International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 6, June-2018

EFFECT OF PREHEATING OF VEGETABLE OILS IN PERFORMANCE AND EMISSION PARAMETERS OF COMPRESSION IGNITION ENGINES -A REVIEW PAPER

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ABSTRACT : Bio fuels can be an alternative of diesel in compression ignition engine. As they are widely available, cheaper and can be produced easily. But the problems arise while using vegetable oils as fuel directly at room temperature. as vegetable oils are viscus, less volatile, poor in atomization. Heating the vegetable oil can reduce viscosity. Preheating this vegetable oils before injecting into combustion chamber reduces viscosity and also atomises fuel. This paper particularly deals with review of preheating of various types of biodiesel and its effect on performance and emission on CI engine.

Keywords Biodiesel, Alternative fuel, heating, diesel, compression ignition engine, diesel-biodiesel blends,engine performance, emissions

1. Introduction

Due to rising environmental degradation and tougher emission lows enforced by world countries led us to think about the alternative of petroleum fuels. The pollution caused by petroleum diesel is higher than that caused by petrol or other fuels. Bio fuels can be used in place of petroleum-based fuels as they are cheaper and safe to store and handle, totally renewable and most importantly easily available at various places across the world. So,in case of Compression ignition engines there is a dire need to reduce emission without affecting performance characteristics. Among the different alternative fuels, vegetable oil having fuel properties similar to diesel has an acceptable engine performance for short-term operation. the concept of using vegetable oils as fuel was exhibited by Rudolf Diesel who developed the first engine to run on peanut oil for short tum usage.

So, the vegetable oils can serve this purpose as they are capable of giving same performance and even at reduced emissions. From edible oils like corn oil, soybeanoil, rapeseed oil, Cottonseed oil, peanut oil, coconut oil, to non-edible oils like palm oil,sunflower oil, jetropha oil,methyl Easter, can be used in the place of diesel in compression ignition engines.

However, long term endurance tests with vegetable oil reported someengine durability issues such as Poor atomization, high viscosity, low heating value etc. High viscosity is one of themajor problems that causes problems in pumping and clogs the fuel filters.as it leads to carbon deposit build up on injectors and valve seat [1] [2]. Consequently, carbon deposition on piston rings and cylinder walls contributes to dilution and thickening of the lubricating oil which may cause break or failure of some mechanical components in the engine. While high viscosity also causes lower thermal efficiency due to poor atomization and combustion characteristics. Also, poor non-volatility of biodiesel lead to problems in atomization and poor combustion inside the combustion chamber in long term. The Low heating value of biodiesel leads to increase in specific fuel consumption

Apart from it the biodiesel has some advantageous properties as higher cetane number which is a measurement of the combustion quality of diesel fuel during compression ignition. Having higher cetane number means that biodiesel fuel has shorter ignition delays that provide more time for the fuel combustion process to be completed. I should also mention here that biodiesel derived from animal fats has higher cetane number compared to biodiesel from vegetable oils. Also,Biodiesel produces fewer emissions that standard diesel. It is also very important to mention here that biodiesel has virtually no sulphur content meaning that it cannot contribute to formation of acid rain like this can be the case with standard diesel

Therefore, vegetable oils cannot be used directly in diesel engines at room temperature. In order to reduce the viscosity of the vegetable oils, three effective methods have been found; transesterification, mixing with lighter oil and heating. The transesterification is an extensive, convenient and most promising method for reduction of viscosity and density of vegetable oils but this adds extra cost of processing because of the transesterification reaction involving chemical and process heat inputs. The other alternative could be use of heated vegetable oils as petroleum fuel The preheating of inlet fuel reduces viscosity and can be implemented as indicated by the results of many studies [3]. Prasad et al. [4] too reported that heating was one of the effective methods to utilise vegetable oils as fuels. Besides that, preheating of vegetable oil to lower its viscosity to that of diesel eased the problem of the injection process.

Heating is also essential to ensure smooth flow of fuel in the fuel system [5]. The general perception is that higher heating temperatures reduce the viscosity of vegetable oils and offer gains in engine performance. However, the fuel injection system is made up of parts that are very close fitting, such as the plunger–barrel assembly. High fuel intake temperature may have adverse effects on these close- fitting parts since diesel engines normally run with fuel supplied at ambient temperature.So, If the preheated biodiesel is used in place of diesel and compare performance of biodiesel with that of the standard diesel we can see that biodiesel has significantly better lubricating properties, combustion characteristics meaning that engine will run smoothly, so the same performance of petroleum diesel can be achieved at reduced emissions in CI engine

2. Effect of preheating on performance and emission parameters

At room temperatures CPO has a viscosity about 10 times higher than that of the diesel so using CPO at room temperature may lead to fuel filter clogging and injections system chocking. Though heating of CPO to higher temperature (100°C) offered no of benefits in terms of performance of engine. However, heating is necessary to avoid fuel filter clogging and making a smooth flow for CPO.A crude palm oil CPO was used by Bari*etal.,*(2002) [6]as a fuel in diesel engine and he studied the effects of CPO on the engine due to high viscosity on performance on engine, maximum pressure, combustion in engine and emissions were studied briefly. And found an optimum temperature of preheatingat which the engine can give almost same performance for CPO and diesel fuel. To take two tests two slightly different setups were used. A Yanmar L 60AE-DTM single cylinder, four stroke, air cooled diesel engine with direct injection and a maximum power of 4.4kw at 3600rpm. A swinging field dynamometer was used. A Brookfield viscometer was used to test viscosity od CPO at different temperatures.Combustion analysis was carried outwith the help of a water cooled piezoelectric pressure transducer fitted on cylinder head at TDC to test viscosity. The encoder is fixed on the output shaft of the engine, using a MSI gas analyseremissions of CO and NO were reduced through the load range. The CPO need to be heated to at least 92c to achieve a viscosity of 8mpas which is similar to diesel viscosity.

The results showed that the friction for CPO was significantly less than that of diesel as the vegetable oils have better lubricating property.It was clearfrom results that the fuel inlet temperature did not have a significant effect on the fuel consumption as the values of thermal efficiencies at different loads and at various fuel temperatures confirmed that the heating the fuel did not benefit the performance. So, heating of CPO offered no advantages in terms of performance but was necessary for the fuel to flow smoothly in fuel lines and for smooth flow, the CPO must be heated to at least 60°C and it should not be heated above 97c as above 97c the bubbles of CPO were formed. CPO has 6% higher peak pressure than that of diesel and also CPO has2.6 shorter ignition delay but lower maximum heat release rate compared with diesel as CPO has double bonds of carbon chain and it produced light volatile compound which resulted in shorter ignition delay and thus lower maximum heating rate. The CO and NO emissions for CPO were higher than those for diesel at all load conditions as at higher temperatures fuel sprays of vegetable oils undergo chemical reactions which includes thermal cracking (producing lighter compounds) and polymerization at spray core (producing heavy, low volatility compounds) The resulting locally rich mixtures causes more CO to be produced during combustion due to lack of Oxygen. The higher peak pressure of CPO lead to higher combustion temperature and the formation of NO took place due to higher temperature and availability of Oxygen.

Canakci *etal.,* (2009) [7]investigated effects of preheated crude sunflower oil PCSO on combustion and emission properties against petroleum diesel in indirect diesel injection diesel engine.He usedIDI because over 2000hr run of engine it showed no adverse effects. In direct injection diesel engine, the power was decreased and during testing in DI injectors were coked, carbon was built up in combustion chamber.An indirect injection four stroke, naturally aspirated four-cylinder engine was used. The distributor pump was mechanically controlled in IDI engine.Using a computer programmethe cylinder gas pressure was averaged to eliminate cycle to cycle variation and using pressure data then heat release was calculated.

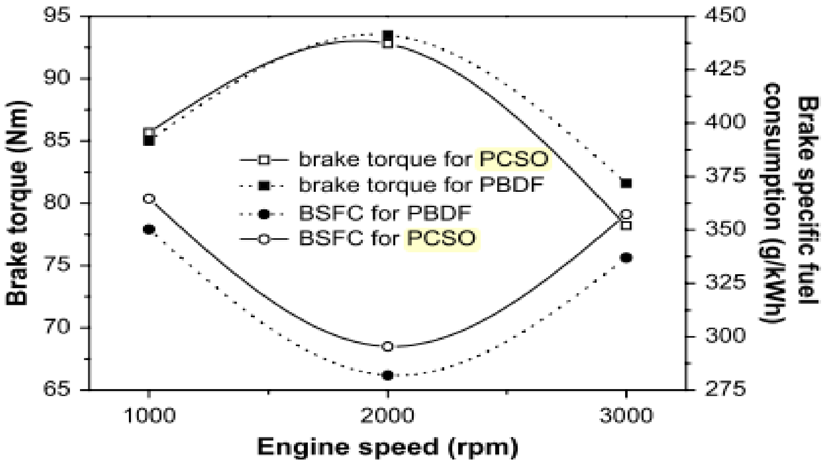

Figure 1The brake torque and BSFC versus engine speed for PCSO and PBDF.

At constant engine speeds 1000 rpm, 2000 rpm, 3000 rpm the full load characteristics of the IDI diesel engine fuelled with PCSO and PBDF were determined.The break torque was reduced by 1.36%. when PCSO was used on an average.At full load Break specific fuel consumption increased by 5% compared to petroleum diesel. PCSO produces nearly 1.080° crack angle advance in the start of injection timing. This provided longer combustion timing for PCSO. So unburnt HC, CO2, emissions and smoke opacity reduced. However, CO emission was increased.

Hazar *etal.*, (2010) [8] studied effects of raw rapeseed oil RRO bland in proportion of 20% and 50% in the diesel fuel on the performance and emission characteristics.To reduce viscosity.The fuel mixtures 020(20% RRO and 80% diesel) and 050(50% RRO and remaining diesel) were preheated at 100°C.To test the performance of the fuel a rainbow type naturally aspired direct injection air cooled four stroke single cylinder diesel engine was used. The dynamometer used in the test was hydraulic dynamometer. The test was started firstly with the diesel fuel and when the engine reached hydraulic dynamometer. The engine was loaded at wide open accelerator position and run at four different speeds CO and NOx emission tests were made by DRAGER MSI COMPACT 150 type emission analyser. This analyser can measure CO and NOx as ppm with 0.005% accuracy.

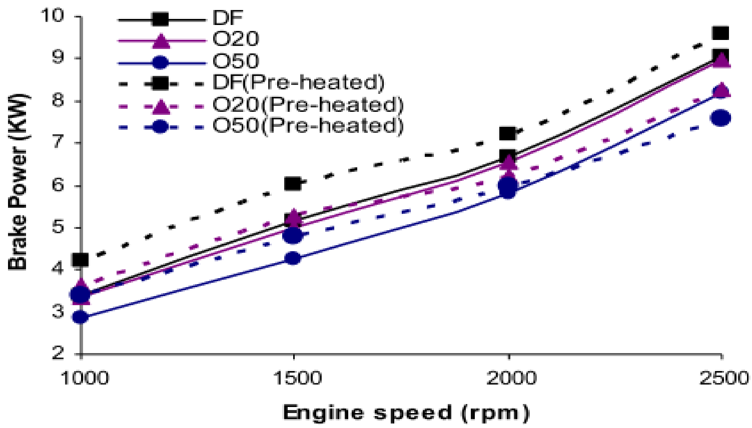

Figure 2. The power variation with preheated DF, O20 and O50 mixtures

Due to preheating the torque was not affected but as the temperature is increased then torque increases. As the diesel fuel has higher calorific value then 020 and 050 blends the output power for blends 020 and 050 is less than diesel fuel with or without preheating. But the fuel consumption of RRO was higher than diesel fuel to obtain some rate of power. So, In spite of fact that the heating values of RRO blends were lower than those of diesel fuel, power output for all test fuels were not different from one another. The higher lubricity of oil could reduce friction loss and may lead to increase in break effective power. Due to higher viscosity and poor volatility of RRO blends smoke emission for RRO blends was higher than diesel fuel.

In Brazil the soy is the most frequently used feedstock for biodiesel production and is widely available throughout the country, although other oleaginous plants are expected to be used. Vegetable oils are widely available and, when used as an energy source, totally renewable. So there is a need to evaluate the utilization of straight vegetable oil (SVO) in small engines to provide small farmers who live far from urban centres with the possibility of producing their own fuel.so Seeing this wide availability of soy vegetable oil it should be used for making the fuel.

P. R. Wander*etal.,* (2011) [9] performed experiment on straight vegetable oilto test the performance of diesel engineinterms of torque, power, specific consumption and emissions,at two inlet fuel temperatures and three injection angles. he used common diesel, soy SVO(filtered at 500 nm) and its blends, referred to as SVOXX, where"XX" is the volume percentage of SVO, and the rest is diesel.Pure diesel is referred to as D100. Experimental results are presented for a compression ignition engine with one-cylinder Agrale M93ID refrigerated by air, fuelled with soy straight vegetable oil (SVO), filtered at 500 nm and blended with diesel at volume percentages of 10, 30, 50, 70 and 100%. Each of the mixtures was tested at two entering temperatures and three end of injection angles (EIAs). The fueltemperatures used were 30 C and 60 C,measured 30 mmfrom the fuel injection pump entrance.An electrical resistance heater in a water reservoir near the enginecontrolledthis temperature.For each mixture and condition of inlet oil temperature and EIA two tests were conducted and the results reported are an arithmetic average of those two tests. results for diesel, SVO70 and SVO100 are presented at 30 C and 60 C, with an EIA of 17 (normal operation) as these conditions exhibited the greatest differences from diesel.

From results a smallincrease in torque observed for the engine running on SVO70 comparedto pure diesel, although at SVO100the torque showed a small reductionrelative to this tendency.With an increase in fuel oil temperaturea reduction intorque was observed;i.e., for diesel operation (D100), due to the lower density ofthe fuels due tothe possibility of partial vaporization as it has smallervapor pressure.The use of higher percentages of vegetable oils decreases the smoke index compared to D100. The influence of different fuel temperatures indicated that lower temperatures generally yield higher torque and power, as well as higher specific consumption.

Rao (2012) [10]investigated the characteristics of a direct injection compression ignition engine running with preheated corn biodiesel. And studied the performance, combustion and emission characteristics. And compared the results of engine characteristics with preheated corn biodiesel (heated up to 45°C) with corn biodiesel without preheating CBD and petroleum diesel PD. The engine used in the tests was Kirloskar single cylinder, naturally aspirated, water cooled, stationary, Direct injection compression ignition DI-CI engine running at 1500rpm. To measure break power or load torquean eddy current dynamometer was used.Using thermostat,the preheating of corn biodiesel is done. The engine load was varied in four steps 0.93kw (25%),!.86kw (50%), 2.79kw (75%), 3.72kw (100%). The break thermal efficiency BTE increased with power output for all fuels at all loads. For CBDPH, the break thermal efficiency was closer to PD, due to low viscosity and increased evaporation of fuel. For all loads the break specific fuel consumption BSFC for CBDPH was lower than CBD but when compared with PD both CBD and CBDPH consume more fuel to produce required break power. This was mainly due to lower calorific value of CBD and at 75% of load the BSC for both CBDPH and CBD was same. The fuel consumption decreased with preheating of fuel as the fuel spray characteristics are improved. The indicated mean effective pressure IMEP increased with power output for all fuels IMEP for CBDPH was higher than that if CBD and PD. The highest peak pressure observed for CBDPH and at 75% load(2.79kw). CBD and CBDPH present low exhaust gas temperature than PD due to low heating value. The CBD and CBDPH records very close exhaust gas temperature. It was observed that CBDPH released lower heat in the beginning of combustion than petroleum diesel PD and CBD and significant rise is recorded at later stage. The CO emissions increase with increase in power output for all fuels due to increase in the fuel consumption with engine power output, but it was observed that CO emission levels are less for CBD than that for PD and are further reduced for CBDPH (due to reduced viscosity and density and increase in rate of evaporation of CBDPH). The HC emissions for CBD, CBDPH were less than that of PD but for all fuels HC emissions were increased with increase in power output. The NOx emissions increased with increase in power output. The reduced NOx emissions were observed for CBDPH when compared to CBD at all power output. It was observed that CBDPH records almost same NOx emissions as diesel.

Murat Karabektas*etal.*, (2012) [11] Performed a study on the preheating of biodiesel named cottonseed oil methyl ester COME.The COME was preheated by using cottonseed oil, methyl alcohol, potassium hydroxide as a catalyst. Up to four different temperature 30, 60, 90, 120 0°C CelsiusCOME was preheated in single cylinder four stroke, naturally aspirated diesel engine. Preheating of COME was carried out by using fuel heating equipment mounted just above pump. The thermostat-controlled resister used for fuel heating equipment. The thermostat was used for keeping the temperature of COME un reservoir at the required value by energizing or deenergizing it. The tests of diesel fuel and preheated COME were performed at full load varying speed conditions. Firstly, the diesel fuel was tested at varying speed to set the base parameters and likewise preheated COME was tested and tested between 1800-3200 rpm with 200 rpm intervals.

By using COME, the brake power of engine decreased as it has lower heating value but preheating of COME decreased viscosity and thus made better atomization of COME thus the combustion characteristics was improved, and break thermal efficiency was increased.

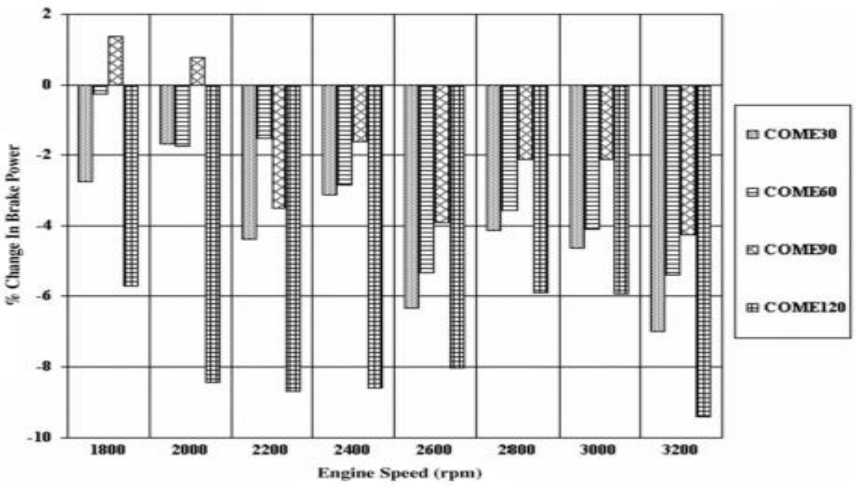

Figure 3. Changes in maximum break power with COME compared to diesel as baseline.

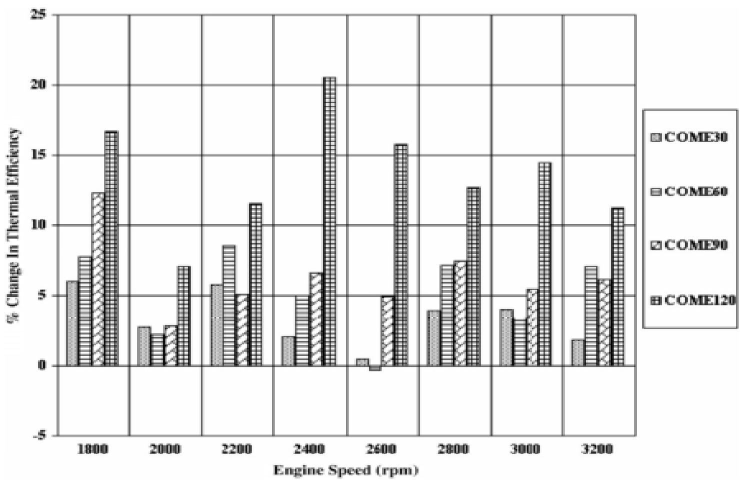

Figure 4. Changes in break thermal efficiency with COME compared to diesel at baseline.

however, for COME 120 was not significant. NOx emissions were high for COME then diesel as better atomisation lead to better combustion and preheating lead to increase the temperature in the cylinder.

If we talk about jetropha , then jetropha is largely available non edible oil in India. Seeing wide availability, the jetropha must be used as a fuel. This will in turn help farmers to earn.Pradhan *etal.,* (2014) [12]used preheated Jatropha oil PJO to evaluate the combustion characteristics of a direct injection diesel engine. He tried to utilize heat from exhaust gas of diesel engine to reduce the viscosity of high viscous oil to improve its engine performance. A typical engine system widely used in the agricultural sector was selected for experimental investigations. The setup comprised a constant speed 5.5kw, 4 stroke, single cylinder, water cooled diesel engine. A helical coil heat exchanger was fitted inside the exhaust pipe line for heating the Jetropha oil.

A three phase 250v AC generator used for loading the engine through electrical load bank comprising of four heating coils. By preheating, the viscosity of Jetropha oil was decreased remarkably with increase in the temperature and it became close to diesel at temperature above 75°C. So heating the Jetropha oil between 90°C and 100°C was adequate to bring down viscosity in close range to diesel. Further optimal fuel inlet temperature was found to be 80°C considering BTE and BSFC consumption. With increase in engine load the BSFC reduced for all HSD, CJO, and PJO and at full load the BSCF of PJO was higher than that of CJO and HSD. BTE increased with increase in percent load for all fuels HSD, CJO, PJO and max BTE was obtained for full load conditions. At full load conditions HSD has higher BTE of 29.88%. The exhaust gas temperature EGT was increased with increase in engine load for all HSD, CJO and PJO. This is due to increase in amount of energy released at higher loads as burning of increased amount of fuel injected to meet extra power requirement to take extraloading.The peak rate of pressure rise ROPR for PJO occurred max before TDC at full engine load and no load due to PJO has lower ignition delay and due to earlier start of combustion than HSD. As PJO has lowest ignition delay than CJO, HSD the peak heat release rate HRR is maximum for PJO before TDC at full load and no load.

Sagar *etal.*,(2010) [13] studied the effects of Neat Karanja oilpreheated from 30°C to 100°C on four stroke single cylinder CI engine. He studies the performance of the engine for a speed range between 1500 to 4000rpm and operating the engine under full load conditions. And then comparedthe performance parameters like Break specific fuel consumption, thermal efficiency, break power, NOx emissions. For the testing A single cylinder 4 stroke, air cooled diesel engine developing power output of 3.7kw is used. A rope break dynamometer is used for loading the engine. A separate heater arrangement is made to preheat the neat Karanja oil. The neat Karanja oil is heated up to these three different temperatures namely 30°C, 70°C, and 100°C. Another fuel tank used for preheating Karanja oil and so the specific heater arrangement is made to preheat the Karanja oil before it is injected into the engine. A resistance controlled by a thermostat was installed around a fuel reservoir at the required temperature. Experiments are initially carried out on the engine using diesel as fuel in order to provide the base line data. Sagar showed thatheating neat Karanja oil to a temperature above 100°C brings its physical properties close to mineral diesel. Break specific fuel consumption BSFC and NOx emissions were high at lower engine speeds but at higher engine speeds NOx emission were higher and BSFC is quite similar to that of diesel. The slightly higher power produced than that of ordinary diesel fuel with the increasing speed of the engine for neat vegetable oil at higher speed of the engine and at high fuel inlet temperature. The NOx emissions from the neat Karanja oils were higher than that of diesel fuel as the fuel inlet temperature was increased. The overall test results showed that the fuel heating was not beneficial at low speed operation.

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