International Journal of Research in Advent Technology, Vol.6, No.8, August 2018
E-ISSN: 2321-9637
Available online at www.ijrat.org

Evaluation of Performance of Single Cylinder 4S- CI Engine Using a Neat Biodiesel Blend

Dr.P.VaraPrasad[1], Dr. P.V. Sanjiv Kumar[2], V. Mallikarjuna [3]
Department of mechanical Engineering., Annamacharya Institute of Technology &Sciences, Rajampet, A.P,India[1,2,3]
Email: pvpd1969@gmail.com1[1]

Abstract- The experimentation was carried out on a single cylinder, water cooled, direct injection diesel engine to operate on polanga oil methyl ester-diesel blend(PME20) for different injection timings such as 23^0bTDC, 20^0bTDC, 26^0bTDC and 29^0bTDC, at rated speed, under varying loads from no load to full load(0%-100%). The exhaustive tests were carried out to evaluate the performance and emission characteristics of diesel engine operated on PME20 (composition of 20% diesel and 80% neat PME fuel) to find optimum fuel injection timing(FIT) amongst selected FITs, in comparison with base line data of high speed diesel(HD) fuelled CI engine. PME20 has shown overall better performance, and emission characteristics, at 26^0bTDC and at 80% of full load.
Keywords- PME20; FIT; HD; bTDC

1. INTRODUCTION

The global concern for air pollution and depletion of ozone layer has forced to re-evaluate the use of conventional fuels like gasoline, diesel and coal as well. In view of continues growth in demand of energy and rise of fossil fuels cost, it is emerged to investigate for most appropriate substitute for diesel fuel. Biodiesel refers to any diesel-equivalent bio-fuel made from renewable biological materials such as vegetable oils or animal fats. It is usually produced by trans-esterification and esterification reaction of vegetable oil with a low molecular weight alcohols such as ethanol and methanol. During this process triglyceride molecule from vegetable oil is removed in the form of glycerin (soap).Once the glycerin is removed from the oil, the remaining molecules are, to a diesel engine somewhat similar to those of petroleum diesel fuel. Biodiesels are essentially free of sulphur and aromatics. Biodiesel is a fuel naturally inbuilt with about 10% of oxygen. The concept of using vegetable oil as a fuel in 1895 when Dr. Rudolf Diesel developed the first diesel engine to run on vegetable oil.

In the present study polanga methyl ester –diesel blend (PME20) was selected as test fuel and investigation was carried out at four different injection timings.

2. LITERATURE REVIEW

Most of the researchers reported that the performance of biodiesel fuelled diesel engine is poor than petro-diesel operated engine. Interestingly, some of the researchers reported that thermal efficiency was higher with biodiesel than diesel fuel [1]. Some of the investigations showed that lower HC, CO and particulate matter emissions, but higher NOx emission for biodiesel [16, 17]. The biodiesel operation reduces the harmful emissions viz., CO, HC and smoke but with little increment of NOx emissions relative to diesel fuel [2]. The biodiesel blends and neat biodiesel in diesel engine reduces carbon monoxides about 3-15% [3] unburnt hydrocarbons about 6-40% [4] and smoke density to 45% [5] compared to ULSD (ultra low sulfur diesel). However, the biodiesel blended fuels operation had shown NOx emissions up to 26% [6], BSFC increased by 6-15% [7] decreases in brake thermal efficiency up to 9% [8]. It was reported that the NOx reduced in descending order are: CME, PME, SME, WME, and RME; PM emissions reduction varies from 53%-69% [9]. 50% jatropha biodiesel blend showed maximum power with less smoke amongst all the biodiesels and their blends than diesel [10]. The rice bran biodiesel fuelled engines produced less CO, unburned HC, and PM emissions when compared to diesel fuel but higher NOx emissions [11]. The biodiesel blended fuels have strong beneficial impacts on HC, CO and PM emissions but adverse effects on NOx emissions [12-14]. Calophyllum Inophyllum (polanga) biodiesel and additives showed BTE increased and lower in BSFC than diesel [15]. There was an improvement in BTE, BSFC and substantial improvements in reduction of emissions for TRCC operated at higher injection pressure by improved combustion, due to better air motion inside the cylinder and high pressure injection increases the oxides of nitrogen (NOx) [18]. With four different fuel injection pressures (18, 20, 22, and 24 MPa) diesel engine operation showed that there was increase in BSFC, CO_2, NOx emissions, while HC and CO emissions were reduced at low injection pressures where as these values decrease with increasing injection pressures [19]. With 5^0 advanced injection timing led to reduction in BSFC, CO, HC and smoke and increase in BTE, peak pressure, HRR_{max}(maximum heat release rate) and NO emission with Jatropha biodiesel operation. However, with 5^0 retarded injection timing, increase in BSFC, CO, HC and smoke and reduction in BTE, peak pressure, HRR_{max} and NO. Nevertheless, BTE, CO, HC and smoke for Jatropha biodiesel are lower than diesel fuel operation [20]. The fish oil methyl ester produced lower smoke, CO, PM emissions in comparison to diesel but slightly higher than Jatropha oil methyl ester. The NOx emissions of fish oil methyl ester were higher than diesel but lower than Jatropha oil methyl ester [21].

3. MATERIAL & METHOD

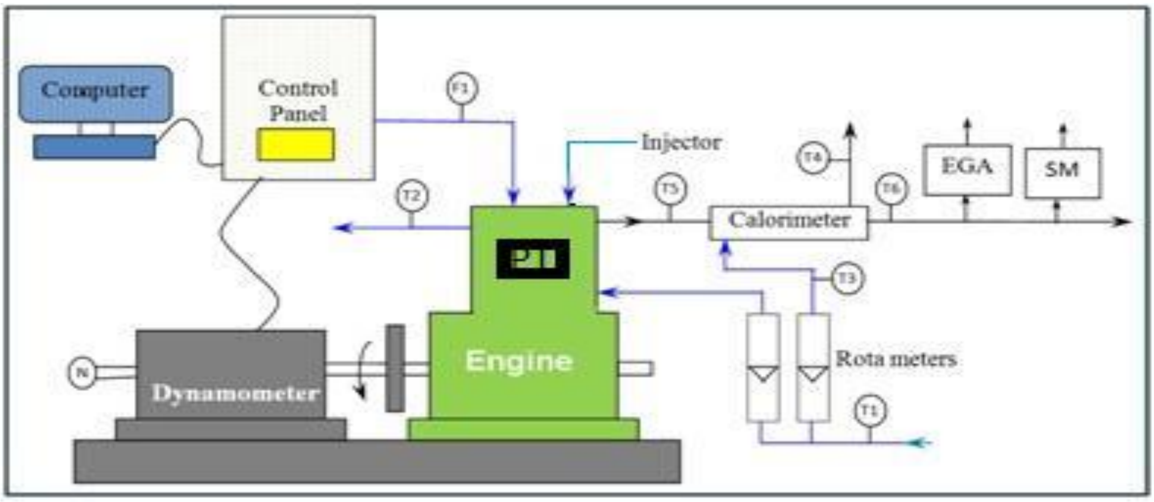
The test fuels in the present study has chosen as neat methyl ester of polanga oil – diesel blend (PME20) and the results compared with normal diesel engine operation. Some of the important properties of neat PME and high speed diesel (HD) fuel were given in Table 1.

Experimental set up was shown in Fig.1. The test setup engine equipped with eddy current type dynamometer for loading and specifications of test engine is shown in table 2. The setup equipped with the necessary arrangements to measure in cylinder pressure and crank-angle etc. The performance parameters like BP, BTE and BSEC were evaluated by measuring the observations viz., speed and load on the engine, rate of fuel consumption, with suitable instruments provided in the engine setup. The emissions were directly measured with exhaust gas analyzer and smoke meter. The change of injection timings set for diesel engine by spill method with removing and adding of shims (0.3mm).Each test conducted on engine after attaining steady condition only.

S. No.	Property	PME	HD	ASTM D6751-02
1	Density (kg/m^3) 15 0C	870	840	-
2	Viscosity (cSt)at 40 ^{0}C	4.35	2.62	1.9-6
3	Cetane index	55	47-55	>49
4	Calorific value(kJ/kg)	39994	43000	-

Table 2 Specifications of Test Engine

Type	Kirloskar, TV1,1 cylinder, 4-s, DI diesel engine
Injection pressure	200 bar
Rated power	5.2 KW (7 HP) @1500 RPM
Cylinder Bore	87.5 mm
Stroke length	110 mm
Compression ratio	17.5 : 1
Standard Injection Timing	23^o bTDC



T1, T3-Water inlet Temperature
T2-Engine water jacket outlet
PT- Pressure transducer
N-RPM encoder
T4-Calorimeter exit temperature
T6- EGT after Calorimeter
EGA-Exhaust gas analyzer
SM-Smoke Meter

Fig. 1 Schematic view of Test Engine Setup

4 RESULTS & DISCUSSION

4.1 Brake Thermal Efficiency (BTE)

The Fig.2 shows the effect of load on BTE for different injection timings (ITs) for polanga oil methyl ester fuel operation. It was observed that the BTE increased with load. The BTE is found to be lower for PME 20 fuel as compared to high speed diesel fuel for entire load range. The lower brake thermal efficiency was attributed to lower calorific value and higher viscosity of biodiesel than high speed diesel fuel. There is more amount of lower energy (heating value) biodiesel is required for maintaining the same brake power output. However, the BTE was found to be high for PME20 fuel at 26^0bTDC IT than other ITs. It may be the reason that better combustion and utilization of heat energy conversion into power at 4/5 of full load. The maximum BTE values were 27.95%, 26.4%, 28.5% and 27.3% at 23^0bTDC, 20^0bTDC, 26^0bTDC and 29^0bTDC for PME20 fuel respectively, where as it was 30.25% for HD fuel, at 80% of full load.

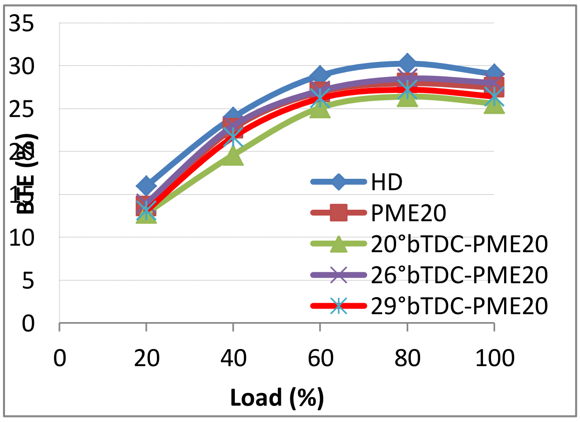


Fig.2 Variation of BTE for different ITs for PME20

4.2 Brake Specific Energy Consumption (BSEC)

The variation in BSEC against the load for different injection timings for PME20 fuel was shown in Fig. 3. The BSEC is an important parameter rather than brake specific fuel consumption when comparing different density and heating value fuels because it taking into account of both the density and calorific value of the fuel. The Fig.3 showed that the BSEC reduced with load. The BSEC was better at 26^0bTDC for PME20 fuel among the selected FITs, however higher than HD fuel. The BSEC values were 12.88 MJ/kW-h, 13.636 MJ/kW-h, 14.59 MJ/kW-h and 14.8 MJ/kW-h at 23^0bTDC, 20^0bTDC, 26^0bTDC and 29^0bTDC, respectively, for PME20 fuel. where as it was 11.9 MJ/kW-h for diesel fuel normal operation, at 80% of full load.

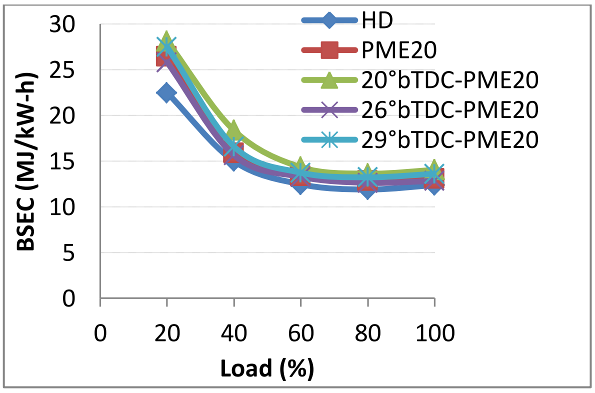


Fig.3 Variation of BSEC with load for different FITs for PME20 fuel

4.3 Carbon Monoxide (CO)

Fig. 4 represents CO versus load for the different injection timings of PME20 fuel. This plot reveals that CO emissions were decreased from low load to medium loads and then increased at higher loads for all test fuels. Since, CO emission generally depends upon the cylinder temperature and availability of oxygen. At lower loads cylinder temperature is low, resulting in more partial combustion. The higher CO emission at the full load was due to the lack of oxygen. The biodiesel blended fuel showed lower CO emission when compared to HD fuel. It was observed that the PME20 fuel has lowest CO emission at 26^0bTDC. The CO values were 0.07% v, 0.08% v, 0.065% v and .08%v at 23^0bTDC, 20^0 bTDC, 26^0 bTDC and 29^0bTDC , for PME20 fuel, respectively.

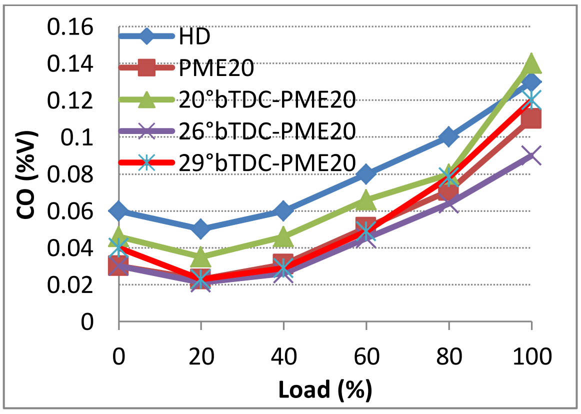


Fig.4 Variations of CO Vs load for different FITs

whereas it was 0.09%v for HD fuel normal operation, at 80% of full load.

4.4 Hydro Carbon (HC)

Fig. 5 shows the variation of HC emission for PME20 fuel for FITs. It demonstrates that the HC emission for all test ITs initially decreased up to medium loads and then increased. The higher emission at lower loads might be attributed to incomplete combustion even though more oxygen presents in case of methyl ester fuels. The HC emissions are serious problem at low loads for diesel engines. The HC emissions were observed to be lower for PME20 fuel at all injection timings than HD fuel normal operation. HC values were lower because of better combustion due to inbuilt oxygen of biodiesel. The HC emissions were higher at high loads due to low volumetric efficiency and more fuel injected into the cylinder. The HC emissions were found to be 28ppm, 30ppm, 25ppm and 28ppm for PME20 fuel at 23^0bTDC, 20^0bTDC, 26^0bTDC and 29^0bTDC respectively, where as it was 36ppm for HD fuel normal operation, at 80% of full load.

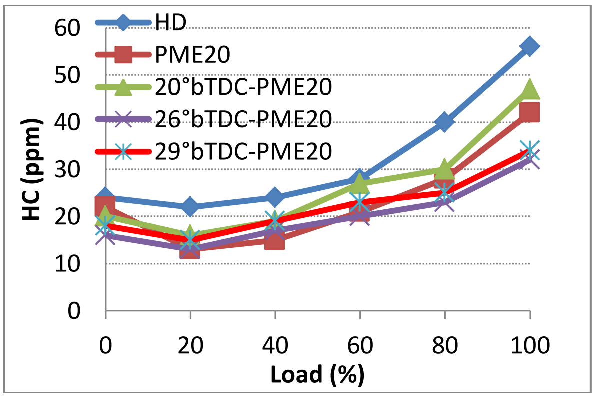


Fig.5 Variations of HC for different FITs for PME20

4.5 NOx

Fig. 6 shows the variation of NOx emission results for different injection timings for PME20 fuel with respect to different engine loads. It demonstrates that the NOx emission increases with load. The NOx formation in diesel engines is a complex phenomenon and it depends upon three important factors namely flame temperature, oxygen concentration and reaction residence time. At all the FITs of polanga oil methyl ester blended fuel showed slightly higher NOx emissions in comparison to HD fuel. The NOx emissions were found to be 1121ppm, 1037ppm, 1130ppm and 1143ppm for PME20 fuel at 23^0bTDC, 20^0bTDC, 26^0bTDC and 29^0bTDC respectively, where as it was 1080ppm for diesel fuel normal operation, at 80% of full load.

4.6 Smoke Opacity

Fig. 7 represents Smoke versus engine load for different fuel injection timings for PME20 fuel operation. It was observed to be the smoke emissions were higher at initial loads, lower at middle loads and then increased at high loads. The higher smoke formation might be affected by the heterogeneous nature of diesel combustion. The biodiesel fuel showed lower smoke emission when compared to HD fuel. The primary smoke formation might be limited due to inbuilt oxygen in biodiesel. It was observed that the PME20 fuel has lowest CO emission at 26 ^{0}bTDC. The smoke values were 34HSU, 41HSU, 30HSU and 37HSU at 23^0bTDC, 20^0bTDC, 26^0bTDC and 29^0bTDC for PME20 fuel respectively, where as it was 46HSU for diesel fuel normal operation, at 80% of full load.

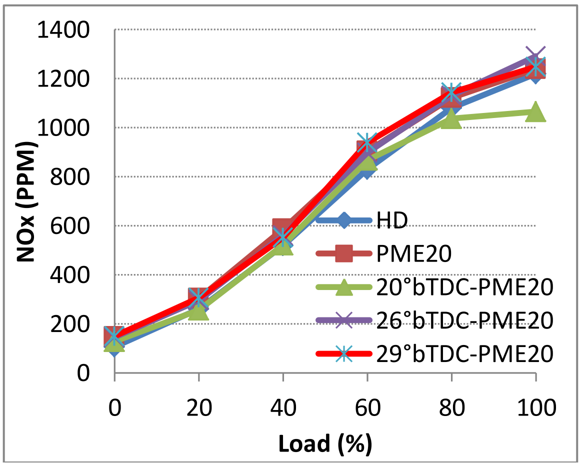


Fig.6 Variation of NOx for different FITs for PME20

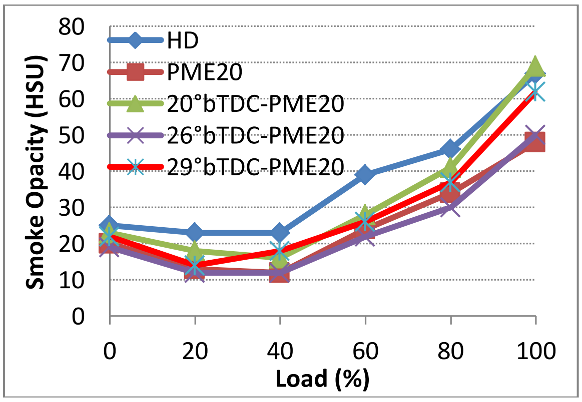


Fig.7 Variations of Smoke for different FITs for PME20 fuel

5. CONCLUSION

The following conclusions were drawn based on the diesel engine running on PME20 fuel at different injection timings. Amongst the selected fuel injection timings 26^0bTDC PME20 fuel has shown better performance and emission characteristics, at 80% of full load.

- The BTE was about 28.5% and 1.75% lower than HD fuel normal engine operation.
- The BSEC was 14.59MJ/kW-h and 2.67 MJ/kW-h higher than HD fuel normal operation.
- The HC emissions were noted as 25 ppm and 30.22% lower than diesel normal operation.
- The CO emissions were found to be 0.065%vol. and lower by about 33% than diesel normal operation.
- The NOx emissions were identified as1130ppm and increased about 4.6% than diesel normal operation.
- The Smoke emissions were 30HSU and 32.78% lower than diesel engine normal operation.

REFERENCES

[1] Agarwal, A.K., and Vegetable oil versus diesel fuel: development and use of biodiesel in a compression ignition engine, TIDE 8(3): pages 191-204, 1998
[2] Dorado, M.P., Exhaust emissions from a diesel engine fueled with transesterified waste olive oil, Fuel, 82, pages 1311-1315, 2003.
[3] Yuan CL, Kuo HH, Chung BC. Experimental investigation of the performance and emissions of a heavy-duty diesel engine fueled with waste cooking oil biodiesel/ultra-low sulfur diesel blends. Energy 36(1), pages 241-48, 2011.
[4] Bhupendra SC, Naveen K, Haeng MC. A study on the performance and emission of a diesel engine fueled with Jatropha biodiesel oil and its blends. Energy 37(1): pages 616-22, 2012.
[5] Leevijit T, Prateepchaikul G. Comparative performance and emissions of IDI turbo automobile diesel engine operated using degummed, de-acidified mixed crude palm oil diesel blends Fuel.90(4):1487-91, 2011.
[6] Mohamed Musthafa M, Sivapirakasam SP, Udayakumar M. Comparative studies on fly ash coated low heat rejection diesel engine on performance and emission characteristics fueled by rice bran and pongamia methyl ester and their blend with diesel. Energy, 36(5):2343-51, 2011.
[7] Buyukkaya Ekrem. Effects of biodiesel on a DI diesel engine performance, mission and combustion characteristics. Fuel 89(10):pages 3099-105, 2010.
[8] Barabas I, Todorut¸ A, Baldean A. Performance and emission characteristics of a CI engine fueled with diesel biodiesel bioethanol blends. Fuel 89(12):pages 3827-32, 2010.
[9] Fujia Wu, Jianxin Wang, Wenmiao Chen, Shijin Shuai A study on emission performance of a diesel engine fueled with five typical methyl ester biodiesels. Atmospheric Environment 43:pages 1481–1485, 2009.
[10] P.K. Sahoo , L.M. Das , M.K.G. Babu , P. Arora , V.P. Singh , N.R.Kumar , T.S. Varyani Comparative evaluation of performance and emission characteristics of jatropha, karanja and polanga based biodiesel as fuel in a tractor engine Fuel 88: pages1698–1707,2009.
[11] Agarwal D, Sinha S, Agarwal AK. Experimental investigation of control of NOx emissions in biodiesel-fueled compression ignition engine. Renewable Energy 31: pages 2356-69, 2006.
[12] Palash SM, Kalam MA, Masjuki HH, Masum BM, Rizwanul Fattah IM, MofijurM. Impacts of biodiesel combustion on NOx emissions and their reduction approaches. Renew Sustain Energy Rev 23:473–90, 2013.
[13] Sivalakshmi S, Balusamy T. Effect of biodiesel and its blends with diethyl ether on the combustion, performance and emissions from a diesel engine, Fuel 2012.
[14] Ozsezen AN, Canakci M. Determination of performance and combustion characteristics of a diesel engine fueled with canola and waste palm oil methyl esters. Energy Conversion Manage 1; 52:108–16, 2011.
[15] Avinash K Hegde and K.V. Sreenivas rao, Performance and emission study of 4S CI engine using Calophyllum Inophyllum biodiesel with additives, International Journal on Theoretical and Applied Research Mechanical Engineering 1: 1-4, 2012.
[16] Ramadhas AS, Muraleedharan C, Jayaraj S. Performance and emission evaluation of a diesel engine fueled with methyl esters of rubber seed oil. Renew Energy 30:1789–800, 2005.
[17] Ozsezen AN, Canakci M, Turkcan A, Sayin C. Performance and combustion Characteristics of a DI diesel engine fueled with waste palm oil and canola oil methyl esters. Fuel 88:629–36, 2009.
[18] S. Jaichandar , K. Annamalai.Combined impact of injection pressure and combustion chamber geometry on the performance of a biodiesel fueled diesel engine. Energy, vol. 55, pages.330-339, 2013
[19] Metin Gumus , Cenk Sayin , Mustafa Canakci. The impact of fuel injection pressure on the exhaust emissions of a direct injection diesel engine fueled with biodiesel–diesel fuel blends. Fuel, vol. 95: pages.486–494, 2012.
[20] T. Ganapathy, R.P. Gakkhar, K. Murugesan Influence of injection timing on performance, combustion and emission characteristics of Jatropha biodiesel engine. Applied Energy 88: pages 4376–4386, 2011.
[21] A Karthikeyan, J Jayaprabakar , Richard Dude Williams Experimental Investigations on Diesel engine using Methyl esters of Jatropha oil and fish oil IOP Conf. Series: Materials Science and Engineering 197 ,pages 1-8,2017.