Effect of Nozzle Opening Pressure on The Performance And Emission of A Di Diesel Engine Using Linseed Biodiesel

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Abstract- *Petroleum based fuels play a vital role in rapid depletion of conventional energy sources along with increasing demand and also major contributors of air pollutants. Major portion of today's energy demand in India is being met with fossil fuels. Hence it is high time that alternate fuels for engines should be derived from indigenous sources. As India is an agricultural country, there is a wide scope for the production of vegetable oils (both edible and non-edible) from different oil seeds.*

The present work focused only on non-edible oils as fuel for engines, as the edible oils are in great demand and far too expensive. The past work revealed that uses of vegetable oils for engines in place of diesel were investigated. Though the concerned researchers recommended the use of vegetable oils in diesel engines, there was no evidence of any practical vegetable oil source engines.

The present investigations are planned after a thorough review of literature in this area. Experiments are carried out in a more popular patter type single cylinder, water cooled engine. Major problems associated with vegetable oils are higher viscosities, lower heating values, raise in stoichiometric fuel air ratio and thermal cracking. We focused on utilization of non-edible oils, their blends with diesel and respective Methyl esters in diesel engines. The neat oil (linseed oil) blends with diesel were heated before entering into combustion chamber. The heating value depends on the increase in percentage of neat oils in mixture to reduce the viscosity of the fuel.

The performance parameters of the test engine Viz. Brake thermal efficiency, Volumetric efficiency are decreased, Brake specific fuel consumption and Exhaust gas temperature are increased in neat oils (linseed oil) compared to diesel. Emission parameters of engine such as Carbon monoxide, Carbon dioxide, Un-burnt hydrocarbons and Smoke are increased, but Nitrogen oxides are decreased in neat oils (linseed oil) and their blends compared to diesel. This variation is observed due to high viscosity coupled with lower heating value of the fuels.

Neat oils (linseed oil) is converted into their respective methyl esters through tran- esterification process. In this process, the performance parameters of engine such as brake thermal efficiency and volumetric efficiency are slightly decreased, Brake specific fuel consumption and Exhaust gas temperature are increased compared to diesel for bio-diesels (linseed oil). Emission parameters of engine such as Carbon monoxide, Carbon dioxide, Un-burnt hydrocarbons and smoke are reduced, but Nitrogen oxides increase for bio-diesels (linseed oil) compared to diesel. This trend is observed due to complete combustion of the bio-diesels, as the viscosity is reduced.

From the experimentation, it is observed that 25% of neat oil (linseed oil) mixed with 75% of diesel is the best suited blend, without heating and without any modification of the engine. Methyl ester of Linseed oil is the better performing fuel due to better performance and lower emissions compared to other chose methyl esters.

Keywords- Biodiesel; Diesel; Ethanol; Combustion; Performance; Emission

I. INTRODUCTION

India is one of the fastest developing countries with a stable economic growth, which multiplies the demand for transportation in many folds. Fuel consumption is directly proportionate to this demand. India depends mainly on imported fuels due to lack of fossil fuel reserves and it has a great impact on economy. India has to look for an alternative to sustain the growth rate. Bio-diesel is a promising alternative for our Diesel needs. With vast vegetation and land availability, certainly bio-diesel is a viable source of fuel for Indian conditions. Recent studies and research have made it possible to extract bio-diesel at economical costs and quantities. The blend of Bio- diesel with fossil diesel has many benefits like reduction in emissions, increase in efficiency of engine, higher Cetane rating, lower engine wear, low fuel consumption, reduction in oil consumption etc. It can be seen that the efficiency of the engine increases by the utilization of Bio-diesel. This will have a great impact on Indian economy. Diesel fuels have deep impact on the industrial economy of a country. These are used in heavy trucks, city transport buses, locomotives, electrical generators, farm equipments, underground mine equipments etc

Biodiesel is a renewable fuel, made from vegetable oils or animal fats. These esters of natural fatty acids with glycerin (named triglycerides) undergo base-catalyzed transesterification, usually with ethanol. The resulting product is a mixture of fatty acid ethyl esters (FAME), corresponding to the fatty acid composition of the fats or oils used. Biodiesel fuel is adapted to the diesel engine and may be used in standard diesel engines

II. PROPERTIES OF FUELS USED

Table - 1 Properties of diesel, linseed biodiesel

Fuel samples Properties	Diesel	Linseed biodiesel	Apparatus used
Fuel density in —	895	885	Hydrometer
Kinematic viscosity at 40°C in cst	4.6	6.00	Redwood viscometer
Flash point in °C	51	160	Ables apparatus
Fire point in °C	57	185	Ables apparatus
Calorific value in —	42000	39539	Bomb calorimeter

III. EXPERIMENTION

Engine components: The various components of experimental set up are given below. Fig.1 shows the photograph of the experimental set up.

The important components of the system are;

- The engine
- Dynamometer
- Smoke meter
- Exhaust gas analyzer

Fig 1.Overall view of the experimental setup

Table-2 Engine Specifications

Manufacturer	Kirloskar oil engines
Model	TV-SR, naturally
Engine	Single cylinder, DI
Bore/stroke	87.5mm/110mm
C.R.	17.5:1
Speed	1500r/min, constant
Rated power	5.2 kW
Working cycle	four stroke
Injection pressure	200bar/23 deg before
Type of sensor	Piezo electric
Response time	4 micro seconds
Crank angle sensor	1-degree crank angle
Resolution of 1 deg	360 deg with a

IV. RESULTS AND DISCUSSION

Performance characteristics of linseed biodiesel with diesel

Variation of brake thermal efficiency with brake power

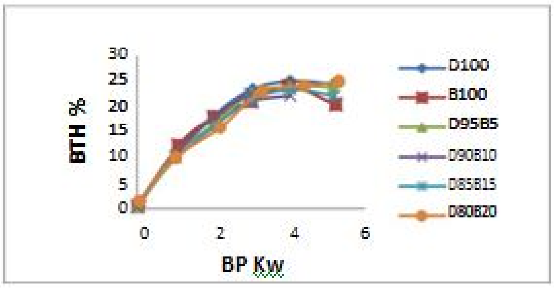

Fig.2: Variation of brake thermal efficiency with brake power

Fig 2 shows the variation of brake thermal efficiency with brake power for neat diesel and Linseed biodiesel and its blends with diesel and Ethanol. From Fig 4.1 it is evident that the brake thermal efficiency is highest with the blend B20 at medium load which is nearer to diesel. The increase in brake thermal efficiency due to high percentage of oxygen presence in the biodiesel, the extra oxygen leads to causes better combustion inside the combustion chamber. The brake thermal efficiency of the engine is improved by increasing the concentration of the biodiesel in the blends and also the additional lubricant provided by biodiesel. The reason for increase in efficiency at blend of 20 % linseed biodiesel may be the property of blend, probably the lower viscosity of biodiesel which helps in better atomization and effective utilization of air resulting in increased efficiency.

Blend B5 shows the minimum efficiency at medium load. The decrease in brake thermal efficiency for higher blends may be due to the lower heating value and higher viscosity of blends with a higher proportion of biodiesel.

Variation of brake specific fuel consumption with brake power

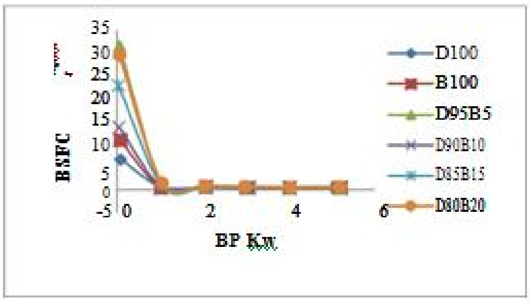

Fig.3: Variation of brake specific fuel consumption with brake power

Fig 3 shows the variation of brake specific fuel consumption with brake power for neat diesel and Linseed biodiesel and its blends with diesel and Ethanol. From Fig 4.2 it is observed that linseed biodiesel blend B10 have specific fuel consumption close to diesel. However if the concentration of Linseed oil in the blend is more than 20%, the specific fuel consumption is found to be higher than diesel at all loads. Biodiesel blend B5 shows higher BSFC than other blends at all loads. As the load increases brake specific fuel consumption decreases for all fuel blends. A close perusal of the results shows that the BSFC for all the blends are more or less close to each other for all the loads. It is due to the fact that engine consumes more fuel with biodiesel blends than with the neat diesel fuel to develop same power output due to lower calorific value of biodiesel blends.

Variation of brake specific energy consumption with brake power

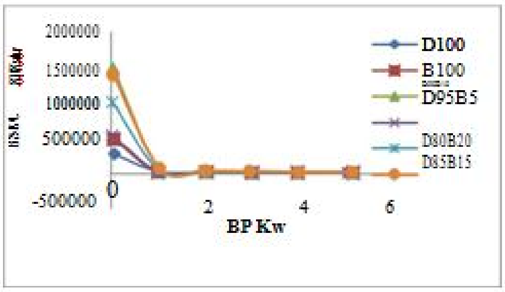

Fig.4: Variation of brake specific energy consumption with brake power

Fig 4 shows the variation of brake specific energy consumption with brake power for neat diesel and Linseed biodiesel and its blends with diesel and Ethanol. It is found from the graph that blend B5 has got highest BSEC at starting low rate of loads and get decreased by increasing the load on engine. the interesting point is that neat linseed biodiesel and blend B10 have almost same BSEC values at starting load rate. Compared to all the blends diesel have lowest BSEC values and as load and BP increases the BSEC decreases to nearly zero line of brake specific fuel consumption. The oxygenated additive Ethanol 3% by volume to all the blends have reduced the CV and cetane no. is increased thus BSEC values initially higher value and as BP increased then get reduced as shown in the fig. above.

Variation of exhaust gas temperature (EGT) with brake power

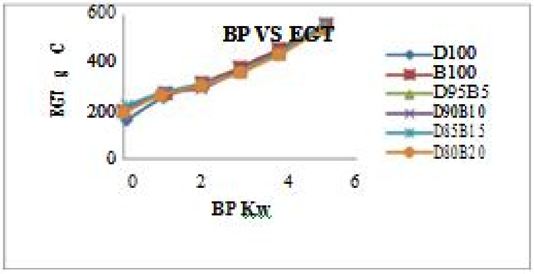

Fig.5: Variation of exhaust gas temperature with brake power

Figure 5 shows the variation of exhaust gas temperature (EGT) with brake power. A reduction in EGT is seen for diesel for all loads when compared linseed biodiesel blends with Ethenol. This is because of the increase in ignition delay which is caused due to increase in the blend density. Hence for linseed oil EGT is high due to high density and lower CV. Further, it takes a longer duration to vaporize the fuel in the pre-mixed combustion phase which reduces the combustion temperature. Besides, the delayed heat release during the later stage of combustion is another reason for the reduction in EGT. Early start of the combustion due to shorter premixed combustion phase and lower calorific value can also lead to reduction in exhaust gas temperature as is seen for the diesel, linseed biodiesel and ethanol blends .The decrease in EGT is advantageous as it can increase the expansion work and life of the engine.

Emission characteristics of linseed biodiesel with diesel

Variation of carbon monoxide with brake power

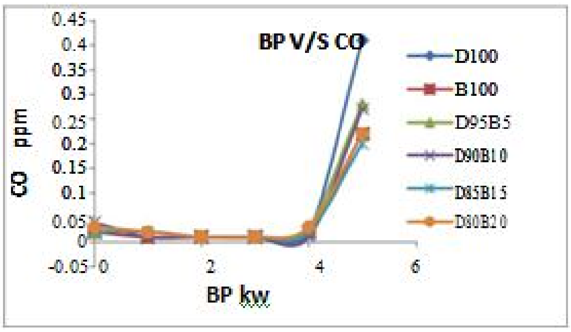

Fig.6: Variation of CO with brake power

Fig 6 shows the variation of carbon monoxide emission with brake power for neat diesel and Linseed biodiesel and its blends with diesel and Ethanol it is observed that the CO emission for all the fuels and linseed biodiesel and its blends is very low. The CO

Emission value is little increased for high load and brake power for blends B15 and B20. CO is the product of incomplete combustion, which is formed due to shortage of air or due to low gas temperature. This is due to the fact that high latent heat of ethanol and low volatility of CSOME produces low combustion temperature and thick quenching layer, which leads to a lower CO oxidation rate and higher CO emission. and at high loads, combustion of blends are almost complete due to the presence of oxygen, which reduces the fuel air rich region leading to lower CO emissions by further oxidation of CO. It is also noticed that for blends B15 and B20 the CO emission is very much reduced and can be neglected.

Variation of hydrocarbon (HC) with brake power

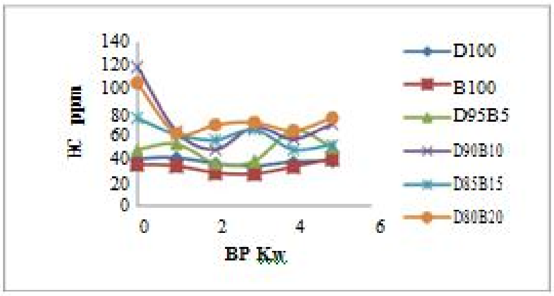

Fig.7: Variation of hydrocarbons with brake power

Fig 7 shows the variation of unburned hydrocarbons emission with brake power for neat diesel and Linseed biodiesel and its blends with diesel and Ethanol. The HC of B100 has lower emissions compared with all other blends. While, HC of B15 blend of biodiesel compared well with diesel and it is nearest to biodiesel and its blends. This is due to the lower HC emissions in the exhaust gas of the engine may be due to the efficient combustion of biodiesel blend with diesel and due to the presence of fuel bound oxygen and warmed-up conditions at higher loads. This is due to the reason that at lower loads the lower cylinder pressure and temperatures were experienced that was caused by lower rate of burning. This feature results in higher HC emissions Moreover, the reason for the increase in HC emissions can be attributed to the lower density and viscosity of ethanol–diesel, biodiesel fuel blends, which causes the formation of fuel droplets with a lower size. These droplets reach to the closer section of the cylinder walls and lead to quenching effect due to leaner mixture and also cause further unburned fuels. Therefore, the HC emission increased on increasing ethanol content in the blends, and reaches its maximum value with the use of B20 blend at higher loads.

Variation of smoke with brake power

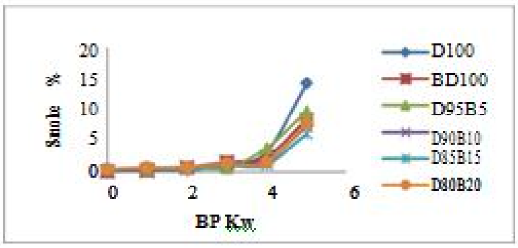

Fig.8: Variation of smoke with brake power

Fig 8 shows the variation of smoke emission with brake power for neat diesel and Linseed biodiesel and its blends with diesel and Ethanol. At very high loads the smoke level for all the blends are fairly lower than that of simple diesel fuel. But, at low and medium loads the smoke level seems to be almost the same for all the blends. Never the less, for blend B15 the smoke level is low for all the loads when compared to that of other blends and diesel. Thus B5 can be considered as better options as far as smoke concentration is concerned. The reason for this reduction in smoke concentration can be attributed to the reduction in density due to the addition of Ethanol and the corresponding altered spray pattern leading to better fuel-air mixing process. Another reason could be the absence of fuel rich zone in the cylinder that leads to reduced smoke. Soot in the particulate matter is considered the main substance for the formation of smoke, which is produced by oxygen deficient thermal cracking of long-chain molecules.

Variation of oxides of nitrogen (NOx) with brake power

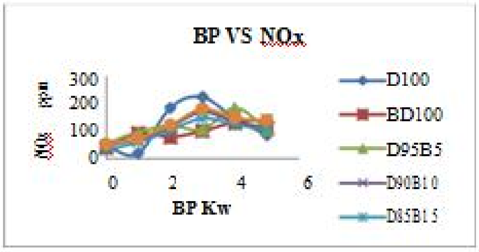

Fig.9: Variation of oxides of nitrogen with brake power

Fig 9 shows the variation of nitrogen oxide emission with brake power for neat diesel and Linseed biodiesel and its blends with diesel and Ethanol. The NOx of blend B15 is slightly lower than that of diesel at medium loads. The B20 blend of linseed biodiesel and ethanol has higher NOx emissions compared with all other blends throughout low and medium loads. The NOx in that emissions decrease with an increase in the biodiesel content of diesel. It may be said this is due to higher combustion temperatures and longer combustion duration. The above curve shows characteristics of the typical NOX curve which is increasing with load and thus the temp in the cylinder increases, and this produces more NOX. NOx emissions from the diesel engine depend on various reasons such as fuel properties and engine operating conditions. It is known that NOx emissions are caused by higher combustion temperature and higher oxygen concentration in the cylinder.

Combustion characteristics of linseed biodiesel with diesel

Variation of cylinder pressure with crank angle

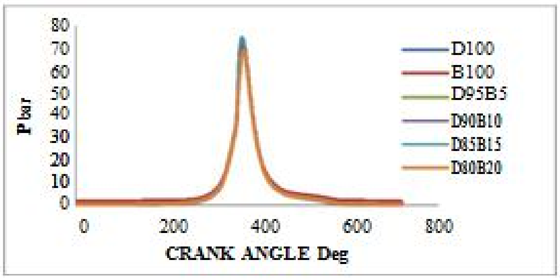

Fig.10: Variation of cylinder pressure with crank angle

Fig 10 shows the variation of cylinder pressure with crank angle for neat diesel and Linseed biodiesel and its blends with diesel and Ethenol.The in-cylinder gas pressure and heat release rate at peak power and peak torque for specified crank angle variations at full load conditions are shown in. The trend of in-cylinder pressure variation at peak power and peak torque shows a similar fashion for all fuels investigated. It is found that the peak in-cylinder of base fuel cottonseed biodiesel is higher than other biofuels investigated as expected due to higher calorific value. The ethanol blended biodiesel fuels have lower peak in-cylinder pressure and this value decrease with increase in ethanol and linseed oil content of the biofuels as expected due to lower calorific value of the ethanol and retarded ignition of premixed combustion. This longer duration of ignition delay leads to abrupt changes in pressure without producing any positive work output. The ignition delay is defined as the time between the fuel injection and start of combustion. Shorter ignition delay leads to earlier combustion which in turn raises the peak pressure inside the engine cylinder for the cetane improved ethanol biodiesel blends.

Variation of net heat release rate with crank angle

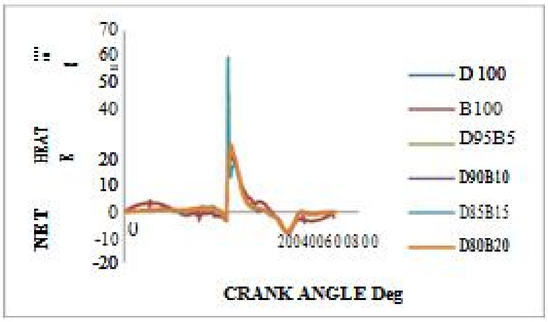

Fig.11: Variation of net heat release rate with crank angle

Fig 11 shows the variation of net heat release rate with crank angle for neat diesel and Linseed biodiesel and its blends with diesel and Ethenol.The B100 has the higher heat release rate at crank angle 380deg, this may be attributed to low vaporization, high viscosity low peak pressure of the blends compared to that of diesel. The heat release rate reduces with increasing blend percentage of Linseed biodiesel and DEE. The lower heat release rate of the linseed biodiesel blends indicates the reduced performance of the engine as the brake thermal efficiency reduces. The higher density as well as viscosity of the linseed biodiesel blends results in improper mixture formation. This results in poor atomization of the fuel which results in reduced heat release rate of the linseed biodiesel blends by combustion. For further crank angle i.e., from 380deg there is a reduction in NHRR for all blends and increase in D100 , this is due to premixed and uncontrolled combustion phase. The heat release rate curves for all the fuels investigated have a similar trend. When the cetane improver like ethanol is added to the linseed biodiesel blended fuels, the ignition delay period gets shortened and ultimately the proportion of fuel burnt in the premixed combustion decreases and results in lower peak combustion temperature.

Variation of cumulative heat release rate with crank angle

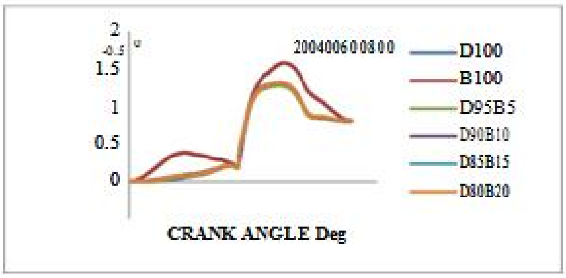

Fig.12: Variation of cumulative heat release rate with crank angle

Fig 12 shows the variation of cumulative heat release rate with crank angle for neat diesel and Linseed biodiesel and its blends with diesel and Ethanol. From fig 4.11, it is seen that the cumulative heat release rate of the neat linseedbiodieselB100 is about 5191.5 kJ/m^3 at 59°CA, which is higher than that of diesel fuel. The blend of B15and B20 released the cumulative heat release rate of about 3514.5 kJ/m^3 at 56°CA and 3491.5 kJ/m^3 at 55°CA, which is comparable with diesel fuel. But other blends show lower heat release rate than diesel fuel.

V. CONCLUSION

- The CI engine characteristics like performance, emission and combustion of pure diesel, linseed biodiesel and their respective blends with ethanol are studied and the following conclusions are found from the graphs.
- Using the Ethanol as a fuel additive improved engine performance significantly Engine thermal efficiency increased up to28.29% and engine fuel consumption decreased.
- The brake specific fuel consumption decreases with the use of these fuel blends with respect to those of the neat linseed bio-diesel, diesel and the corresponding brake thermal efficiencies increase.
- The smoke, unburned HC, CO, and CO2 emissions are very much reduced with the use of these fuel blends with respect to those of the neat linseed oil or its neat bio-diesel and diesel.
- The NOx emissions are also much reduced due to the presence oxygenated additive ethanol with the use of these fuel blends with respect to those of the neat linseed bio-diesel and diesel.
- From the analysis results, plots of the history in the combustion chamber of the net heat release rate and cylinder temperatures reveal some very interesting features, which shed light in the combustion mechanism when using these fuel blends. It is revealed that with the use of these blends versus the corresponding neat linseed bio-diesel and diesel cases, the fuel injection pressure diagrams are delayed, dynamic injection timings decrease, ignition delays increase, and maximum cylinder pressures decrease.
- The maximum heat release rate and cylinder pressure generally increased both the combustion duration and engine stability slightly reduced
- These results and the widely differing physical and chemical properties of ethanol against those for the linseed bio-diesel and diesel are used to aid the correct interpretationof the observed engine behavior
- performance- and emissions-wise when using these blends against those for the baseline fuels, i.e. neat bio-diesel and diesel
- The ethanol blends show a little better behavior against their corresponding neat Linseed biodiesel and diesel fuel.

Hence, by observing from above conclusions the blend B15 is found optimal compared to other blends in all parameters and can be substituted as alternative fuel in direct injection CI engine.

REFERENCES

[1] A.GoudwinAntony, S.Dinesh, K.Rajaguru, V.Vijayan, S.Aravind (2017), Analysis and optimization of performance parameters in computerizes I.C.Engine using Diesel blended with Linseed oil and Leishmaan's solution, Vol.21, No.2 (2017)193-205

[2] CH.S.NagaPrasad (2010), Experimental Investigation on performance and emission characteristics of diesel engine

using biodiesel as an alternative fuel,”Doctor of Philosophy”

[3] KambizTahvildari, SouriMohammedi (2014), Synthesis of Ethyl Ester (Biodiesel) from Linseed oil using Transestrification double step process (TDSP),”Academic Research International Vol.5 (2) March 2014.

[4] P.Karthikeyan,P.Lokesh&P.Suneel (2017),Performance and characteristics of direct injection diesel engine using linseed oil as biodiesel by varying injection timimg,”International Journal of Ambient Energy” ISSN:0143-0750

[5] S.narasimhakumar(2014),Influence of Linseed oil based Biodiesel on Exhaust Emission and Combustion characteristics with fixed Injection timimg using ceramic coated diesel engine,” Scholar Journal of Engineering and Technology(SJET),Sch.J.Eng.Tech.,2014;2(2B0):2 81-290.

[6] Sandeepkumar, Dr.Amitpal, ManishJain,AnandBag hel(2015),An Experimental analysis of biodiesel production from Linseed oil,”IJETMAS”Vol.2,ISSN 2349-4476.

[7] Christopher A. Sharp". Exhaust Emission and Performance of Diesel Engines with Bio Diesel as Fuel. Fuel 1998, 77, pp 1389-1391.

[8] Selvan.P, Sudalaiyandi.K, Dr.SelwinRajadurai.J (2016), Preparation characterization and performance analysis of biodiesel from Linseed oil,”IJSRD”, Vol.4.Issue 01, 2016\ISSN:2321-0613.

[9] S.Chiranjeeva Rao et al, “Fuelling diesel engine with diesel, linseed derived biodiesel and its blends at different injection pressures: performance studies‖, IJMIE Volume 2, Issue7.

[10] Wulff et al, ―Dual Fuel composition including acetylene for use with diesel and other internal combustion engines‖, patent no: US 6,287,351 B1, patent date: Sep11,2001.

[11] Murthy P.V.K, Murali Krishna M.V.S.Sitarama Raju A, Vara Prasad C.M. Performance Evaluation of Low Heat Rejection Diesel Engine with Pure Diesel. International journal of applied engineering research, Dindigul Volume 1, No 3, 2010.

[12] K.R Gopalkrishna, Sudhir Gopalkrishna, S.C.Sharma .Text book of Elements of mechanical engineering.

[13] Ashish Jawalkar, Kalyan Mahantesh, M Jagadish, Madhusudhan Merawade, M C Navindgi. Performance and emission characteristics of mahua and linseed biodiesel operated at varying injection pressures on CI engine. UG Students, Department of Mechanical Engineering, PDA College of Engineering, and Gulbarga IJMER, Vol.2, Issue.3, May-June 2012 pp-1142-1149, ISSN: 2249-6645.

[14] S. Jaichandar, and K. Annamalai, The Statusof Biodiesel as an Alternative Fuelfor Diesel Engine – An Overview, Journal of Energy & Environment 2 (2011) 71-75.