INTERNATIONAL JOURNAL OF
ENERGY AND ENVIRONMENT

Volume 2, Issue 2, 2011 pp.383-390

Journal homepage: www.IJEE.IEEFoundation.org

Effect of orange peel oil addition on the performance of cottonseed oil fuelled DI diesel engine

Leenus Jesu Martin. M[1], Edwin Geo. V[2], Prithviraj. D[3]

[1] Department of Automobile Engineering, SRM University, Chennai-603203, India.
[2] Department of Mechanical Engineering, GKM College of Engineering and Technology, Chennai-600063, India.
[3] Department of Mechanical Engineering, SRM University, Chennai-603203, India.

Abstract
The world petroleum situation due to rapid depletion of fossil fuels and the degradation of the environment due to the combustion of fossil fuels have caused a resurgence of interest in finding alternative fuel. Vegetable oil based fuels are biodegradable, non-toxic and significantly reduce pollution. Cottonseed oil, which is considered, is not suitable as a fuel for diesel engines straight because of its high viscosity. Addition of a small quantity of another light vegetable oil, Orange Peel oil reduces the viscosity and improves the performance of the engine largely. Blends of varying proportions of cottonseed oil and orange peel oil were prepared, analyzed and their properties were calculated. The performance of the engine using diesel, the blends and cottonseed oil were evaluated using a single cylinder, four stroke, direct injection compression ignition engine. The results obtained were compared with baseline data generated with raw cottonseed oil and diesel. 15% of Orange peel oil by volume addition to cottonseed oil exhibited the best performance and smooth engine operation with out any problem.

Keywords: Cottonseed oil, Orange peel oil, Viscosity, Blend, Performance.

1. Introduction

Vegetable oils like Rice bran oil, Jetropha carcus, Cottonseed, Rapeseed, Sunflower and others can be used as alternate fuels for Compression Ignition engines. These fuels are renewable and sulphur free. A number of studies have been conducted with vegetable oils as engine fuels [1, 2, 3, 4]. But neat vegetable oils cause several problems related to carbon deposits build up and have poor performance compared to diesel due to the high viscosity and low volatility. To over come these problems several methods have been evolved like, transesterification of the vegetable oil in to its esters[5, 6], blending with diesel[7, 8], blending with lighter fuels like, orange peel oil, alcohols[9, 10], Oxygenated organic compounds [11] and emulsion with water.

High viscosity of the vegetable oils exerts a strong influence on the shape of the fuel spray. This leads to a poor atomization, large droplet size and high spray jet penetration inside the combustion chamber. Hence distribution of the droplets and mixture formation are poor which further results in poor utilization of air. Combustion, power developed and fuel consumption are all affected. In order to reduce viscosity and to improve the performance light vegetable oils like Eucalyptus oil and orange peel oil can be added

to the fuel [10]. The brake thermal efficiency of the engine has improved with reduction in HC and CO emissions. In this work, an attempt has been made to improve the performance of the cottonseed oil blended with orange peel oil in small proportions by volume. A significant reduction in HC, CO and smoke emissions were noticed with increased brake thermal and volumetric efficiencies.

2. Experimental setup

The present study is limited to investigate the effect of blending Orange Peel oil (OPO) with cottonseed oil (CSO) as an alternate fuel for a Compression Ignition Engine. The high viscous CSO is blended with OPO in the ratios 95:5, 90:10 and 85:15 by volume and thoroughly mixed to get the test fuel. The engine used for the test is a Kirloskar (TV1), single cylinder, four stroke, direct injection, water cooled and naturally aspirated compression ignition engine which develops 5.2 kW of power at the rated speed of 1500 rpm. This engine was used because of its popularity in the fields of power generation and agriculture. The engine is connected to a Saj Fraud eddy current dynamometer and suitable arrangements to acquire all the controlling parameters have been made. An online data acquisition system is used to connect the probes through an A/D converter and the data is fed to the computer. A specialized software (Engine Soft) for the engine analysis gives the output in the graphical and numerical form. Smoke was measured with a Bosch smoke meter. CO and HC emissions were measured with a Crypton exhaust gas analyzer. The experimental setup is shown in Figure 1.

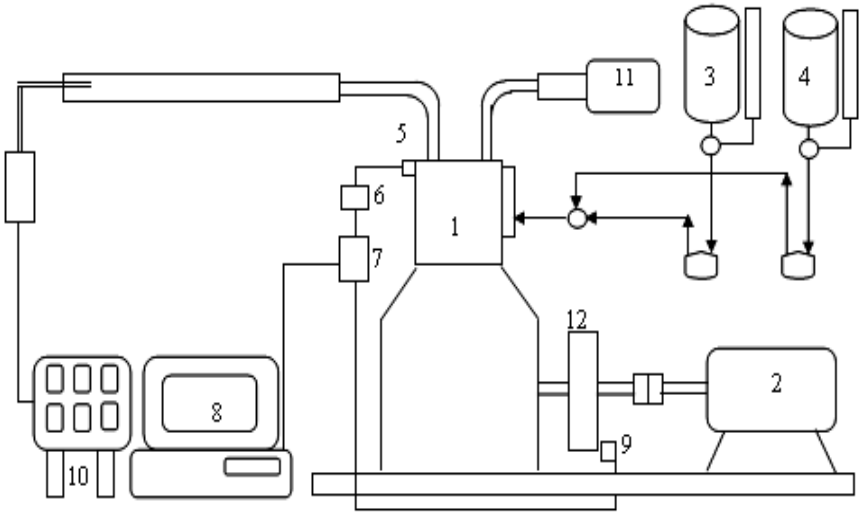

Figure 1. Schematic diagram of experimental setup: 1. Engine, 2. Eddy current dynamometer, 3. Diesel fuel tank, 4. CSO/Diesel fuel tank, 5. Pressure transducer, 6. Charge amplifier, 7. Analog to digital convertor, 8. Computer, 9. TDC pickup, 10. Exhaust gas analyzer, 11. Air surge tank, 12. Flywheel

3. Results and discussion

The results of the blend for the ratios 85% CSO with 15% OPO, 90% CSO with 10% OPO and 95% CSO with 5% OPO are compared for clarity. The values of 80% CSO with 20% OPO are very close to 85% CSO with 15% OPO values.

3.1 Brake thermal efficiency

Figure 2 shows the variation of brake thermal efficiency with OPO addition with CSO. It can be seen that the thermal efficiency is lower for CSO than diesel. This is due to the poor mixture formation of CSO due to the high viscosity, density and low volatility. The brake thermal efficiency of diesel at peak power was 32.3% but it was 28% for CSO. An addition of 5% of OPO itself improved the efficiency significantly. Increase in efficiency was noticed up to 15% OPO blend with diesel and afterwards the performance started deteriorating. The increase in brake thermal efficiency is due to the high combustion rate and improved flame propagation through the mixture, which has resulted in a rapid heat release.

3.2 Volumetric efficiency

Figure 3 shows the variation of volumetric efficiency of diesel, CSO and the blends. Volumetric efficiency is lower for CSO than for diesel at all the loads due to the high temperature of the retained

gases, which depends on the exhaust gas temperature. The hot exhaust gas retained inside the cylinder heat the incoming fresh air, reduces the quantity of air intake, and lowers the volumetric efficiency. A marginal improvement in the volumetric efficiency was noticed with OPO addition.

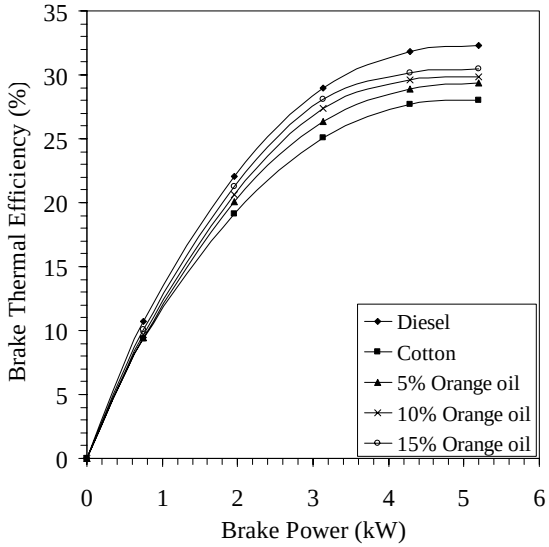

Figure 2. Variation of brake thermal efficiency with brake power

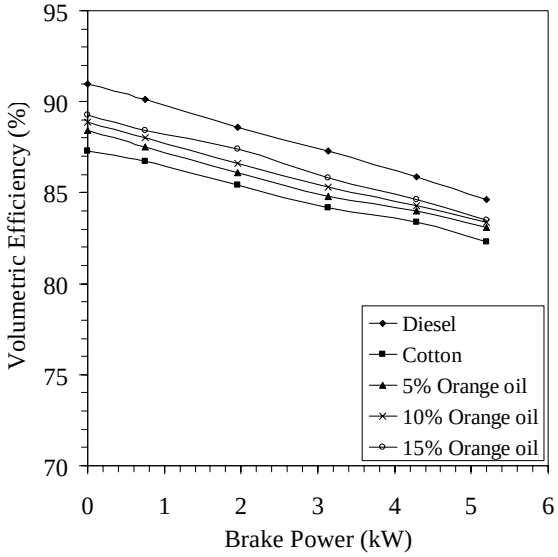

Figure 3. Variation of brake volumetric efficiency with brake power

3.3 Exhaust gas temperature

The variation of exhaust gas temperature of diesel, CSO and the blends are shown in Figure 4. The exhaust gas temperature was the highest for CSO and the least for diesel for all loads. This is due to the slow combustion of CSO due to the high viscosity and poor volatility. The maximum temperature of EGT at peak load is 445.1ºC for CSO and 407.3ºC for diesel. With the increase in the proportion of the OPO in the blend, the EGT gradually dropped due the improved combustion because of better mixture formation due to the reduced viscosity.

3.4 Smoke emission

Figure 5 shows the smoke emission. As the blend proportion increases, there is a drop in the smoke emission. The maximum smoke emission for 15% orange oil blend is 3.5 BSU as against 3.4 BSU for diesel. The smoke reduction is due to the improved combustion due to reduced viscosity.

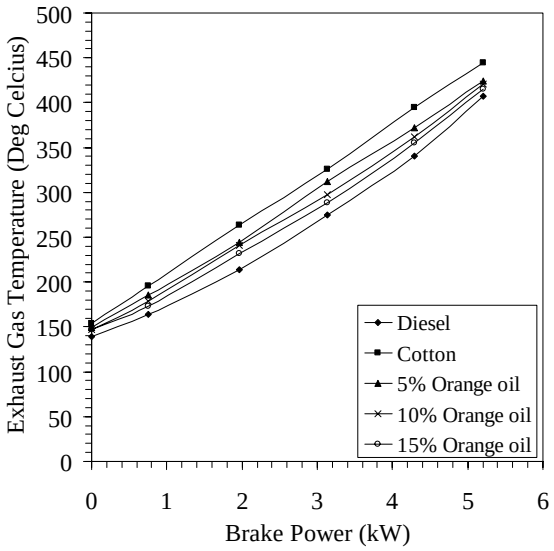

Figure 4. Variation of exhaust gas temperature with brake power

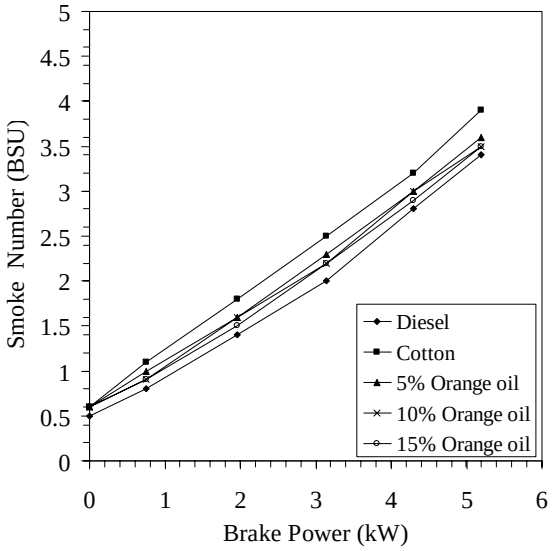

Figure 5. Variation of smoke emission with brake power

3.5 HC emission

The variation of HC emission is shown in Figure 6. With 15% blend a slight reduction of HC emission was noticed. The reduction in HC reduction is due to the improved mixture formation and complete combustion because of the changed physical properties as compared to neat CSO.

3.6 CO emission

The variation of CO is shown in Figure 7. CO emission of CSO is the maximum at all the power outputs. This is due to the fuel richness of the CSO in the air fuel mixture. To compensate for the low thermal efficiency, more fuel is injected to maintain the same load conditions. As the OPO in the blend proportion increases, CO level also decreases. This is attributed to the same reasons as that for HC emission.

3.7 Cylinder peak pressure

Figure 8 and Figure 9 shows the variation of peak cylinder pressure and maximum rate of pressure rise respectively. The peak pressure and maximum rate of pressure rise are the lowest for CSO. The peak pressure is 73.21bar with diesel and 70.36 bar with CSO. At the optimum blend, the Pressure is 72.17 bar at the maximum power output. The peak pressure depend upon the combustion rate in the initial stages, which in turn is influenced by the amount of fuel taking part in the un controlled combustion. The

addition of OPO has reduced the delay period, improved the mixture preparation and resulted in the increase of peak pressure and maximum rate of pressure rise.

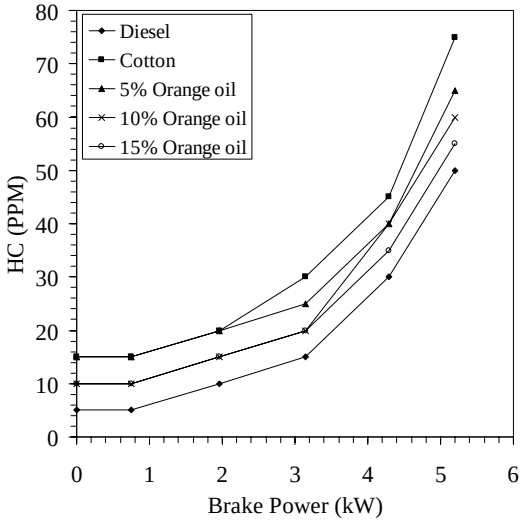

Figure 6. Variation of HC emission with brake power

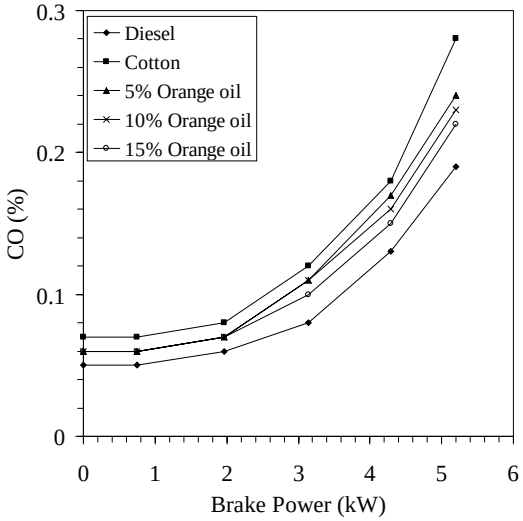

Figure 7. Variation of CO emission with brake power

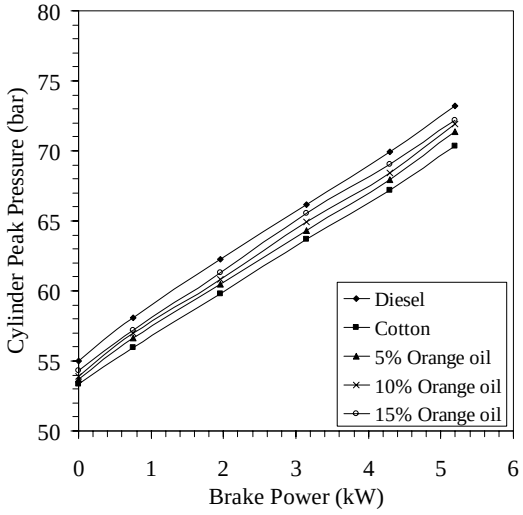

Figure 8. Variation of cylinder peak pressure with brake power

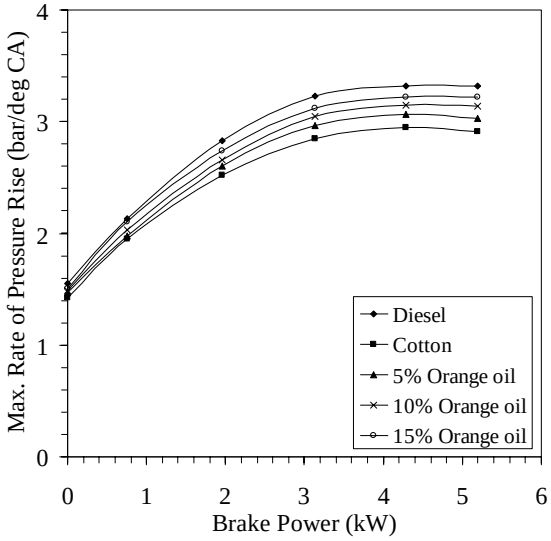

Figure 9. Variation of maximum rate of pressure rise with brake power

3.8 Heat release rate

The variation of heat release rate with crank angle at full load is shown in Figure 10. It can be observed that the heat release rate is high for diesel, is a consequence of premixed combustion phase. The premixed combustion phase is significantly lower for CSO compared to diesel. This is mainly due to high viscosity and low volatility of CSO leading to a reduction in fuel air mixing rates. The diffusion burning, indicated by the second peak is also higher with CSO due to the late burning of CSO. It also observed that higher premixed mixed combustion for orange oil addition with CSO. This is due to more quantity of fuel being prepared during ignition delay period leads to bulk burning of fuel in the initial stage of combustion (premixed combustion).

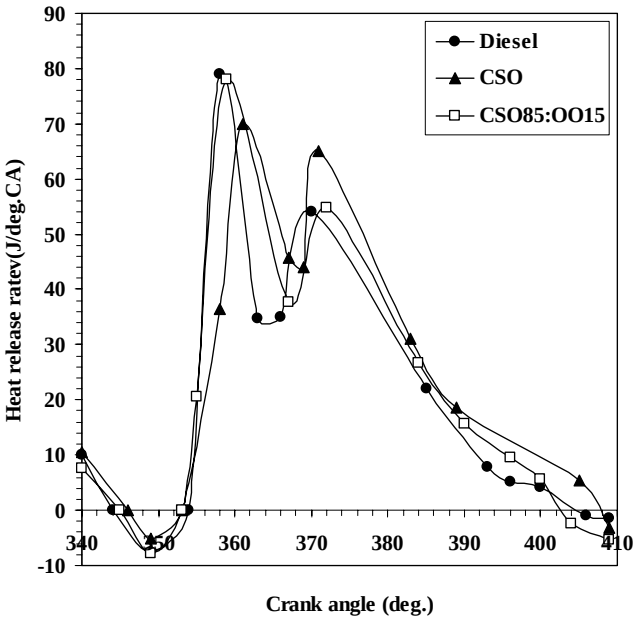

Figure 10. Variation of heat release rate with crank angle at full load

4. Conclusion

The diesel engine was successfully operated using OPO and CSO blends and compared with diesel as fuel. Based upon the results the following conclusions are made.

- The use of the neat CSO results in inferior performance and high emissions as compared to diesel because of its high viscosity, poor atomization and mixing.

- Engine operation with the blend of orange oil with CSO results in better performance than neat CSO. At full load, the brake thermal efficiency with neat CSO is 28% and for the optimum blend of 15% orange oil, it is 30.5 % while that of diesel is 32.3%.
- There is a reduction in smoke level with CSO-OPO blend in comparison to neat CSO due to better mixture formation with the blend resulting in improved combustion. The smoke level with 15% OPO blend is 3.5 BSU, for neat CSO it is 3.9 BSU and for diesel it is 3.4 BSU.
- Both HC and CO emission are found to be high for CSO under normal operating conditions. The CSO-OPO blend results in lower CO and HC emissions at high load. This may be because of its reduced viscosity at high operating temperatures. The HC and CO emission for the optimum blend quantity of 15% OPO is 55 ppm and 0.22% respectively.
- The cylinder peak pressure is 72.2 bar and maximum rate of pressure rise is 4.5 bar/°CA with 15% OPO**,** which is higher compared with neat CSO. This is mainly due to increased premixed combustion with OPO.
- Heat release with neat CSO indicates higher diffusion burning and lower premixed burning rates as compared to diesel. Blending of OPO with CSO increases the premixed combustion phase which leads to increase in the brake thermal efficiency.

Overall, it is concluded that an optimum blend of 15% OPO with CSO can be used as a CI engine fuel.

References

[1] Kensuke Nishi, Koji Korematsu and Junya Tanaka. 2004. Potential of Rapeseed oilas Diesel Engine Fuel. SAE technical paper series. 2004-01-1858.

[2] Seppo A. Niemi, Timo T. Murtonen, Mika J. Lauren and Vaino O. K. Laiho. 2002. Exhaust particulate Emissions of a Mustard Seed Oil driven tractor Engine. SAE Technical paper series. 2002-01-0866.

[3] Karaosmanoglu,F. Kurt,G. and Ozaktas,T. 2000. Long term CI engine test of sunflower oil. Renewable energy 19 :219-221

[4] Masataka Hashimoto. Tomohisha. Ichiro Asano. Takeshi Arakawa. 2002. Combustion of Rape-Seed oil ia diesel engine. SAE technical paper series. 2002-01-0867:1-12

[5] Zafur Dugler. Cafer Kaplan. 2001. Utilization of Sunflower Methyl Ester as a Diesel Engine Fuel. SAE technical paper series. 2001-01-3633.

[6] Dilip Kumar Bora. Milton Polly. Vikas Sanduja amd Das,L.M. 2004. Performance Evaluation and Emission Charecteristics of a Diesel Engine Mahua Oil Methyl Ester(MOME). SAE technical paper series. 2004-28-0034.

[7] Wincenty Lotko. Rafal Longwic and Marek Swat. 2001. The effect of Rape oil – Diesel oil Mixture composition on Particulate Matter Emission level in Diesel Engine. SAE technical paper series. 2001-01-3388.

[8] Forson, F. K. Oduro, E. K and Hammond-Donkoh,E. 2004. Performance of Jetropha oil blends in a diesel engine. Renewable Energy 29 : 1135-1145.

[9] Senthil Kumar, M. Ramesh,A. Nagalingam,B. Complete Vegetable Oil Fueled Dual Fuel Compression Ignition engine. Society of Automotive. SAE paper No. 2001-28-0067, 2001.

[10] Yoshimoto,Y. Onodera, M and Tamaki, H. 2001. Performance and emission characteristics of diesel engine fueled by vegetable oils. Society of Automotive Engineers. 2001-01-1807/4227.

[11] Yasufumi Yoshimoto and Masayuki Onodera. 2002. Performance of a diesel engine fueled by rapeseed oil blended with oxygenated organic compounds. SAE technical paper series. 2002-01-2854.

M. Leenus Jesu Martin is presently working as Professor in the Department of Mechanical Engineering and doing his PhD under the guidance of Dr. D.Prithviraj at SRM University, India. He obtained his B.Tech Degree from the Madras Institute of Technology, Chennai, India with Automobile Engineering as Specialization and ME Degree with IC Engines as specialization from the College of Engineering, Guindy, Chennai, India. He is working with SRM University since 1987.

V. Edwin Geo is a graduate in Mechanical Engineering from Noorul Islam College of Engineering, Kanyakumari. He did his post graduate studies in Thermal Power Engineering in Annamalai University and he completed his doctoral degree in Internal Combustion Engineering at College of engineering, Guindy, Anna University. Now he is working as a Professor in GKM College of Engineering and Technology. He has published more than 20 scientific research papers of which 8 papers have been published in international journals, 2 papers in national journals and 10 papers at international and national conference proceedings. He got as research fund of Rs 7 lakhs from AICTE under RPS scheme to develop an electronically controlled hydrogen engine.

D. Prithviraj is presently working as Professor and Head of the Department of Mechanical Engineering, SRM University. He has worked with Indian Institute of Technology (IITM) Chennai, India for more than three decades in various capacities like Professor and Head, Mechanical Engineering, Dean, Administration, IITM, Chennai etc. He is an expert in the field of thermal engineering with specific interests in the area of Turbo Machines.