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Influence of Additive on the Performance and Emission of Biodiesel Fueled Diesel Engine

M. Shahabuddin [1], H.H. Masjuki[2], M.A. Kalam[3], M. A. Hazrat[4]
[1,2,3,4] Centre for Energy Sciences, Department of Mechanical Engineering
University of Malaya, 50603 Kuala Lumpur, Malaysia
([1]shahabuddin.suzan@yahoo.com, [2]Masjuki@um.edu.my, [3]kalam@um.edu.my, [4]alihazrat20@gmail.com)

Abstract- As an alternative fuel biodiesel can be played an important role to meet the future energy demand. Biodiesels have lot of good advantages over diesel which attract the users to use it as the substitute of diesel. It has huge biodegradability, less environmental impact, higher flash point and cetane number, higher lubricity and so on. However, for the widespread practical applicability of biodiesel more investigation is required related to the engine performance and emission. In this paper the effect of additives (1% and 2% with 20% blended biodiesel) on the performance and emission is investigated in an Isuzu 4FBI four-cylinder diesel engine. The break power and the break specific fuel consumption was measured using computer controlled eddy current dynamometer and the load cell arrangement, while the emission parameters was investigated using Bosch and Bacharach exhaust analyser. Investigations result implied that 1% additives with 20% blended biodiesel (B20+1 %.) showed better performance as compared to diesel, pure biodiesel (B100), 20% blended biodiesel (B20) and 20% biodiesel with 2% additives (B20+2%) with respect to overall engine performance and emission.

Keywords- *Additive; Biodiesel; Brake Power; Emissions*

I. INTRODUCTION

The large amount of petroleum fuel is expenses in the transportation sector especially in diesel engine. However the total crude oil reserves in the world is unknown which is diminishing swiftly. Therefore the researchers are worried about the future energy resource. Thus concentration is focused on the alternative fuel. As an alternative fuel pure bio diesel is formulated from animal fat and vegetables, which are more bio degradable, nontoxic and environment friendly [1]. The Biodiesels are more compatible with the environment as compared to diesel which emit low carbon and smoke [2]. In Malaysia palm oil is used as a biodiesel which is known as Palm Oil Methyl Ester (POME). To use this fuel (blended or pure form) in diesel engine, need not to change the design and can be achieved more or less same performance. The use of B20+1% (20% blended biodiesel with 1% additive) with catalytic converter reduce the particulate matter (PM) by 30%, carbon monoxide (CO) by 21%, total hydrocarbons (THC) by 47% and sulfer and aromatic content considerably [3]. To increase the performance (about 30%) of diesel engine turbocharger with intercooler is used now a day and plays a significant role on diesel engine performance. However the use of turbocharger in bio diesel fuelled engine is not suitable instead of catalytic converter for the improvement of emission behavior. In addition, several factors are responsible for the exhaust emission of diesel engine i.e., fuel and lubricant quality, engine operating condition, emission reduction technique etc. [4, 5]. This paper presents the experimentally analyzed different parameter of a Turbocharged indirect injection (IDI) Diesel engine performance exhaust emissions while running with POME blended anti-corrosion additive and compared with diesel and biodiesel blends without additives.

II. EXPERIMENTAL SET-UP AND APPARATUS

Tests were carried out with conventional diesel fuel powered natural aspirated engine as the baseline study. The similar engine was coupled with turbocharger for the next test stage. At this stage, 20% biodiesel blended diesel fuels as well as conventional diesel fuel were used to obtain the comparison results. The tests were conducted at the Heat Engines Laboratory of Mechanical Engineering Department, University of Malaya based on the SAE Recommended Practice. The Isuzu 4FBI four-cylinder diesel engine which is controlled by CP CADET 10 Data Acquisition System was used in this experiment. The engine specification and the details of instrumentation have been fully described by Masjuki et al. [6]. The engine is operated between 1000 to 4000 rpm. The exhaust emissions were measured by using a HORIBA MEXA 9100-D Gas Analyzer. Meanwhile, the fuel blends were prepared at the laboratory by blending conventional diesel with biodiesel by using a homogenizer dispersion system to achieve a homogeneous fuel blend between diesel fuel and biodiesel. The characteristics of fuels were also obtained using several instruments in accordance with ASTM methods. Table 1 shows some obtained important characteristics

TABLE 1. FUEL CHARACTERISTICS OF BIODIESEL BLENDED FUEL AND CONVENTIONAL DIESEL (OD)

Properties	OD	B20	B100
Calorific value MJ/kg	45.8	44.74	39.21
Kinematic viscosity (cSt) at 40 °C	3.6	4.05	5.85
Cetane index ASTM D976	53	52	37
Conrad son carbon residue ASTM D 198%wt	0.14	0.01	-
Sulfur content %wt	0.1	0.03	-

Additive: The additive used in this experiment is IRGANOR NPA (Product name) as a corrosion inhibitor for fuels.

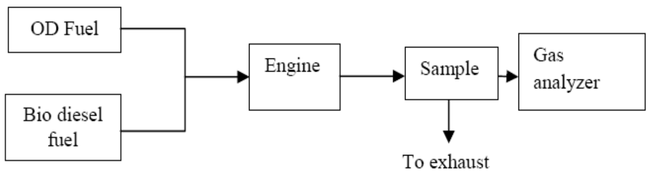

FIGURE 1 SCHEMATIC DIAGRAM OF EXPERIMENTAL SET-UP

III. RESULTS AND DISCUSSIONS

The parameter of diesel engine for different fuel through experiment is done in the Tribology Laboratory, Department of Mechanical Engineering, and University of Malaya. And various parameters are compared with one another, including petro diesel.

3.1 Brake power output

The results of brake power output from turbocharged diesel engine for all tested fuels are shown in Fig. 2. Which illustrates that fuel "B20+1%" produces higher brake power over the entire speed range with compared to other fuels. It is found that fuel "B20+1%" produces an average of 11.50 kW brake power over the entire speed range which is 1.68% higher than fuel B20. Thus the result implied that the addition of additive in the biodiesel is more effective than without additive biodiesel with respect to break power. It is also clear from the Fig. 2 that 1% additive with biodiesel is more suitable than addition of 2% additives with respect to the performance of the engine which is due to the good combustion quality and reliable fuel viscosity of B20+2%. Furthermore, the fuel B20+1% showed higher performance with compared to ordinary diesel (OD) also. Overall results of different fuels regarding brake power are accumulated in Fig. 2.

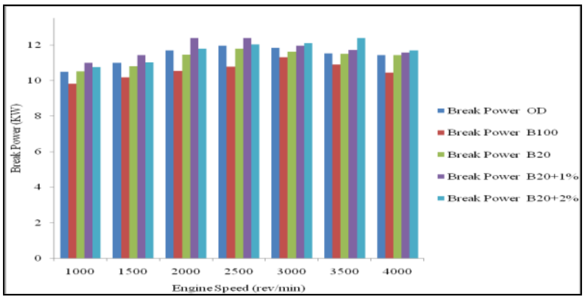

FIGURE 2: BRAKE POWER OUTPUT VS. ENGINE SPEED

3.2 Specific fuel consumption

Fig. 3 illustrated the break specific fuel consumption (BSFC) of all test fuels at different engine speed. It was found that the fuel consumption in pure biodiesel (B100) was maximum while the biodiesel "B20+1 %" was the minimum. The fuel consumption of B100, B20+1% and B20+2% was 711 g/kwh, 405 g/kwh and 536 g/kwh respectively. From the result it can be noted that 1 % addition of additive is optimum while the fuel B20+ 2% consumed more fuel than B20+1%. These results might be the consequence of better combustion, reliable viscosity and good wear properties of B20+1% with compared to other fuels. In addition the BSFC of B20+1% was lower than ordinary diesel also.

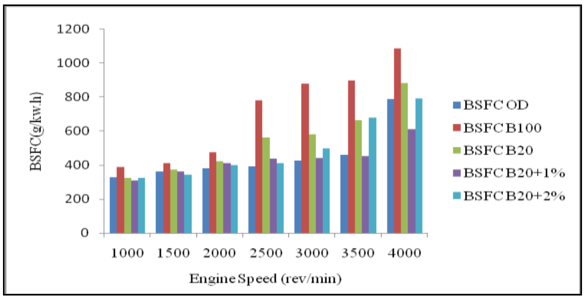

FIGURE 3: BREAK SPECIFIC FUEL CONSUMPTION VS. ENGINE SPEED

3.3 Emission characteristics

Following comparison with petro diesel shows the emission behavior of B100 and B20 fuel.

TABLE 2: AVERAGE BIODIESEL EMISSIONS COMPARED TO CONVENTIONAL DIESEL, ACCORDING TO EPA.

Emission Component	**B100**	**B20**
Total Unburned Hydrocarbons	-67%	-20%
Carbon Monoxide	-48%	-12%
Particulate Matter	-47%	-12%
NOx	+10%	+2%
Sulfates	-100%	-20%
PAH	-80%	-13%

3.3.1 Oxides of Nitrogen (NOx) emission

The effect of biodiesel blended additive on Nitrogen Oxide (NOx) emission is shown in Fig. 4. It is found that the NOx emission decreases while additive is used in blended fuel. The result showed that NOx is reduced dramatically while the engine was run by B20+1% fuel. It was found that the fuel B20+1% has the highest potentiality in order to achieve better fuel quality with less NOx formation. In addition, with the presence of additive, the combustion temperature was reduced results controlled NOx. Another important advantage of additive is it reduces the friction between the cylinder wall and piston ring thus the heat loose is minimized. This condition was also observed by the several researchers who conducted some studies in terms of flame and combustion stability of oxygenated and renewable fuels [7, 8]. Over the entire speed range, B20+1% fuel produced an average of 95 ppm of NOx while fuel B20 produced 123 ppm NOx. Hence the reduction of 28 ppm was due to the effect of 1% additive in the B20 fuel.

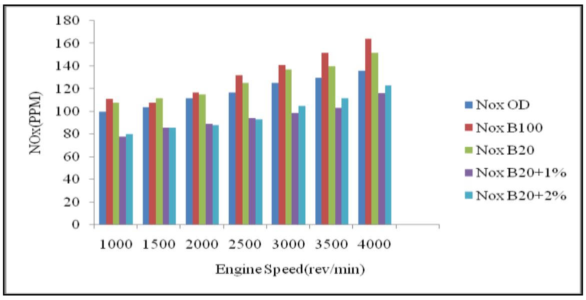

FIGURE 4: NOX CONCENTRATION VS. ENGINE SPEED

3.3.2 Carbon Monoxide (CO) emission

Incomplete combustion is the mainly responsible for the formation of CO emission. Mostly CO is produced when air-to-fuel ratios are too low during vehicle starting, when cars are not tuned properly, and at higher altitudes where thin air reduces the amount of oxygen available for combustion. Two-thirds of the carbon monoxide emissions are come from transportation sources. In urban areas, the passenger vehicle contribute to the formation of carbon monoxide pollution is more than 90%. [9]. From the Fig. 5 it is observed that due to the lean mixture the CO emission for all tested fuels is less than 1% . It is found that among all the fuels, fuel B20+1% produce lowest level of CO emissions which is on average of 0.141 %, B20 is 0.213% and OD is 0.296%. The difference between B20+1% and B20 showed the effect of additive in Biodiesel fuel. The details results for all tested fuels are shown in Fig. 5.

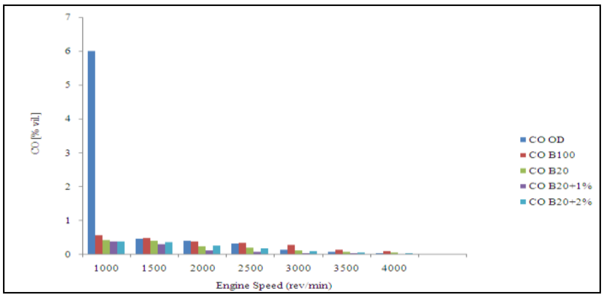

FIGURE 5: CO CONCENTRATION VS. ENGINE SPEED

3.3.3 Hydrocarbon (HC) Emission

Fig. 6 showed the HC emissions for all tested fuels. It was found that fuel B20+1% emit lower HC emission which is followed by B20+2%, B100, B20 and OD fuels respectively. The maximum level of HC was produced from OD fuel. It can be seen that additive added biodiesel produces lower HC emission as compared to OD fuel. This is mainly due to complete combustion of the additives added biodiesel in the combustion chamber.

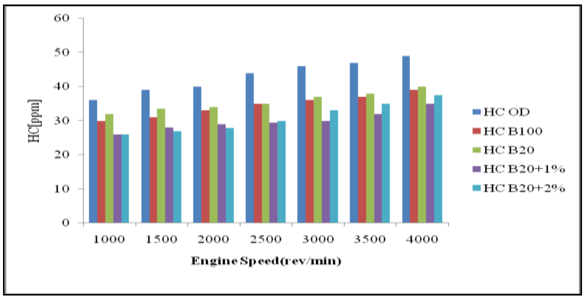

FIGURE 6: HC CONCENTRATION VS. ENGINE SPEED

3.4 Exhaust Temperature

Fig. 7 illustrates the effect of engine speed on exhaust temperature for different test fuels, which showed nearly same exhaust temperature. From the graph it can be concluded that, the exhaust gas temperatures are increased with the engine speed. In addition, the exhaust temperature of ordinary fuel was maximum while the temperature was minimum for B20+2% in all test speeds.

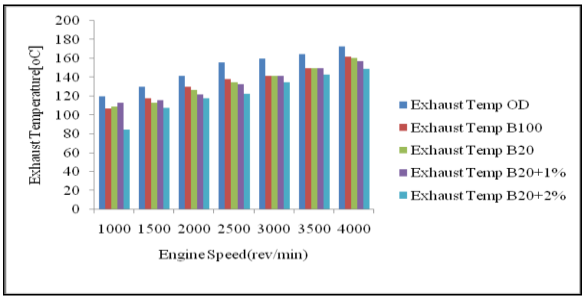

FIGURE 7: EXHAUST TEMPERATURE VS. ENGINE SPEED

IV. CONCLUSIONS

The following conclusions can be drawn from the present investigation:

- Fuel “B20+1%” produces 1.73% and 9% higher brake power as compared to fuel B20 and OD respectively.
- Fuel “B20+1%” consumes 26% and 6% lower SFC as compared to fuel B20 and OD respectively.
- Fuel “B20+1%” reduces CO, NOx and CO_2 emissions as compared to other tested fuels.

Hence, it can also be concluded that the additives in the biodiesels have the great influence on the Brake power, SFC and emissions performance.

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