PERFORMANCE EVALUATION OF COMPRESSION IGNITION ENGINE POWERED BY NEAT BIODIESELS

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ABSTRACT

Experiments have been carried out to evaluate the performance characteristics of a diesel engine when powered with neat jatropha methyl ester (JME), Castor methyl ester (CAME) and cottonseed oil methyl ester (COME). Tests on ordinary diesel fuel have also been carried out to obtained base line data for comparison purposes. The diesel engine ran well on all the fuels mentioned above. A series of tests are conducted and repeated three times for each of the test fuels. The engine works at a fixed speed of 1500 rpm, but at different loads respectively, i.e. 20%, 40%, 60%, 80% and 100% of engine full loads. The performance characteristics of the engine are analyzed and compared with diesel fuel operation. The experimental results show that the basic engine performance – power output and fuel consumption are comparable to diesel when powered with neat biodiesel. It was found that the engine offer slight higher thermal efficiency when it is powered by neat biodiesel compared to diesel, while lower exhaust gas temperature was observed with all neat biodiesels.

Keywords: Compression Ignition (CI) engine, Biodiesel, performance.

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1.INTRODUCTION

In recent years, diminishing of fossil fuel sources, growing of demand and cost of petroleum-based fuels, and environmental hazards as a result of burning of them have encouraged researchers to investigate possibility of using alternative fuels instead of the fossil fuels. Therefore, the researchers have focused on finding alternative new energy resources and utilizing them. They have stated that it is necessary to reduce consumption of the petro fuels due to the negative effects on human life by producing alternative renewable fuels. As known fossil energy sources have been exhausted rapidly nowadays, it is predicted that fossil fuel sources will be depleted in the near future. According to some studies, it is estimated that crude oil will last only for roughly 80 more years, gaseous fuels for about 150 years, and coal for 230 years [1]. Biofuel is a renewable energy source produced from natural (plant) materials, which can be used as a substitute for petroleum fuels. The most common biofuels, such as ethanol from corn, wheat or sugar beet and biodiesel from oil seeds, are produced from classic food crops that require high-quality agricultural land for growth [2, 3]. Serious problems face the world food supply today. Food versus fuel is the dilemma regarding the risk of diverting farmland or crops for liquid biofuels production in detriment of the food supply on a global scale. There is disagreement about how significant this is what is causing it, what the impact is, and what can or should be done about it. Biofuel production has increased in recent years. The rise in world oil prices led to a sharp increase in biofuels production around the world. Some commodities such as corn, sugar cane, and vegetable oil can be used either as food, feed or to make biofuels. Vegetable oils are a renewable and potentially inexhaustible source of energy with energy content close to diesel fuel. On the other hand, extensive use of vegetable oils may cause other significant problems such as starvation in developing countries. Forest and agricultural

Table 2. Physical properties of biodiesels and diesel fuel

Property	Fuel			
	Diesel	JME	CAME	COME
Density (kg/m3)	815	879	913	857.3
Kinematic Viscosity at 40°C (cSt)	4.3	4.84	11	5.94
Calorific value	42.5	38.5	39.16	36.89

(MJ/kg)				
Cetane Number	48	51	50	45.5

Table 2: Engine Specification

Sr.No	Item	Technical Data
1	Model	VRC 1
2	Make	COMET
3	Rated BH/kW	5.0/3.7
4	Bore x Stroke (mm)	80.0x110.0
5	Swept Volume (CC)	553
6	Compression Ratio	17.5:1
7	Rated RPM	1500
8	No. of Cylinder	1
9	Method of Cooling	Air
10	Bearing Type	Bush
11	Sp. Fuel Consumption gms/Kwhr	251
12	Lubrication System	Plunger Pump
13	Crank Shaft Height (mm)	203

education, science and modern technology leads in the solving the problems of global food resources. Biofuels can be classified based on their production technologies: First-generation biofuels; second generation biofuels; third generation biofuels; and fourth generation biofuels. Classification of biofuels based on their generation technologies is shown in Table 1. The first-generation biofuels appear unsustainable because of the potential stress that their production places on food commodities. Second generation biofuels need to build on the need for sustainable liquid fuels through processing including pyrolysis and hydrothermal liquefaction. Fischer–Tropsch and other catalytic processes in order to make more complex molecules and materials on which a future sustainable society will be based [2]. The term biodiesel commonly refers to fatty acid methyl or ethyl esters made from vegetable oils or animal fats, whose properties are good enough to be used in diesel engines. Biodiesel is a promising nontoxic and biodegradable renewable fuel comprised of mono-alkyl esters of long chain fatty acids, which is produced by a catalytic transesterification reaction of vegetable oils with short-chain alcohols. Biodiesel has become an interesting alternative to diesel engines, because it has similar properties to the traditional fossil diesel fuel and may thus substitute diesel fuel with none or very minor engine modifications [4].

There are four issues related to biodiesel where public knowledge is still low:

1. Biodiesel has around 9% less heating value in volume than conventional diesel fuel. Thus, if engine efficiency is the same, engine fuel consumption should be proportionally higher, and consequently vehicle autonomy proportionally lowers, when using biodiesel.
2. Biodiesel fuels have higher lubricity than conventional fuels, but they can contribute to the formation of deposits, the degradation of materials or the plugging of filters, depending mainly on their degradability, their glycerol (and other impurities) content, their cold flow properties, and on other quality specifications.
3. Biodiesel is 100% renewable only when the alcohol used in the transesterification process is also renewable.
4. Biodiesel fuels also have an interesting potential to reduce chemical emissions.[5]
5. Other studies have clearly indicated that the use of biodiesel may potentially reduce the dependence on petroleum diesel fuel and improve environmental aspects with satisfactory performance [6].

2. FUEL PROPERTIES

The important chemical and physical properties of biodiesel were determined by standard ASTM (American Society for Testing and Materials) and AOCS (American Oil Chemists Society) methods and compared with diesel are given in Table 1. The heating value of the neat biodiesels is comparable to the diesel oil and the cetane number is lower than the diesel fuel. However, the kinematic viscosity and the flash point of neat biodiesels are several times higher than the diesel oil.

3. EXPERIMENTAL PROCEDURE

Tests were conducted in the lab on a single cylinder four-stroke, naturally aspirated, constant speed compression ignition engine. The engine was tested at a rated speed of 1500 rpm under steady state conditions. Each test was repeated three times to ensure the repeatability in the data. Load on the engine is varied from partial to full load condition. The engine specifications are given in table 1. Engine was loaded with single phase alternator (6 kVA, 50 Hz, 1500 rpm), gravimetric type fuel sensor was used to measured fuel flow, and temperature of exhaust gas was measured using PT 100 RTD (resistance temperature detector).

4.TEST FUELS

Performance of the engine with conventional diesel fuel was used as the basis for comparison. Jatropha methyl ester (JME), Castor methyl ester (CAME) and Cotton seed oil methyl ester (COME) were tested in the engine. All biodiesel were used in their neat form and no blends were used in experimentation.

5.DISCUSSION OF RESULTS

The performance parameters considered are Brake Power, Brake-specific fuel consumption (BSFC) and Brake Thermal efficiency. These engine parameters are evaluated with neat jatropha methyl ester (JME), Castor methyl ester (CAME), Cotton seed oil methyl ester (COME) and diesel as fuels. The load on the engine is varied from 20% to 100% in steps of 20%. For all fuel the performance of engine was evaluated and compared with the performance obtained with diesel fuel operation.

5.1 Brake Power

Fig. 1 shows the variation of the engine power with load for various biodiesel respectively. As expected and as a general trend, initially the engine power increases as the load on the engine varied. Further, it may be noticed that the power produced decreases with the increase in load for neat CAME oil. Whereas power produce with JME and COME was observed same as diesel fuel operation at all loading condition of the engine. From these result it is clear that, biodiesel does not cause any loss of power unless the maximum power is demanded. At partial load operation, no differences in power output should be expected, since an increase in fuel consumption in the case of biodiesel would compensate its reduced heating value. At full-load conditions, a certain decrease in power has been found with biodiesel, but such a decrease is lower than that corresponding to the decrease in heating value, which means that a small power recovery is often observed.

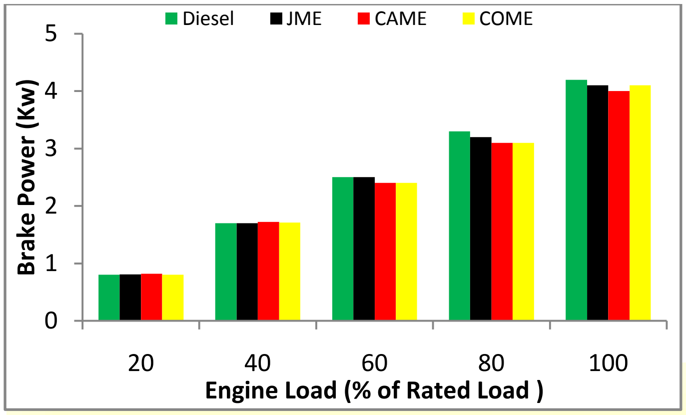

Fig.1. Engine load Vs Brake power

5.2 Brake Specific Fuel Consumption

Brake-specific fuel consumption (bsfc) is the ratio between mass fuel consumption and brake effective power, and for a given fuel, it is inversely proportional to thermal efficiency [5]. If the latter is unchanged for a fixed engine operation mode, the specific fuel consumption when using a biodiesel fuel is expected to increase by around 14% in relation to the consumption with diesel fuel, corresponding to the increase in heating value in mass basis [5]. The results for the variation in the brake specific fuel consumption (bsfc) with increasing load on the engine up to full load are presented in fig. 2. For all fuel the specific fuel consumption varies with increasing load. For neat JME and COME, brake specific fuel consumption has high value at low load but decreases as the load increases. It was observed at all loading conditions fuel consumption has high value for neat CAME at all loading condition among all fuels tested. Least fuel consumption was observed for JME compared with COME and CAME. An increase in bsfc is an expected phenomenon when using biodiesel. Such an increase is generally in proportion to the reduction in heating value (9% in volume basis, 14% in mass basis). [5].

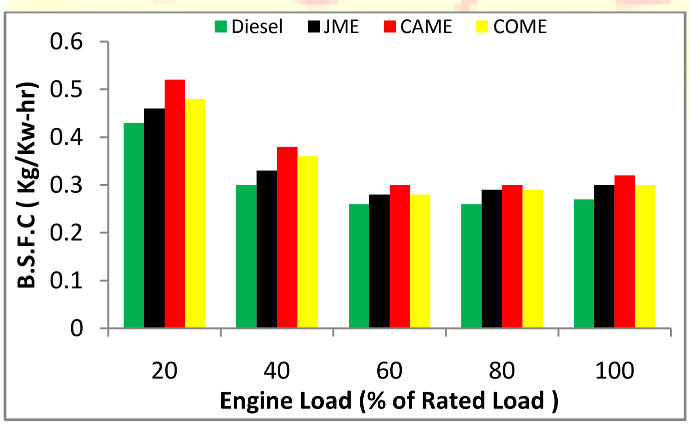

Fig.2. Engine load Vs B.S.F.C

5.3 Thermal Efficiency

Thermal efficiency is the ratio between the power output and the energy introduced through fuel injection, the latter being the product of the injected fuel mass flow rate and the lower heating value. Thus, the inverse of thermal efficiency is often referred to as brake-specific energy consumption [5, 7]. Since it is usual to use the brake power for determining thermal efficiency in experimental engine studies, the efficiency obtained is really a brake-specific efficiency. This parameter is more appropriate than fuel consumption to compare the performance of different fuels, besides their heating value. Fig. 3 shows the variation of brake thermal efficiency with load. Brake thermal efficiency was observed slightly higher than that of the corresponding diesel fuel, for JME and CAME at all loading condition of the engine. This means that the increase of brake specific fuel consumption is lower than the corresponding decrease of the lower calorific value of the neat JME and CAME oil, which could have been caused by reductions in friction loss associated with higher lubricity of neat biodiesel. It can be seen from the Fig. 3 that the efficiency for neat CAME has lower value than JME, CAME and diesel fuel. However it was expected higher than diesel fuel.

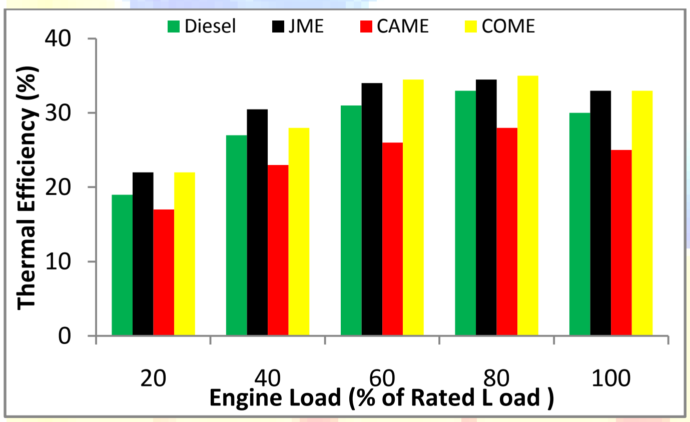

Fig.3. Engine load Vs Thermal Efficiency

5.4 Exhaust Gas Temperature

The variation of exhaust gas temperature for different fuel inlet temperature with respect to the load is indicated in Fig.4, The exhaust gas temperature for the fuels tested increases with Fig. 3.Variation of thermal efficiency with load. increase in the load. The amount of fuel injected increases with the engine load in order to maintain the power output and hence the heat release and the exhaust gas temperature rise with increase in load. Exhaust gas temperature is an indicative of the quality of combustion in the combustion chamber [8]. At all loads, diesel was found to have the higher temperature and the temperatures for the neat CAME was higher at low loads. Except CAME at 20% load, all biodiesels showed lower exhaust gas temperature compared to diesel. This decrease is more at higher load with respect to the lower loading condition of the engine. The exact reason for lower exhaust temperatures compared to diesel could not been identified. However, it may be due to lesser calorific value of biodiesel.

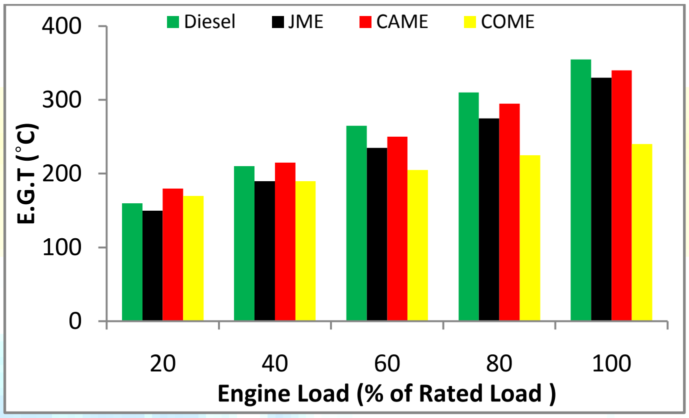

Fig.4. Engine load Vs E.G.T

6.CONCLUSIONS

In this work a four stroke, single cylinder, constant speed, air cooled, direct injection diesel engine developing a power output of 3.7 kW at 1500 rev/min typically used in agricultural sector was tested using neat jatropha methyl ester (JME), Castor methyl ester (CAME) and cottonseed oil methyl ester (COME). The performance of the engine is analyzed when it is powered by neat biodiesels of different origin. The results obtained through the experiments can be summarized as under:

1. At partial load operation, no differences in power output were observed, since an increase in fuel consumption in the case of biodiesel would compensate its reduced heating value. At full-load conditions, a certain decrease in power has been found with biodiesel, but such a decrease is lower than that corresponding to the decrease in heating value, which means that a small power recovery is often observed.
2. An increased bsfc has been found when using biodiesel. Such an increase is generally in proportion to the reduction in heating value.
3. The thermal efficiency of diesel engines is not appreciably affected when substituting diesel by biodiesel fuel in its neat form. However, it was observed higher than diesel for

neat JME and CAME. While COME offers lower thermal efficiency at all loading condition of the engine.

4. Exhaust gas temperature was found lower for all fuels under test except for CAME at 20% loading condition of the engine. This decrease in temperature was observed higher at higher load with respect to the lower loading condition of the engine.

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