Performance Study of Single Cylinder Four Stroke C.I. Engine by using Castor Methyl Ester Blends with Diesel

Nitesh Jain[1], Riyaz Rafique[2], Dr. G. R. Selokar[3]

[1]*M.Tech. Scholar, Department of Mechanical Engineering,*

[2]*Assistant Professor, Department of Mechanical Engineering,*

[3]*Professor, Department of Mechanical Engineering*

[1, 2, 3]*School of Engineering, Sri Satya Sai University of Technology and Medical Sciences, Sehore, Madhya Pradesh, India*

Abstract: The depletion of oil resources as well as the environmental regulation has led to the development of alternate energy sources. In this present work the performance characteristics of a single cylinder diesel engine when fuelled with blends of Castor oil and diesel are evaluated. Experiments were conducted with different blends (B10&B20) of Castor oil and diesel as various loads. The results show that the brake thermal efficiency of diesel is slightly higher at all loads followed by blends of Castor oil and diesel, it has been established that 20% of Castor oil biodiesel can be use as a substitute for diesel without any engine modification thus Castor oil as non-edible oil can be a good renewable raw material for biodiesel production.

Keywords: alternate fuels, blends, diesel engine, Castor oil, performance, Transesterification.

I. INTRODUCTION

Conventional energy sources such as oil, coal and natural gas have limited reserves that are expected not to lost for an extended period. World primary demand is projected to increase by 1.5% per year between 2007 to 2030, from just over 12,000 million tonnes of oil equivalent to16800 million tones-as overall increase of 40%. As world reserves of fossil fuels and raw material are limited, it has stimulated active research interest in non petroleum and non polluting fuels. Diesel engines are the major source of power generation and transportation hence diesel is being used extensively, but due to the gradual impact of environmental pollution there is an urgent need for suitable alternate fuels for use in diesel engine without any modification.

There are different kinds of vegetable oils and biodiesel have been tested in diesel engines its reducing characteristic for green house gas emissions. Its help on reducing a country's reliance on crude oil imports its supportive characteristic on agriculture by providing a new market for domestic crops, its effective lubricating property that eliminates the need of any lubricate additive and its wide acceptance by vehicle manufacturers can be listed as the most important advantages of biodiesel fuel. There are more than 350 oil bearing crops identified, among which only Jatropha, ongamia, sunflower, Soyabean, cottonseed, rapeseed, palm oil and peanut oil are considered as potential alternative fuels for diesel engines. The present study aims to investigate the use of Castor oil blend with diesel as an alternate fuel for compression ignition engine.

II. MATERIALS AND METHODS

Biodiesel Preparation: Biodiesel is the ester of vegetable oils produced through a process called transesterification. Transesterification is a chemical reaction which occurs between triglyceride and methyl alcohol in the presence of potassium hydroxide (KOH). It consists of a sequence of three consecutive reactions where triglycerides are converted to diglycerides; diglycerides are converted to monoglycerides followed by the conversion of monoglycerides to glycerol. In each step an ester is produced and thus three ester molecules are produced from one molecule of triglyceride.

Castor oil used in the present investigation was taken from the local market of Bhopal, Madhya Pradesh, India and filtered by cheesecloth to remove solid particles. The moisture content was removed by heating the oil in an oven up to 110°C for one hour now the oil is taken in a round bottom flask and heated around 50-60°C on a hot plate having magnetic stirrer arrangement, then methanol and potassium hydroxide are added to the oil. The mixture was stirred continuously. Alcohol to vegetable oil molar ratio is one of the important factors that affect the conversion efficiency of the process for the transesterification process 3 mol of alcohol are required for each mole of the oil. However, in practice the molar ratio should be higher than this theoretical ratio in order to drive the reaction towards early completion.

After the completion of reaction, the products are allowed to separate into two layers, the lower layer contains glycerol and the top layer contains ester which is separated and purified using water. Water is sprayed over the ester and stirred gently and allowed to settle in the separating funnel, the lower layer is discarded and upper layer (purified biodiesel) is separated.

Biodiesel (methyl esters of Castor oil) have several outstanding advantages among other new-renewable and clean engine fuel alternatives. The properties of diesel and biodiesel (Castor oil methyl ester) used in present investigation were compared with diesel fuel in Table.1

Table.1 Properties of diesel and biodiesel

Properties	Diesel	Biodiesel(Castor oil methyl ester)
Specific gravity (gm/cm^3)	0.823	0.920
Calorific value (kj/kg)	43000	39000
Cetane number	48	47
Kinetic viscosity	3.9	38
(at40°C) [cSt]		
Flash point (°C)	56	245
Fire point (°C)	64	276
Stoichiometric	15	12.41
A/F		
Carbon (%)	86	78.92
Hydrogen (%)	14	13.41

Table.2 Specification of test engine.

Company and Model Type	Kirloskar oil Engine , SV1 Single cylinder, 4-Stroke, diesel engine
Bore	87.5mm
Stroke	110mm
Rpm	1800rpm
Rated power	8 HP
Type of cooling	Water cooled
Compression ratio	16.5:1

III. EXPERIMENTAL SETUP AND PROCEDURE

A four stroke, Single cylinder, water cooled diesel engine was used for the performance test. The technical specification of the test engine is shown in Table.2 The experimental setup diagram is shown in picture.1 Experiments were carried out initially using neat diesel fuel to generate the base line data. After recording the base line data, tests were carried out using 10 and 20% biodiesel blends. The engine tests were conducted at various loads and the parameters related to performance were recorded.

Picture:1 Experimental setup

consumption, heat supplied, speed and time for 5ml fuel consumption.

IV. RESULTS AND DISCUSSION

A series of engine tests were carried out using diesel and biodiesel to find out the effect of various blends on the performance of the engine. Investigations are carried out on the engine mainly to the effect of brake horse power, brake specific fuel consumption, torque, air consumption, brake thermal efficiency, fuel

4.1 Brake horse power

In fig.1 compare variation of brake horse power for Castor oil blended with diesel. Brake horse power is plotted against the load. Brake horse power is increased with increase in load. This is due to increase in fuel consumption with increase in load. The Brake horse power for B10 is reduced by 15.26%, 7.99%, 11.36% and 7.87 % as compared to diesel at different load. Similarly BHP for B20 is reduced by 16.32%, 8.90%, 3.09% and 3.60% as compared to B10 at different load. This is due to decrease in calorific value of fuel with increase in biodiesel percentage in the blends.

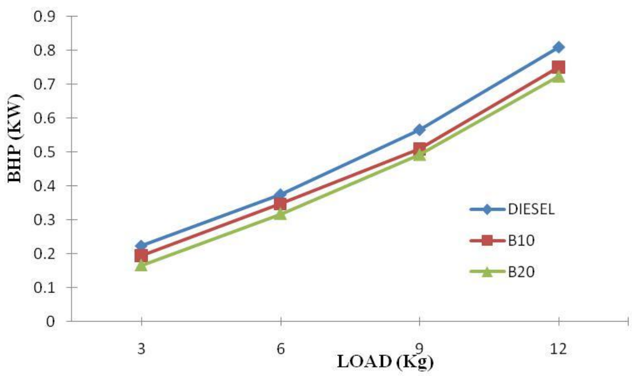

Fig.1 Variation of BHP for blended with diesel

4.2 Brake specific fuel comsumption

In fig.2 compare variation of BSFC for Castor oil blended with diesel. BSFC is plotted against the various loads. The BSFC decreases with increase in load; BSFC for B10 is increased by 290.6%, 22.03%, 25.58% and 26.92% as compared to diesel at different load. Similarly BSFC for B20 increased by 22.50%, 12.12%, 9.53% and 12.13% as compared to B10 at different load. This is caused due to effect of delay in ignition pressure, higher viscosity and lower calorific value of the fuel.

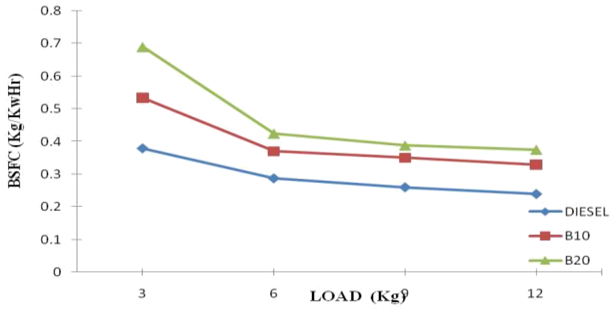

Fig.2 Variation of BSFC for blended with diesel

4.3 Torque

In fig.3 we plotted Torque against the various loads. The torque increases with increase in load. This is due to increase in fuel consumption with increase in load. The Torque for B10 is reduced by 12.5%, 6.66%, 8.69% and 4.33% as compared to diesel at different load. Similarly torque for B20 is reduced by 14.28%, 7.14%, 0.87%and 2.59% as compared to B10 at various load, this is due to decrease in calorific value of fuel with increase in biodiesel percentage in the blends.

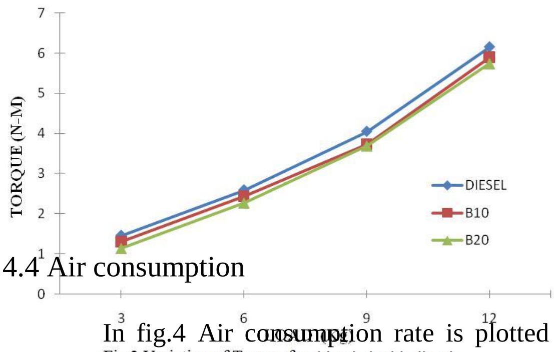

Fig.3 Variation of Torque for blended with diesel

4.4 Air consumption

In fig.4 Air consumption rate is plotted against different loads. Air consumption increases with increase in load. The air consumption for B10 is increased by 8.33%, 4.44%, 7.93% and 11.49% as compared to diesel at different load. Similarly air consumption for B20 is increased by 10%, 6.25%, 5.97% and 9.37% as compared to B10 at different load, this is due to lower calorific value of fuel.

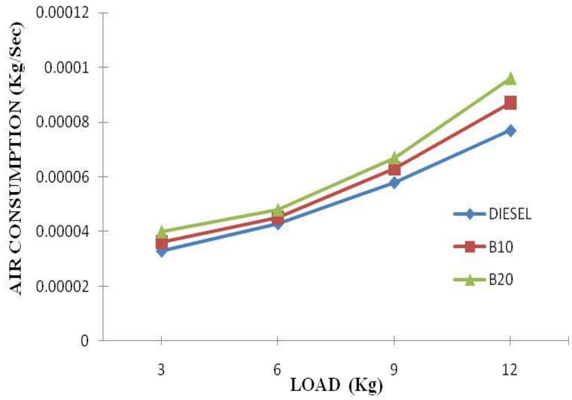

Fig.4 Variation of Air Consumption for blended with diesel

4.5 Brake thermal efficiency

In fig.5 Brake thermal efficiency is plotted against the various loads for Castor oil blended with diesel. The brake thermal efficiency is defined as the actual brake power per cycle divide by the amount of fuel chemical energy. Brake thermal efficiency for B10 is reduced by 27.86%, 16.59%, 21.85% and 24.10% as compared to diesel at different load. Similarly BTE for B20 is reduced by 28.99%, 14.45%, 10.52% and 13.86% as compared to B10 at different load. This reduction in brake thermal efficiency with biodiesel blends was due to higher viscosity, poor spray characteristics and lower calorific value. The higher viscosity leads to decreased atomization, fuel vaporization and combustion and hence the thermal efficiency of the biodiesel blends is lower than that of diesel.

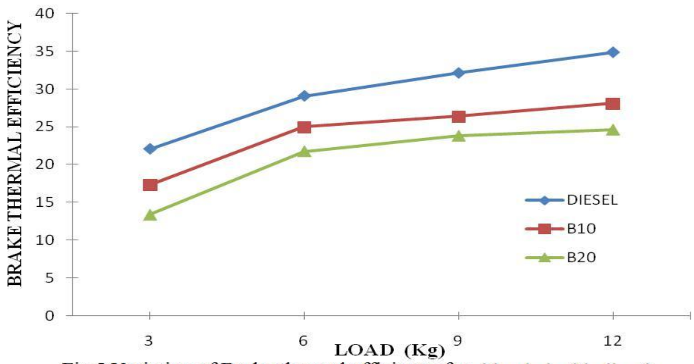

Fig.5 Variation of Brake thermal efficiency for blended with diesel

4.6 Fuel consumption

In fig.6 variations of fuel consumption for Castor oil blended with diesel are plotted against various loads. Fuel consumption increases with increase in load, fuel consumption for B10 is increased by 18.26%, 16%, 17.10% and 21.17% as compared to diesel at different load. Similarly fuel consumption for B20 is increased by 9.83%, 4.83%, and 6.72% and8.99% as compared to B10 at different load. This is due to higher viscosity of fuel.

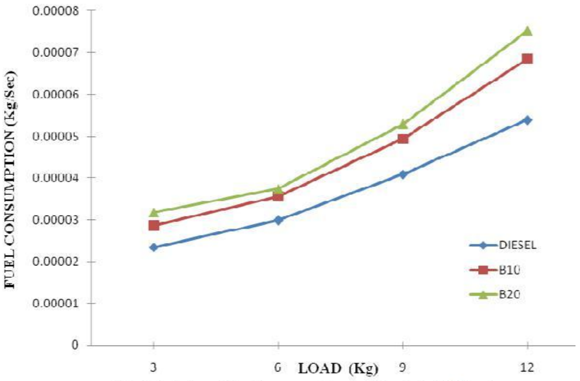

Fig.6 Variation of Fuel consumption for blended with diesel

4.7 Heat supply

In fig.7 the variation of heat supply for Castor oil blended with diesel at various load conditions are plotted. The heat supply increases with increase in load. The heat supply for B10 is increased by 9.86%, 7.38%, 8.62% and 13.08% as compared to diesel at different load. Similarly for B20 heat supply is increased by 9.84%, 4.85%, 6.72% and 8.988% as compared to B10 at different load, this is due to lower calorific value, higher viscosity coupled with density of fuel.

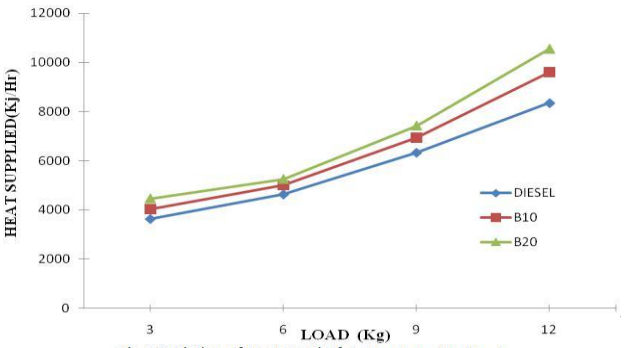

Fig.7 Variation of Heat supply for blended with diesel

4.8 Speed

In fig.8 we compared variation of speed for Castor oil blended with diesel at various load condition. The speed reduces with increase in load. The Speed for B10 is reduced by 2.45%, 1.24%, 2.47% and 2.19% as compared to diesel at different load. Similarly Speed for B20 is reduced by 1.7%, 1.64%, 2.19% and 2.16% as compared to B10 at different load. This is due to lower calorific value of fuel.

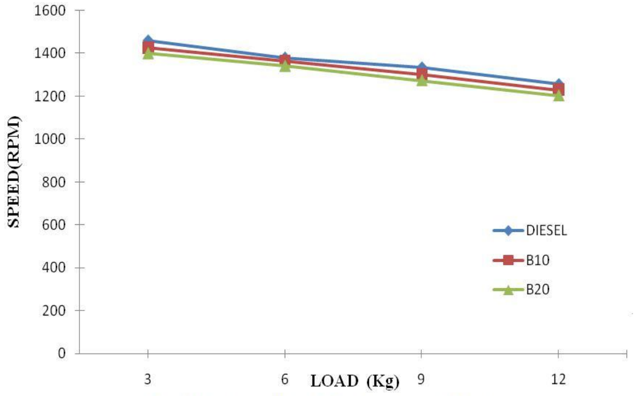

Fig.8 Variation of Speed for blended with diesel

V. CONCLUSION

From the experimental analysis it was found that the blends of Castor oil and diesel could be successfully used with acceptable performance up to a certain extent. Based on the result of this study properties of Castor oil suggest that it cannot be used directly as CI engine fuel due to higher viscosity, density which will result in low volatility and poor atomization of oil during oil injection in combustion chamber causing incomplete combustion and carbon deposits in combustion chamber. Biodiesel blends produce lower brake thermal efficiency and higher brake specific fuel consumption then diesel because of low calorific value. The properties results of all blends show that blends up to 20% straight Castor oil have value of viscosity and density equivalent to specified range for CI engine fuel, therefore it can be concluded that up to 20% blends can be used to run the CI engine at short term basis..

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