STUDY ON THE IMPACT BIODIESEL ONTO FUEL PUMP AND NOZZLE WEAR IN 5 KVA GENERATOR DIESEL ENGINE

By: **Mardono**[1)] and **Maymuchar**[2)]
Engineer[1)] and Researcher[2)] at "LEMIGAS" R & D Centre for Oil and Gas Technology
Jl. Ciledug Raya, Kav. 109, Cipulir, Kebayoran Lama, P.O. Box 1089/JKT, Jakarta Selatan 12230 INDONESIA
Email : mardono@lemigas.esdm.go.id ; maymuchar@lemigas.esdm.go.id,
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ABSTRACT

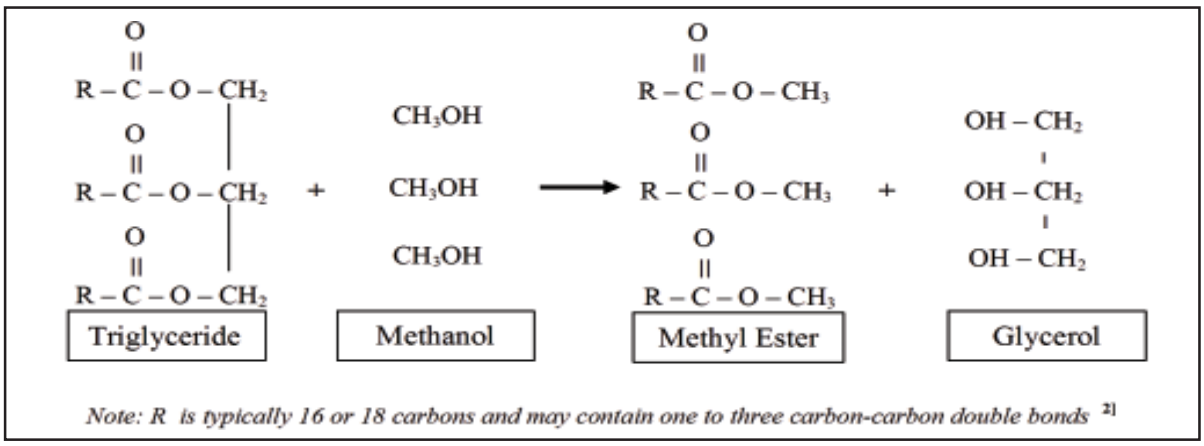
One of diesel fuel functions is to lubricate fuel pump components. Wearing process on fuel pump causes fuel pressure to the combustion chamber will drop. The pump will not distribute the hydrocarbon well in to the combustion chamber, as result incomplete combution process will occur. The objective of this study is to observe the impact of biodiesel on fuel pump and injector of the diesel engine. A 5 KVA generator diesel engine was used in this study and was operated using 48 CN diesel fuel ("Minyak Solar 48") (B0), biodiesel 50%-volume (B50) and biodiesel 100% (B100). Each of which was subjected to 100 hour running operation and 1000 Watt load. The results of this research show that biodiesel have a positive impact in reducing wear occurence in the generator diesel engine fuel pump components or injector nozzle.

Key words : *lubricity, fuel pump, biodiesel, injector nozzle*

I. INTRODUCTION

The use of biodiesel as an alternatif fuel for diesel engine has become a government program in developing biofuels. As stated in President Instruction No. 1, 2006 the aim of this government policy is to reduce the dependence on the petroleum. Therefore, it needs a breakthrough on the advancement of alternatif renewal energy resources. Biodiesel made of vegetable oils such as palm oil, coconut oil, jatropha curcas L oil, or used cooking oil is one of the alternatif fuels which has a good prospect in the near future. After processing via transestrification, the vegetable oils are transformed to fatty acid methyl ester (FAME) which has chemical and physical characteristics similar to diesel fuels.

The transesterification process of vegetable oil to biodiesel (methyl ester) is assumed as the following reactions: [2]



Note: R is typically 16 or 18 carbons and may contain one to three carbon-carbon double bonds [2]

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The mixture of biodiesel in the petroleum-based Diesel fuel is often written as B-XX, where XX is the amount of % volume Biodiesel. For examples, B-10 is 10%-volume Biodiesel in the mixture, B-50 is 50%-volume Biodiesel in the mixture, B-100 is 100% Biodiesel. Referring to the decree of Directorate General of Oil and Gas No. 3675 K/24/DJM/2006 dated March 17 2006 [2] about diesel fuel specification, allowable of FAME to either 48 CN or 51 CN diesel fuels is not more than 10% volume.

However, this maximum specification is still debatable, especially by engine and vehicle manufacturer. The world engine and vehicle associations (ACEA, Alliance, EMA, JAMA) specifications in the World-wide Fuel Charter (WWFC) September 2006 are still strictly limiting of the FAME content in the diesel up to 5% volume for the category 1, 2 and 3, and for category 4, it should be "non-detectable". [1]

Basically, biodiesel (FAME) that is produced by transesterification process of vegetable oils such as palm oil, jatropha oil or used cooking oil, has to meet the biodiesel specification as stated by the government. The biodiesel (methyl alkyl) specification stated by government is shown in the SNI 04-7182-2006.

The main objective of this study is to observe the impact of mixed fuels consisted of 48 CN diesel fuel and pure methyl ester on the fuel pump and fuel injector of 5 KVA generator diesel engine.

This article describes the result of this study.

II. RESEARCH METHODOLOGY

The research was carried out via lubricity test and running test.

The lubricities of the 100% biodiesel (B-100), the mixture of 50% by volume biodiesel and diesel fuel (B-50), and 48 cetane number grade Diesel fuel (B-0) were measured using HFRR based on the ASTM D 6079 method. The running test was conducted by using 5KVA generator Diesel engine for 100-hour operation with 1000 Watt-load.

Evaluation was carried out by analyzing the lubricity characteristic differences of the diesel fuel B-0, biodisel B-50 and 48 CN Diesel fuel B-100 and the impact on the condition of fuel system after 100 hr operation on the 5KVA generator Diesel engine. The fuel system observed consists of the fuel injector nozzle air flow and the weight of the fuel pump plunger and barrel to see the wear impact.

III. RESULT AND DISCUSSION

A. Lubricity

Lubricity is sometime referring to film strength i.e. the ability of a liquid to lubricate. This is relevant to the satisfactory operation of Diesel engines which rely on the fuel to lubricate many of the moving and rubbing metal parts of the fuel injection equipment[4]. The lubricity characteristic is needed by the diesel fuel to avoid the wear of the parts in the fuel system such as fuel pump and injector.

The 51 CN Diesel fuel ("Minyak Solar 51") lubricity is specified into a maximum scare diameter @ 60° C 460 micron.[3] High Frequency Reciprocating Wear Rig (HFRR) used for lubricity test is equipped with hardened steel ball oscillating transversely in loaded contacts with a hardened steel plate immerse in the test fuel. There will be a wear scare between the ball and the plate which is loaded by 200 g at the 60° C for 75 minutes. The lubricity is represented by

Table 1
The fuel lubricity analysis result of B-0, B-50 and B-100

Characteristic	Unit	Fuels			Test Method
		B-0	B-50	B-100	
Lubricity, Scare Diameter	micron	286	256	196	ASTM D 6079

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the scare diameter (micron) on the tested ball.[4] The less the scare diameter is, the better the fuel lubricity performance.

The lubricity analysis results of B-0, B-50 and B-100 are shown in Table 1.

Table 1 shows that the biodiesel B-100 used in this study has scare diameter of 196 microns, while B-50 and 48 CN grade Diesel fuel have 256 and 286 micron scare diameter respectively. Comparison with the Indonesian specification of 51 CN Diesel fuel which its maximum limit the lubricity scare diameter is 460 micron, all the fuels tested show excellent lubricity performance especially with biodiesel B-100.

The 50% volume addition biodiesel improves the 48 CN Diesel fuel lubricity by 30 points, from 286 to 256 micron. As a result the biodiesel addition enhances the lubricity performance of the Diesel fuel, as shown in Figure 2. By means of Microsoft Excel software, the correlation coefficient R and the determination coefficient R^2 obtained are -0.9820 and 0.9643. It means that the biodiesel addition has strong negative correlation with scare diameter. The higher biodiesel content in the Diesel fuel, the lower scare diameter of HFRR ball will be obtained. In another word, the biodiesel in the diesel fuel have positive effect on enhancing the lubricity of the Diesel fuel.

B. Running Test

The engine used in this test is the 5 KVA generator Diesel engine with specification of 4 Stroke Diesel engine, water cooling, direct injection, 583 cc cylinder displacement. Figure 1 shows the 5 KVA generator Diesel engine used as the engine test.

The observation and the measurements on the fuel system before and after 100 hours running operation of 5 KVA generator Diesel engine to see the impact on the components of fuel system are:

- The measurement of the injector nozzle flow to see the probability of the wear at the injector nozzle.
- The plunger and barrel weight measurement to see the wear at fuel pump parts.

1. The Effect of Injector Nozzle Air Flow Rate on Needle Lift

The measurement of Injector Nozzle Air Flow was carried out before and after it is used for 100 hour running operation.

Figure 1
5 KVA Generator Diesel Engine

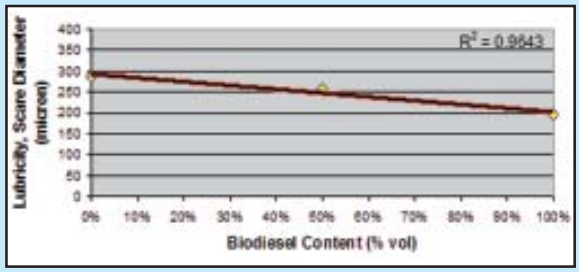

Figure 2
The effect of biodiesel addition to the 48 CN Diesel fuel lubricity

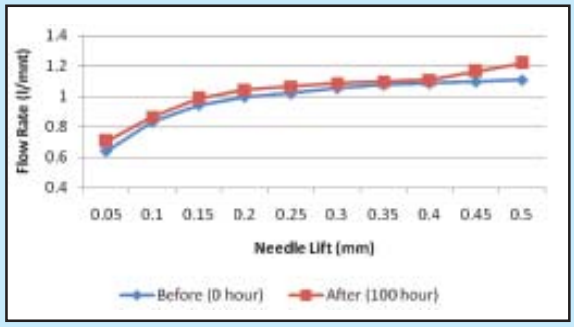

Figure 3
The injector nozzle air flow measurement at the use of diesel fuel B-0

Figure 3, Figure 4 and Figure 5 show the nozzle air flow test result before and after 100 hours running operation at the variation of needle lift between 0.05 to 0.5 mm for B-0, B-50 and B-100.

Figure 3 shows the difference between the injector nozzle flow rate at 0 hour and after 100 hour operation by using B-0. The flow rate after running 100 hours is higher than before running. It means that wearing process of injector nozzle occurs after 100 hour running operation. By using B-0, the average increase of the nozzle air flow (with the needle lifted 0.05 – 0.5 mm) after 100 hour operation is 5.08%.

Figure 4 shows that the air flow through the nozzle after 100 hour operation with biodiesel B-50 is also higher than that is before the operation. The increase of the average nozzle air flow (with the needle lifted 0.05 – 0.5 mm) after 100 hour operation is 4.75%. This fact shows that wearing process occurs on the nozzle hole after 100 hour operation.

Figure 5 shows that the air flow through the nozzle after 100 hour operation with biodiesel B-100 is higher than that is before the operation. The improvement of the average nozzle air flow (with the needle lifted 0.05-0.5 mm) after 100 hour operation is 1.72%. In conclusion that the injector nozzle experienced process after 100 hour operation.

Based on the air flow rate study, it can be concluded that the nozzle wear when using biodiesel B-100 is less than that of using either diesel fuel B-50 or 48 CN Diesel fuel. The different of air flow rate after and before 100 hours running of the nozzle B-100, B-50 and B-0, are 1.72%, 4.74% and 5.08% respectively. The higher different number means the higher wearing value.

According to the result of correlation calculation, the correlation coefficient R is - 0.9083 and determination coefficient R^2 is 0.8250, which means that the biodiesel addition has strong negative correlation with injector nozzle wear. Enhancing the biodiesel content will reduce wearing process on injector nozzle. Therefore, the addition of biodiesel to the 48 CN Diesel fuel have positive impact on reducing wear of the injector nozzle.

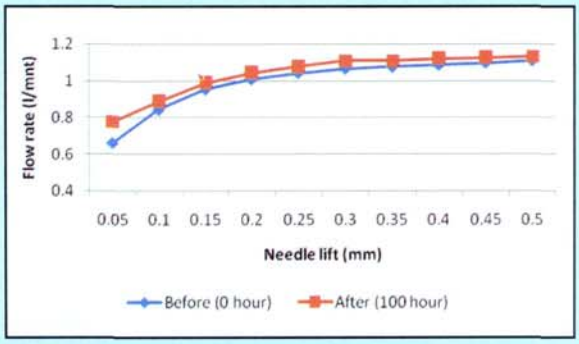

Figure 4
Injector nozzle air flow measurement at the use of diesel fuel B-50

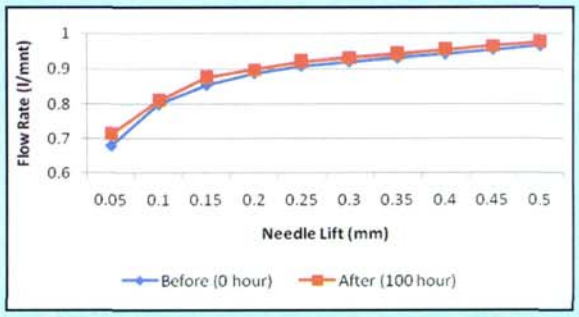

Figure 5
Injector nozzle air flow measurement at the use of diesel fuel B-100

Table 2
Weight measurement of the plunger and barrel fuel injection pump before and after 100 hour operation

Fuel	Before (0 hour)		After (100 hours)		Weight Reduction Plunger (%)	Weight Reduction Barrel (%)
	Plunger (gr)	Barrel (gr)	Plunger (gr)	Barrel (gr)		
B-0	122.200	255.700	122.185	255.619	0.0123%	0.0317%
B-50	122.269	256.062	122.260	256.051	0.0074%	0.0043%
B-100	121.967	255.813	121.959	255.803	0.0066%	0.0039%

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2. The effect of weight of injection fuel pump plunger and barrel on running hours operation

The lubrication process in the fuel pump is dependent on the fuel used. The effect of the fuel to the wearing process inside the fuel pump can be represented by the weight of plunger and barrel of the fuel injection pump before and after 100 hour running operation. The weight differences show the value of the wearing process occurs inside the fuel pump.

Table 2 shows the result of the weight measurement of the plunger and barrel fuel injection pump of diesel generator engine 5 KVA before and after 100 hour operation.

The decrease of plunger weight on B-0, B-50 and B-100 is 0.0123 %, 0.0074% and 0.0066% respectively. It shows that the wear of plunger fuel pump of B-0 is higher than B-50 and B-100.

The result of correlation calculation gets correlation coefficient R is -0.9235 and determination coefficient R^2 is 0.8528. It means the biodiesel addition has strong negative correlation with decreasing of plunger weight. This means that the improving biodiesel content will reduce the wearing process of plunger.

The decrease of barrel weight when using B-0, B-50 and B-100 are 0.0317%, 0.0043% and 0.0039% respectively. It shows that the wear of barrel fuel pump is higher when it is used B-0 than that it is used B-50 and B-100. The result of correlation calculation gets correlation coefficient R = -0.8722 and determination coefficient R^2 = 0.7608, that means the biodiesel addition has strong negative correlation with decreasing of barrel weight. This means that the rising biodiesel content will reduce wearing of barrel.

IV. CONCLUSION

Based on the results of the lubricity and wearing analysis this study has demonstrated that :

- The more biodiesel content in 48 CN Diesel fuel ("minyak solar 48") the higher the increase of the lubricity performance of the fuel.
- The biodiesel content in 48 CN Diesel fuel has strong correlation with reducing wear of injector nozzle, it means the increasing biodiesel on diesel fuel will reduce wearing process on injector nozzle.
- The decreasing of plunger weight shows that the wear of fuel pump plunger when using biodiesel is lowers than 48 CN Diesel fuel.
- The biodiesel addition has strong negative correlation with decreasing of barrel weight, means that the rising biodiesel content will reduce wearing process of barrel.

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