EXPERIMENTAL DETERMINATION OF BRAKE THERMAL EFFICIENCY AND BRAKE SPECIFIC FUEL CONSUMPTION OF DIESEL ENGINE FUELLED WITH BIO-DIESEL

A. V. KRISHNA REDDY [1] M. SHIVA SHANKAR [2] K. APPARAO[3]

1. M Tech student, Siddaganga Institute of Technology, Tumkur-572103.

2. Assistant professor, Siddaganga Institute of Technology, Tumkur-572 103.

3. Professor, Dept. of Mechanical Engineering, L.B. Reddy College of Engineering, Mylavaram-521230.

***Abstract* - The rapid depletion in world petroleum reserves and uncertainty in petroleum supply due to political and economical reasons, as well as, the sharp escalations in the petroleum prices have stimulated the search for alternatives to petroleum fuels. The situation is very grave in developing countries like India which imports 70% of the required fuel, spending 30% of her total foreign exchange earnings on oil imports. Petroleum fuels are being consumed by agriculture and transport sector for which diesel engine happens to be the prime mover. Diesel fuelled vehicles discharge significant amount of pollutants like CO, HC, NOx, soot, lead compounds which are harmful to the universe. Though there are wide varieties of alternative fuels available, the research has not yet provided the right renewable fuel to replace diesel. Vegetable oils due to their properties being close to diesel fuel may be a promising alternative for its use in diesel engines. The high viscosity and low volatility are the major drawbacks of the use of vegetable oils in diesel engines. India is the second largest cotton producing country in the world today. The cotton seeds are available in India at cheaper price.**

Experiments were conducted on 5.2 BHP single cylinder four stroke water-cooled variable compression diesel engine. Methyl ester of cottonseed oil is blended with the commercially available Xtramile diesel. Cottonseed oil methyl ester (CSOME) is blended in four different compositions varying from 10% to 40% in steps of 10 vol%. Using these four blends and Xtramile diesel brake thermal efficiency (BTE) and brake specific fuel consumption (BSFC) are determined at 17.5 compression ratio.

***Key words* – Bio-diesel, Cottonseed Oil, Transesterification, Brake Thermal Efficiency, Brake Specific Fuel Consumption**

I. INTRODUCTION

Energy is considered as a critical factor for economic growth, social development and human welfare. Since their exploration, the fossil fuels continued as the major conventional energy source with increasing trend of modernization and industrialization, the world energy demand is also

growing at faster rate. To cope up the increasing energy demand, majority of the developing countries import crude oil apart from their indigenous production. This puts extra burden on home economy. Hence, it is utmost important that the options for substitution of petroleum fuels be explored to control this burgeoning import bill.

There is limited reserve of the fossil fuels and the world has already faced the energy crisis of seventies concerning uncertainties in their supply fossil fuels are currently the dominant global source of co_2 emissions and their combustion is stronger threat to clean environment increasing industrialization, growing energy demand, limited reserve of fossil fuels and increasing environmental pollution have jointly necessitating exploring some alternative of conventional liquid fuels. Among the possible options of the conventional liquid fuels, vegetable oils have been considered as appropriate alternative due to prevalent fuel properties [1]. It was thought of as feasible option quite earlier. However despite the technical feasibility, vegetable oils as fuel could not get acceptance, as they were more expensive than petroleum fuels. This led to the retardation in scientific efforts to investigate the further acceptability of vegetable oil as fuel. Later due to numerous factors as stated earlier, created resumed interest of researchers in vegetable oil as substitute fuel diesel engines. In view of the potential properties, large number of investigation has been carried out internationally in the area of vegetable oils as fuel [2]. Some of the vegetable oils from farm and forest origin have been identified. The most predominantly sunflower, soybean, cottonseed, canola and peanut oil have been reported as appropriate substitute of petroleum based fuels. The vegetable oils can used in diesel engines by various techniques such as fuel modification by esterification, diesel-vegetable blends, vegetable oil heating etc.[3]. The present work was undertaken to study the evaluation of diesel-cottonseed oil and their effects on engine performance. Experiments are carried out at a constant speed of 1500 rpm and at different loads between no-load to full-load with each combination of fuels. Various performance parameters such as brake specific fuel consumption, brake thermal efficiency and exhaust gas temperature are studied.

II. VEGETABLE OILS AS ALTENATE FUELS

Vegetable oils have become more attractive recently because of their environmental benefits and the fact that it is made from renewable resources. More than 100 years ago, Rudolph Diesel tested vegetable oil as the fuel for his engine.

Vegetable oils have the potential to substitute for a fraction of the petroleum distillates and petroleum based petrochemicals in the near future. Vegetable oil fuels are not now petroleum competitive fuels because they are more expensive than petroleum fuels. However, with the recent increases in petroleum prices and the uncertainties concerning petroleum availability, there is renewed interest in using vegetable oils in Diesel engines. The Diesel boiling range material is of particular interest because it has been shown to reduce particulate emissions significantly relative to diesel. There are more than 350 oil bearing crops identified, among which only sunflower, safflower, soybean, cottonseed, rapeseed and peanut oils are considered as potential alternative fuels for Diesel engines [4].

A. Direct Use of Vegetable Oils

The use of vegetable oils as an alternative renewable fuel to compete with petroleum was proposed in the beginning of the 1980's. The most advanced study with sunflower oil occurred in South Africa because of the oil embargo. The first International Conference on Plant and Vegetable Oils as fuels was held in Fargo, North Dakota, in August 1982.

III. BIO DIESEL

Bio-diesel is the name for a variety of ester-based oxygenated fuels derived from natural, renewable biological sources such as vegetable oils. Bio-diesel operates in compression ignition engines like petroleum diesel thereby requiring no essential engine modifications. Moreover it can maintain the payload capacity and range of conventional diesel. Bio-diesel fuel can be made from new or used vegetable oils and animal fats. Unlike fossil diesel, pure bio-diesel is biodegradable, nontoxic and essentially free of sulphur and aromatics.

A. Transesterification of Vegetable Oil

Chemically, transesterification (also called alcoholysis) means taking a triglyceride a molecule or a complex fatty acid, neutralizing the free fatty acids, removing the glycerin and creating an alcohol ester. A catalyst is usually used to improve the reaction rate and yield. Theoretically, the transesterification reaction is an equilibrium reaction. In this reaction, however, a larger amount of methanol was used to shift the reaction equilibrium to the right side and produce more methyl esters, the proposed product. Among the alcohols that can be used in the transesterification reaction are methanol, ethanol, propanol, butanol and amyl alcohol. Methanol and ethanol are used most frequently. Ethanol is preferred alcohol in the transesterification process compared to methanol because it is derived from agricultural products and is renewable and biologically less objectionable in the environment. However methanol is used because of its low cost and its physical and chemical advantages (polar and shortest chain alcohol). Alkalis, acids or enzymes can catalyze the transesterification reaction.

The most important variables that influence trans-esterification reaction time and conversion are: Oil temperature, Reaction temperature, Ratio of alcohol to oil, Type of catalyst and concentration, Intensity of mixing and purity of reactants [5-7].

B. Benefits of Biodiesel:

The lifecycle production and use of biodiesel produces approximately 80% less carbon dioxide emissions, and almost 100% less sulphur dioxide. Combustion of biodiesel alone produces over a 90% reduction in total unburned hydrocarbons, and a 75-90% reduction in aromatic hydrocarbons. Biodiesel further provides significant reductions in particulates and carbon monoxide than conventional diesel fuel. Neat biodiesel fuel is non-toxic and biodegradable. Cetane number is significantly higher than that of conventional diesel fuel. Lubricity is improved over that of conventional diesel fuel.

C. Disadvantages of Bio-diesel:

Quality of bio-diesel depends on the blend thus quality can be tampered. Bio-diesel has excellent solvent properties. Any deposits in the filters and in the delivery systems may be dissolved by bio-diesel and result in need for replacement of the filters. There may be problems of winter operability. Neat bio-diesel demands compatible elastomers (hoses, gaskets, etc.).

D. Cottonseed Oil

India is the fifth largest cotton producing country in the world today, the first-four being the U.S, china, Russia and Brazil. Our country produces about 8% of the world cotton. Cotton is a tropical plant. Cottonseed oil is a vegetable oil extracted from the seeds of the cotton. After being freed from the linters, the seeds are shelled and then crushed and pressed or treated with solvents to obtain the crude cotton seed oil. Cotton seed oil is one of the most widely available oils and it is relatively inexpensive.

IV. FUEL PROPERTIES

The properties of the test fuels are determined and are listed in table I

TABLE I
TEST FUEL PROPERTIES

	CSOME	Xtramile Diesel
Specific Gravity	0.874	0.848
Flash Point ˚C	138	46
Fire Point ˚C	167	53
Kinematic Viscosity at 40˚C (mm2/s)	4.3	4.02
Calorific Value (kj/kg)	40860	43130

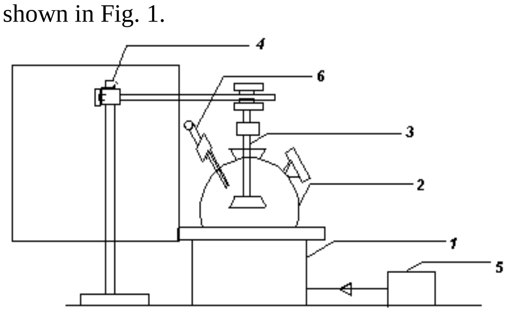
V. EXPERIMENTAL SETUP

The experimental setup consists of

1. Setup for transesterification of cottonseed oil.
2. Setup for the investigation of the performance characteristics of C.I engine using cottonseed oil and diesel blends.

A. Transesterification of cottonseed oil:

The transesterification setup consists of a round bottom flask. A heater with temperature control was used for heating the oil in round bottom flask. A stirrer was used for mixing the oil vigorously. Transesterification involves making triglycerides of cottonseed oil to react with methyl alcohol in the presence of a catalyst (NaOH) to produce glycerol and fatty acid ester. For this process, a specified amount (1000gm) of cottonseed oil, (200ml) methanol and sodium hydroxide (50gm) were taken in around bottom flask. The contents were heated up to 70^{o}C and stirred vigorously till ester formation begin (approximately for one hour) .The mixture was allowed to cool over night without stirring. Two layers were formed. The bottom layer consists of glycerol and fatty acids and top layer was the ester. Fatty acids and glycerol were removed by using a separator vessel. Pictorial representation of the apparatus used for the transesterification of the cottonseed oil is shown in Fig. 1.



1_Heater 2_Flask 3_Stirrer 4_Stirrer stand 5_Power point 6_Thermometer

Fig. 1 Experimental setup for esterification process

B. Engine experimental setup

The experimental setup used for finding the performance of the engine is shown Fig. 2. The specifications of the engine are listed below.

Specifications of the engine:
Name of the engine: KIRLOSKAR, TV1
General details: 4 stroke, C.I, Vertical
Type of cooling: Water cooled
Number of cylinders: 1
Bore: 87.5 mm
Stroke: 110mm
Rated power: 5.2 B.H.P at 1500 rpm
Dynamometer: Eddy current dynamometer
Compression ratio: 12:1 to 17.5:1

Fig. 2 Engine experimental setup

Four stroke single cylinder water cooled variable compression ratio diesel engine used is shown in Fig. 2 which is coupled to an eddy current dynamometer by using jaw coupling. A standard air tank with orifice plates is fixed within the rig for measuring the actual volume of air drawn into the cylinder. The entire setup is mounted on a centrally balanced base frame. A differential transduce is provided at the orifice plate in order to facilitate the measurement of air flow rate. Fuel sensor and glass tube mounted to the fuel tank measures the fuel consumed by the engine. The thermocouples necessary for the measurement of temperature at different locations are provided. A pressure transducer is fitted to the cylinder head. The speed of the engine is measured using a non-contact proximity sensor, while torque is measured using strain gauge based load cell. All the sensors are routed to the computerized data acquisition system for acquiring the readings which is situated in control panel.

In the present work, experiments were carried out at a constant speed of 1500 rpm with varying load conditions, from 20% to 80% in steps of 20%. Engine is tested by using CSOME – Xtramile diesel blends and Xtramile diesel (XB0). Blending of cottonseed oil methyl ester with Xtramile diesel is done from 10% to 40% in steps of 10 volume%. Following notations are given XB10, XB20, XB30 and XB40 for 10%, 20%, 30%, and 40% blends respectively

VI. RESULTS AND DISCUSSIONS

Experiments were conducted with Xtramile diesel, blends of CSOME with xtramile diesel. Performance of the engine was studied for the above fuel combinations. The results were plotted.

1. The variation of the brake thermal efficiency with load for xtramile diesel and CSOME blends are shown in Figure3. The brake thermal efficiency is always found to be lower with CSOME blends as compared with xtramile diesel. This is because of the fuel properties such as viscosity and density. Blends of CSOME are having It is observed that Brake thermal efficiency is increasing with increase in load.

2. Figure 4 shows the plots of brake specific fuel consumption against load for the CSOME blends and xtramile diesel. It is observed that brake specific fuel consumption for blends of CSOME in different proportions is more when compared with xtramile diesel. This is due to the lower calorific values of the blends of CSOME when compared with xtramile diesel.

3. The variation of the exhaust gas temperature with load for different fuels used is shown in Fig. 5. It is observed that exhaust gas temp is high for blends of CSOME when compared to xtramile diesel for the operating range. This is because with increase in load the temperature of combustion chamber increases as more fuel is burned and thus resulting in higher exhaust gas temperature.

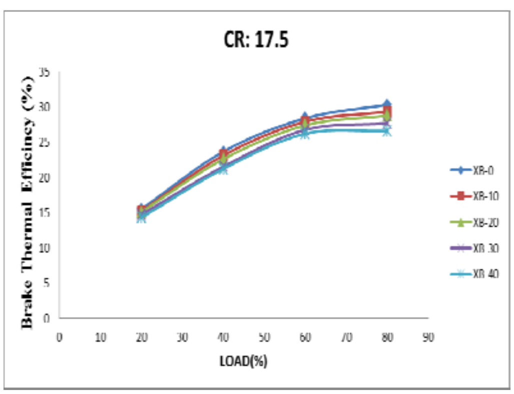


Fig.3 Variation of brake thermal efficiency vs. load

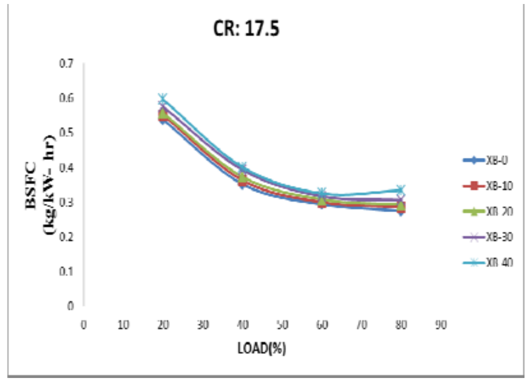


Fig: 4.Variation of brake specific fuel consumption vs. load.

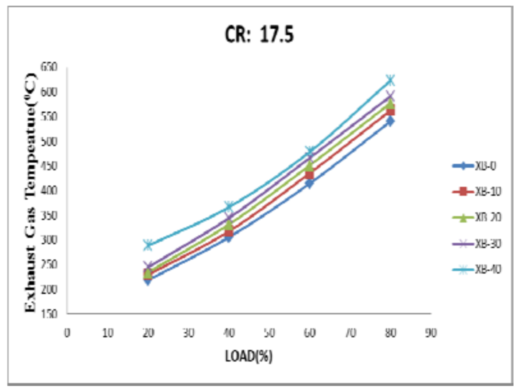


Fig.5 Variation of exhaust gas temperature vs. load

VII. CONCLUSIONS

- Properties of the 10% and 20% blends of CSOME are nearer to the diesel fuel.
- The performance of the cottonseed oil methyl ester fuelled engine is comparable with diesel engine.
- Engine could be run without any difficulty using cottonseed oil methyl ester blends.
- These blends of cottonseed oil can be recommended for present diesel engines without any modification.
- Thus the above investigations suggest that esterified vegetable oils can be effectively employed in emergency as a suitable alternative fuel in existing diesel engine.

REFERENCES

[1] B.S.Samaga, "vegetable oil as alternative fuels for the C.I. engines", *VIII National conference on I.C engines and combustion* 1983.

[2] B.N.Jajoo and R.S.Keoti, "Evaluation of Vegetable oils as Supplementary Fuels for Diesel Engines" *XV National conference on I.C engines and combustion*, Anna University, Chennai, 1997.

[3] Rosca Radu and Zugravel Mircea, "The Use of Sunflower oil in Diesel Engines", *Transactions of Society of Automotive Engineers*, paper no.972979, USA

[4] V.V.Mahajani, "Sustainable development through bio diesel", Institute of chemical Technology, University of Mumbai.

[5] Dr.D.K.Tuli," Bio diesel: An alternative fuel", Indian Oil Corporation (R&D).

[6] Ayhan Demirbas, "A survey of bio diesel fuels from vegetable oils via catalytic and non catalytic supercritical alcohol transesterifications and other methods" *Journal of Energy Conversion and Management* September 2002

[7] M.Sai Murugan, K.Ganesan and S.Karhtick, Bio diesel as an alternative fuel for diesel engine", proceedings of the *All India seminar/conference on advances in Mechanical Engineering*, S.V.U.College of Engineering, Tirupati, Aug.2004.

[8] www.journeytoforever.com

[9] www.energyquest.ca.gov

[10] www.howstuffworks.com