iJET International Journal of Engineering & Technology
CENTRE OF PROFESSIONAL RESEARCH PUBLICATIONS
ISSN 2049-3444

International Journal of Engineering and Technology Volume 4 No. 5, May, 2014

Effects of Using Biodiesel on Engine Generator Components

Ihwan Haryono[1], M Taufiq Suryantoro[2]
[1]The Center for Thermodynamics, Engines and Propulsion (BTMP)
Building 230, PUSPIPTEK, South Tangerang, Indonesia15314
[2]University of Indonesia, Depok, Jakarta, Indonesia

ABSTRACT

The purpose of using biodiesel in automotive is to save petroleum fuel consumption and improve air quality. In low composition, biodiesel has been used by the Indonesian people and have chances to be increased. The advantages of biodiesel on the engine performance have been known as well as emissions and lubrications, while the long-term effects on the engine components are still a lot of studies and researches. Wear of engine components used in an engine can be predicted by used oil analysis. This paper presents used oil analysis resulted from two series of identical tests using 3.5 kVA engine generators fuelled by 5% biodiesel (BS_5) and 50% (BS_50) in composition. Used oil analysis was done after completion of 100 hours durability tests. The results indicated that the effect of the difference in composition was not significant to the used oil conditions and component wears.

Keywords: *Engine Generator, Used Oil, Biodiesel, Metals Wear*

I. INTRODUCTION

The use of biodiesel fuel in automotive is to save fuel consumption from petroleum and improve air quality. Biodiesel fuel sold in the domestic Indonesian market, named Bio-solar, is a mixture with a composition of 5% to 10% pure biodiesel and have chances to be increased in quantity. The basic parameters of biodiesel will have slightly different characteristic to the petroleum diesel.

Research on the use of biodiesel is mostly done around the world. Research aimed to optimize both quantity and quality. The advantages of biodiesel in terms of performances and emissions compared to petroleum diesel also have been known. The effects of using biodiesel associated with the engine components is still a topic of research interest.

Some properties of biodiesel such as viscosity, density and surface tension are higher. The properties lead to imperfect fuel spray and produce lubricating oil dilution and result on the components wear and corrosion as well as reducing oil lifetime. Oxidation products on used engine oil of an engine fuelled by biodiesel are also aggressive towards soft metals such as Pb and Cu bearing component materials [1]. Besides corrosive to metals Pb and Cu, the results on the test bench oxidation test method ASTM D6594 also showed decreasing in viscosity, TBN and increasing TAN after completion of heating 135 °C for 160 hours [2]. The study by the same method coupled with testing engine for 300 hours showed the results where the negative effects of increasing wear of metals Pb and Cu in the presence of Fatty Acid Esters Methyl biodiesel in the engine lubricant [3]. Besides corrosive to soft metals, dilution of biodiesel in the lubricant oil also improves oxidation thereby increasing the buildup of deposits on pistons [4]. In some cases, due to the properties quality of biodiesel causes problems on fuel supply system and the accumulation of debris on the injector choking [5].

Tests and reviews papers which consistent with the results reported by other researchers [6, 7]. A study found that the usage of biodiesel which reflect the wear of metal engine component condition with normal levels. The wear metals are monitored including Fe, Al, Cu, Pb, Cr and Si. Only the Cu metal that higher than the other samples, which is probably derived from a cooler material [8].

Testing of the usage biodiesel in engines that give different results indicated the formation of carbon deposits fewer and wear metals were lower [9]. Some researchers also reported a decline in deposit formation in the components around the engine due to lower soot formation from biodiesel [10]. However, reports regarding the effect of biodiesel on engine lubricants oil lead to dilution into the engine and resulting in serious damage or engine failure has not been found.

A comparative test of usage biodiesel between 5% composition of biodiesel (95% Bio-solar+5% biodiesel) with 50% composition (50 % Bio-solar+50% biodiesel) has been carried out in the Center for Thermodynamics, Motor and Propulsion (BTMP). The test was carried out for 100 hours using engine-generator. Evaluation of the effects to the generator engine components was done through the used oils analysis.

This paper reports the results of the used oils analysis after completion of the tests. The purpose of this study was to determine the amount of dilution of biodiesel fuel (fuel diluents) to the engine generator oils after 100 hour durability test and evaluate the effect of the usage of biodiesel fuel to the used oils conditions and engine components wears.

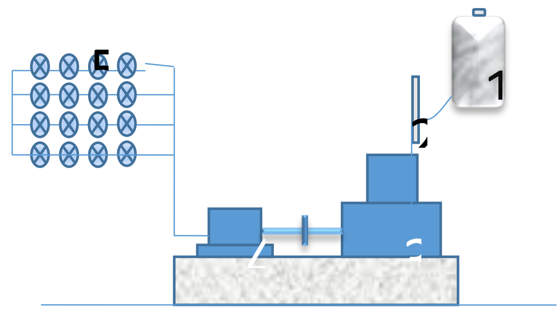
II. METHODOLOGY

The engine generators durability test was done in test cell 10 of The Center for Thermodynamics, Engines and Propulsion using two series of identical tests. The specifications of the test engine generators used are shown in Table 1.

Table1. Specification of Test Engine Generators

Test Engine	YANMAR™
Generator Type	Dongdong 3.5 kVA
Engine Type	J48
Coolant	Air
Stroke	4 – stroke
Engine capacity	200 cc
No of cylinder	1
Rpm	3000
Generator Type	Revolving Field AC
Output Power	3.5 kVA

During the test, the generators was using engine oil MEDITRAN S™, produced by Pertamina Co, SAE 40 API service CF/CF-2.
Used oil analysis performed at an independent laboratory Petrolab Services Co, Rawangmangun, Jakarta.



1. Fuel tank 2. Burette 3. Diesel Engine 4. Generator 5. Dummy load (lamps)

Fig. 1. Test Schematic

Prior to durability testing for 100 hours, both engines were overhauled to ensure the condition of engine components still good and working properly. Once re-assembled the engine components, the engine made a run-in for 10 hours using diesel fuel (Bio-solar).

During durability test, a dummy load was used to accommodate the electricity generated by the test generator. The dummy load was in the form of a series of light and loaded 75% of the maximum load (Figure 1). During durability test, the test generators was turning on continuously (24-hours per day) except when checking the condition if there were problems that interfere with engine performance.

The fuel was a blend of 5% and 50% pure biodiesel (palm methyl ester) with 95% and 50% Bio-solar respectively. Bio-solar is a brand of diesel fuel produced by Pertamina Co. (Bio-solar have max 10% FAME content). The specifications of pure biodiesel (palm methyl ester) are shown in Table 2.

Table 2. Specification of Pure Biodiesel

PROPERTIES	METHOD	SPECIFICATIO N	UNIT	RESULTS
Density (at 40°C)	EN ISO 12185	850 – 890	kg/m^3	856
Viscosity (at 40°C)	ASTM D 445	2.3 – 6.0	mm^2/s	5.07
Flash Point, PMCC	ASTM D 93	120 Min	°C	176
Cloud Point	ASTM D 2500	18 Max	°C	18
Water Content	EN ISO 12937	0.05 Max	%wt	0.041
Acid Number	ASTM D664	0.8 Max	mg KOH/g	0.196
Free Glycerol	ASTM D6584	0.02 Max	%wt	<0.001
Total Glycerol	ASTM D6584	0.24 Max	%wt	0.199
Alkil Ester	EN 14103	96.5 Min	%wt	99.28
Monoglyceride Content	EN 14105	0.8 Max	%wt	0.642

III. RESULTS AND DISCUSSIONS

The test results are shown in Table 3. Both the test results show in consistency. Both results indicate the condition of the lubricant oil tested is still good to be used. The all the parameters indicate the value relatively low comparing to the limit. The diluted fuel (fuel diluents) entered into the engine oil which was tested by distillation method show the same results, that is 1%. This value is within the tolerance limits that are commonly used in the amount of 5% [11].

Table 3. Used Oil Analysis

PROPERTIES	METHOD	UNIT	BS_5	BS_50	LIMIT *)
Viskosity @40ºC	ASTM D445-09	cSt	13.47	13.17	Max 99-188
TBN	ASTM D2896-07a	mg KOH/g	11.74	12	Min 4
CONTAMINANTS					
Natrium (Na)	ASTM D5185-09	ppm	2	2	50
Silikon	ASTM D5185-09	ppm	9	7	45
WEAR METAL					
Ferro (Fe)	ASTM D5185-09	ppm	40	40	125
Cuprum (Cu)	ASTM D5185-09	ppm	3	4	35
Aluminium (Al)	ASTM D5185-09	ppm	5	6	25
Chromium (Cr)	ASTM D5185-09	ppm	0	0	15
Nickel (Ni)	ASTM D5185-09	ppm	0	0	10
Tin (Sn)	ASTM D5185-09	ppm	0	0	20
Lead (Pb)	ASTM D5185-09	ppm	0	0	25
FTIR					
Soot	ASTM E2412-04	abs/0.1mm	0.03	0.04	0.8
Oxidation	ASTM E2412-04	abs/0.1mm	0.04	0.17	0.5
Nitration	ASTM E2412-04	abs/0.1mm	0.04	0.06	0.5
Sulfation	ASTM E2412-04	abs/0.1mm	0.05	0.07	0.5
Glycol	ASTM E2412-04	%	0	0	3
Water content		%	0	0	0.2
OTHERS					
Pentane Insolubles	ASTM D893	%	0.071	0.92	-
Toluene Insolubles	ASTM D893	%	0.015	0.2	-
Fuel diluents	ASTM D322-97	%vol	1	1	-

*) Source: Petrolab Services Co.

The property of viscosity show little difference, 13.47 cSt and 13.17 cSt. This value is still low compared to the value in allowing limit. The value of Total Base Number (TBN) show little difference. Value of Total Base Number (TBN) shows the content of additives in lubricants. The content of additives in lubricant serves to neutralize the alkaline acid oxidation products. Oxidation processes which caused by prolonged use and overheat produce some acid components which corrosive to metals.

Besides the acid products, the oxidation produced other insoluble materials in the lubricant and dirt on the various engine components lubricated. The increasing in viscosity and decreasing in TBN indicate the oil lubricants oxidation. By 1% fuel dilution, resulted only 0.3 cSt viscosity differences and 0.26 mg KOH/g on TBN. These little differences due to fuel dilution in the used oil still low at 1%.

The test results show the content of wear metals more consistent. The difference in biodiesel composition does not affect to the wear of metals Fe, while for metals Copper (Cu) and aluminum (Al) increasing by 1 ppm. Wear of metal Fe relatively higher compared to other metals. Wear of metal Fe are 40 ppm, either for 5% biodiesel fuel or 50%. This value is quite high at 32% of the allowable wear, while the wear metals Cu and Al, 11% and 24% respectively. Fe content is probably derived from components of cylinder liners, valve (valve), rod cam (camshaft) and gear. Metal Al is the material of the piston while the Cu component derived from bearing or bushing. Thus, it can be understood that the wear of metals derived from the friction resulting from the piston lubrication arrangement set and cylinder walls.

Another test that produced almost the same on Fe metal wear which is higher than the other metals as described in reference [12]. Tests performed on a single-cylinder marine diesel engines, four-stroke, and swirl chamber with air conditioning for 150 hours using 100% rapeseed methyl ester (RME). After 150 hours of testing the fuel dilution into lubricant oil was 3.5%. The biodiesel dilution resulted declining in the value of TBN and viscosity of the lubricant. The fall in viscosity lubricant resulted in the ability of coating metal surfaces rubbing two also declined. This condition occurs in the cylinder liner wall components that have the main material is Fe with its lubricating properties that have a dominant contribution of friction. Friction on engine components is highest in the composition of the ring - cylinder wall causing wear on the cylinder wall that is Fe higher [13].

The difference in biodiesel fuel composition indicate having effect on PI and TI values. The difference in composition result 0.85% for PI and 0.2% for TI. These values are around 28% and 10% of maximum value for oil replacement. Pentane In-soluble value (PI) and Toluene in-soluble (TI) provides an indication of lubricant start oxidizing. PI indicates the total in-soluble in the lubricant, while TI shows in-soluble of inorganic materials. As a general guide to the boundary lubricant oil replacement, maximum values 3% of PI and maximum 2% of TI [14]. This value is consistent to the results of FTIR test that detects low oxidation. The values are 0.04 and 0.17 for 5% biodiesel and 50% respectively. Likewise FTIR other test parameters which detects the presence of oxidation, nitration, soot and sulfation. For higher biodiesel composition, test for PI and TI show higher result, but it is difficult to justify how significant effect of biodiesel composition to the PI and TI in the used oil. While the content of glycol and water is not detected. Nitration is another form of oxidation. Soot and sulfation derived from products of combustion in the engine that went into the lubricant (diluted). Glycol was derived from cooling system leak [15]. These parameters are the components that can degrade performance of a lubricant.

IV. CONCLUSION

After 100 hours of two identical durability tests on 3.5 kVA engine generators using a blend 5% and 50% of pure biodiesel (palm methyl ester) with diesel (Bio-solar) produced by Pertamina Co., resulted on the same 1% fuel dilution on the engine generator oils. The fuel dilution didn't result significant effect on the engine oils degradation. The effects of fuel dilution showed no significant difference effects to the engine generator components after completion of the tests.

REFERENCES

[1]. Lubes ' n ' Greases (2007). BIODIESEL 'S EFFECT ON ENGINE OILS. Lubes ' n ' Greases. http://univrsallubes.com/assets/uploads/lubetalk/1207-2-Biodiesel.pdf.

[2]. Simon Watson A.G. and Victor W. Wong. The Effects of Fuel Dilution with Biodiesel on Lubricant Acidity, Oxidation and Corrosion - a Study with CJ - 4 and CI - 4 PLUS Lubricants (2008) August 7th Conference. Sloan Automotive Laboratory Massachusetts Institute of Technology. Diesel Engine - Efficiency and Emissions Research (DEER).

[3]. Richard M. Katherine and Stuart McTavish. Impact of Biodiesel on Lubricant Performance Corrosion (2009) SAE International Paper. 2009-01-2660.

[4]. Gary M. Parson. Biodiesel and Engine Lubrication Part 2. (2007) A Technical Publication. Chevron Products Company.

[5]. Kousoulidou Marina, Fontaras Giorgos, Giorgos Mellios, Leonidas Ntziachristos. Effect of Biodiesel and Bioethanol on Exhaust Emmissions (2008) Technical Paper 2008/5. The European Topic Centre on Air and Climate Change (ETC / ACC).

[6]. A. Tandon, Kumas A., P. Mondal, P. Vijay, Bhangale UD, Dinesh Tyagi. Tribological Issues Related to the Use of Biofuels: A New Environmental Challenge (2011) British Journal of Environment & Climate Change. 1 (2): 28-43, 2011. www.sciencedomain.org.

[7]. Banga Sangita and Pradeep K. Varshney. Effect of Impurities on the Performance of Biodiesel (2010) Journal of Scientific & Industrial Research. Vol. 69. August 2010 pp. 575-579.

[8]. Schumacher, LG, Charles L. Peterson, J. Gerpen Van. Engine Oil Analysis of Diesel Engines Fueled with Biodiesel Blends (2001) July 29 - August 1, 2001uly 29 - August 1, Paper No. 01-6053. Annual International

Meeting sponsored by ASAE. Sacramento Convention Center. Sacramento, CA.

[9]. Raheman Hifjur, Jena J. Prakash, S. Jadav Snehal. Performance of a diesel engine with blends of biodiesel (from a mixture of oils) and high - speed diesel (2013) International Journal of Energy and Environmental Engineering, 2013, 4:6. http://www.journal-ijeee.com/content/4/1/6.

[10]. Xue Jinlin, Tony Grift E, Hansen Alan C. Effect of biodiesel on engine performances and emissions (2011) Renewable and Sustainable Energy Reviews 15. 1098-1116. http://www.researchgate.net/publication/227421399_Effect_of_biodiesel_on_engine_performances_and_emissions.

[11]. Angeles Rolly. *Tables on Oil Analysis* (2003). http://www.rsareliability.com/Oil%20Analysis%20Tables.pdf.

[12]. Levent Yuksek, Kaleli Hakan, Özener Orkun, Özoğuz Berk. The effect and Comparison of Biodiesel - Diesel Fuel on Crankcase Oil, Diesel Engine Performance and Emmissions (2009) FME Transactions 37, 91-97 Faculty of Mechanical Engineering, Belgrade.

[13]. Smolenski Donald J and Shirley E. Schwartz. Automotive Engine - Oil Condition Monitoring (1994) Handbook of Lubrication and Tribology. Vol. III.

[14]. Marbach, H.W. and Frame, E.A. Investigation of Portable Army Oil Analysis Requirements for Application. (1999) U.S. Army TARDEC Fuels and Lubricants Research Facility and (SwRI), Southwest Research Institute, San Antonio, TX.

[15]. Alistair Geach. Infrared Analysis as a Tool for Assessing Degradation in Used Engine Lubricants (2003) WearCheck Africa.

