COMPARISION DEPOSIT FORMATION ON THE VALVE DIESEL ENGINE CAUSED BY BIODIESEL AND PETROLEUM DIESEL FUELS

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ABSTRACT

The research on the influence of the biodiesel to the formation of deposits on the intake and exhaust valves diesel engine has been carried out by means analysis of merit rating. The fuels used on this study are FAME (B-100), a mixture of 50% (v)of FAME in diesel fuel 48 (B-50), and diesel fuel 48 (B-0). The objective of this research is to obtain data which represent the influence of the biodiesel to the formation of deposits on the intake and exhaust valve diesel engine. The test used a diesel engine driving 5 KVA generator which is operated for 100 hours with 1.000 Watt electrical load. The results of the study show that the use of either FAME or biodiesel as alternative fuel in the diesel engine generator 5 KVA has a positive effect on reducing the deposit on the intake and exhaust valves.

Keywords: *biodiesel, intake valve, exhaust valve, diesel engine*

I. INTRODUCTION

The use of biodiesel as an alternative fuel for diesel engines is a government policy which aim to develop the application of biofuels. This program has already stated in Presidential Decree No. 1 2006. This program becomes a priority to decrease the dependence on fossil fuels in the future.

The specification of Diesel Fuel 48 or 51 stated in the Directorate General of Oil and Gas No. SK. 3675K/24/DJM/2006 dated March 17, addition of FAME into diesel fuel up to 10% of volume is allowed. This 10% addition of FAME is still debatable, especially by the manufacturers of vehicles and machinery. According to World Association of the vehicle and engine manufacturers (ACEA, Alliance, EMA, JAMA) in the World-Wide Fuel Charter (WWFC) September 2006 still restricts the content of FAME in diesel fuel to a maximum of 5% by volume of Categories 1, 2 and 3, whereas Category 4 is mentioned "non-detectable". The limitation of biodiesel is due to the negative side at high concentration, i.e : unstable to oxidation, the problem of viscosity at low temperatures, hygroscopic properties, the compatibility of the components of natural rubber seals and the formation of deposits on parts of the engine including the intake and exhaust valve.

Intake and exhaust valve are parts of the engine mechanism that are located on cylinder head. The function of these valve are to regulate fluid or gas in and out the combustion chamber. Intake valve regulates the fresh air needed for combustion coming into the cylinder. This air intake process occurs due to the piston movement from top to bottom dead center. Whereas the exhaust valve is to let the combusted gas flows from the combustion chamber. The mechanism of exhaust gases of the combustion occurs in exhaust stroke where the piston moves from the bottom dead center to the top dead center. The more fluid can move in and out of the engine the more efficient and power the engine is. Therefore, the intake and exhaust valve plays a significant role in an engines performance.

The objective of this research is to obtain data which represent the influence of the biodiesel to the formation of deposits on the intake and exhaust valve diesel engine.

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II. RESEARCH PREPARATION AND METHOD

A. Test Fuel

There are 3 kinds of fuel used in this research that is diesel fuel with cetane number 48, Fatty Acid Methyl Ester (FAME) or biodiesel, and diesel fuel and biodiesel blend.

1. Diesel Fuel 48 grade

One of the fuels used is diesel fuel 48 which has a minimum cetane number 48. This fuel is used as a reference fuel for comparison to other fuels. The fuel is later referred to as B-0.

2. Fame

Palm-based biodiesel is often called FAME has a chemical formula:

$$R - \overset{\overset{O}{\|}}{C} - O - CH_3$$

FAME is the result of trigliseride process of palm oil with methanol (CH3OH) via transesterification process using a catalyst of sodium hydroxide (NaOH). The fuel is later referred to as B-100.

3. Biodiesel

Biodiesel is a mixture of petroleum diesel fuel 48 with biodiesel FAME. The blending concentrations are respectively 50% and then called as B-50.

B. Test Engine

Diesel engine generator with a 5 KVA capacity as a test engine that is widely used in community as a power supply for small houses. The main specification of the diesel engine used are listed in Table 1.

Table 1
Test engine specification

Type	:	4 stroke, 1 cylinder, Horizontal
Type Injection	:	Direct Injection
Displacement	:	583 cc
Power (Cont.)	:	9,2 HP / 2400 rpm
Power (Max)	:	10,5 HP / 2400 rpm

The test engine shows on Figure 1.

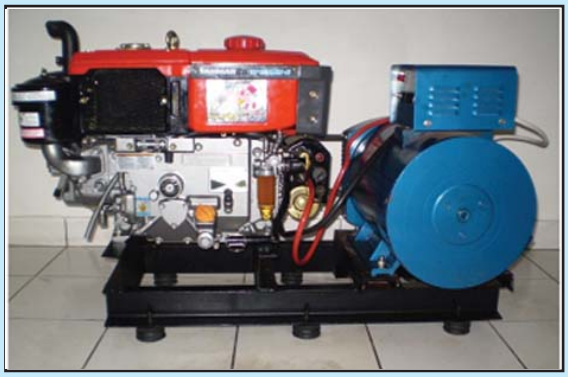

Figure 1
Diesel engine generator 5 KVA

Figure 2
Parts of valve observed

The research was conducted in two phases of test; fuel characteristics test and applied test. The fuel used by the test parameters tested characteristics cetane number, distillation, viscosity, density and lubricity in accordance with the specifications and standard test methods. The applied test is carried out by using a diesel engine driving generator. The 5KVA generator diesel engine is run by fuel B-0, B-50 and B-100. Each of the fuel was used to operate the engine test for 100 hours with 1.000 Watt electric load. After 100

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hours of operation, the engine was overhauled and the deposits on valve was assessed and weighed.

Intake and exhaust valve for each test of each fuel must be in new condition. Replacing parts were also done to the parts which affect the performance of the engine such as fuel filters, oil filters, etc.

The Evaluation is done by comparing the results of assessment of intake and exhaust valve engine with fuel B-100, B-50 with B-0. Valve condition assessment was done in two ways that is merit analysis by using standard CEC (The Coordinating European Council) and weighing the deposit. The observed parts of the valve are head/topside valve and tulips/ underside valve (Figure 2).

III. RESULT AND DISCUSSION

A. Characteristic Fuel

The laboratory test results show the main characteristics of the sample B-0 used as reference fuel and B-50 which meets the requirements of test specifications set by the government according to Director General of Oil and Gas Decree No.3675.K/24/

Table 2
Characteristic B-0 and B-50 test result

No	Characteristic	Unit	Result		Diesel fuel 48 specification	Test method
			B-0	B50		
1	Kinematic viscosity @ 40°C	mm^2/s	4,4	4,9	2,0-5,0	D445
2	Density @ 40°C,	kg/m^3	849	867	815-870	D1298
3	Cetane number	CN	48,6	50,2	Min48	D613
4	Flash point	°C	67	96,5	Min60	D93
5	Cooper corrosion	No.ASTM	No.1	No.1	Max No 1	D130
6	Carbon residu	% massa	0,01	0.09	Max 0,1	D4530
7	Acid number	mg-KOH/g	0,09	0.2	Max 0,6	D664
8	Sulphur content	% m/m	0,15	0.09	Max 0,35	D1266
9	Lubricity, scare *diameter*	micron	286	205	-	D6079
10	Calorific value	Mj/Kg	4377	39.9	-	D240

Table 3
Characteristic B-100 test result

No	Characteristic	Unit	B-100	Biodiesel specification	Test method
1	Kinematic viscosity @40°C	mm^2/s	6,0	2,3-6,0	D445
2	Density @40°C,	kg/m^3	884	850 - 890	D1298
3	Cetane number	CN	51,4	min 51	D613
4	Flash point	°C	134	min 100	D93
5	Cooper corrosion	No.ASTM	No.1	max No. 3	D130
6	Carbon residu	% massa	0,028	max 0,05	D4530
7	Acid number	mg-KOH/g	0,32	max 0,8	D664
8	Sulphur content	% m/m	0,01	Max 0,01	D1266
9	Lubricity, scare diameter	micron	196	-	D6079
10	Calorific value	Mj/Kg	38.3	-	D240

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DJM/2006 decree dated March 17, 2006 for diesel fuel 48. The result is showed in Table 2.

From the results of laboratory tests the main characteristics of the sample B-100, which is used as biodiesel fuel meets the requirements of test specifications set by the government according to the Indonesian National Standard as outlined in the SNI 04-7182-2006. The result is shown in Table 3.

B. Rating Top Head and Tulip Intake Valve

Rating deposit at the top of intake valve has been done for fuel B-0, B-50, and B-100. The results of deposit rating top head intake valve for B-0, B-50 and B-100 is shown in Table 5.

From the results of merit rating deposits at the top head intake valve, the value of merit rating for B-0, B-50 and B-100 is the same, 8.643 respectively.

Table 5
Merit rating and effect deposit top head intake valve

Merit Rating		
B-0	B-50	B-100
8,643	8,643	8,643
Effect	B50:B0	B-100:B0
	0,00%	0,00%

Figure 3
Deposit on top head intake valve for B-0, B-50 and B-100 After 100 hour Operation

Figure 4
Deposit on tulip intake valve B-0, B-50 and B-100 After 100 hour operation

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There are no differences shown in the formation of deposits on intake valve top head in biodiesel addition. Physically the deposit on the top head intake valve for fuel B-0, B-50 and B-100 is shown in Figure 3.

The results of the intake valve tulips deposit rating to B-0, B-50 and B-100 is shown in Table 6. From the results merit rating tulips intake valve deposits, the value of merit rating to B-0, B-50 and B-100 are 8.643, 9.643 and 9.708, respectively. Value shows the addition of biodiesel tends to reduce deposit formation in the intake valve tulips. The value of merit rating tulips intake valve B-50 to B-0 is 10,37% and B-100 to B-0 rises 12.32%.

Physically deposits on the tulips intake valve to fuel B-0, B-50 and B-100 after 100 hours of operation is shown in Figure 4.

Weight measurements showed that the intake valve deposits on the B-0 is heavier than the B-50 and B100 (see Table 7). Although the results of the rating on the top head have the same value but the tulip rating results B-0 are relatively poor.

C. Rating Top Head and Tulip Exhaust Valve

The results merit rating top head exhaust valve deposits the value of merit rating to B-0, B-50 and B-100 respectively 8.342, 8.643, and 8.643 (see Table 8). The value shows that the addition of biodiesel tends to reduce deposit formation in the top head exhaust valve. The effect value of merit rating top head exhaust valve B-50 to B-0 rose 3.60%, and B-100 to B-0 rose 3.60%. Physically deposit on top head exhaust valve to fuel B-0, B-50 and B-100 after 100 hours of operation is shown in Figure 5.

Table 6
Merit rating and effect deposit
Tulip intake valve

Merit Rating		
B-0	B-50	B-100
8,643	9,643	9,708
Effect	B50:B0	B-100:B0
	10,37%	12,32%

Table 7
Weight Measurement of Intake Valve

Fuel	Inlet Valve Weight (gr)		Effect
	0 hour	100 hours	
B-0	470.005	471.655	0.1650
B-50	470.400	470.944	0.0544
B-100	475.976	476.568	0.0592

Table 8
Merit rating and effect deposit
Top head exhaust valve

Merit Rating		
B-0	B-50	B-100
8,342	8,643	8,643
Effect	B50:B0	B-100:B0
	3,60%	3,60%

Figure 5
Deposit on top head exhaust valve B-0, B-50 and B-100
After 100 hour operation

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Rating deposits in the exhaust valve tulip has been done for the fuel B-0, B-50, B-100 and the result is shown in Table 9. From the results merit rating tulips exhaust valve deposits, the value of merit rating to B-0, B-50 and B-100 are respectively 4.812, 5.237, and 6.827. The value shows that the addition of biodiesel tends to reduce deposit formation in the exhaust valve tulips. The value of merit rating tulips exhaust valve for the B-50: B-0 rose 8.84%, and B-100: B-0 rose 41.87%. Physically the deposits on the tulips exhaust valve to fuel B-0, B-50 and B-100 after 100 hours of operation is shown in Figure 6.

The results of weighing the deposit that occurs at the outlet valve is shown in Table 10.

IV. CONCLUSIONS

After assessing parts of the intake and exhaust valve in 100-hour-engine operation to see the impact of using biodiesel on the formation of deposits on engine valves 5 KVA Diesel generator, it can be summed up as follows:

- The rating of the valves above shows that the use of biodiesel as a fuel substitution for diesel fuel on the generator 5 KVA diesel engine has a positive effect on reduction of deposit formation on valves, especially the tulips.
- Biodiesel does not make a difference in the formation of deposits on the top head intake valve, the value of merit rating to B-0, B-50 and B-100 is the same that is 8.643.
- The addition of biodiesel tends to reduce the formation of deposits on the intake valve tulips, the effect of tulips rating B-50: B-0 and B-100: B-0 are 10,37% and 12.32% respectively.

Table 9
Merit rating and effect deposit
Tulip exhaust valve

Merit Rating		
B-0	B-50	B-100
4,812	5,237	6,827
Effect	B50:B0	B-100:B0
	8,84%	41,87%

Table 10
Weight Measurement of Exhaust Valve

Fuel	Exhaust Valve Weight (gr)		Effect
	0 hour	100 hours	
B-0	409.651	418.251	0.8600
B-50	403.401	406.325	0.2924
B-100	403.098	405.389	0.2291

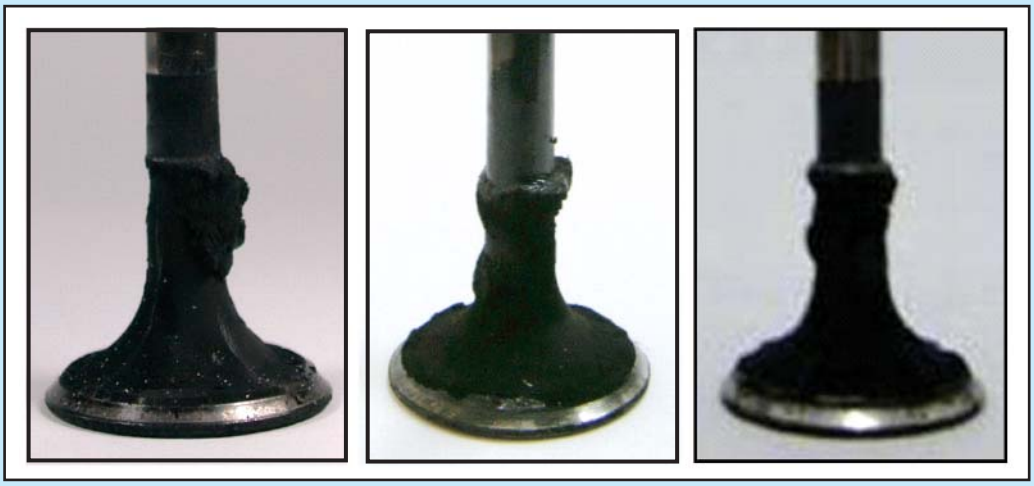

Figure 6
Deposit on tulip exhaust valve B-0, B-50 and B-100
After 100 hour operation

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- The addition of biodiesel tends to reduce the formation of deposits on the top head exhaust valve, the effect of tulips rating B-50: B-0 and B-100: B-0 are 3.60%.
- The effect of addition of biodiesel 50% to diesel fuel tends to reduce the formation of deposits in the tulip exhaust valves 8.84%, but using 100% biofuel will reduce deposit on the exhaust valve 41.87%.

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