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Performance of Diesel Engine Fueled with Different Types of Biodiesel–A Review

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Abstract

From the last century every useful work is achieved by varying the thermodynamic parameters or states like temperature, pressure and volume and this variation is done ultimately by some energetic fuels whatever its state may be either liquid, solid or gas. In this review paper it is shown that how liquid fuel (especially diesel fuel) getting challenges by biodiesel known as its alternate or substitute. In this era highways are busy mostly by heavy vehicles like trucks, buses, millers and trolleys and light vehicles like cars, jeeps and taxies all are having diesel engine to run on the roads. However, there are some other vehicles like scooter, motor cycles and four wheelers which are powered by petrol small in numbers compared to vehicles powered bydiesel. On the other hand increasing stringent emission regulation will make the use diesel very difficult in the coming days. Regarding the health and environment there is an alternate of diesel called biodiesel. This paper collects experimentally investigated records and results of engine performance like brake power, torque, brake specific fuel consumption and thermal efficiency of diesel engine with biodiesel compared to conventional diesel.

Keywords: Diesel engines; Biodiesel; Performance parameters.

1. Introduction

Today's energy demand has grown up and to meet the energy needs, the distillation of crude oil should be done on large scale as consequence environment pollution will increase, in addition with depletion of petroleum sources. This could be the right time for alternates to deploy all over the world's fuelpump. Biodiesel is the good alternate which is renewable in nature made from biomass like vegetable oil, animal fat and their derivatives.Biodiesel are obtained from biomass like vegetable oil and animal oil and we are surrounded by them. Biodiesel is come in this category of biofuel. It is composed of fatty acid obtained by some chemical reaction of alcohol such as methanol with vegetable oil. In this reaction we requires strong base catalyst (KOH) which attacks the triglyceride molecules and new generated chemical compound called methyl ester (biodiesel) **(**MA Kalam et al.,2002**).**

Biodiesel is a fatty acid composed of saturated and unsaturated chain of mono-alkyl ester. Combustion behavior of biodiesel also depends on the percentage of saturated and unsaturated chain. Biodiesel is the alternate which has property enough same as conventional diesel. Biodiesel is close to diesel in some properties, but there are still little bit differences also. Biodiesel have high incompressibility, density, viscosity, pour point, flashpoint and cetane number, near-zero aromatic compounds and no sulfur link **(**GKnotheet al.,1995, MCanakci et al.,2005**).** Biodiesel has low heat value about (10 -12) % than diesel on mass basis. Chemical structure of biodiesel contains 76 -77 % of carbon 10-12% hydrogen and 11-12 % oxygen. There are some differences in injection, combustion, performance and emission characteristics with biodiesel compare to conventional diesel. These all properties depend on their hydro-carbon ratio which is affected by fatty acid content **(**A N Ozsezen et al., 2008 **).** Biodiesel has high cetane number and excellent lubricity (Anand K et al., 2008, F Ma et al., 1999, J Munson et al., 1999, H Jianbo et al., 2005).

2. Engine performance

2.1 Brake specific power

To compare the engine brake specific power the operating mode should be same and off course engine speed and load are the main operating parameter. However, the fuel consumption may be different for every biodiesel used in experiments because of its different heating values so it is not counted as the operating parameter in comparing engine performance. In an experiment of water-cooled, naturally aspirated DI diesel engine was tested by Ahmet et al. with WPOME, COME and PBDF at 2000 rpm under full load condition the maximum power output generated with biodiesel WPOME and COME was 65.8 kW and 66.6 kW respectively, slightly lower than power generated by PBDF which was 68.3 KW. Fig.1 shows the variation of brake power under full load condition at 2000 rpm.

As seen in figure the power speed curves are similar and the region of this similarity defined by author was large amount of biodiesel supplied compared to conventional diesel because the injection pump delivers fuel on volume basis and the density of biodiesel is higher than diesel result in higher mass delivery of biodiesel compared to diesel in combustion chamber. Similar results were reported by few researchers (Rakopoulos et al., 2008), in the experiment he used two biodiesels based on sunflower and cottonseed oils on a DI diesel engine (Mercedes-Benz, OM366LA). In one study the researchers (Zafer) tested the diesel engine made of Land Rower TDI

110, four cylinder, direct injection, turbocharged with intercooler. This engine could produce the power of 82 kW at 3850 rpm and torque of 235 Nm at 2100 rpm.

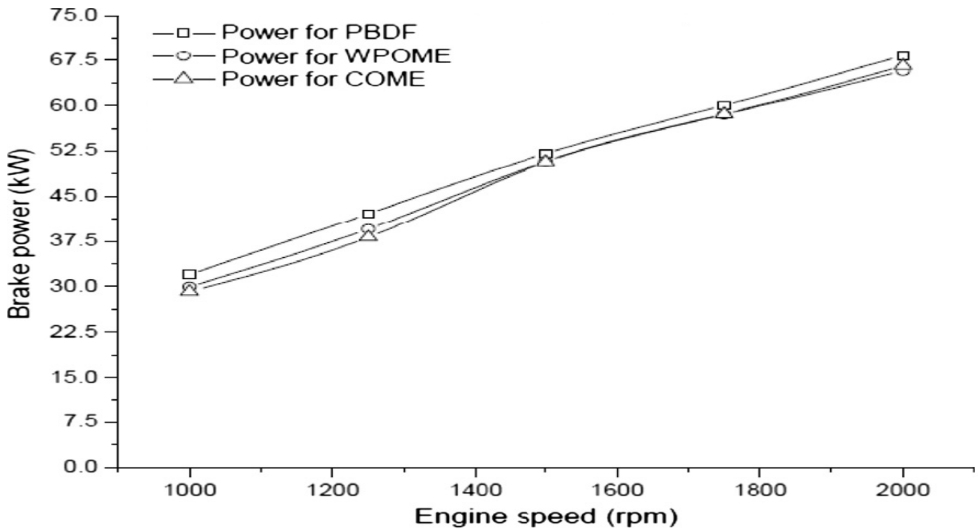

Fig. 1: Comparison of brake power for COME, WPOME and PBDF (HanbeyHazar)

2.2 Brake specific fuel consumption

The quantity of fuel in mass per kilowatt hour (Kg/KWh) is known as the specific fuel consumption of engine. Y. He et al. performed a test on a single cylinder diesel engine type S195. Four parameters of engine like intake-valve-closing angle (α), exhaust-valve-opening angle (β), fuel-delivering angle (θ) and injection pressure (*P*, in 104 Pa) were taken and found out the mathematical relation of these parameter with specific fuel consumption. Rapeseed biodiesel blends with diesel in the test were used and experimentally found 30:70 was most optimized ratio in respect of engine performance. There is a relation given below that was used by the author containing both the term efficiency and specific fuel consumption as shown below.

$$g_e = \frac{3.6}{\eta_e H_u} \times 10^6$$

Whereg_e, η_e and H_u are specific fuel consumption, thermal efficiency and low calorific value respectively. It is to be seen in relation the specific fuel consumption is inversely proportional to thermal efficiency and accordingly, the efficiency will improve against the decreased specific fuel consumption. Quadratic regression was developed for orthogonal test to make the relation among four parameters and specific fuel consumption to find out the most influencing factor which would affects the thermal efficiency of engine. It was found experimentally that, the injection angle was the most influencing factor which truly employed the significantly decreased specific fuel consumption and resulted in increased thermal efficiency.

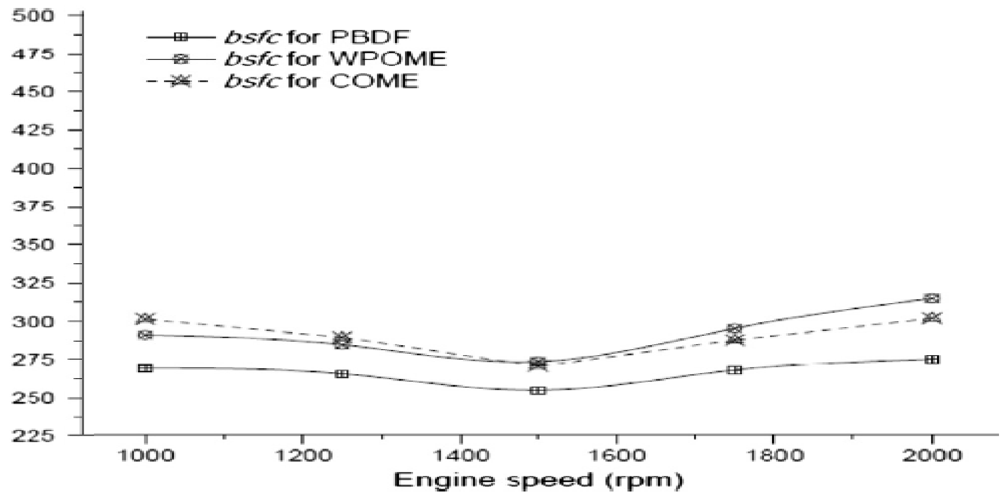

Fig. 2: Variation of BSFC with WPOME, COME and PBDF at all Engine Speed (HanbeyHazar).

The researchers tried to approach the problem of relation between the fuel delivery angle and fuel consumption rate and obtained the optimum fuel delivery angle was (20^o -21^o) before CA or (2^o -3^o) advanced delivery of rapeseed biodiesel blend compared to diesel. Due to lower cetane number, advanced injection angle and high viscosity, biodiesel blend got longer combustion time as compare to diesel, resulting to better results of engine performance. Few researchers have found increased *bsfc (brake specific fuel consumption)* with WPOME and COME compared to PBDF [9] as shown in Fig. 2. Heating value of biodiesel is fairly lower than diesel so, to generate equal power engine consumed more biodiesel fuel with lower heating value than higher heating value of diesel fuel. The bsfc of WPOME and COME was 10% and 9% higher than diesel respectively. This upwards in bsfc was due to 8.9% and 8.2% lower energy content biodiesels than diesel but viscosity and density of biodiesel is obvious more than convention diesel. Mass of fuel delivered per KW of power produce at shaft is called bsfc. Density of WPOME and COME was found 4.17% and 5.14% respectively, higher than PBDF. This combined effect was the reason of increased bsfc with biodiesel compared to diesel. Same results came out with WFOME fuel when compared to diesel fuel (Zafer) increased fuel consumption was found in the experiment.

2.3 Thermal efficiencyand torque

In an experiment performed by few researchers (K. Anand et al.), neat karanji biodiesel and its blend with methanol was tested for brake thermal efficiency of engine. As seen in the Fig.3. approximate similar efficiency curve was obtained for the two fuels as mentioned above when engine operating under low condition, but as the test moved on higher load (above half load) then, there was significantly decreased in efficiency of about 4.2% with a measurement uncertainty of 1.1% is obtained at 80% loadand 16.67 $s^{-1}$for neat karanji biodiesel compared to its blend with methanol.

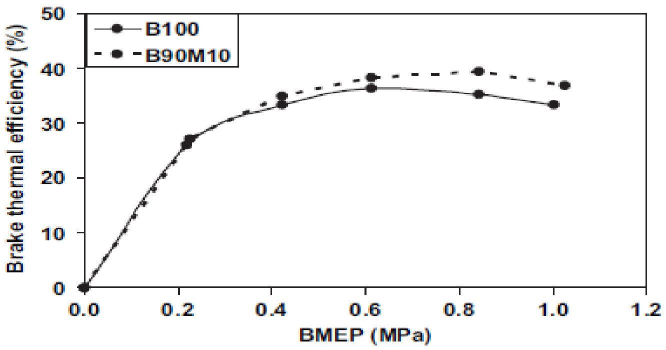

Fig. 3: Variation of brake thermal efficiency with neat biodiesel and its blend with methanol under varying load condition (He Y. et al.)

The combined effect of high flame speed, high oxygen content (S Kalligeros et al., 2003) and low viscosity (improved spray quality) provide high burning rate of blended fuel in diffusion combustion phase over neat biodiesel and contribute in improving efficiency under high loads.Y. He et al. used regression orthogonal test design and suggested, efficiency can also be improved by adjusting the fuel delivery or SOI timing and it was found by author that $(20\text{-}12)^o$ before CA was the optimized value. To evaluate the torque characteristics of engine Zafer took diesel and WFOME and found maximum torque with both the fuel was at 2000 rpm, as it can be seen in Fig. 9. Torque for the two fuels was approximately same at all the speed ranges, as 220 Nm for diesel fuel and 216.8 Nm for biodiesel there was very little difference between them. Maximum and average value of torque of WFOME fueled engine was 1.45% and 4.3% lower torque than diesel respectively. It was suggested that the region of high density and viscosity with WFOME.

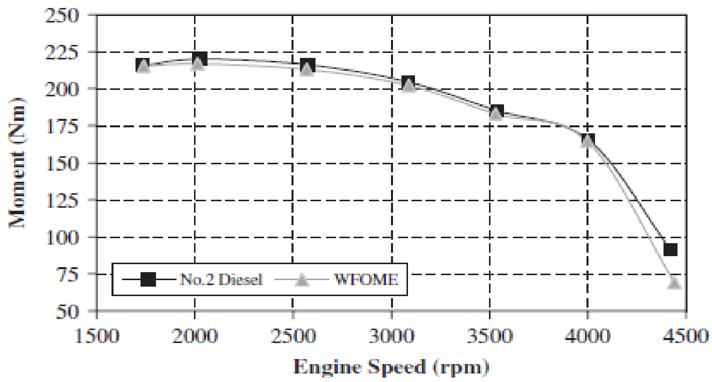

Fig. 4: Variation of Torque with respect to engine speed (Anand K. et al.)

3. Conclusion

In this review, it was shown that there are so many different types of biodiesel and blends of biodiesel with diesel as alternative fuel which can be used successfully operated in different types of diesel engines such as direct, indirect, turbocharged and naturally aspirated without modifications. The following conclusion has been given from review of papers:

As it has been studied from experiments conducted by various researchers and found brake power generated by engine was lower with biodiesel compared to diesel and to compensate this discrepancy bsfc was increased. In some experiments recovery of brake power was also found when engine operating under full load condition. Thermal efficiency of engine was found similar with pure biodiesel and blended biodiesel at low loads.However at high loads efficiency got decrease for pure biodiesel compared to blended one. Same result came for torque as it was for brake power of engine. Torque obtained from engine with biodiesel was found to be decreased but the increasing trend was seen as the percentage of biodiesel was increased, however it was still lower than torque produced with diesel fuel.

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