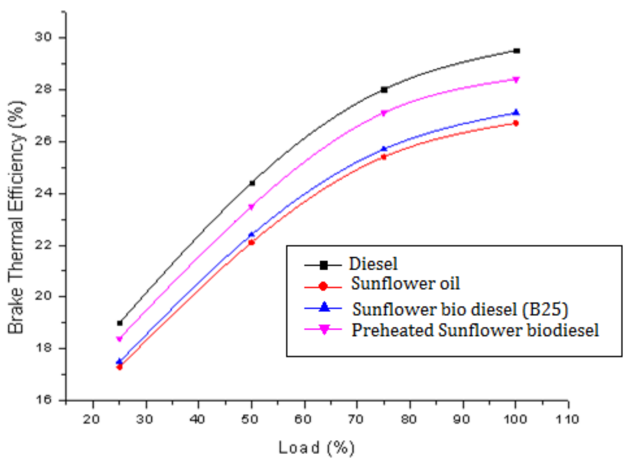

Figure 4. Variation of Brake Thermal Efficiency with load

The above Graph supports with this information. The engine with Diesel as fuel is giving an efficiency of 29.5 % and it is dropped to 26.7% when Sunflower Bio Diesel is used". "With the blend B25 marginal increase in the efficiency 0.4 % is achieved and further improvement of 0.8 % is seen with preheating. Still the efficiency is lower by 1.6% compared to Diesel operation.

3.4. Exhaust Gas Temperature

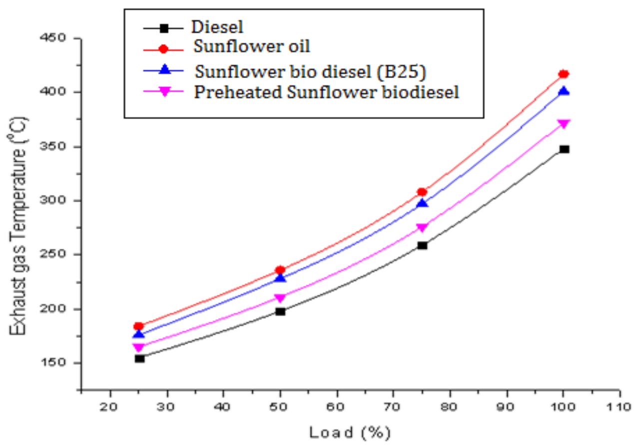

Figure 5. Variation of Exhaust gas Temperature with load

The purpose of measuring and comparing temperature of exhaust gas is to understand the effective utilization of heat energy by the engine. "When the combustion is ineffective the heat energy conversion into work will be less indicating lower thermal efficiency, It Is inferred that the temperature of the exhaust is 348℃ when Diesel is used and it is increased to 417℃ when Diesel is replaced by Sunflower BioDiesel. A drop in 16℃ is noticed when the blend B 25 is used".

3.5. Oxides of Nitrogen

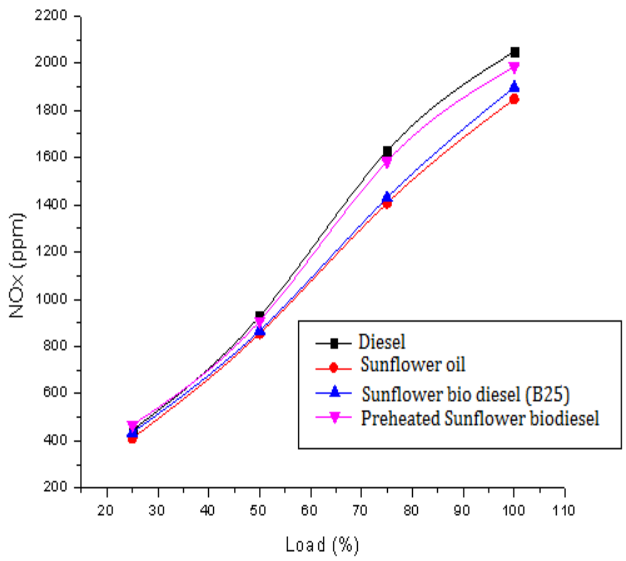

Figure 6. Variation of NOx emissions with load

Graph depicts the trends of variation of NOx emissions for the results taken on the conduct of load test". "The important concern of Diesel engine is higher NOx and it is also noted from this figure that the NOx emission for Diesel operation is found to be 2048 ppm". "When Sunflower BioDiesel is used it is 1843 ppm showing beneficial trend that is reduction of NOx to 1848 ppm.

3.6. Unburned Hydrocarbons

Graph illustrates the how the unburned Hydrocarbon s are affected for these fuels at varied load conditions". "It is noted that 197 ppm of Unburnt HC is found in the exhaust gas with Diesel fuel. It is increased to 207 ppm when BioDiesel is used indicating incomplete combustion

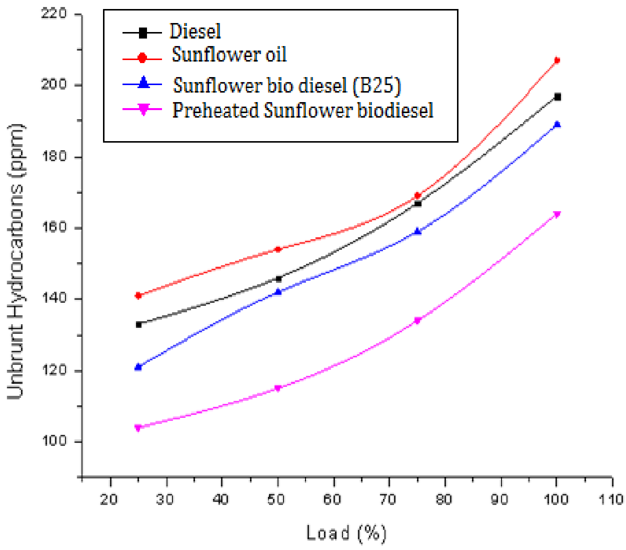

Figure 7. Variation of unburned Hydrocarbons with load

3.6. Carbon Monoxide

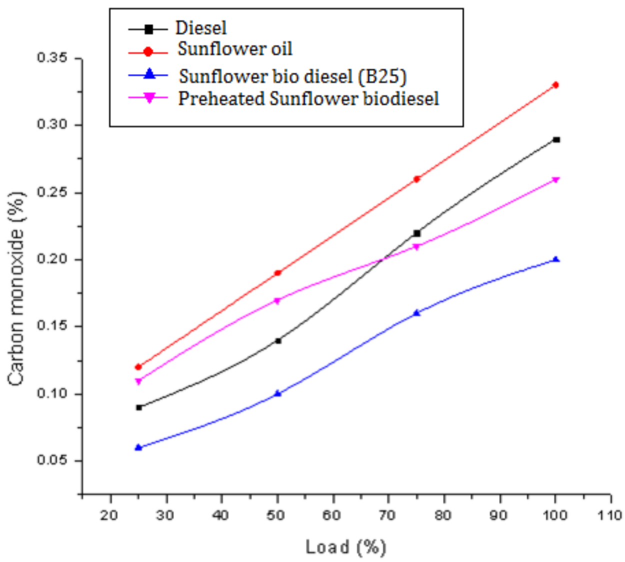

Figure 8. Variation of Carbon monoxides with load

Graph presents the information about CO emissions for these fuels which are drawn from the measurements by conducting performance tests on the test engine". "The CO emission for when Diesel is used is noted to be 29% by volume which is increased by 3% more when Sunflower BioDiesel is used. For the blend it is reduced to 25% and with preheating of Sunflower BioDiesel a considerable decrease that is to 21% which means an 8% decrease is noticed and is very much appreciable.

3.7. Smoke

In the Graph "it is noticed that the smoke emission for Diesel operation is 3.0 BSU which was seen increased ton3.3 BSU for Sunflower Bio Diesel. When the blend is used it is further increased to 3.9 but reduced significantly when the BioDiesel is preheated. That is very clear that the vaporization of the fuel is high when the oil is pre heated and it helps the effective atomization of fuel leading to decrease suspended particles.

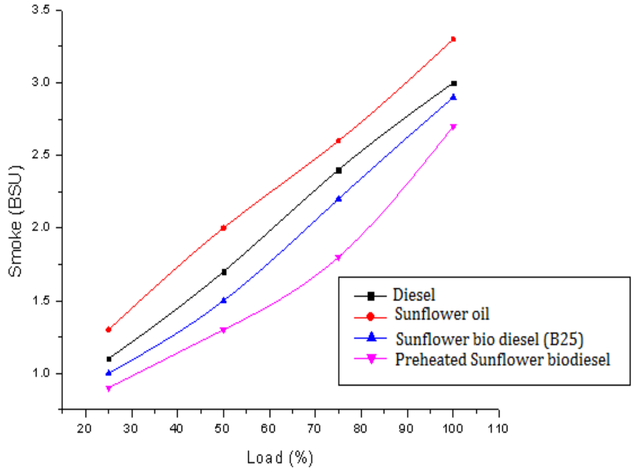

Figure 9. Variation of Smoke with load

4. Conclusions

- Some useful inferences could be made while determining the combustion, performance and emission parameters when preheated (158°C) sunflower bio diesel oil is used as fuel while altering injection pressure and injection timing.
- The preheated sunflower biodiesel shows greater performance and emission results as compared to sunflower biodiesel.
- The preheated sunflower biodiesel shows greater performance and emission results as compared to sunflower biodiesel.
- The ignition delay decreases with increase in injection pressure at all injection timings. The maximum value of injection delay (12°CA) found with 21°CA bTDC of injection timing and 210 bar of injection pressure.
- The magnitude of Peak cylinder pressure 75bar is found maximum with the combination of 230 bar Injection pressure and 21°CA bTDC Injection timing.
- The minimum BSFC which is 0.315 kg/kwh found with the combination of 230 bar Injection pressure and 21°CA bTDC Injection timing.
- The maximum Brake Thermal Efficiency 28.6% is observed with the combination of 21°CA bTDC of Injection timing and 230 bar Injection pressure.
- Minimum NOx which is 1579 ppm is found with combination of 17°CA bTDC of Injection timing and 210 bar Injection pressure. The maximum NOx that is 2015 ppm is found with 21°CA bTDC of Injection timing and 230 bar Injection pressure.
- The minimum value of Unburned Hydrocarbon emissions that is 145 ppm found with 21°CA bTDC of Injection timing and 230 bar of Injection pressure.
- The minimum value of CO emission that is 0.15 %Vol found with 21°CA bTDC of Injection timing and 230 bar of Injection pressure.

- The minimum value of smoke emission that is 2.0 (BSU) found with 21℃A bTDC of Injection timing and 230 bar of Injection pressure.
- It is noted that the values of combustion, performance, and emission parameters are favorable at 21℃A bTDC of Injection timing and 230 bar of Injection pressure except for NOx emissions.

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