Experimental investigation of Performance Parameters of Four Stroke Single Cylinder Direct Injection Diesel Engine Operating on Ethanol and Waste Frying Oil Ethyl Ester Blends With Conventional Diesel Fuel

[1]Akhand Pratap Singh, [2]Mukesh Kumar Bunkar
[1,2]Dept. of Mechanical Engineering, UIT-RGPV, Bhopal, MP, India

Abstract
The main objective of this study is to investigate the performance parameters of four stroke single cylinder direct injection diesel engine operating on ethanol and waste frying oil ethyl ester (WFOEE) blends on diverse ratio with conventional diesel fuel. The experimental investigation of performance parameters of a diesel engine is carried out using ethanol and waste frying oil ethyl ester blends with petro- diesel and results compared with conventional diesel fuel. The complete experiments were performed on a single cylinder direct injection diesel engine runs at constant speed and 50% engine load. The result showed that the brake specific fuel consumption (BSFC) of diesel engine increased when the engine was operating on E20, WFOE30 and WFOEE50 blends as compared to petro-diesel fuel. It is also investigated that the brake specific energy consumption (BSEC) of WFOEE50 is increased by 14.6% and the brake thermal efficiency (BTE) is decreased by 6.88% in comparison to petroleum diesel fuel when the engine brake load were 50%. When the blends E20, WFOEE30 and WFOEE50 used in diesel engine the fuel consumption was increased as compared to diesel fuel. The result showed that the WFOEE50 when used in diesel engine consumed more fuel in comparison to E20. The viscosity and fire point of WFOEE30 and WFOEE50 were higher in compared to petro-diesel fuel that is advantageous to easy in handling and transportation. The higher viscosity of WFOEE30 and WFOEE50 provide lubrication that result the less wear of engine and increase engine life. Biodiesel clean burning diesel alternative fuel. It has many attractive features including renewability, biodegradability, low emission and non toxic.

Keyword
Diesel (CI) engine, Performance, Ethanol & WFOEE

I. Introduction

From 1973 to 2004 the global primary energy consumption increased from 252 to 463 billion MJ [1]. The lack of conventional fossil fuels, their increasing costs and rising emissions of combustion-generated pollutants will make bio-based fuels more attractive [2]. Due to the rise in price of petroleum products, especially after the petrol crisis in 1973 and then the Gulf War in 1991, geographically reduced availability of petroleum and more rigorous governmental regulations on exhaust emissions, many researchers have studied alternative fuels and alternative solution methods [3-4]. Due to the depletion of petroleum reserves and increases in environmental concerns the importance of biodiesel increases gradually [5]. Recently biodiesel has turned into more attractive because of its ecological benefits [6-7]. As a future prospective fuel, biodiesel has to compete economically with petroleum diesel fuels. The use of raw vegetable oils in engines without any modification results in poor performance and leads to wear of engine components [8]. The value of higher viscosity causes poor fuel atomization during the injection process that increases the engine deposits and increases more energy consumption to pump the fuel which wears fuel pump elements and injectors [9]. Biodiesel has relatively higher flash point (150oC) that makes it less volatile and safer to transport or handle than petro- diesel fuel [10]. The investigations showed that esters of vegetable oils provide better performance and minimized emissions than that of raw vegetable oils. Since the biodiesels are derived from plant oils, they produce negligible net green house gas emissions [11]. Reuse of WCO minimize the production cost of biodiesel significantly but also helps the government to disposing waste oils, maintaining treating oily waste water and public sewers. A lot of quantities of WCO are generated in food processing industries, fast food shops and house cooking every day. Waste cooking oil was selected as an alternate because it is cheaper and it also avoids the price of waste product disposal and treatment [12].

Biodiesel showed higher BSEC in comparison to diesel fuel for all engine brake loads. At 100% load condition, BSEC of 15.5 MJ/kWh was observed with biodiesel, which was 3.1 MJ/kWh higher than that of diesel. This is mainly because of lower calorific value of biodiesel. The brake thermal efficiency of biodiesel was slightly lower than that of traditional diesel fuel at 100% load condition. With the use of biodiesel the NO and smoke emission decreased as compared to diesel. Biodiesel showed lower heat release rate, a minute ignition delay and slightly higher combustion duration compared to diesel [13]. The biodiesel has lubricating properties that can diminish engine wear and extend engine life [14].

The Brake thermal efficiency of diesel engine is less due to the lower calorific value and higher viscosity of biodiesel. Higher viscosity of biodiesel fuel resulted poor fuel atomisation during the spray process which increasing the engine deposits and also requires more energy to pump the fuel that wear out the diesel engine fuel pump elements and injectors [10]. The thermal efficiency of CI engine depends on the fuel–air ratio and the compression ratio. With fixed compression ratio, the thermal efficiency mainly depends only on the fuel–air ratio [15]. Maximum brake thermal efficiency of 23.1% was observed with biodiesel (WCO-ME), which is 6% lower than that of diesel at 100% load condition.

II. Experimental Setup

The detail technical specification of diesel engine and experimental set up mentioned as following.

Table 1: Technical Specification Diesel (CI) Engine

Engine Parameters	Details
Make	Kirloskar Oil Engine, pune
Model	SV1
Type	CI Four Stroke Engine, Totally Enclosed, Vertical, Water Cooled
No. of Cylinder:	ONE

Bore Size	87.5 mm
Stroke Length	110 mm
Cubic Capacity	662 CC
Compression Ratio	16.5:1
Engine RPM	1500
Rate of Output	5.88kW / 8 HP

The experimental setup of test engine is shown in fig. 1.

Fig. 1: Experimental set up of Test Engine

III. Result & Discussion

A. Properties of Fuels

The properties of Diesel, Ethanol and WFOEE fuels are carried out by the help of IOCL, Bhopal and Department of Chemistry in Shree Institute of Science and Engineering College Bhopal. The results of fuel properties are mentioned in Table 2.

Table 2: Compared the Physical properties of Diesel Ethanol & WFOEE.

Property of Fuel	Diesel	Ethanol	WFOEE
Density at 50 °C (kg/m^3)	832	79	878
Specific Gravity	0.836	0.79	0.876
Kinematic Viscosity at 40°C (cst)	2.645	1.136	4.821
Cloud Point (°C)	6.6	5.4	1
Pour Point (°C)	3.1	-118	-4
Flash Point (°C) at 40°C	51	21	172
Lower Calorific Value (kJ/kg)	42610	26520	36860

B. Performance of Diesel Engine

All the experiments are perform at a constant speed of 1500 RPM by varying the brake load and the data obtained from the experiments are used to evaluate the performance characteristics of diesel engine.

The performance parameters of diesel engine shows the brake specific energy consumption (BSEC) of WFOEE30, WFOEE50 & E20 blends are increased as the percentage of engine brake loads are increased. It also observed that the brake thermal efficiency (BTE) of WFOEE30, WFOEE50 and E20 blends are decreased as compare to diesel. The brake power of E20 is approximately equal to diesel, while the brake specific fuel consumption is slightly higher than that of diesel. WFOEE30, WFOEE50 & E20 showed higher BSEC (Brake Specific Energy Consumption) and brake thermal efficiency of WFOEE30, WFOEE50 & E20 resulted decreased than that of diesel fuel for all loads.

1. Fuel Consumption (FC)

Fig. 2 shows the varition in Fuel Consumption (FC) for diesel, WFOEE30, WFOEE50 and E20 blends are used in diesel engine. When the WFOEE30, WFOEE50 and E20 blends are used the diesel engine connsumed more fuel as compared to diesel. The fuel consumption of WFOEE30 and WFOEE50 blends are increased by approximately 10.6% and 14.6% respectively than that of pure diesel fuel when the brake load on engine is 50% and runs at constant speed of 1500 rpm. It is observed that at same load conditon the diesel engine consume more fuel (WFOEE30 , WFOEE50 and E20) in comparison to conventional diesel. During testing of diesel engine WFOEE50 blend is increased by 1.5% more than that of the E20.

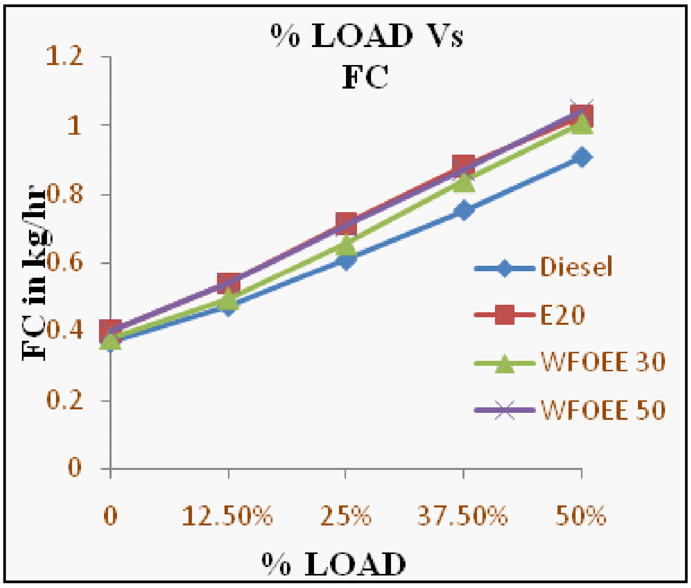

Fig. 2: Variation of FC with % Load for Diesel, WFOEE and Ethanol Blends

2. Brake Specific Fuel Consumption (BSFC)

Fig. 3 shows the varition in BSFC (Brake Specific Fuel Consumption) for diesel, WFOEE30, WFOEE50 and E20 blends are used in diesel engine. The brake specific fuel consumption is an essential parameter to compare engines and determine of fuel efficiency of an engine. The BSFC of diesel engine decreses as the loads are increase. The brake specific fuel consumption of WFOEE30 & WFOEE50 are increased by 10.6% and 14.6% correspondingly than that of diesel fuel when the engine brake load is 50 % and runs at constant speed . It is investigated that the

BSFC of E20 is increased by 12.86% as compared to petrolium diesel. It is observed that the BSFC of E20 is increased by 1.5% more as compared to WFOEE50 at 50% engine loads.

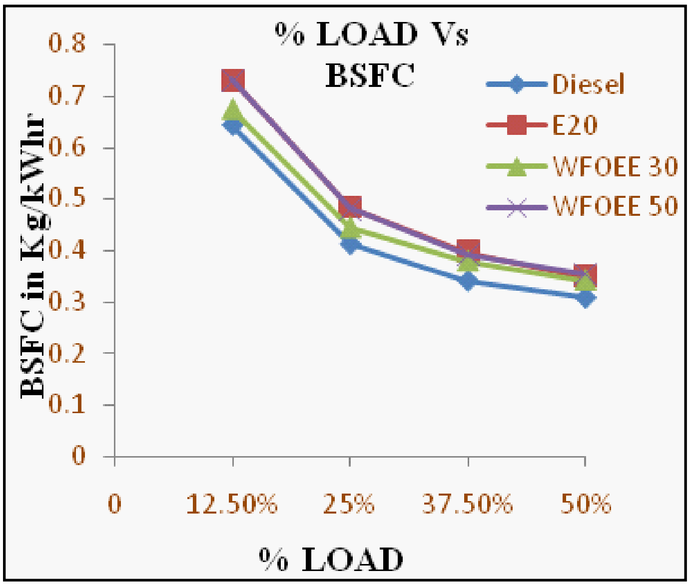

Fig. 3: Variation of BSFC with % Load for Diesel, WFOEE and Ethanol Blends

3. Brake Specific Energy Consumption (BSEC)

Fig. 4 shows the varition in BSEC (Brake Specific Energy Consumption) for diesel, WFOEE30 , WFOEE50 and E20 blends are used in diesel engine. The lower calorific value and higher viscosity of WFOEE30 & WFOEE50 blends resulted higher brake specific energy consumption in diesel engine as compared to diesel fuel. WFOEE30, WFOEE50 and E20 are resulted higher Brake Specific Energy Consumption (BSEC) than that of diesel for all engine loads. As the loads are increased the diesel engine consumed more energy for all blends. The engine shown BSEC of WFOEE is increased by approximately 3.96% while the BSEC of WFOEE30 is by approximately 6.05% and WFOEE50 is increased by 6.88% higher than that of diesel for 50% engine load. It is observed that when the E20 blend is used the BSEC of E20 is decreased by2.44% as compared to WFOEE50 blend.

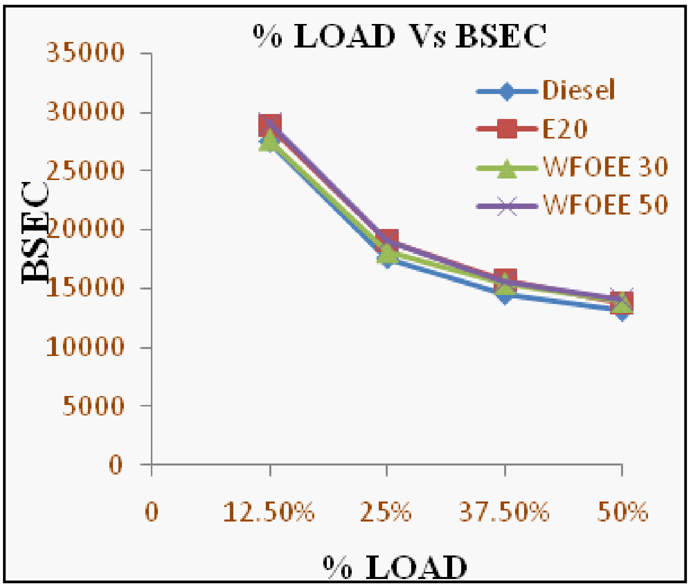

Fig. 4: Variation of BSEC with % Load for Diesel, WFOEE and Ethanol Blends

4. Brake Thermal Efficiency (BTE)

Figure 4 shows the varition in Brake Thermal Efficiency (BTE) for diesel, WFOEE30, WFOEE50 and E20 blends are used in diesel engine. The brake thermal efficiency of WFOEE30, WFOEE50 and E20 is decreased as the engine loads are increased. The brake thermal efficiency of WFOEE30 & WFOEE50 blends are decreases with 6.04% and 6.88% respectively as compared to diesel when the engine runs at constant speed and 50% brake load. It also observed that the brake thermal efficiency (BTE0 of WFOEE30 and WFOEE50 blends is decreased by 1.63 and 2.44% respectively as compared to conventional diesel for all engine brake loads.

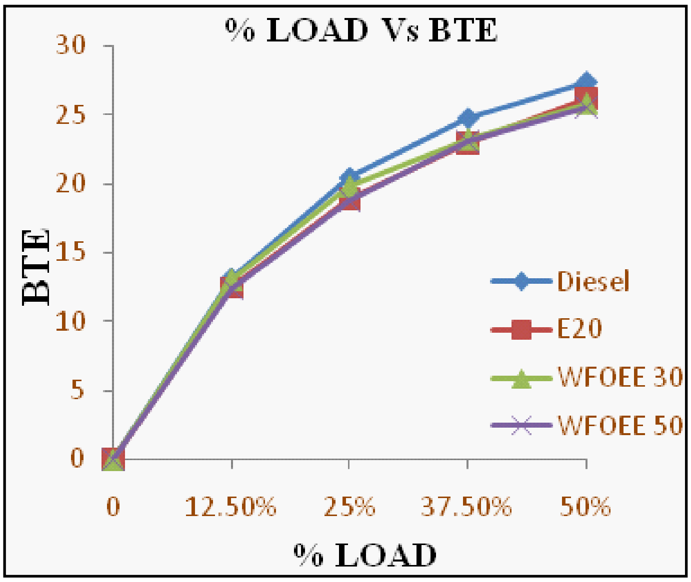

Fig. 5: Variation of BTE with % Load for Diesel, WFOEE and Ethanol Blends

IV. Conclusion

The performance of four stroke single cylinder DI diesel engine fuelled with WFOEE30, WFOEE50 & E20 blends are investigated and results compared with conventional diesel fuel. The fuel properties of WFOEE blends have comparatively higher flash point 1720C which makes it less volatile and safer to transport than petroleum diesel fuel. The brake thermal efficiency (BTE) of WFOEE and ethanol blends are decrease as compared to petroleum diesel fuel for all engine brake loads. The Brake Specific Energy Consumption (BSEC) of WFOEE30 & WFOEE50 blends is higher as compared to conventional diesel fuel due to its lower calorific value and higher viscosity.

From the above investigation it can be concluded that the diesel engine running normally during testing of diesel engine when the engine fuelled with WFOEE30, WFOEE50 and E20 blends. The WFOEE50 resulted poor performance as compared to WFOEE30 and E20 blends. WFOEE30 and WFOEE50 blends obtained from waste frying oil can be used as an alternate fuel for conventional diesel fuel in future.

V. References

[1] IEA, Energy Statistics from International Energy Agency, 2006, pp. 6.

[2] Sensoz, S., Angin, D., Yorgun, S.,"Influence of particle size on the pyrolysis of rapeseed (Brassica napus L.), Fuel properties of bio-oil", Biomass Bioenergy 19, 2000, pp. 271–279.

[3] Demirbas, M. F., Balat, M.,"Recent advances on the production and utilization trends of biofuels - a global

perspective", Energy Convers. Mgmt. 47, 2006, pp. 2371–2381.

[4] Durgun, O., Sahin, Z.,"Theoretical investigations of effects of light fuel fumigation on diesel engine performance and emissions", Energy Convers. Mgmt. 48, 2007, pp. 1952–1964.

[5] Chen, X., Du, W., Liu, D.,"Response surface optimization of biocatalytic biodiesel production with acid oil", Biochemical Engineering, 40, 2008, pp: 423–429.

[6] Balat, M.,"Fuel characteristics and the use of biodiesel as a transportation fuel", Energy Sources Part A (28), 2006 (b), pp. 855–864.

[7] Balat, M.,"Production of biodiesel from vegetable oils: A survey", Energy Sources Part A (29), 2007, pp. 895–913.

[8] Bari, S., Yu, C.W., Lim, T.H.,"Performance deterioration and durability issues while running a diesel engine with crude palm oil", Proc Instn Mech Engrs. Part D, J Automobile Engineering 216, 2002, pp. 785–792.

[9] Kinast, J.A.,"Production of biodiesels from multiple feedstocks and properties of biodiesels and biodiesel/diesel blends", Des Plaines, National Renewable Energy, Laboratory Report, Department of Energy, U.S., 2001.

[10] Krawczyk, T., "Biodiesel", INFORM 7 (8), 1996, pp: 801–822.

[11] Peterson, C.L., Hustrulid, T., "Carbon cycle for rapeseed oil biodiesel fuels", Biomass and Bioenergy 14(2), 1998, pp: 91–101.

[12] Thanh, L.T., et al., "A two-step continuous ultrasound assisted production of biodiesel fuel from waste cooking oils: a practical and economical approach to produce high quality biodiesel fuel", Bioresource Technology, 101, 2010, pp: 5394–5401.

[13] G.R., Kannan, K.R., Balasubramanian, S.P., Sivapirakasam, and R., Anand, "Studies on biodiesel production and its effect on DI diesel engine performance, emission and combustion characteristics", International Journal of Ambient Energy, 32 (4), 2011, pp: 179-193.

[14] Von Wedel, R., "Technical handbook for marine biodiesel in recreational boats". Prepared for National Renewable Energy Laboratory, US Department of Energy, Subcontract No. ACG – 7 - 16688-01 under Prime Contract No. DE - AC36 - 83CH10093, 1999, pp: 32.

[15] Mathur, M.L. and Sharma, R.P., "Internal combustion engines", New Delhi, Dhanpat Rai & Sons, 1997.

Akhand Pratap Singh received his B.E degree in Industrial Production Engineering from University Institute of Technology – RGPV, Bhopal, India, in 2010 and the M.E degree in Heat Power Engineering from University Institute of Technology – RGPV Bhopal, India, in 2012. He was worked as an assistant professor with Department of Mechanical Engineering in Shree Institute of Science and Technology, Bhopal from 2012 to 2013. Presently, he is working as a Training Officer in Industrial Training Institute Anuppur, India. His research interests include alternative fuels & performance of diesel engine.