PERFORMANCE AND EMISSION CHARACTERISTICS OF A DIESEL ENGINE FUELLED WITH BIODIESEL BY USING LINSEED OIL

L.Narsinga Rao[1], R.Shiva[2], T.Suneel[3]

[1]*M.Tech, Dept.of mechanical Engineering, V.R.Siddhartha Engineering College, A.P, India*
[2]*M.Tech, Dept.of mechanical Engineering, GDMM College of Engineering & Technology, A.P, India*
[3]*M.Tech, Dept.of mechanical Engineering, QIS College of Engineering & Technology, A.P, India*

Abstract: *Biodiesel obtained from various renewable sources has been recognized as one of the alternative fuel due to its biodegradability, high cetane number, no sulphur emissions and low volatility. Biodiesel derived from non-edible feed stocks such as linseed oil are reported to be feasible choices for developing countries including India where consumption and cost of edible oil is very high .The aim of present work is to optimize the biodiesel production from linseed oil through trans esterification process. The various performance and emission parameters like brake power (BP), brake specific fuel consumption(BSFC), Brake thermal efficiency (BTE), CO emissions, CO_2 emissions, HC emissions, NOx emissions and smoke were evaluated at different loads in a 4 stroke, single cylinder Diesel engine. These performance and emission parameters of diesel fuel were compared with that of B25, B50, B75 and B100.*

Key Words: *Biodiesel, Alternate fuel, Trans esterification, Performance, Emissions, Linseed oil.*

1. Introduction

Due to scarcity and increasing costs of conventional fossil fuels, biodiesel as a fuel has become more attractive fuel. Experts suggested that current oil and gas reserves would tend to last only for few decades. To fulfill the rising energy demand and replace reducing oil reserves renewable fuel like biodiesel is within the forefront of other technologies. Biodiesel has proved to be a possible alternative for diesel in compression ignition engine. Biodiesel burns like petroleum diesel as it involves regulated pollutants. Diesel fuel can be replaced by biodiesel made from vegetable oils. Biodiesel is now mainly being produced from soybean, rapeseed, and palm oils. In developed countries, there is a growing trend toward using modern technologies and efficient bio-energy conversion using a range of biofuels, which are becoming cost wise competitive with fossil fuels. India enjoys some special advantages in taking up plantation of tree-borne oil seeds for production of bio diesel due to vast unutilized land. The use of biodiesel results in substantial reduction of un-burnt carbon monoxide and particulate matters. It has almost no sulphur, no aromatics and more oxygen content, which helps it to burn fully. Its higher cetane number improves the combustion. Sunflower and rapeseed are the raw materials used in Europe whereas soyabean is used in USA. Thailand uses palm oil, Ireland uses frying oil and animal fats. In India vast research has been done on biodiesel from jatropha oil. It is proposed to use non-edible oil for making biodiesel, as consumption from edible oil is very high in India.

2. Production of Biodiesel From Linseed Oil

- Firstly the required sample of linseed oil was taken in a conical flask and preheated to 60^{0}C.
- Then methanol (by volume) and KOH (by weight) was mixed and stirred in a separate conical flask.
- After that the stirred sample was added in the preheated linseed oil sample and again mixed properly by stirring.
- This mixture was then constantly stirred for different reaction time (30 min, 45min, and 60min) at a constant temperature of 60^{0}C inside a water bath shaker.
- After this the stirred sample was taken out and was poured in a separating funnel to separate the glycerol from the methyl ester.
- After 24 hours the glycerol was removed and separated to obtain the methyl ester.
- For the purification purpose methyl ester was washed and dried to remove the excess methanol, KOH, and other impurities.

Fig 2.1: Separation of Glycerol from Linseed methyl ester

Table 2.1: Production in India

Vegetable Oil	MT
Groundnut	0.12
Soya	1.76
Rape/Mustard	2.01
Sunflower	0.21
Palm oil	0.08
Cotton seed oil	1.13
Other & oil fats	2.14
TOTAL	**7.45**

3. Literature Survey

Patil et al. [12] compared the biodiesel production from edible and non edible oils in order to optimize the biodiesel production process. A two step transesterification was used for non edible oil and single step transesterification process was used for edible oil. Yield of about 90-95% for Jatropha Curcus, 80-85% for Pongamia glabra, 80-95% canola, 85-96% for corn were obtained using KOH as a catalyst. It was founded that high FFA oils could not be transestrified with the alkali catalyst. Molar ratio of 6:1, 0.5% H_2SO_4 acid catalyzed esterification process at 40±5^{0}C, and 9:1, 2% KOH alkali catalyzed at 60OC were favored for jatropha oil. An alkali transesterification process was applied to convert the canola and corn oil to its esters. The maximum ester yield for canola and corn was obtained at 1% and 2% alkali catalyst, 9:1methanol to oil ratio and at 60^{0}C and 80^{0}C, respectively. Further research and development on some advanced methods such as supercritical methanol process, microwave method were suggested. **Canakci et al. [13]** investigated the use of low cost, high FFA feedstock's to obtain the biodiesel. Feedstock with high FFA could not be transestrified with traditional alkaline catalysts. Alkali catalysts form soaps with high FFA and removes the catalysts from the reaction which prevents the separation of glycerin and the ester.FFA content varied with the variation in molar ratio, reaction time and acid catalyst amount. The two step transesterification reduces the FFA content to less than 1%. FFA level was decreased faster by ethanol than by methanol. The acid value of yellow and brown grease was decreased to 2 mg KOH/g by two step acid catalyst pretreatment process of the mixture.

In the first pretreatment step, using a 10:1 molar ratio and 30 min of reaction time, the acid value of the high FFA feedstock was reduced from 41.33 mg KOH/g to 1.37 mg KOH/g using 15% acid catalyst.NAOH as a catalyst was more effective than KOH. **Raheman et al. [18]** evaluated the performance of Ricardo E6 diesel engine with biodiesel from mahua oil (B100) by varying the compression ratio and ignition timing. They observed that brake thermal efficiency decreases and brake specific fuel consumption (BSFC) increases at all compression ratio (18:1 to 20:1) and injection timing (35O- 45O b TDC).According to them a reverse trend was observed with these parameters when there was increment in compression ratio and with advancement with injection timing. They also observed that with the blend BSFC increment and the performance was decreased. They concluded that blending could be done up to 20 % at any compression ratio and injection timing. At last they concluded that MBD (100) could be used without affecting the performance of Ricardo engine at CR20 and IT b40.

Table 3.1: Properties of Diesel and Linseed Biodiesel

Property of oil	ASTM standards	Diesel	Linseed biodiesel (B100)
Density (kg/m3)	-	850	875.8
Kinematic viscosity (cSt)	1.9-6.0	2.049	4.336
Flash point (^{0}C)	>130	78	154
Fire point (^{0}C)	>53	83	160
Cloud point (^{0}C)	-3 to 12	<10	-2
pour point (^{0}C)	-15 to 10	-6	-6
Calorific value (kj/kg)	>33000	42000	38896.2

4. Experimental Setup

Table 4.1: Test Engine Specifications

Model	TV1(Make Kirloskar)
Type	1 Cylinder, 4 stroke Diesel, Water cooled
Compression ratio	17.5:1
Rated power	5.2 kW
Bore	87.5 mm
Speed	1500 RPM
Stroke length	110 mm
Capacity	661 cc
Dynamometer	Eddy current Type

Fig 4.1: Experimental setup of computerized Engine

5. Results &Discussion

The experiments were performed with the diesel, B25, B50, B75 and B100 at compression ratio 17.5 in the diesel engine. The performance parameters like brake specific fuel consumption (BSFC), brake thermal efficiency (BTE) and also the emission parameters like CO, CO2, UBHC, NOx and Smoke emissions were evaluated.

5.1 Performance characteristics:

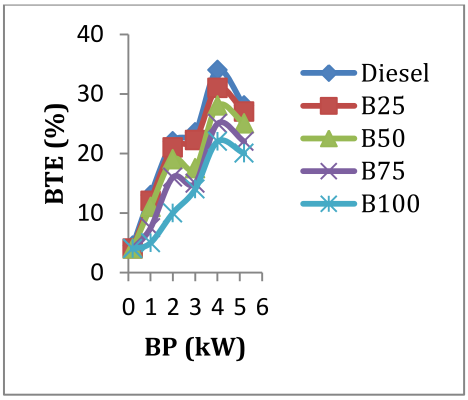

Fig 5.1: BP Vs BTE

The above fig 5.1 shows that the variation of Brake Thermal Efficiency with Brake power output for Linseed oil and its blends with Diesel in the test engine. Brake thermal Efficiency for 25% blend of Linseed oil is very close to that of Diesel. Maximum Brake thermal efficiency is obtained at 4 kW load. Brake thermal efficiency for 25% and neat linseed oil is lower by 10.41% and 34.60% respectively compared to diesel at rated load. This is attributed to lower calorific value, high viscosity coupled with density of the fuel.

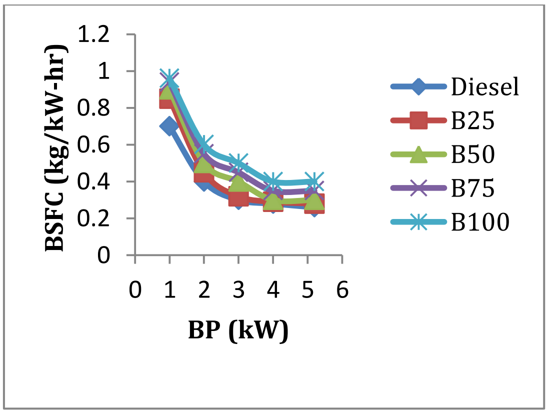

Fig 5.2: BP Vs BSFC

The above fig 5.2 shows the variation of brake specific fuel consumption with Brake power output for Linseed oil and its blends in the test engine. 25% blend of Linseed oil has the lowest BSFC compared to its other blends. BSFC for 25% blend of linseed oil is slightly higher than that of diesel. At rated load, BSFC of neat linseed oil is 0.325 Kg/kw-hr, whereas for diesel it is 0.210 Kg/Kw-hr. At rated load, BSFC of neat linseed oil is higher by 54.76% compared to diesel. This observed phenomenon is due to higher viscosity of the fuel.

5.2 Emission Characterist

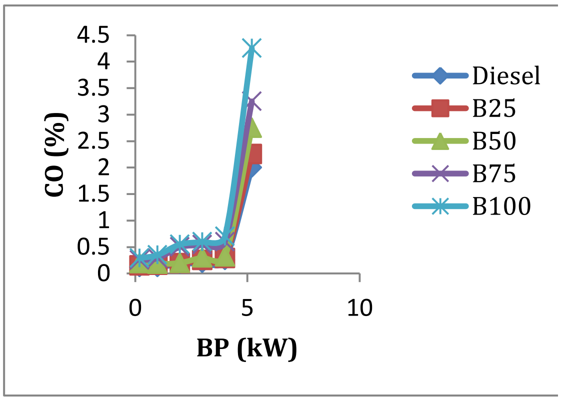

Fig 5.3: BP Vs CO

The above fig 5.3 shows the variation of Carbon monoxide emissions with Brake power output for Linseed oil and its blends with Diesel in the test engine. CO emission for 25% blend of Linseed oil is compared with diesel at all loads. Neat Linseed oil has the highest CO emission for all loads compared to all other blends. CO emission for Neat Linseed oil at rated load is higher by 96% compared to diesel. This is the result of incomplete combustion

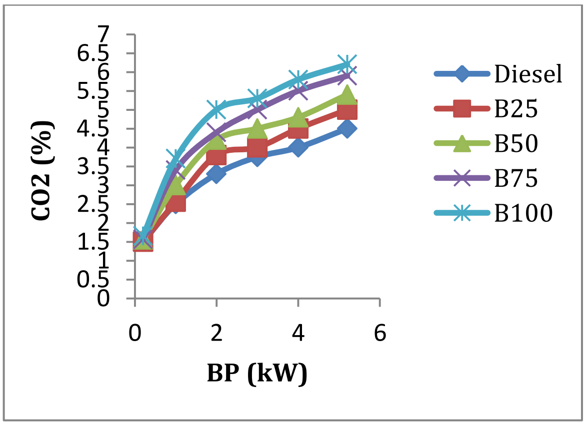

Fig 5.4: BP Vs CO2

The above fig 5.4 shows the variation of Carbon Dioxide emission with Brake power output for Linseed oil and its blends with Diesel in the test engine. 25% blend of Linseed oil has lower CO2 emission compared to all other blends. Neat Linseed oil has the highest CO2 emission for all loads. CO2 emission for Neat Linseed oil at rated load is higher by 19.18% compared to Diesel. Excess supply of oxygen is the influencing criterion.

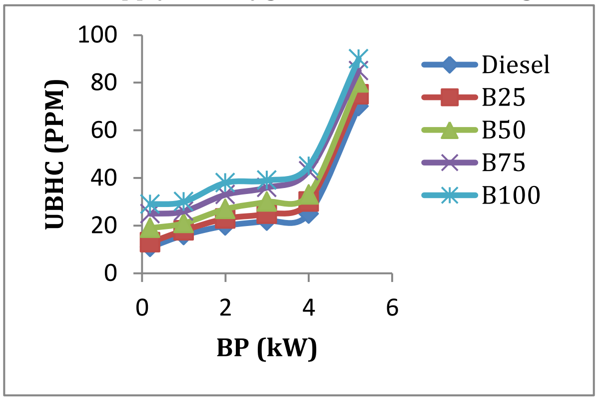

Fig 5.5: BP Vs UBHC

The above fig 5.5 shows the variation of Un-burnt hydro carbon emission with Brake power output for Linseed oil and its blends with Diesel in the test engine. 25% blend of Linseed oil has lower UBHC emission compared to all other blends for all loads. UBHC emission for 25% blend and Neat Linseed oil is 79 ppm and 89ppm, whereas for diesel it is 74 ppm. UBHC emission for 25% blend and neat linseed oil at rated load is higher by 6.75% and 20.27% respectively compared to diesel. In this phenomenon formation of rich air–fuel mixture plays a vital role.

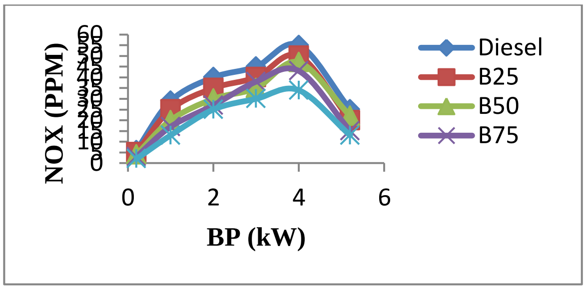

Fig 5.6: BP Vs NOx

The above fig shows the variation of Nitrogen Oxide emission with Brake power output for Linseed oil and its blends with Diesel in the test engine. Diesel has higher NOx emission compared to all other blends. NOx emission for 25 % blend of Linseed oil is well compared with diesel at all loads. NOx emission for 25% blend of Linseed oil at rated load is 55 ppm, whereas for diesel it is 58 ppm. The difference is 3 ppm. i.e. Linseed oil NOx emission is lower by 5.45% compared to diesel. Lower peak combustion temperature in the combustion chamber influences this factor.

Conclusions:

- Brake thermal efficiency for Linseed oil is lower by 34.60% compared to diesel. This is due to lower calorific value and high viscosity of the oils.
- Brake specific fuel consumption is higher by 54.76% compared to diesel at rated load. This is result of high viscosity of the fuels.
- CO emission for Linseed oil 96% compared to diesel at rated load. This is attributed to incomplete combustion of the fuels.
- CO2 emission for Linseed oil 19.18% compared to diesel at rated load. This is a result of excess availability of oxygen during combustion.
- UBHC emission for Linseed oil 20.27% compared to diesel at rated load. This is because of rich air- fuel mixture i.e incomplete combustion.
- NOx emission for Linseed oil 44% compared to diesel at rated load. This is result of incomplete combustion of fuels.
- 25% blend of chosen Non edible vegetable oils with 75% of diesel is used as alternate fuel in C.I. Engine without pre heating of the oil before entering into combustion chamber as per the analysis of graphs.
- The performance and emissions for 25% blend of Linseed oil is better than that of all other blends and is alternate fuel to diesel in C.I.Engine.

References:

[1] Puhan, S., Vedaraman, N., Rambrahaman, B.V., Nagarajan, G. Mahua (Madhuca indica) seed oil: a source of renewable energy in India. *Journal of Scientific and Industrial Research* 64, Page 890–896, 2005.
[2] Ayan Demribas "Biodiesel a realistic fuel alternative for diesel engine"
[3] National Council of Applied Economic Research (NCAER) & The Solvent Extractors' "Overview of Indian Oilseed Sector Outlook for India's Edible Oil Sector, Issues & Challenges" 15th March 2013, Delhi.
[4] Sonntag NOV. "Structure and composition of fats and oils" In: Swern D, editor 4th edition. Bailey's industrial oil and fat products, vol.1, 4th edition. New York: *John Wiley and Sons*; 1979.
[5] Weisz PB, Haag WO, Rode weld PG. "Catalytic production of high-grade fuel (gasoline) from biomass compounds by shape selective catalysis" *Science,* 206, Page 57–8, 1979.
[6] Schwab AW, Dykstra GJ, Selke E, Sorenson SC, Pryde EH. "Diesel fuel from thermal decomposition of soybean oil" *Jaocs*, 65, Page 1781–6, 1988.
[7] Ayhan Demirbas "Progress and recent trends in biodiesel fuels" *Energy Conversion and Management,* 50, Page 14–34, 2009.
[8] Fangrui Ma, Hanna, M. A. "Biodiesel Production: A Review", *Bioresource Technology*, 70, Page1-15, 1999.
[9] C.B. Prakash "A critical review of biodiesel as a transportation fuel in Canada". A technical report. Canada: GCSI – Global Change Strategies International, Inc., Transportation Systems Branch; March 25, 1998.
[10] Report of the committee on development of bio-fuel, Planning Commission India, 2003.
[11] Aggarwal, D. L. Kumar, Aggrawal, A.K., "Performance Evaluation of a Vegetable oil fuelled CI Engine" *Renewable Energy*, 2007.
[12] Prafulla D. Patil, Shuguang Deng "Optimization of biodiesel production from edible and non-edible vegetable oils" *Fuel*, 88, Page 1302–1306, 2007.
[13] M. Canakci, J. Van Gerpen "Biodiesel production from oils and fats with high free fatty acids" *American Society of Agricultural Engineers* 44, Page 1429–1436, 2001
[14] Rajeev Kumar, Pankaj Tiwari, Sanjeev Garg "Alkali transesterification of linseed oil for biodiesel production" *fuel,* 104, Page 553-560, 2013
[15] Ashish Jawalkar1, Kalyan Mahantesh1, M Jagadish "Performance and Emission Characteristics of Mahua and Linseed Biodiesel Operated at Varying Injection Pressures on CI Engine" *International Journal of Modern Engineering Research (IJMER),* 2, Page 1142-1149, 2012.
[16] B. Sanjay Gandhi, S. Sam Chelladurai, D.Senthil Kumaran "Process Optimization for Biodiesel Synthesis from Jatropha Curcas Oil" Distributed *Generation & Alternative Energy Journal*, 26, Page 6-16, 2011
[17] Sukumar Puhan, R. Jegan, K. Balasubbramanian, G. Nagarajan "Effect of injection pressure on performance, emission and combustion characteristics of high linolenic linseed oil methyl ester in a DI diesel engine" *Renewable energy* ,34, Page 1227–1233, 2008.
[18] H. Raheman, S.V. Ghadge "Performance of compression ignition engine with Mahua (Madhuca indica) biodiesel" Fuel, 86, Page 2568–2573, 2007.
[19] B. Gokalp , E. Buyukkaya , H.S. Soyhan "Performance and emissions of a diesel tractor engine fueled with marine diesel and soybean methyl ester" *Biomass and bioenergy* ,35, Page 3575-3 583, 2011.

BIOGRAPHIES

L.Narsinga Rao is M.Tech student of Thermal Engineering at V.R.Siddhartha Engineering college, Vijayawada, A.P, India.

R.Shiva is M.Tech student of Thermal Engineering at GDMM College of Engineering & Technology,Nandigama, A.P, India.

T.Suneel is M.Tech student of Thermal Engineering at QIS College of Engineering & Technology,Ongole, A.P, India A.P, India.