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Performance Evaluation Of B5 Bio-Diesel – Effect On Euro II Diesel Engine & Engine Lubricant

A. Chausalkar, Reji Mathai, A.K. Sehgal, S.K. Majumdar, R.B.Koganti, R.K.Malhotra
Indian Oil Corporation Ltd, Research & Development Centre, Faridabad, India

R.K.Kannan, C.Prakash
Ashok Leyland, Chennai, India

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ABSTRACT

Biodiesel is gaining momentum as an alternative renewable fuel for petroleum diesel. Higher lubricity of biodiesel is a benefit to fuel pumps and overall reduction in engine wear. The uncertainty lies with the formation of hard deposits that may form on fuel injector tips and piston rings causing premature wear and failure of an engine. It is highly dependent on the type of engine, biodiesel feedstock and production method. With the introduction of biodiesel as an alternative renewable fuel, its impact on lubricant and its drain period, engine components and performance has to be evaluated. In order to study the effects of biodiesel blends on engine performance and lubricating oil, two long duration endurance tests of 1000 hrs were conducted using petroleum diesel and 5 % biodiesel blend (B5) on a new generation multi-cylinder Euro II compliant engine. SAE grade 15W 40 engine oil meeting API CH4 was used for both the tests. During the 1000hrs endurance tests, the engine performance and oil consumption were evaluated periodically. The oil performance was monitored through oil sample analysis. The experimental results indicate that the engine can be safely operated with B5 fuel, without significant changes in the engine power, fuel economy and lubricating oil properties.

INTRODUCTION

Due to gradual depletion of world petroleum reserves and the impact of environmental pollution of increasing exhaust emissions, there is an urgent need for suitable alternative fuels for use in diesel engines. Alternative fuels for diesel engines have become increasingly important due to increased environmental concerns, and several socio-economic aspects. In view of this, bio fuel is a promising alternative because it has several advantages. It is renewable, environ-friendly and has a convenient production process. For diesel engines, biodiesel is an emerging alternative fuel and many researchers are engaged in exploring different aspects of biodiesel. Christopher et al. indicated that the use of biodiesel contributes to a ten fold reduction in engine wear [1]. The addition of biodiesel, even in small quantities has been shown to provide increase in fuel lubricity using a variety of bench scale test methods. BOCLE (Ball-On Cylinder Lubricity Evaluator) and HFRR (High Frequency Reciprocating Rig) test results reported that biodiesel has improved lubricity over diesel [2]. By weight, biodiesel contains less carbon, than diesel. Bio diesel also contains oxygen molecule which helps to burn the fuel blend easily and give less emissions. Different blends of biodiesel tested in diesel engines indicate the compatibility of biodiesel with engine components [3]. However due to lower calorific value of biodiesel, the engines operated with biodiesel-diesel blend developed lower power output. Therefore, it is necessary to use optimum blend of biodiesel to minimize the reduction in power output. Earlier studies have been limited to power output and emissions only. The effect of bio diesel blend on engine lubricant has to be studied. This paper makes an effort not only to compare the effect of bio diesel on engine performance but also on the engine lubricant. This paper presents the results of endurance tests conducted on two similar engines using petroleum diesel and B5 using the same quality of engine oil in both the tests.

EXPERIMENTAL SECTION

2.1 TEST ENGINE

Engine endurance test was conducted on a six-cylinder turbo charged 4 stroke, water cooled diesel engine with a rated power of 97 kW at 2400 rpm meeting EURO II norms. For each test a freshly prepared engine was chosen and running-in was carried out. The test cycle shown in the figure-1 was programmed on the computerized test bench and the fast ramping requirements were met by the computer controls. Provisions for measuring different parameters such as coolant temperature, oil pressure, boost pressure and temperature etc. were done on the bench. During the test, the fuel consumption, blow-by and smoke measurements were measured at regular intervals.

2.2 TEST OIL

The test oil used was SAE 15W40 meeting API CH_4 and ACEA E-5 performance category.

Table-1 PI Data of test oil

S.No	Parameters	Values
1	KV @100 C, cSt	14.42
2	KV @ 40 C, cSt	102.10
3	VI	135

4	TBN, mgKOH/g	11.4
5	Flash point COC C	226 min
6	Pour Pour C	-27 max
7	CCS @ -20 C, cP	5630 max
8	Foaming Tendency/Stability Seq I Seq II Seq III	 10/nil 50/nil 10/nil
9	Sulfated Ash %wt	1.38
10	Elements, ppm, Ca Zn P	3430 1340 1190

Table-2 Specification of Test fuels

Fuel Properties	**B5 Blend**	**Petroleum Diesel**
Acidity, inorganic, mg of KOH/gm	Nil	Nil
Acidity, total, mg of KOH / gm., Max	0.04	Nil
Ash, % wt., Max	<0.01	<0.01
Carbon residue (Ramsbottom) on10% residue, % wt., Max	0.1	0.30
Cetane No., Min.	49.6	51
Pour point ^oC, Max	-9	3 Wint. 15 Sum
Copper strip corrosion for 3 hrs at 100 ^oC	No.1	No. 1
Distillation % v/v recovered at 350^{o}C Min 370^{o}C Min	 94.0 98.0	 Min. 85 Min. 95
Flash point, ^oC (Abel), Min	66	Min. 35
K. V, cSt at 40 ^oC	3.0	Min. 2.0 Max. 5.0
Sediment, % wt, Max	<0.0	0.05
Density at 15 ^oC, Kg/m^3	844.9	820 to 860
Total sulphur, ppm, Max	280	Max. 500
Water, % vol, Max	Nil	Max. 0.05
Cold filter plugging (CFPP), ^oC	-3	6(Winter 18Sum

2.3 TEST FUELS

The fuels used are petroleum diesel as such in one test and the 5% bio diesel in petroleum diesel (B5) in another test. Table-2 gives the typical properties of the fuels used in this program.

2.4 TEST PROCEDURE

Test cycle consists of four different stages simulating thermal shock test. Each cycle includes low idle, high idle, maximum power and maximum torque conditions. Fuel delivery was increased by 5 % and the fly up speed by 10%. The complete cycle was of 4 min duration. All the ramp times were within 10 seconds. Progress of the engine test and performance of the oil was monitored. Oil samples were drawn at every 50 hours and were analyzed.

The used oil rejection criteria, given in Table-3, are usually followed where petroleum diesel is used as a fuel.

Table-3 Pass and Fail criteria of oil

Sno	**Property**	**Limits**
1	Kinematic Viscosity @ 100C cSt	+25% of upper limit -15% of lower limit
2	TBN, mg KOH/gm	Not less than 4
3	Soot % wt	Max 5
4	Wear Metals, max	
	Fe	150 ppm
	Si	40 ppm
	Cr	50 ppm
	Ni	20 ppm
	Cu	90 ppm
	Al	40 ppm
	Sn & Pb	To Report
	Engine Blow by, Max	100 Lpm

2.5 TEST PLAN

In the first test, endurance test was conducted for 1000 hours following the test cycle as given in fig-1, using petroleum diesel on a new assembled engine. Engine performance and oil performance were continuously recorded in terms of various parameters such as engine speed, load, smoke density, blow by, wear elements at regular intervals.

In the second test, a similar test was carried out with B5 (5% bio diesel) as a fuel was carried out on another freshly built engine. Engine was operated under similar conditions and the parameters were recorded in order to draw comparison between the two fuels namely the petroleum diesel and 5% bio diesel blend (B5).

3. RESULTS AND DISCUSSION

A comparative study is done on the performance of the engine oil using both diesel and bio diesel blend (B5) as a fuel on the basis of the results obtained in the tests.

Various parameters such as change in boost pressure, BSFC, engine oil viscosity, oil consumption and wear metal analysis, soot, TBN trends of used oil are discussed. The smoke values are not measured on a continuous basis. The intermittent smoke values measured with both the fuels are in range of 0.6 to 0.95 Fsn.

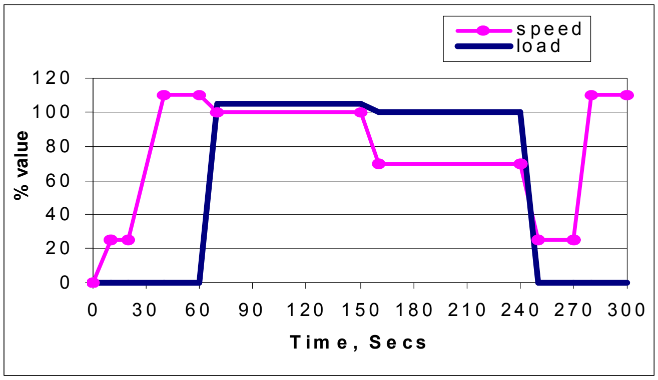

Fig-1: Test Cycle

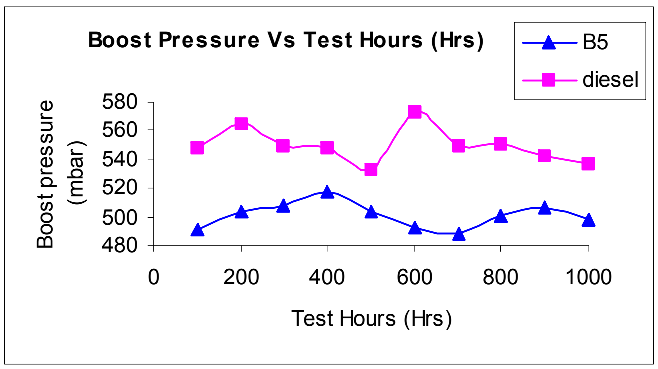

Fig-2: Variation of Boost Pressure @2400 Rpm

Boost pressure indirectly shows the power output of the engine. Fig-2 indicates higher value of boost pressure for petro diesel than with Biodiesel and this trend is due to the lower calorific value of biodiesel.

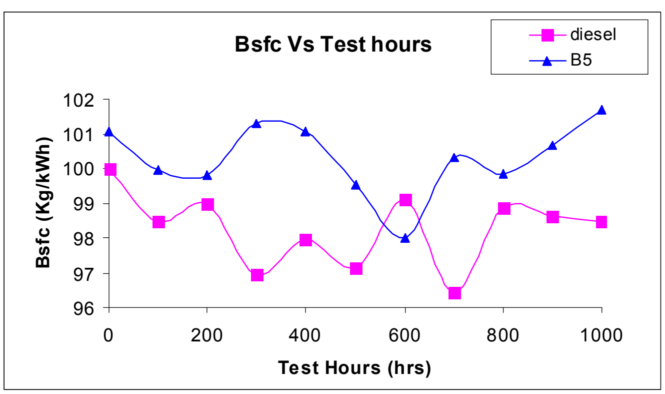

Fig -3: Variation of Brake Specific Fuel Consumption

BSFC trend as given in Fig-3 indicates the performance of the engine for both the fuels B5 and petro diesel. BSFC in case of B5 is slightly higher than diesel due to lower calorific value and boost pressure of B5 than diesel.

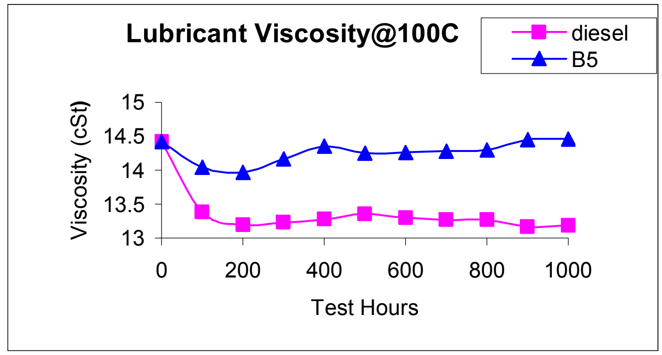

Fig-4: Variation of Kinematic Viscosity of Lubricant

The viscosity change of the engine oil while running the engine with both diesel and bio diesel blend B5 is graphically represented in fig-4. The change in viscosity of engine oil with both the fuels is within the specified oil rejection limits mentioned above in Table-3. The minor difference in engine viscosity change by using B5 as fuel is within the repeatability values of engine test.

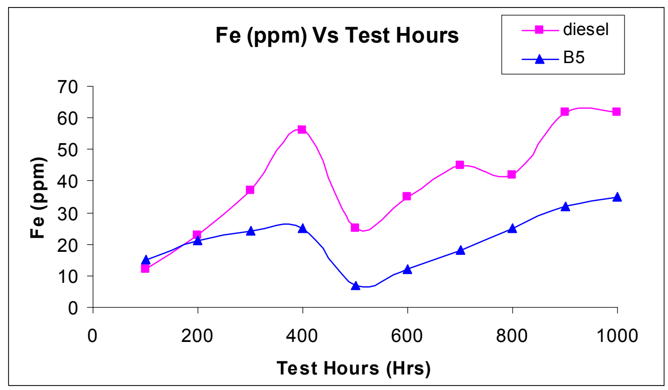

Fig-5: Variation of Fe in ppm

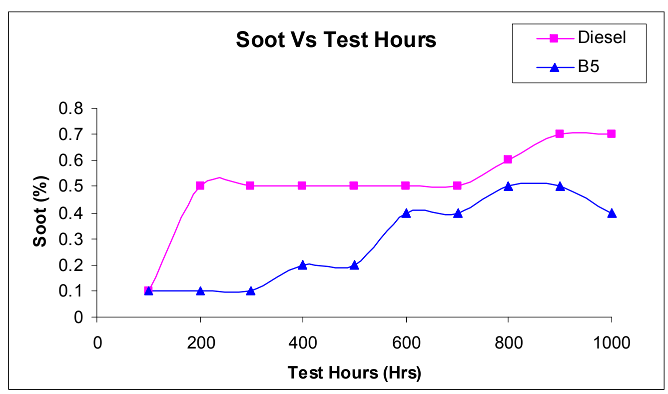

Fig-6: Variation of soot content in Oil

Fig 5-7 discusses the performance of engine oil with the use of petro diesel and B5. The lubricity benefit of bio diesel, especially compared to low-sulfur petroleum diesel, helps to reduce fuel pump and fuel injector wear. Oil samples were drawn at intervals of 50 hrs during the test of 1000 Hrs. Endurance test of B5 indicates Fe levels between 7 ppm – 35 ppm which is very well below the specified lubricant rejection limit of 150 ppm. The wear values of the Fe for petrodiesel are in the range of 25-65 ppm. Moreover, other metals such as Cu, Al, Si etc are well within the specified limits for both the fuels.

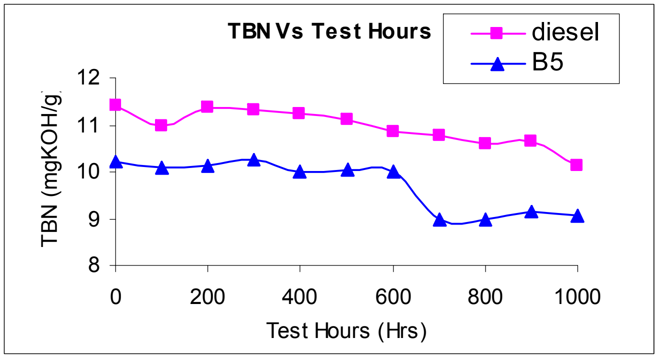

Fig-7: Variation of Total Base Number (TBN)

The remaining value of TBN at the end of each drain interval of the engine oil for both the fuels are well within the acceptable limits, which imply that the oil is capable of effectively neutralizing acids formed during the combustion in the cylinder. In case of B5, the TBN values of the engine oil are observed to be lower than the values for petroleum diesel [3]. This is possibly due to slightly higher acidic property of B5 over petrodiesel. The first oil change was at 400 Hrs and thereafter there is no oil change up to 1000 Hrs. For both the fuels, TBN values for the oil is observed to show decreasing pattern with the test hours. But for both the fuels, the minimum TBN value of the engine oil is higher than the stipulated values required for an oil ensuring sufficient reserves at the end of each oil drain.

OIL CONSUMPTION DETAILS

This section gives details about the oil consumption pattern during the endurance test carried on B5 and petro diesel.

Table-4: Oil consumption details for diesel and B5

Description	**Petrodiesel**	**B5**
Duration of Test , hrs	1000	1000
Average oil Cons. (gm/hr)	18.83	17.60
Oil to fuel ratio	0.11%	0.121%
Brake Specific oil Consumption (kg/hp-hr)	0.2374	0.2288

Table 4 shows low oil consumption values for diesel and B5 and are well within the manufacturers prescribed limits. Endurance test results indicate that oil consumption figures are within the acceptable limits for the fuels. The use of B5 as fuel has not affected the performance of the engine oil in a manner that is different from petro diesel. The engine oil drain period was extended to 600 Hrs in the second stage of the test beyond the stipulated 400 Hrs and inspite of this, no affect on the engine oil deterioration was observed with both B5 and petro diesel.

CONCLUSION

The experimental results and their comparative study indicate that:

- Difference in change in viscosity of lubricating oil using diesel and B5 as fuel is negligible and B5 does not affect the oil viscosity and is able to maintain its viscosity through out the test.
- BSFC for B5 is slightly higher than diesel due to lower boost pressure and lower calorific value of B5 than diesel.
- Lower levels of Fe (ppm) indicate low rate of engine wear in case of B5 fuel.
- Enough TBN reserves of lubricating oil are found for both the fuels. However, the reserve TBN of the engine oil when using petro diesel is at a higher value than biodiesel blend.

It can be concluded that by mixing 5% biodiesel in petro diesel, there is no adverse affect on the engine components, lubricating oil and the emission performance of the engine.

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