International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

MEASUREMENT OF FUEL PROPERTIES AND PERFORMANCE ANALYSIS OF DI DIESEL ENGINE FUELED WITH SAFFLOWER OIL-DIESEL BLENDS

Dr. K. Kalyani Radha[1] Dr. B. Omprakash[2] ,

1.Associate Professor, *Dept. of Mech Engg, JNTUACEA, Ananthapuramu, A.P, INDIA.*
2. Associate Professor, *Dept. of Mech Engg, JNTUACEA Ananthapuramu, A.P, INDIA*

Abstract:**In the proposed project, Fuel properties like, viscosity, calorific value, density, specific gravity, flash and fire points of diesel fuel and various proportions of Safflower of oil-diesel blends are to be found out by conducting experiments in the laboratory. In this project, it is also planned to carry out an experimental investigation on 4- stroke Direct Injection Diesel Engine run with different proportions of Safflower oil blended with Diesel, with a piston having five number of grooves on it to create turbulence in order to find out thermal efficiency of the engine. Experiments are carried out on a diesel engine using Grooved piston and blends of Safflower oil biodiesel as alternative fuel, which is a single cylinder, four-stroke, water cooled, and constant speed engine capable of developing a power output of 3.7 kW at 1500 rpm. Performance parameters such as brake power, specific fuel consumption, and thermal efficiency are calculated based on experimental analysis of the engine. At all the load conditions, performance of the engine is obtained better for blend B40 (40% Safflower oil + 60% of Diesel). At all the load conditions, Brake thermal Efficiency is more for the all blends compared to that of diesel and is highest for blend B40. At all the load conditions, Indicated Thermal Efficiency is less for the blend B40. At 3/5th load and 4/5th load conditions, Indicated thermal efficiency is more for the blend B30 compared to that of diesel and other blends. At full load condition, it is more for blend B20 than that of blend B40 by 6.21%. All the properties of blends obtained better than that of diesel fuel.**

Keywords: Diesel Engine, Turbulence, Safflower oil, Engine Performance, Emissions.

I.INTRODUCTION

Now-a-days, increase in the population of automobile vehicles directly causing increase in the Emissions. Moreover, petroleum products are going to extinct in coming decades. Hence there is a need for best alternate fuel to replace the diesel usage. In search of that best alternate fuel, in this project Safflower oil biodiesel is used and experimental investigation is done to measure performance of engine and emission characteristics.To obtain a better combustion with lesser emissions in direct-injection diesel engines, it is necessary to achieve a good spatial distribution of the injected fuel throughout the entire space available in the combustion chamber. In DI diesel engines, swirl can increase the rate of fuel-air mixing due to the turbulence provided by the grooved piston.

II.LITERATURE REVIEW

There is a wide variety of Alternative Fuels available as renewable fuels to replace diesel fuel. *SwarnaKumarietal [1]*, have concluded based on experimentation conducted on a Diesel Engine with various proportions of Safflower oil blended with diesel fuel, that, the thermal efficiency of an engine is increased by 5.2% with blend B20 in comparison with diesel. The smoke opacity of the engine is found low with the fuel B20 and all the emissions are compared with Diesel.

Subba Reddy etal [2], have carried out an experimental investigation on D.I Diesel Engine with three different tangential grooved pistons with cotton seed oil methyl ester blended with diesel in various proportions. They have reported a decrease in Brake Specific Fuel Consumption and a slight increase in thermal efficiency, when the engine is operated on blended fuel of 20% cotton seed oil methyl ester and 80% diesel (20BD), compared to that with diesel fuel.

Prathibhaetal[3], have carried out an experimental investigation to study about influence of the air swirl in the cylinder upon the performance and emission of a single cylinder diesel direct injection engine by using diesel on volume basis. The swirl intensification was done by cutting grooves over the piston crown. In this work three different configurations of piston i.e. in the order of number of grooves 6,9,12 are used to intensify the swirl for better mixing of fuel and air and their effects on the performance and emission are recorded.In several other reported research works, it has been concluded that the thermal efficiency of an engine enhances with the turbulence created with the help of grooves provided on the piston crown.

III.MEASUREMENT OF FUELPROPERTIES

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

Fig.1 Safflower Oil

A.*DensityMeasurement:*Empty beaker of capacity 50ml is taken and weighed that empty beaker using a Digital Weighing Machine. Reading is noted down. Now Fuel sample of 50ml is measured in a beaker and weighed by using that Digital weighing machine. Beaker with fuel weight also noted. By subtracting the weight empty Beaker from the weight of Beaker with fuel, mass of fuel can be obtained. Now, by dividing mass of fuel with volume of fuel taken in that beaker, Density of that fuel is calculated. The same procedure is repeated for diesel and all other blends.

TABLE 1
DENSITYOFTHE FUELS

S.no	Fuel / Blend	Value(kg/m^3)
1.	Diesel	805.3
2.	B10 (10% Safflower oil+ 90% Diesel)	811
3.	B20(20% Safflower oil+ 80% Diesel)	811.9
4.	B30(30% Safflower oil+ 70% Diesel)	821.2
5.	B40(40% Safflower oil+ 60% Diesel)	832.3

*A. Specific Gravity Measurement:*Fuel of 50ml is taken in a beaker and measured its density by using the above procedure. By dividing density of fuel with density of reference fluid i.e., water, Specific gravity of that fuel is calculated.

TABLE 2
SPECIFIC GRAVITYOFTHE FUELS

S.no	Fuel / Blend	Value
1.	Diesel	0.805
2.	B10 (10% Safflower oil+ 90% Diesel)	0.811
3.	B20(20% Safflower oil+ 80% Diesel)	0.8119
4.	B30(30% Safflower oil+ 70% Diesel)	0.8212
5.	B40(40% Safflower oil+ 60% Diesel)	0.8323

Fig.2 Digital Weighing Machine

B. Viscosity Measurement: The instrument used to measure Viscosity is Red Wood Viscometer. First of all, apparatus is cleaned and filled with water up to the mark. The fuel is poured into the cup till it reaches pointer provided inside the cup for reference. Make sure while pouring the fuel into the cup, the orifice is closed by the valve ball. Then, carefully insert the cap and thermometer of required range till the bulb of thermometer touches fuel level inside the cup. After checking all the connections, electrical supply is given to the apparatus and slowly increased the load. Continuous stirring is required for uniform distribution of heat energy from water in the jacket to the fuel in the cup. After reaching the required temperature of fuel, collect 50ml of fuel into a beaker by slowly lifting the ball valve. Simultaneously note down the time taken for 50ml of fuel collection. By using the formula, Find out the kinematic viscosity. Repeat the experiment for diesel and all other blends.

Fig.3 RedWood Viscometer

TABLE 3
VISCOSITYOFTHE FUELS

S.no	Fuel / Blend	Value(cSt)

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

1	Diesel	3.9575
2.	B10 (10% Safflower oil+ 90% Diesel)	4.189
3.	B20(20% Safflower oil+ 80% Diesel)	4.50
4.	B30(30% Safflower oil+ 70% Diesel)	4.535
5.	B40(40% Safflower oil+ 60% Diesel)	5.13

C .Calorific Value Measurement: Bomb Calorimeter is used to measure Calorific value of the fuel. The apparatus is cleaned and filled with water up to required level. The weight of the empty utensil is measured using digital weighing machine. Reading is noted. The required volume of fuel is taken in the utensil and measured weight of utensil with fuel. Reading is noted down. By subtracting the weight of empty utensil from the weight of utensil with oil, weight of fuel at that volume is obtained. The utensil with fuel is carefully placed inside the ring to set in it. Electrodes are connected with a conducting wire and threaded it till one end of thread gets dipped in the fuel taken in crucible. After filling the oxygen, carefully place it in the apparatus. Check for any leakage. After giving all the connections, apparatus is closed and electrical supply is given to electrodes. Note down the reading of initial temperature as T_1. Stirrer is kept ON. After sometime fire is given wait till the uniform temperature is obtained. Note down this reading of final temperature as T_2. By using the formula and substituting the values of T_1, T_2, mass of water taken in the apparatus and mass fuel measured, calorific value of that fuel is calculated.

Fig.4 Bomb Calorimeter

TABLE 4
CALORIFIC VALUEOFTHE FUELS

S.no	Fuel / Blend	Value(kJ/kg)
1	Diesel	41991.94
2.	B10 (10% Safflower oil+ 90% Diesel)	37672.2
3.	B20(20% Safflower oil+ 80% Diesel)	37382.41
4.	B30(30% Safflower oil+ 70% Diesel)	38058.58
5.	B40(40% Safflower oil+ 60% Diesel)	34677.74

C .Flash and Fire Point Measurement: The apparatus used to measure Flash and Fire point is Pensky-Martin apparatus. At first, cup in the apparatus is removed and cleaned. Sample fuel is poured into the cup up to the mark provided in the cup [11]. Then cup is closed and thermometer is inserted in the slot provided for it [12]. After checking all the connections, electrical supply is given to heat the apparatus. Gradually load is varied as per requirement. LPG supply is kept ON maintained a small flame [13]. To maintain the uniform temperature, sample fuel is frequently stirred using the stirrer. Meanwhile, lid is partially opened to check whether the vapors are formed [14]. At the appropriate temperature, while the lid is opened, if flame catches the vapors, then, a pop sound will be heard. That temperature is considered as Flash point of that sample fuel [15]. If experiment proceeds further, at a particular temperature, flame continuously burns rigorously due to the presence of more vapors. That temperature is noted as Fire Point.

Fig.5 Pensky-Martin Apparatus

TABLE 5
FLASHAND FIRE POINTSOFTHEFUEL

S.no	Fuel / Blend	Flash point(°C)	Fire point(°C)
1.	Diesel	52	56
2.	B0 (10% Safflower oil + 90% diesel)	70	78
3.	B0 (20% Safflower oil + 80% diesel)	74	80
4.	B0 (30% Safflower oil + 70% diesel)	78	82
5.	B0 (40% Safflower oil + 60% diesel)	80	88

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

IV.EXPERIMENTAL WORK

In order to find out the effect of turbulence created by the Grooves provided over the Piston crown, on the performance and emission characteristics of DI Diesel Engine when run with Safflower oil diesel blends, a single cylinder vertical type four stroke, water-coo1ed, self-governed type, compression ignition engine is used in the present work.

Figure 6 Grooved Piston

TABLE 6
ENGINE SPECIFICATIONS

Engine type	4- Stroke Diesel Engine
B.H.P	5HP
Rated speed	1500 rpm
Bore size	85mm
Stroke length	110mm
Number of cylinders	Single cylinder
Cooling	Water cooling
Cylinder arrangement	Vertical

V. RESULTS AND DISCUSSIONS

*A. Brake Thermal Efficiency:*Brake thermal efficiency is more for all the blends compared to that of diesel. Among all the blends, B40 blend has more brake thermal efficiency at all load conditions. This is may due to complete combustion of fuel admitted into the cylinder. The values of brake thermal efficiency of blend B40 at loads 0, 500, 1000, 1500, 2000, 2500 are 0, 12.62, 13.36, 15.54, 16.6, and 17.45 respectively. Fig.7 clearly shows the variation of brake thermal efficiency with the load.

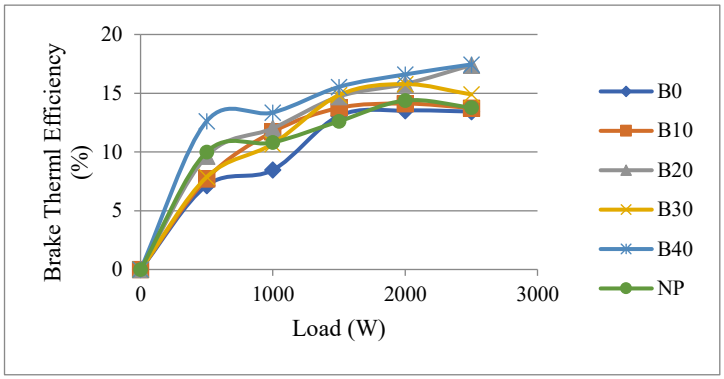

Fig.7Load Vs Brake Thermal Efficiency

*B. Indicated Thermal Efficiency:*At 3/5th load and 4/5th load conditions, Indicated thermal efficiency is more for the blend B30 compared to that of diesel and other blends. At full load condition, it is more for blend B20 than that of blend B40 by 6.21%.At all load conditions, indicated thermal efficiency is less for blend B40. This may due to variation in amount of total power produced by the engine with respect to heat supplied in the form of fuel.Fig.8 shows the variation of indicated thermal efficiency with load.

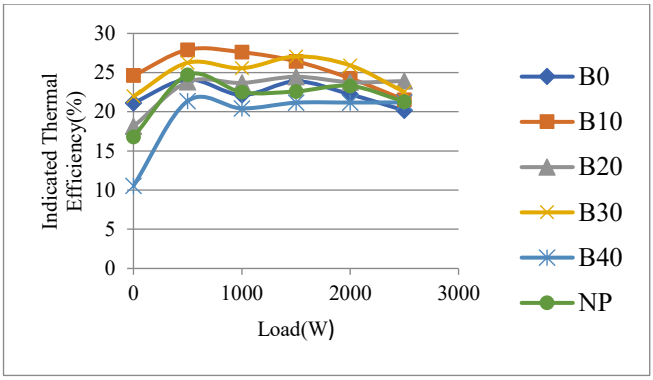

Fig. 8Load Vs Indicated Thermal Efficiency

*CMechanicalEfficiency:*At all load conditions, mechanical efficiency is more for the blend B40 compared to that of diesel and other blends.

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

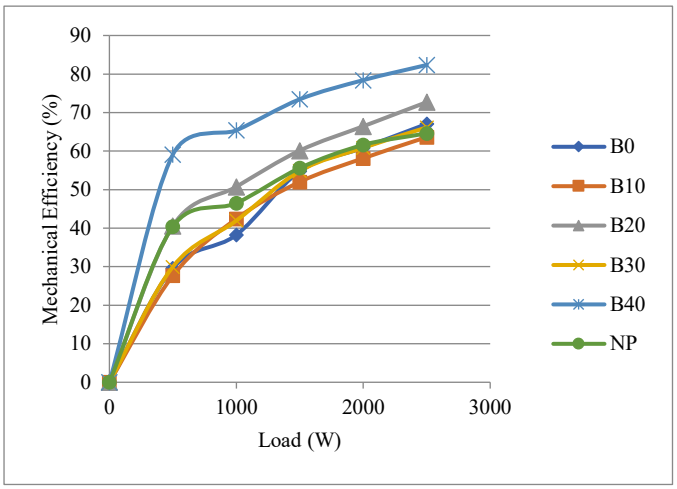

Fig. 9 Load Vs Mechanical Efficiency

D. Brake Specific Fuel Consumption: At all the load conditions, Brake Specific fuel consumption is more for the blend B10. At 2/3rd load condition, brake specific fuel consumption is more for diesel than that of all the considered blends of safflower oil and diesel. This may due to the variations in the calorific values of diesel and safflower oil or it may be due to the variation in the mass of fuel admitted. Fig. 10 clearly shows the variation of brake specific fuel consumption with load.

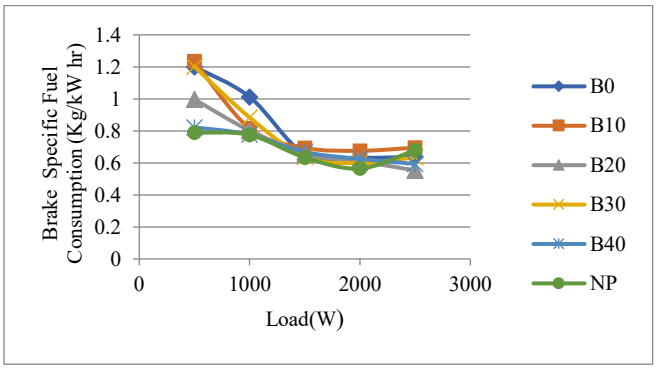

Fig. 10 Load Vs Brake Specific Fuel Consumption

VI. CONCLUSIONS

Experiments are conducted on a four stroke diesel engine run with Safflower oil diesel blends (biodiesel), using grooved piston having five number of grooves on its crown. The calculations are done and graphs are drawn.

From the experimental analysis following conclusions were obtained:

1. At all the load conditions, Brake thermal Efficiency is more for the all blends compared to that of diesel and is highest for blend B40.
2. At all the load conditions, Indicated Thermal Efficiency is less for the blend B40. At 3/5th load and 4/5th load conditions, Indicated thermal efficiency is more for the blend B30 compared to that of diesel and other blends.

3. At full load condition, it is more for blend B20 than that of blend B40 by 6.21%.
4. At all the load conditions, Mechanical Efficiency is more for the blend B40.
5. At all the load conditions, BSFC is lower for all blends compared to that of diesel. But at 5/6th load, and 6/6th load, BSFC is more for the blend B10 compared to that of diesel by 8.48% and 5.244% respectively.
6. Density and Specific gravity values are obtained more for blends than that of diesel.
7. Calorific value is more for diesel than that of all the blends considered.
8. Viscosity of diesel is lower than that of all other blends.
9. Flash and Fire points of diesel are lower than that of blends.

VII. SCOPEOF FUTURE WORK

This work can be extended by varying the number of grooves over piston crown or by varying the dimensions of groove cut or by using various types of alternate fuels performance and emission characteristics of engine can be find out.

REFERENCES

[1] A. SwarnaKumari, C.H. Penchalayya, A.V. Sita Rama Raju., "Performance evaluation of diesel engine with safflower oil , *Journal of Engineering Studies and Research, Volume 19(2013)No.2".*

[2] C.V. Subba Reddy, C. Eswara Reddy and K. Hema Chandra Reddy., "Effect of tangential grooves on piston crown of DI diesel engine with blends of cotton seed oil methyl ester", *IJRRAS 13(1), October 2012".*

[3] V.V PrathibhaBharathi, Dr. G. Prasanthi., "The influence of air swirl on combustion and emissions in a diesel engine, *IJRMET Vol. 3, Issue 2, May - Oct 2013".*

[4] ShyamPandey, Amit Sharma, P. K. Sahoo., "Experimental investigation on the performance and emission characteristics of a diesel engine fuelled with ethanol, diesel and jatropha based biodiesel blends", *IJAET Vol. 4, Issue 2, Sept 2012".*

[5] B.Madhubabu, Prof. K. Govindarajulu and Dr.S.L.V.Prasad**, "**Experimental investigation of a single cylinder 4- stroke di diesel engine by swirl induction with two different configuration pistons", *IJAIEM, Volume 3, Issue 11, November 2014.*

[6] Hansen, A.C., Mendoza, M., Zhang, Q. and Reid, J.F. (2000). "Evaluation of oxydiesel as a fuel for direct injection compression–ignition engines", *Final Report for Illinois Department of Commerce and Community Affairs, Contract IDCCA 96-32434.*

[7] Xueliang H; ShuSong L, (1990); "Combustion in an internal combustion engine". *Mechanical Industry Press, Peking*.

[8] Arturo de Risi, Teresa Donateo, DomenicoLaforgia," Optimization of the combustion chamber of direct injection diesel engines" *SAE2003-01-1064.*

[9] Sehmusaltun" Performance and exhaust emissions of a di diesel engine fueled with waste cooking oil and inedible animal tallow methyl esters" *Turkish j. eng.env. sci.35 (2011), 107 – 114.c_t ŕub˙itak.*

[10] S.Jaichander, k.annamalai"Performance and emission analysis on pongamia biodiesel with different open combustion chambers in a di diesel engine" *Journal of scientific and industrial research,*

[11] *Kotla, P. (2024). Bridging Legacy Systems with Modern Automation: UiPath RPA in Financial Institutions. Available at SSRN 5346246.*

[12] *Chawla, N., Kotla, P., Venna, S. R., & Patel, M. B. (2025, August). Comprehensive Analysis of Robotic Process Automation for Software Project Management. In 2025 2nd International Conference on Intelligent Algorithms for Computational Intelligence Systems (IACIS) (pp. 1-4). IEEE.*

[13] *Hameed, R., Palanivel, R., Kotla, P., Padma, L., & Jeyanthi, S. (2025, August). Blockchain-Integrated Reputation Evaluation Framework for Peer Review. In 2025 Third International Conference on Networks, Multimedia and Information Technology (NMITCON) (pp. 1-5). IEEE.*

[14] *Kotla, P. (2022). Accelerating Shared Services with UiPath: Lessons from Early Automation Centres of Excellence (CoEs). Available at SSRN 5379367.*

[15] *Kotla, P. (2023). Combining Document Understanding and Action Center in UiPath for Human-In-The-Loop Claims Processing.*