A PRODUCTION OF BIODIESEL FROM WASTE COTTON SEED OIL AND TESTING ON SMALL CAPACITY DIESEL ENGINE

Sandeep Singh[1], Sumeet Sharma[2] & S.K. Mohapatra[3]

[1]Department of Mechanical Engineering, BBSBEC, Fatehgarh Sahib-140407, (India)

[2,3] Department of Mechanical Engineering, Thapar University,Patiala-147004,(India)

ABSTRACT

Many researchers have done a lot of experimental studies in the field of biodiesel to find an alternative to mineral diesel. It has shown that cotton seed biodiesel can be used as an alternative fuel in diesel engine without modification. An experimental study was carried out to find out the effect of blends (B10, B15, B20) of cotton seed biodiesel with diesel on engine performance .Waste cotton seed oil is an edible vegetable oil, which is used as a large quantity in various sweet shops, confectionaries, college canteens etc and very little research has been done to utilize this waste oil as a replacement for mineral diesel. In the present work, the transesterification process for production of cotton seed oil methyl ester has been investigated. Results showed that biodiesel obtained under the optimum conditions has comparable properties to substitute mineral diesel, hence, cotton seed oil methyl ester could be recommended as a mineral diesel fuel substitute for compression ignition (CI) engines in transportation as well as in the agriculture sector.

Keywords: Biodiesel, Cotton seed oil, Transesterification

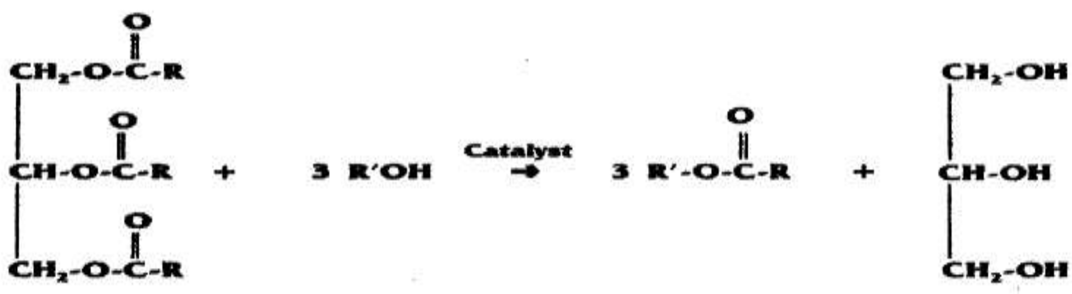
I INTRODUCTION

The diesel engine is typically more efficient than the gasoline engine due to higher compression ratio. Diesel engines also do not suffer from size and power limitations, which the SI engine is prone to. Hence, keeping these factors into account, they are the invariable choice for industrial, heavy duty and truck/trailer engines. Buses and certain locomotives also use diesel engines. India is an agriculture based economy and agriculture is an energy transformation process as energy is produced and consumed in it [1]. The production of energy is carried through process of photosynthesis in which solar energy is converted into biomass. Agriculture in India is heavily based upon petroleum and its derived products such as fertilizers and pesticides. Thus, keeping the above discussion in mind it is imperative for the Indian economy to find a substitute to fuel variety of diesel engines that it is so much dependent upon so as to fulfill its journey to becoming a developed nation [3,5].

The consumption of diesel is 4-5 times higher than petrol in India. Due to the shortage of petroleum products and its increasing cost, efforts are on to develop alternative fuels especially, to the diesel oil for full or partial replacement [7]. It has been found that the vegetable oils are promising fuels because their properties are similar to that of diesel and are produced easily and renewably from the crops [9, 12]. Vegetable oils have comparable energy density, cetane number, heat of vaporization and stoichiometric air–fuel ratio with that of the diesel fuel [2].

II TRANSESTERIFICATION

To obtain biodiesel, the vegetable oil or animal fat is subjected to a chemical reaction termed as transesterification. In this reaction, the vegetable oil or animal fat is reacted in the presence of a catalyst (usually a base like KOH) with an alcohol (usually methanol CH_3OH) to give the corresponding alkyl esters (or for methanol, the methyl esters) of the FA (fatty acid) mixture that is found in the parent vegetable oil or animal fat. Figure 1 below depicts the transesterification reaction [8, 12].



Triacylglycerols (Vegetable oil) **Alcohol** **Alkyl Ester (Biodiesel)** **Glycerol**

Figure 1 [2]

The reaction mix is kept just above the boiling point of the alcohol (around 70 °C, 158 °F) to speed up the reaction though some systems recommend the reaction take place anywhere from room temperature to 55 °C (131 °F) for safety reasons. Recommended reaction time varies from 1 to 8 hours; under normal conditions the reaction rate will double with every 10 °C increase in reaction temperature [14]. Excess alcohol is normally used to ensure total conversion of the fat or oil to its esters. The glycerin phase is much denser than biodiesel phase and the two can be gravity separated with glycerine simply drawn off the bottom of the settling vessel. In some cases, a centrifuge is used to separate the two materials faster [15].

III ENGINE TEST

A four stroke, single cylinder variable compression ratio diesel engine is employed for the present study. AVL 437 Smoke meter is employed to measure the smoke opacity of exhaust gas emitted from the diesel engine. The performance tests are carried out on the C.I. engine using various blends of biodiesel and diesel as fuels. The tests are conducted at the constant speed of 1500 rpm at various loads. The experimental data generated are documented and presented here using appropriate graphs. These tests are aimed at optimizing the concentration of ester to be used in the biodiesel-diesel mixture for 1 hr engine test operation. In each experiment, engine parameters related to thermal performance of engine such as brake power, brake thermal efficiency, brake specific fuel consumption, exhaust gas temperature and applied load are measured.

IV COMPARATIVE ANALYSIS OF RICE BRAN OIL BIODIESEL AND DIESEL

Fuel properties	Cotton seed biodiesel	Diesel
Density (Kg/m^3)	890	831
Viscosity (cSt)	3.6	3.2
Flash point (^{0}C)	155	60
Cetane number	50.4	46.3
Calorific value (KJ/Kg)	40000	42000

V RESULTS AND DISCUSSIONS

Worldwide, biodiesel is largely produced by methyl transesterification of oils. The recovery of ester as well as its kinematic viscosity is affected by the transesterification process parameters such as catalyst concentration, reaction temperature and reaction time. The above parameters were standardized to obtain methyl ester of waste cotton seed oil with lowest possible kinematic viscosity and highest level of recovery. The engine performance parameters of B10, B15, B20 and diesel were compared.

5.1 Brake Power (BP)

Graph of the brake power (BP) as a function of load obtained during engine operation on different blends of biodiesel i.e. B10, B15 and B20 with diesel (petrodiesel) at compression ratio of 18:1 has been shown in Figure 5.1.

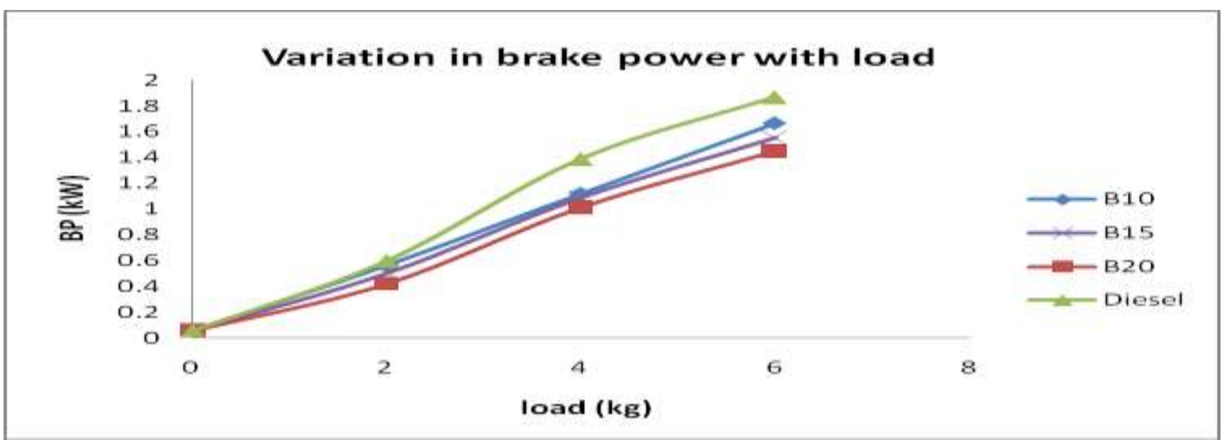


Fig 5.1, Variation in brake power with change in load

Brake power of the engine increases with increase in the load on the engine. Brake power is the function of calorific value and the torque applied. Diesel has more calorific value than the biodiesel, so diesel has the highest brake power among the different blends of biodiesel. Due to the more calorific value of B10 blend of biodiesel than B15 and B20, it has the more brake power as shown in figure 5.1. It can also be seen that as we increases the load, torque increases and thus there is an increase in brake power with the load.

5.2 Brake specific fuel consumption (BSFC)

Graph of the brake specific fuel consumption (bsfc) as a function of load obtained during engine operation on different blends of biodiesel i.e. B10, B15 and B20 with diesel (petrodiesel) at compression ratio of 18:1 has been shown in Figure 5.2.

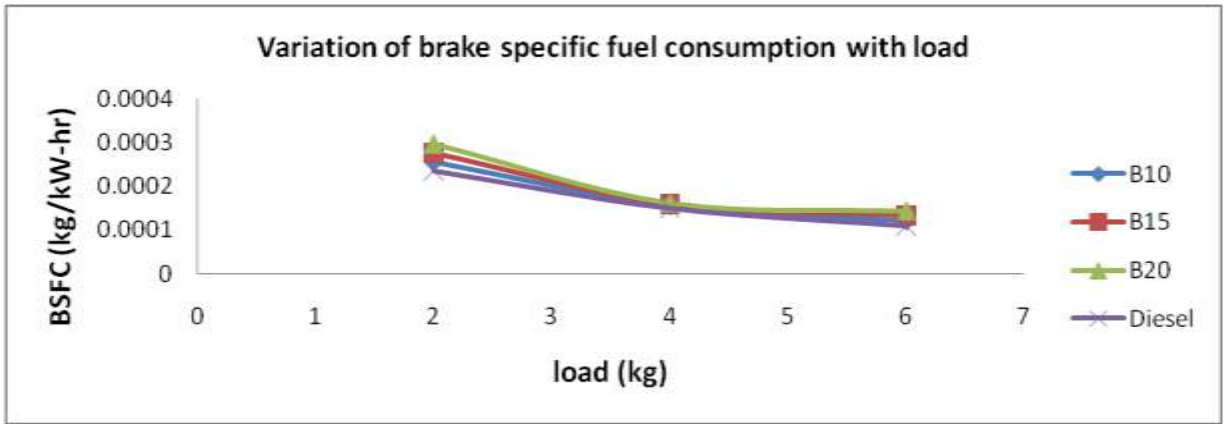


Fig 5.2, Variation in brake specific fuel consumption with change in load

For all blends and petro diesel tested, bsfc decreased with increase in load. One possible explanation for this reduction is the higher percentage of increase in brake power with load as compared to fuel consumption. In case of biodiesel mixtures, the bsfc values were determined to be higher than those of neat diesel fuel. This trend was observed owing to the fact that biodiesel mixtures have a lower heating value than does neat diesel fuel, and thus more biodiesel mixtures was required for the maintenance of a constant power output. Among the three different blends of biodiesel B10 has the lowest value of brake specific fuel consumption.

5.3 Brake thermal efficiency (BTE)

Graph of the brake thermal efficiency as a function of load obtained during engine operation on different blends of biodiesel i.e. B10, B15 and B20 with diesel (petrodiesel) at compression ratio of 18:1 have been shown in Figure 5.3.

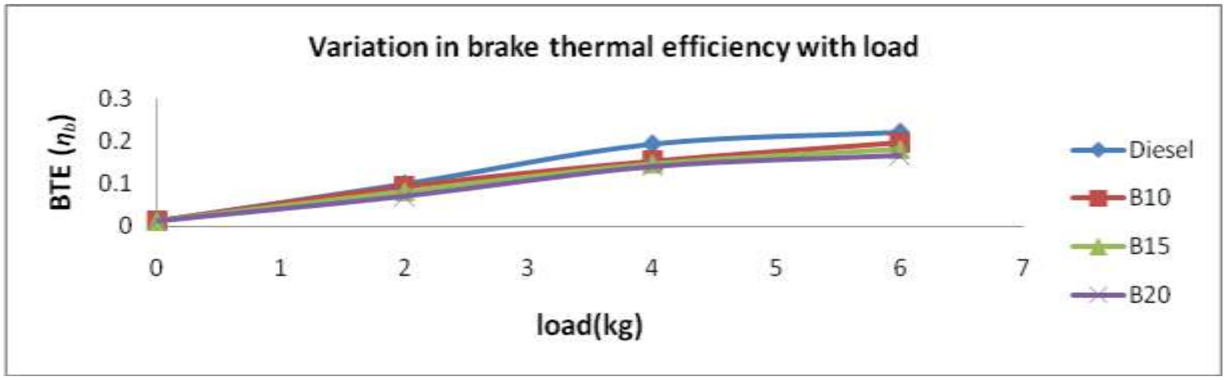


Fig 5.3, Variation in brake thermal efficiency with change in load

In all cases, brake thermal efficiency increases with an increase in load. This can be attributed to reduction in heat loss and increase in power with increase in load. It is also observed that diesel exhibits slightly higher thermal efficiency at most of the loads than CSOME and its blends. The factors like lower heating values and higher viscosity of the esters may affect the mixture formation process and hence result in slow combustion hence reducing the brake thermal efficiency. The molecules of bio-diesel (i.e. methyl ester of the oil) contain some amount of oxygen, which takes part in the combustion process. Test results indicate that when the mass percent of fuel oxygen exceeds beyond some limit, the oxygen loses its positive influence on the fuel energy conversion efficiency in this particular engine. So the brake thermal efficiency of diesel is more than that of biodiesel blends. Among the three different blends of biodiesel, B10 has higher brake thermal efficiency than B15 and B20.

5.4 Exhaust gas temperature (EGT)

Graph of the brake thermal efficiency as a function of load obtained during engine operation on different blends of biodiesel i.e. B10, B15 and B20 with diesel (petrodiesel) at compression ratio of 18:1 have been shown in Figure 5.4.

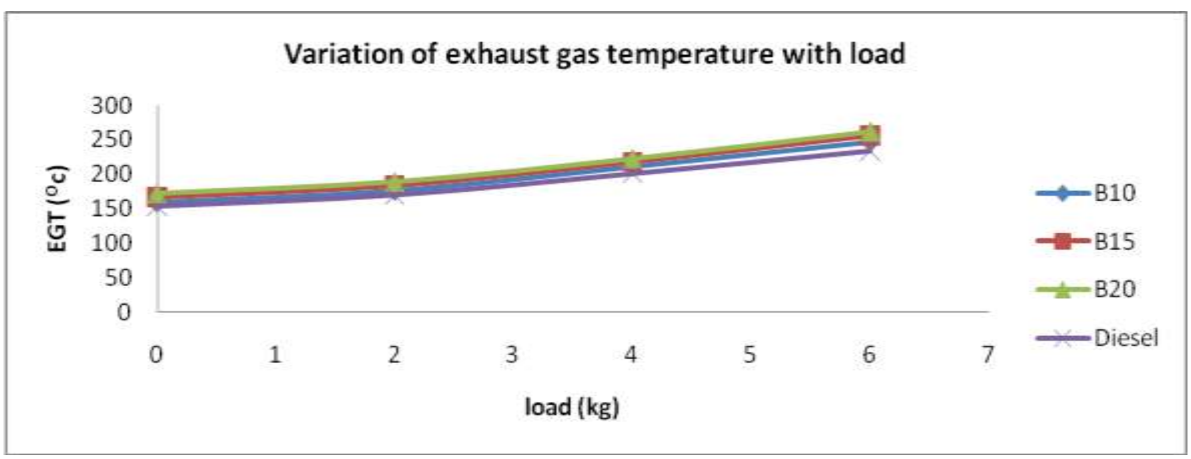


Fig: 5.4, Variation in exhaust gas temperature with change in load

The biodiesel contains some amount of oxygen molecules in the ester form. It is also taking part in combustion. When biodiesel concentration is increased, the exhaust gas temperature increases by small value. Using different blends of biodiesel of cotton seed methyl ester, higher exhaust gas temperature is attained at full load, which is indicating more energy loss in this case. The exhaust gas temperature increases with increase in load. The reason of EGT being more in the case of biodiesel blends is the presence of more oxygen atoms in the biodiesel. So, the exhaust gas temperature increases and it increases with increase in load. As the load on the engine increases, more fuel is burnt. So exhaust gas temperature increases continuously with rise in load.

VI CONCLUSIONS

The overall studies based on the production, fuel characterization, engine performance of different biodiesel blends of waste cotton seed oil methyl esters were carried out. The kinematic viscosity of diesel, waste cotton seed oil biodiesel were found as 2.8, 3.6 centistokes respectively at 40^0C. The results indicated that the waste cotton seed oil biodiesel had the kinematic viscosity 75.69 percent more than that of diesel. The waste cotton seed oil biodiesel was found to have higher flash and fire point than those of mineral diesel. The graphical results show that diesel has better performance characteristics than biodiesel and biodiesel blends. Among the three different blends of biodiesel, B10 has the better performance characteristics than B15 and B20 blend of biodiesel when fuelled in an internal combustion engine.

REFERENCES

[1] Knothe, Van Gerpen and Krahl, Michael J. Haas and Thomas A. Foglia, "The Biodiesel Handbook",2005.

[2] Md. Nurun Nabi, Md. Mustafizur Rahman, Md. Shamim Akhter, "Biodiesel from cottonseed oil and its effect on engine performance and exhaust emissions", *Applied Thermal Engineering* 29 (2009) 2265–2270.

[3] Christos E. Papadopoulos, Anastasia Lazaridou, Asimina Koutsoumba, Nikolaos Kokkinos, Achilleas Christoforidis, Nikolaos Nikolaou, "Optimization of cotton seed biodiesel quality (critical properties) through modification of its FAME composition by highly selective homogeneous hydrogenation", *Bioresource Technology*, 101 (2010) 1812–1819.

[4] Y. Zhang, M.A. Dube, D.D. McLean, M. Kates, "Biodiesel production from waste cooking oil, Process design and technological assessment", *Bioresource Technology*, 89 (2003) 1–16.

[5] Ayhan Demirbas, "The Progress and recent trends in biodiesel fuels", *Energy Conversion and Management,* 50 (2009) 14–34.

[6] M.E. Borgesa, L. Diaza, M.C. Alvarez-Galvanb, A. Brito, "High performance heterogeneous catalyst for biodiesel production from vegetal and waste oil at low temperature", *Applied Catalysis B: Environmental*, 102 (2011) 310–315.

[7] Ayhan Demirbas, "importance of biodiesel as transportation fuel", *Energy Policy,* 35 (2007) 4661–4670.

[8] S.S. Ragit, S.K. Mohapatra, K. Kundu, Prashant Gill, "Optimization of neem methyl ester from transesterification process and fuel characterization as a diesel substitute", *Biomass and Bioenergy*, 35 (2011) 1138-1144.

[9] A.P. Sathiyagnanam, and C.G. Saravanan, "Experimental Studies on the Combustion Characteristics and Performance of A Direct Injection Engine Fueled with Biodiesel/Diesel Blends", vol III,2011.

[10] A. Siva Kumar, D. Maheswar, K. Vijaya Kumar Reddy, " Comparision of Diesel Engine Performance and Emissions from Neat and Transesterified Cotton Seed Oil", *Jordan Journal of Mechanical and Industrial Engineering*, Volume 3, Number 3, September 2009 ISSN 1995-6665;pp. 190 – 197.

[11] L.Ranganathan, G.Lakshmi Narayana Rao, S.Sampath, "Experimental Investigation of a Diesel Engine Fuelled With Optimum Biodiesel Produced From Cotton Seed Oil" *European Journal of Scientific Research*, Vol.62(2011), pp. 101-115.

[12] Satishchandra Shamrao Ragit, "Process standardization, characterization and experimental investigation on the performance of biodiesel fuelled C.I.Engine", PhD. Thesis, Department of mechanical engineering, Thapar university, Patiala.

[13] R.Anand, G.R.Kannan, K.Rajasekhar Reddy and S.Velmathi, "The performance and emissions of a variable compression ratio diesel engine fuelled with biodiesel from cottonseed oil", Vol. 4, no. 9, November 2009, *ARPN Journal of Engineering and Applied Sciences*, pp. 72-87.

[14] M. L. Karont and A. M. Altschul, "Effect of moisture and of treatments with acid and alkali on rate of formation of free fatty acids in stored cottonseed", with seven figures.

[15] V.Sitaram Prasad, S.K.Mohapatra, J.K.Sharma, P.L.Bali, "Performance and Evaluation of a Diesel Engine Fuelled with Filtered Pongamia oil and its Standardization Characteristics", pp. 65-74, *SGI Reflections*, July 2011.

[16] K.Anbumani and Ajit Pal Singh, "Performance of Mustard and Neem oil Blends with Diesel Fuel in C.I.Engine", vol.5, no. 4, april 2010, *ARPN Journal of Engineering and Applied Sciences*, pp. 14-20.