EXPERIMENTAL INVESTIGATION ON PERFORMANCE AND EMISSION PARAMETERS OF SINGLE CYLINDER DIESEL ENGINE USING CASTOR SEED METHYL ESTER BLENDS

[1]K.SRINIVASA REDDY, [2]J.NAVEEN, [3]K.M.V.RAVITEJA

[1,2,3]Assistant Professor, Department of mechanical engineering, K L University.
K L University, Green Fields, Vaddeswaram, Guntur District, A.P, INDIA
E-mail: [1]srinivas.kunduru2000@hotmail.com, [2] naveenj315@gmail.com, [3] leo.raviteja@gmail.com

Abstract— In the present investigation castor-diesel blend is used as an alternate fuel. The properties of castor seed oil are determined and castor seed oil is converted in castor seed methyl esters by esterification process. The performance and emissions parameters of single cylinder, stationary diesel engine were calculated with the blends (B10, B20, B30) prepared and with the standard diesel and graphs were plotted. The obtained results were compared with the base line data obtained by using diesel and optimum castor seed oil blend B10 is obtained. The blend showed best performance in brake thermal efficiency, increase in brake thermal efficiency, and decrease in brake specific consumption and reduction in CO, HC emissions. Finally results shows that castor seed methyl esters can be used as alternate fuel for Diesel engines.

Keywords— Castor Seed oil, Esterification, Performance and Emission Parameters.

I. INTRODUCTION

The world is presently confronted with double crises of fossil fuel depletion and environmental degradation. The fact that petroleum based fuels will neither be available in sufficient quantities nor at a reasonable price in future has revived interest in exploring alternative fuels for diesel engines. Since the dawn of oil age man has burnt about 800 million barrels of petroleum. About 71 barrels are burnt everyday throughout the world. And this consumption rate goes on increasing by 2% every year. The 2% doubles the quantity every 34 years. Somewhere between 1000 to 1600 billion barrels of fuel consumption are assumed to be in formation where economic recovery is possible. By 2010 the world would have consumed about one-half of the total amounts that is technically and economically feasible to extract. And at the current rate of consumption 1600 billion barrels would be depleted in 60 years. It's high time to think about the alternative fuels.

Biodiesel is the name of a clean burning alternative fuel, produced from domestic, renewable resources. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend. It can be used in compression-ignition (diesel) engines with little or no modifications. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulphur and aromatics.

II. EXPERIMENTAL DETAILS

2.1 Materials and Methods

A sample of castor oil was collected from castor seeds by using oil extraction technique called as mechanical press. The produced crude oil is filtered by using the serigraphy papers and filtered oil is preheated by direct heating. The molar ratio 16:1 we mixed methanol and KOH by the titration up to dissolving the KOH completely. This solution is mixed with castor seed crude oil and heated further to separate glycerine and other fatty acids about 6 hours at constant temperature in between 60°c to 75°c. The mixture solution is cooled by using conical flask for about 1 day at atmospheric temperature. The obtained glycerine and bio-diesel is separated and blends we required were prepared. This entire process is called as Esterification process. To determine the properties of the blends prepared different tests have been performed. For measuring flash point and fire point of blends we have used pensky marten flash point and fire point setup, for measuring calorific value of oils equipment known as Bomb Calorimeter, For determining viscosity of blends Redwood Viscometer was used.

III. PREPERATION OF CASTOR SEED BLENDS

3.1 Esterification process

The method used for preparation of biodiesel from Castor seed oil for this work. Esterification which is a process of using methanol in the presence of a catalyst, such as potassium hydroxide (KOH), to chemically break the molecule of castor seed oil into an ester and glycerol. This process is a reaction of the oil with an alcohol to remove the glycerine, a by-product of biodiesel production.

In this experiment 1000 ml of raw castor seed oil is taken in a container and is stirred with a mechanical stirrer and simultaneously heated with the help of a heating coil The speed of the stirrer is minimum and when the temperature of the raw oil reaches 60 °C the KOH-alcohol solution is poured into the raw oil container and the container is closed with a air tight lid. Now the solution is stirred at high speeds. Care should be taken that the temperature does not exceed 60 °C as ethanol evaporates at temperatures higher than 60 °C. Also the KOH-alcohol solution is mixed with the oil only at 60 °C because heat is generated when KOH and alcohol are mixed together and the temperature of the raw oil should be more than this when mixing is done if the reactions have to take place properly. After stirring the oil-KOH-alcohol solution at 60 °C for half an hour the solution is transferred to a glass container.

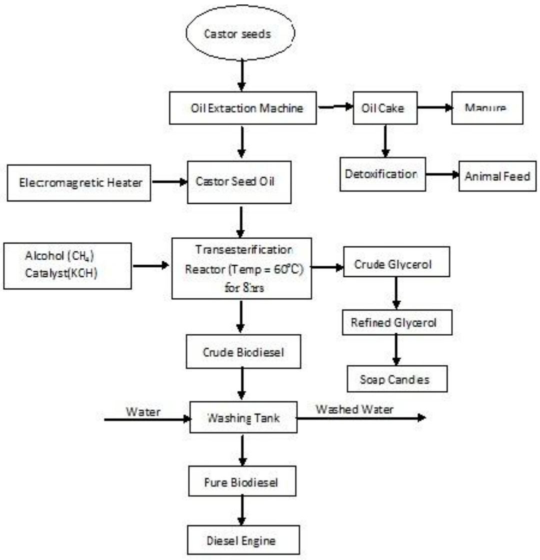


Fig1.Flow chart of castor seed oil esterification process

Figure below (left to Right) are the blends B10. B20, B30, B40, B50, Diesel.

3.2 Properties of castor seed oil:

Table1: Properties of diesel and castor seed oil.

Property	Pure diesel	Castor seed oil
Boiling point	180°-360°C	313°C
Specific gravity(gm/cm³)	0.835	0.92
Flashpoint	58°C	296°c
Calorific value(KJ/Kg)	42500	38443
Dynamic Viscosity at 40°c (centi-poise)	0.278	0.385
Transport information	hazardous	Non hazardous

3.2.1 Experimental Observation

3.2.1.1 Specific Gravity-Results:

Specific gravity is the relative measure of the density of the substance. It is defined as the ratio of density of the substance to the reference density. Hydrometer is used to measure the specific gravity of the blends prepared and tabulated as shown below.

Table2: Specific gravity results

S. No	Oil	Blend	Specific gravity
1	Diesel	D100	0.84
2	Castor oil	B100	0.92
3	Castor Seed Oil Methyl Ester Blend with Bio-Diesel (CSOME)	B10	0.80
		B20	0.82
		B30	084

3.2.1.2 Flash and Fire point for Blends and Diesel

Flash point is the minimum temperature to which it must be heated to give off sufficient vapor to form an inflammable mixture with air. At this temperature the vapor may cease to burn when the source of ignition is removed. The fire point is the minimum temperature to which it must be heated so that vapors burn at least 5 seconds.

Table3: Flash point and Fire point results

S. No	Oil	Blend	FLASH POINT	FIRE POINT
1	Diesel	D100	50	54
2	Castor oil	B100	296	345
3	Castor Seed Oil Methyl Ester Blend with Bio-Diesel (CSOME)	B10	52	56
		B20	47	55
		B30	48	51

3.2.1.3 Viscosity results

Viscosity is the property of a homogeneous fluid, which causes it to offer frictional resistance to motion. Viscosity may be expressed as dynamic and kinematic viscosities. Dynamic viscosity is the tangential force on unit area of either of the two parallel planes at unit distance apart when the space between the planes moves relatively to the other with unit velocity in its own plane. Redwood viscometer is used to determine viscosity property for blends and diesel.

Table 4: Viscosity results for blends and Diesel

S. No	Oil	Blend	Kinematic viscosity(mm²)	Dynamic viscosity(centi-poise)
1	Diesel	D100	3.81	0.278
2	Castor oil	B100	15.98	0.385
3	Castor Seed Oil Methyl Ester Blend with Bio-Diesel (CSOME)	B10	4.54	0.240
		B20	4.97	0.228
		B30	5.68	0.308

3.2.1.4 Carbon results

The carbon residue property is a measure of the tendency of fuel to form carbonaceous deposits in the engine, which can lead to stress, corrosion or cracking of components. A destructive –distillation method for estimation of carbon residues in the fuels and lubricating oils Conrad son carbon test is used. Experimental setup of Canradson carbon residue test is shown in figure below.

Table 5: Results of carbon residue for CSOME and Diesel

Oil		% of carbon
Diesel	D100	0.12
Castor Seed Oil Methyl Ester Blends with Bio-Diesel(CSOME)	CSOME	0.23

3.2.1.5 Calorific value Results

Calorific value of the fuel is the thermal energy released per unit quantity of fuel when the fuel is burned completely and the products of combustion are cooled back to initial stage temperature of the combustion mixture. A Bomb calorimeter is used to measure the calorific value of blends prepared.

Table 6: Calorific value results of blends

Oil	Crude	B10	B20	B30
TSOME (KJ/Kg)	38443	41682	41242	40586
Diesel (KJ/Kg)	42500	42500	42500	42500

4. Diesel engine experimental setup

The Engine chosen to carry out experimentation is a single cylinder, four stroke, vertical, water cooled, direct injection computerized Kirloskar make CI Engine. This engine can withstand higher pressures encountered and also is used extensively in agriculture and industrial sectors. Therefore this engine is selected for carrying experiments.

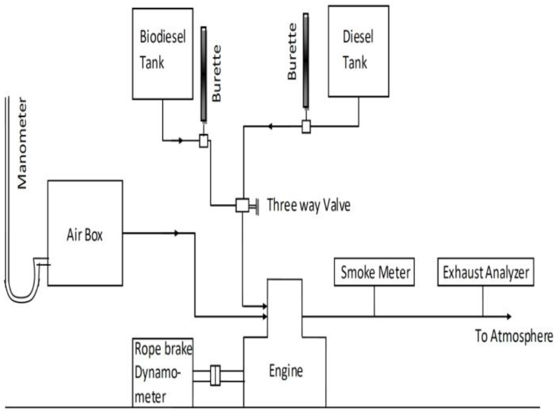


Figure shows four stroke single cylinder Diesel engine.

Specifications of diesel engine:

Table 5: Diesel engine speciations.

Brake horse power	5HP
Speed	1500 RPM
Bore	80mm
Stroke	110mm
Compression ratio	16.5:1
Method of start	Crank shaft
Orifice diameter	20mm
No of cylinders	1
Type of ignition	Compression ignition
Make	Kirloskar

3.2.1.5Exhaust gas analyzer

All emissions like Carbon monoxide, Carbon dioxide, Un-Burnt Hydrocarbons, Nitrogen oxide and unused oxygen are found in 5 gas emission analyzer of model “5G -10 PLANET EQUIPMENT” is used. In this cable one end is connected to the inlet of the analyzer and the other end is connected at the end of the exhaust gas outlet. The measuring method is based on the principle of light absorption in the infrared region, known as "non-dispersive infrared absorption".

Figure below shows the 5mode gas emission analyzer.

Table 6: specifications of exhaust gas analyzer

CO	0 to 9.99%vol. Res. 0.01%
HC	0 to 20000ppm. (propane) Res. 1ppm
Co2	0 to 20.00% vol. Res. 0.10%
O2	0 to 25% Res. 0.01%
Lambda	0.200 to 1.800% Res. 0.001%
Air/Fuel	0 to 30:1 Res.1

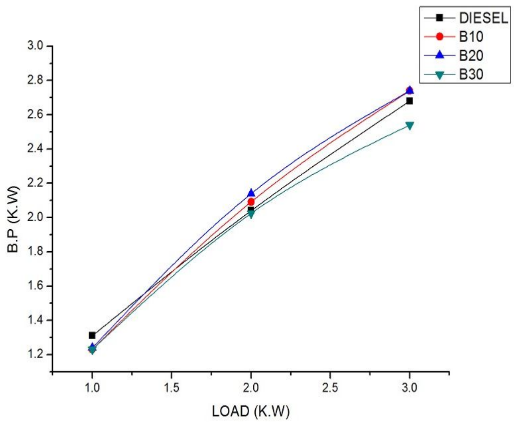
V. RESULTS AND DICSUSSIONS

Performance and emission parameters.

The performance and emission parameters of a conventional diesel, diesel and bio-diesel blends were investigated on single cylinder diesel engine at various loads were discussed as per the results obtained and graphs were plotted.

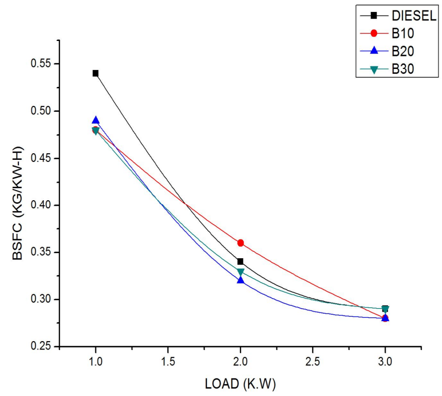
LOAD Vs BRAKE POWER

The variation of Load Vs Brake power is plotted and shown in graph below. The graph reveals that as load increases brake power also increases. The brake power of a diesel engine was high while using castor seed oil blends when compared with diesel. It is observed that the brake power is higher for CASTOR blends than diesel due to the non-availability of oxygen at higher loads and more complete combustion of fuel in the engine.



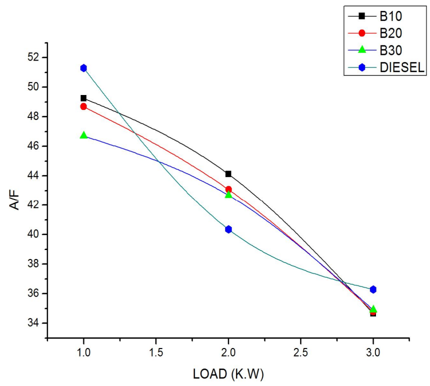
LOAD Vs BRAKE SPECIFIC FUEL CONSUMPTION

The variation of Load Vs Brake specific fuel consumption was shown in graph below. The graph reveals that Load increases with decrease in Brake specific consumption that means fuel consumption decreases. It is observed that all blends of Castor oil shows higher specific fuel consumption a long with sole fuel of the engine. It is due to high viscosity and poor volatility of the Castor oil as results in poor atomization and mixture formation and increases in fuel consumption. B30 oil shows the maximum specific fuel consumption than other blends of Castor oil and one interesting point is that B20 having less fuel consumption compared to other blends.



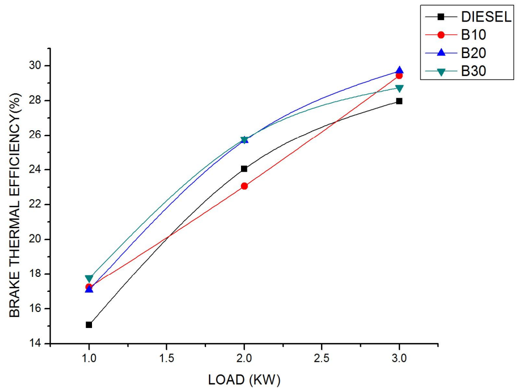
LOAD Vs AIR FUEL RATIO

The variation of Load Vs Air Fuel Ratio is plotted and shown in graph below. After analyzing the Air-Fuel ratio in case of Diesel, Castor oil. It has been found that Air-Fuel ratio is increasing when compared to Diesel due to decrease in fuel consumption.



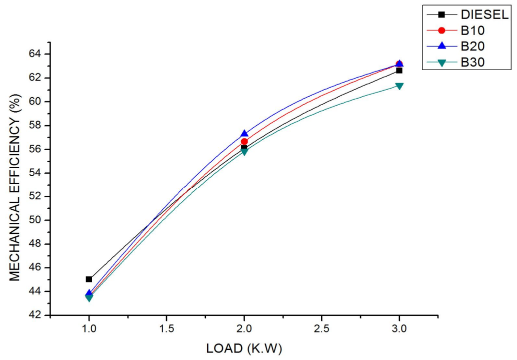
LOAD Vs BRAKE THERMAL EFFICIENCY

The variation of Load Vs Brake Thermal Efficiency was plotted and shown in graph below. As the Load increases the Brake Thermal Efficiency also increased and blend B10 has showed maximum when compared to pure diesel. Fig. shows that the brake thermal efficiency with respect to load of the engine. It is due to high viscosity of the castor oil leads to lower the break thermal efficiency for other blends.



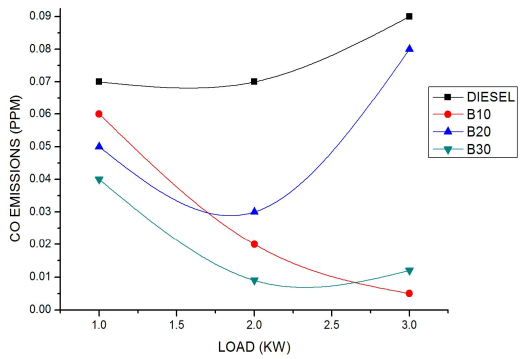
LOAD Vs MECHANICAL EFFICIENCY

The variation of Load Vs Mechanical Efficiency is plotted and shown in graph below. The graph reveals that as Load increases Mechanical Efficiency also increases. The Mechanical Efficiency of a diesel engine was high while using castor seed oil blends.



LOAD Vs CO Emissions

The variation of Load Vs CO emissions was plotted and shown in graph below. As load increases the Co emissions of blends has reduced and it is interesting to note that B10 has shown maximum reductions in CO gas when compared with all the other blends the reason is complete combustion takes place in blends.



CONCLUSIONS

Based on the experimental results the following conclusions are arrived:
The Maximum brake thermal efficiency for B10 (46.61%) was achieved which means there was an increase of 8.47% compared with diesel. In B10 fuel the Brake Specific Fuel Consumption is lower than diesel by 27.5%. As a C I Engine fuel, B10 Blend results in an average reduction of smoke densities from all the blends and when compared with diesel. Since B10 blend reduces the environmental pollution, high in thermal efficiency when compared with diesel it will be a promising energy source for sustaining the energy. From the above points it is concluded that the Castor seed oil can be used as a substitute fuel for the diesel fuel.

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