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Experimental Investigation of Compressed Ignition Engine Using Cotton Seed Oil Methyl Ester as Alternative Fuel

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Abstract: — *this paper gives the brief out line about the worldwide production cottonseed & its oil, Cotton Seed Oil (CSO) properties, its comparison with diesel and Jatropha biodiesel. It investigates the performance of a diesel engine using diesel fuel and cottonseed oil (CSO) biodiesel in terms of brake thermal efficiency and indicated thermal efficiency for conventional diesel, cottonseed oil, as well as for Jatropha oil. For this aim, A Single Cylinder, 4-stroke vertical, water-cooled, self-governed diesel engine developing 5 HP at 1500 rpm (Rope brake dynamometer with spring balances and loading screw. Brake drum diameter = 0.400 m.) engine is selected for the testing with diesel fuel and neat bio-diesel, which is cottonseed oil methyl ester, at full load conditions. The evaluation of theoretical data showed that the brake thermal efficiency and indicated thermal efficiency of CSO biodiesel was slightly higher than that of diesel fuel and Jatropha oil. This study reveals that the use of cottonseed oil biodiesel improves the performance parameters of CI engine compared to conventional diesel fuel.*

Keywords:—*Alternative fuel, Biodiesel, cottonseed oil methyl ester, Engine Performance.*

I. Introduction

Because of the reduction of petroleum of reserves and air pollution emerged from exhaust emissions, there have been great efforts to use alternative fuels in diesel engines for substitution diesel fuel **[1]**. Research on vegetable oil use in diesel engine is still progressing today. The results of exhaust emissions characteristics of ordinary Malaysian coconut oil blended with conventional diesel oil in a diesel engine. The results showed that the addition of 30% coconut oil with diesel oil produced higher brake power with a net reduction in exhaust emissions. The experiments were undertaken to test a diesel engine using oil composed of cottonseed oil and conventional diesel fuel **[12, 13]**. The experimental results showed that a mixing ratio of 30% cottonseed oil and 70% diesel was optimal in ensuring relatively high thermal efficiency of the engine. The use of hazelnut oil as an alternative fuel in pre-chamber diesel engines, and compared it with diesel **[14]**. The results showed that the hazelnut oil may be employed in most diesel operating conditions in terms of the performance and emission parameters without any modification or preheating of the fuels. A series of engine tests, with and without preheating have been conducted using each of the above fuel blends for comparative performance evaluation.

The results of the experiment in each case were compared with baseline data of diesel fuel. Significant improvements have been observed in the performance parameters of the engine as well as exhaust emissions, when lower blends of karanja oil were used with preheating and also without preheating. Karanja oil blends with diesel (up to K50) without preheating as well as with preheating, can replace diesel for operating the CI engines, giving lower emissions and improved engine performance. It can also be concluded that preheating of the fuel has some positive effects on engine performance and emissions when operating with vegetable oil **[10, 11]**. A heat exchanger, preheated *Jatropha* oil has the potential to be a substitute fuel for diesel engines. Optimal fuel inlet temperature was found to be 80°C considering the brake thermal efficiency, brake specific energy consumption and gaseous emissions. A comparable engine performance and emissions are reported by using preheated peanut, sunflower and canola oils in two DI diesel engines. Seven non-edible vegetable oils including *Jatropha* oil as an alternative fuel for diesel engine **[5, 6]**. *Jatropha* oil was identified as a leading candidate for the commercialization.

Vegetable oils are considered to be suitable for Thailand due to its agricultural economy, and can help alleviate the problem of under-priced agricultural products. Thailand is blessed with many feedstocks, suitable for vegetable oil production such as palm, *Jatropha*, coconut and sunflower. These crops can be used to produce vegetable oil for usage in the agricultural sector; to decrease the dependence on imported oil and to help stabilize the price of agricultural products. The use of non-edible vegetable oils compared to edible oils is very significant because of the tremendous demand for edible oils as food, making them too expensive to be used as fuel at present. The scientific name of *Jatropha* is *Jatrophs curcas* L. and *Jatropha* oil is one such kind of non-edible vegetable oil. Not only does *Jatropha* have a yield of well over 200 gallons of oil per acre per year, eleven times that com and it can potentially be used for food crops in subsequent years. *Jatropha* is a perennial which can grow in arid conditions on any kind of ground, and does not suffer in droughts or require irrigation. Therefore, unlike the common biofuel crops of today (corn and sugar); they are very easy to cultivate, even on poor land. *Jatropha* is fast growing, begins yielding oil in the second year and continues for forty to fifty years. Optimal yields are obtained from the sixth year. By investigating *Jatropha* oil and its methyl ester to find out their suitability for use as petro-diesel.

Different properties of *Jatropha* oil were experimentally determined and compared with theoretical equations developed in the study. The study suggested that *Jatropha* oil can be used as a source of triglycerides in manufacture of biodiesel cost-effectively. *Jatropha* oil in a diesel engine is investigated **[3, 4]**. Acceptable thermal efficiencies of the engine were obtained with blends up to J50. The performance of *Jatropha* oil blends in a diesel engine is examined. The most significant conclusion from the study was that the J2.6 produced maximum values of brake power and brake thermal efficiency as well as minimum values of specific fuel consumption. It indicates that the successful use of *Jatropha* oil is a function of engine type, and percentage of *Jatropha* oil in the blends.

Figure 1: Jatropha fruits and seeds

Different vegetable oils such as soybean oil, castor oil, rapeseed oil, Jatropha curcas oil, cottonseed oil are considered as alternative fuels for diesel engines. The important advantages of vegetable oils as fuel are that they are renewable, can be produced locally, cheap and less pollutant for environment compared to diesel fuel. According to literature, use of vegetable oils as fuel in diesel engines causes several problems, namely poor fuel atomization and low volatility originated from their high viscosity, high molecular weight and density. After the use of vegetable oils for a long period of time, these problems may cause important engine failures. To improve fuel properties and decrease viscosity and density of oils, various methods such as heating the vegetable oils, mixing with diesel fuel, emulsion with alcohol and transesterification have been employed **[7, 8 and 9]**. Many experiments have clearly revealed that the widely applied and convenient method for reduction of viscosity and density of vegetable oils is transesterification.

The fuels produced via transesterification of the oils are called biodiesel. An important property of biodiesel is its oxygen content of about 10%, which is usually not contained in diesel fuel. In spite of transesterification treatment, viscosity and density of biodiesel is still higher than that of diesel fuel. It is well known that viscosity of fuels affects some processes such as atomization, vaporization and fuel–air mixing in the engine. The engine performance and emissions of diesel engines fuelled with biodiesels have been examined by many investigators. The biodiesels used in the experiments performed by these investigators were produced from different vegetable oils such as cottonseed, sunflower, rapeseed, soybean, karanja, rubber seed, etc **[2]**. In this study, the performance parameters and thermal efficiencies of a single-cylinder, four-stroke diesel engine using diesel fuel and biodiesel, which is cottonseed oil methyl ester (CSOME), have been calculated. The calculations are done from theoretical data for petroleum diesel, Jatropha biodiesel and cottonseed oil methyl ester.

1.1 Fuel Modification

The alternative diesel fuels must be technically and environmentally acceptable and economically competitive. From the view point s of requirements, triglycerides (vegetable oils or animal fats) and their derivatives may be considered as viable alternative for diesel fuels. The problems with substituting triglycerides for diesel fuels are mostly associated with high viscosity, low volatility and poly un-saturated character. The problems have been mitigated by developing vegetable oil derivatives that approximate the properties and performance and make them compatible with the hydro carbon based diesel fuels by following methods: Dilution (blending), Pyrolysis (cracking), Micro-emulsification and Transesterification.

1.1.1 Transesterification

Transesterification is the reaction of vegetable oil or animal fat with an alcohol, in most cases methanol, to formesters and glycerol. The transesterification reaction is affected by alcohol type, molar ratio of glycerides to alcohol, type and amount of catalyst, reaction temperature, reaction time and free fatty acids and water content of vegetable oils or animal fats. The transesterification reaction proceeds with or without a catalyst by using primary or secondary monohydric aliphatic generally, the reaction temperature near the boiling point of the alcohol is recommended. Nevertheless, the reaction may be carried out at room temperature. The reactions take place at low temperatures (~65°C) and at modest pressures (2 atm, 1 atm = 101.325 kPa). Bio-diesel is further purified by washing and evaporation to remove any remaining methanol. The oil (87%), alcohol (9%), and catalyst (1%) are the inputs in the production of bio-diesel (86%), the main output. Pretreatment is not required if the reaction is carried out under high pressure (9000 kPa) and high temperature (~240°C), where transesterification take place with maximum yield obtained at temperatures ranging from 60 to 80°C at a molar ratio of 6:1. The alcohols employed in the transesterification are generally short chain alcohols such as methanol, ethanol, propanol, and butanol. It was reported that when transesterification of soybean oil using methanol, ethanol and butanol was performed, 96–98% of ester could be obtained after 1 h of reaction as shown in Table 1 & 1.1.

Table 1: Properties of Diesel and Crude Oils

S.NO	PROPERTY	DIESEL	COTTONSEED	NEEMSEED
1	Calorific Value	43,000 kJ/kg	39,648kJ/kg	35,125 kJ/kg
2	Flash Point	44^0 C	234^0C	178^0C
3	Fire Point	49^0 C	192^0 C	209^0 C
4	Viscosity	0.278 poise	2.52 poise	1.864 poise
5	Density	835 kg/m^3	850 kg/m^3	928 kg/m^3

Table 1.1: Blending Percentage of Fuel

NOTATION	FUEL QUANTITY (Liters)	BIO-DIESEL QUANTITY (ml)	DIESEL QUANTITY (ml)
C10	1	100	900
C20	1	200	800
C30	1	300	700

II. CSO Fuel Properties

The comparison of chemical properties of cottonseed oil (CSO) with Jatropha and Petroleum Diesel is as under as shown in the Table 2.

Table 2: Chemical Properties of CSO, Jatropha, Diesel

S.No	Properties	Cotton seed oil	Jatropha oil	Diesel
1	Specific Gravity	0.91	0.8621	
2	Flash point (0C)	207	174	56
3	Calorific Value(MJ/Kg	38.0	39.174	49.62
4	Cetane No.	52	46-70	51

III. Experimental Setup

The CI engine with rope brake dynamometer manufactured by Kirloskar Oil Engine Ltd. India was selected. Specifications:

1. Engine: Single Cylinder, vertical, water cooled, self-governed diesel engine developing 5 HP at 1500 rpm

2. Brake Dynamometer: Rope brake with spring balances and loading screw. Brake drum diameter = 0.400 m.

IV. Theoretical Calculations

From the above theoretical data (Table: 1) and engine specification values are find out for CSO as shown in Table 2.

i. Stroke to bore ratio = L/d = 110/ 80 = **1.3750**

ii. Displacement or swept volume = Vs= (π/4) ×d2 ×L = (π /4) × (0.08)2 ×0.11 = **5.5292 ×10 - 4 m3**

iii. Cubic Capacity = Vs × K (K= No . Of Cylinder) = **5.5292 ×10 - c1 = 5.5292 ×10 - 4 m3**

iv. Indicated power = ip = 5HP = **3.7 Kw**

v. Indicated thermal efficiency = η ith = ip / mass of fuel × CV = 3.7 /(4.69×10 - 4 × 38.0 ×10 3) = **0.2076 % $\eta\ i^{th}$ = 20.76%**

vi. Brake power= bp = η mech × ip = 0.8 × 3.7 = **2.96**

vii. Brake thermal efficiency = η bth. = bp /(mass of fuel ×CV of fuel) = 2.96 / (4.69×10 - 4 × 38.0 ×103) = **0.166080 % $\eta\ b^{th}$ =16.61 %**

viii. Frictional power = fp = ip – bp 3.7-2.96=**0.74Kw**

Table 2: Efficiencies Comparison of CSO, Jatropha, Diesel

S.No	Properties	Jatropha	Cotton seed oil	Diesel
1	Brake thermal efficiency(%)	16.11	16.61	14.69
2	Indicated thermal efficiency(%)	20.13	20.70	17.57

V. Conclusions

At constant speed of 1500 rpm it is observed that brake thermal efficiency ($\eta\ b^{th}$) with use of CSO methyl ester is slightly greater in comparison with Jatropha biodiesel and petroleum diesel. It is also observed that indicated thermal efficiency ($\eta\ i^{th}$) with use of CSO methyl ester is considerably greater (i.e. 20.70%) in comparison with Jatropha biodiesel and petroleum diesel. Thus, in developing nations CSO is available in ample quantity, if it is processed as per the fuel requirements in mass production then there is a chance for reducing its overall cost. Then it will become a renewable source of energy in the case of diesel fuel scarcity

References

[1] Kapilan N. Nadar and Rana Pratap Reddy. Combustion And Emission Characteristics Of a Dual Fuel Engine Operated With Mahua Oil and Liquefied Petroleum Gas. Thermal science: Vol. 12 (2008), No. 1, pp. 115-123

[2] Kapilan N. Nadar, Rana Pratap Reddy and Eswara Rao Anjuri , comparison of performance of biodiesels of mahua oil and Gingili oil in dual fuel engine. Thermal science: Vol. 12 (2008), No. 1, pp. 151-156

[3] Lakshmi Narayana Rao Gattamaneni, Saravanan Subramani, Sampath santhanam, And Rajagopal Kuderucombustion And Emission Characteristics Of Diesel Engine Fuelled With Rice Bran Oil Methyl Ester And Its Diesel Blends. Thermal science: Vol. 12 (2008), No. 1, Pp. 139-150

[4] D. Ramesh and A. Sampathrajan. ―Investigations on Performance and Emission Characteristics of Diesel Engine With Jatropha Biodiesel and Its Blends‖. Agricultural Engineering International: the CIGR Ejournal. Manuscript EE 07 013. Vol. X. March, 2008.

[5] B.K. Barnwal, M.P. Sharma, "Prospects of biodiesel production from vegetable oils India," Renewable and Sustainable Energy Reviews, Vol. 9, 2005, 363-378.

[6] D. Agarwal, L. Kumar, A.K. Agarwal, "Performance Evaluation of a Vegetable oil fuelled CI Engine". Renewable Energy, accepted 29th June 2007.

[7] R. Sarin, M. Sharma, " Jatropha Palm biodiesel blends: An optimum mix for Asia", FUEL, Vol. 86, 2007, 1365-71.

[8] S. P. Chincholkar*, Saurabh Srivastava, A. Rehman, Savita Dixit and Atul Lanjewar, 22 Biodiesel as an Alternative Fuel for Pollution Control in Diesel EngineAsian J. Exp. Sci., Vol. 19, No. 2, 2005, 13-

[9] T. Venkateswara Rao a,*, G. Prabhakar Rao a, and K. Hema Chandra Reddy b , Experimental Investigation of Pongamia, Jatropha and NeemMethyl Esters as Biodiesel on C.I. Engine Volume 2, Number 2, Jun. 2008ISSN 1995-6665Pages 117 – 122, Jordan Journal of Mechanical and Industrial Engineering,

[10] F. Karaosmanoplu," Vegetable oil fuels: A review", Energy Sources, Vol. 70, 1999, 221-231.

[11] Yasuhito shibata, Hiroshi koseki, and Okiyasu shimizu, spontaneous ignition of biodiesel:a potential fire risk, thermal Science: Vol. 12 (2008), No. 2, pp. 149-158

[12] Breda kegl and Stanislav pehan, influence of biodiesel on injection, Fuel spray, and engine characteristics, thermal science: Vol. 12 (2008), No. 2, pp. 171-182

[13] V. Nagaraju and N. Henein,Wayne State University and A. Quader and M. Wu Delphi, Effect of Biodiesel (B-20) on Performance and Emissions in a Single Cylinder HSDI Diesel Engine, SAE technical paper series 2008-01-1401, 2008 World Congress Detroit, Michigan April 14-17, 2008.

[14] Agarwal AK, Rajamanoharan K (2009). Experimental investigations of Yilmaz N, Morton B (2011). Effects of preheating vegetable oils on performance and emission characteristics of two diesel engines. Biomass Bioenerg., 35: 2028-2033.