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Implementation of sediment separator core hole in an effort to reduce the filter clogging rate of CAT 16M Grader

Agung Suprapto[1], Nova Risdianto Ismail*[2], Dadang Hermawan[3], Purbo Suwandono[4], Leo Hutri Wicaksono[5]

[1,2,3,45]Jurusan Teknik Mesin , Fakultas Teknik, Universitas Widyagama Malang Jl. Borobudur No.35, Kota Malang,, Jawa Timur 65142

A R T I C L E I N F O

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A B S T R A C T

The Cat 16M Grader is a heavy equipment that is widely used to support mining operations. The development of this heavy equipment is required to use biodesel fuel (B30). The problem with B30 fuel is oxidation which results in the formation of sediment and can cause filter clogging. Filter clogging can affect engine power and filter replacement time. From these problems, the researcher proposed to modify the number of sediment separator core holes to reduce the filter clogging rate on the Cat 16M grader. Modified number of sediment separator core holes are 40, 20 and 10 holes with 8 mm hole dimension. Data was collected experimentally by implementing the modified sediment separator core on a Cat 16M grader for 250 hours of operation. The research resulted in the number of sediment separator core holes 10 at 250 hours of operation producing the highest sediment volume of 92 ml, the filter with the lowest clogging rate and the lowest fuel pressure difference. In addition, using the number of sediment separator cores 10 at 250 hours of operation produces the highest engine power, the highest filter clogging efficiency and has a high economic value.

Introduction

Coal is the largest mining commodity in Indonesia, especially in the Kalimantan area [1]. Coal has great potential in increasing non-oil and gas exports [2], investment [3,4] and can support state revenues [5]. In coal mining, many use heavy equipment to support work operations [6].

Heavy equipment such as excavators and dump trucks have an important role in mining operations,

**Corresponding author*: nova@widyagama.ac.id
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because the equipment functions to dig, load, and transport materials [7]. This heavy equipment includes the Caterpillar 16M Grader [8].

In its development, the government requires the use of biodiesel fuels such as B30 [9] and will continue to be developed into B35 [10]. This regulation is to support B30 fuel, as an environmentally friendly alternative fuel [11,12].

Although B30 fuel has the potential to reduce environmental impact, its use in graders such as the Caterpillar 16M poses new challenges. Oxidation processes still occur which result in the hydroperoxides formed polymerizing with free radicals and forming sediment [13]. This can lead to clogging of the fuel filter [14], deposits in the injection system and engine combustion chamber [15], which in turn speeds up filter replacement time [16].

Some efforts to reduce fuel sediment include storage methods that do not exceed 4 weeks [17]. Meanwhile, to reduce fuel filter clogging by adding monopalmitin before mixing with diesel [18]. In addition, the size and dimensions of filter contamination also affect the volume of sediment [19,14].

In an effort to reduce filter clogging, the researcher proposed adding a biodiesel sediment separator in the position before the fuel passes through the main filter on the Caterpillar 16M grader. The biodiesel sediment separator works by utilizing the different specific gravity of the fuel. The biodiesel sediment separator was modified with a hole diameter of 8 mm with the number of holes in the sediment separator core varied by 40 holes, 20 holes and 10 holes. The biodiesel sediment separator was implemented when the CAT 16M grader was operating. This study is expected to provide information on sediment deposition volume, fuel pressure difference, filter clogging rate, engine power, fuel clogging efficiency and economic value.

Research Methods

The research was conducted by experimentally implementing a modified sediment separator to evaluate the performance of Filter B30 on a Caterpillar 16M Grader. The experiment compared testing on Filter B30 without sediment separator and with sediment separator using variations in the number of sediment separator holes (40, 20, and 10 holes).

Data collection was done through direct testing on the machine. Sediment volume data was taken after the Caterpillar 16M Grader engine used a sediment separator for 250 working hours. For data on fuel pressure difference, filter clogging rate and engine power are taken every 50 working hours. From this data, the fuel clogging efficiency and economic value are calculated.

Research tools and materials

A. Tools

The equipment used are: ET Tools (Electronic Technician) Caterpillar which serves to measure the level of clogging, fuel pressure difference and engine power. CAT data link cable that serves to connect the engine with ET Tools. 100 mm measuring cup to measure sediment volume.

B. Materials

1. Cat 16M grader machine

Researchers used 3 Caterpillar branded 16M grader machines with machine numbers GD016-0016, GD016-0054 and GD016-0055. These graders were operated at the same place and workload.

Figure 1. Caterpillar 16M Grader
Source : Data internal

2. Sediment Separator

Sediment separator Type SP1PPS fuel has been specified with the standard installation and mounting on the caterpilar engine and then modified the separator core.

Figure 2. Sediment separator

Sediment separator core with 3 variations in the number of holes. The sediment separator core can be seen in Figure 3.

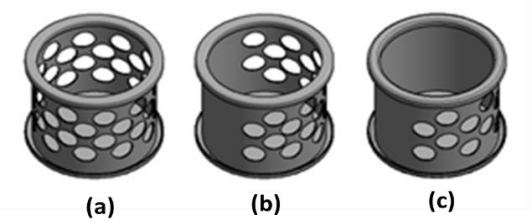

Figure 3. Number of holes in the sediment separator core (a) 40, (b) 20, (c) 10 holes.

Installation of the sediment separator before the main filter, between the fuel pump and the main filter. The installation scheme can be seen in Figure 4.

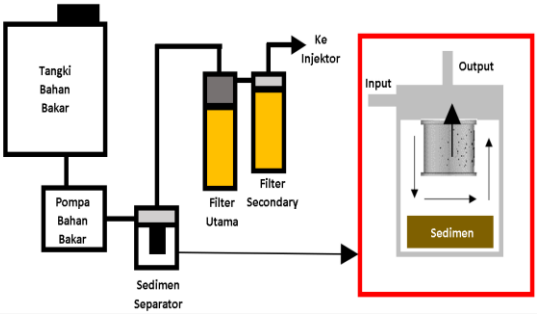

Figure 4. Schematic of sediment separator installation
Source : Data internal

Results and Discussion

1. Sediment volume in the separator

In this study, researchers compared the volume of sediment collected in the separator when the Cat 16M grader had been operating for 250 hours. Figure 5 shows the sediment volume of the research results.

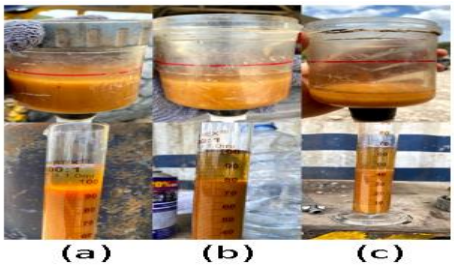

Figure 5. Sediment volume for each number of sediment separator holes (a) 10, (b) 20, and (c) 40.

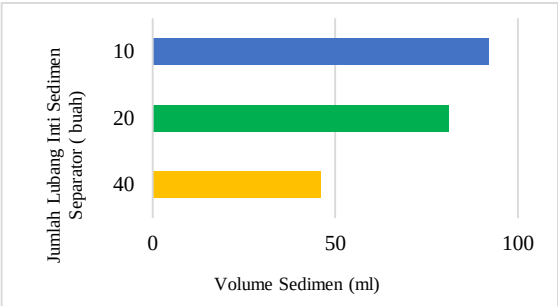

Figure 6. Sediment volume at varying number of sediment separator core holes

Figure 6 shows that the volume of sediment during 250 hours of using sediment separators with variations in the number of holes 40, 20 and 10 shows a significant difference. The number of holes 40 produces a sediment volume of 46 ml, the number of holes 20 produces a sediment volume of 81 ml and the number of holes 10 produces a sediment volume of 92 ml. This finding confirms that the smaller the number of holes in the sediment separator core, the greater the sediment volume produced.

The number of holes in the sediment separator core is small, so the sediment is more inhibited in the sediment separator core compared to the larger number of holes. The small volume of sediment in the sediment separator allows some of the sediment to flow towards the filter, so that the filter quickly becomes blocked. This is

in line with previous research, where sediment flowing towards the filter causes clogging [19,20].

2. Fuel filter clogging rate

Figure 7 shows the fuel filter clogging rate during 250 hours of sediment separator use. The number of holes in the 40 sediment separator core has a filter clogging rate of 25%, the number of holes in the 20 sediment separator core has a filter clogging rate of 17%, the number of holes in the 10 sediment separator core has a filter clogging rate of 15% and the filter without sediment separator has a clogging rate of 26%. The test time from the beginning to 250 hours of use of the core sediment separator and without sediment separator experienced an increasing fuel filter clogging. This increase in clogging can reduce filter life [21,22], where the standard filter life for 250 hours has a maximum standard clogging rate of 20%. At the number of core holes 40 sediment separator and without sediment separator has exceeded the standard clogging rate, while using the number of core holes 20 and 10 sediment separator is still below the standard clogging rate of 20% at 250 hours of use. So it is recommended to use a sediment separator core with the number of holes 10 which has the smallest clogging rate.

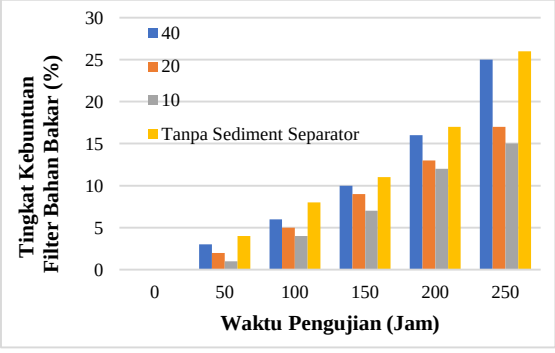

Figure 7. Fuel filter clogging rate

3. Fuel pressure differential

Figure 8 shows the variation of the pressure difference between the input and output of the fuel filter for 250 hours, the number of sediment separator core holes 40 has a pressure difference of 256 kPa, the number of sediment separator core holes 20 has a pressure difference of 199 kPa and the number of sediment separator core holes 10 has a pressure difference of 173 kPa, and without sediment separator the pressure difference is 267 kPa. The higher the pressure difference, the higher the filter clogging. The high pressure difference indicates that the fuel filter is obstructed by sediment material that does not settle on the sediment separator [18].

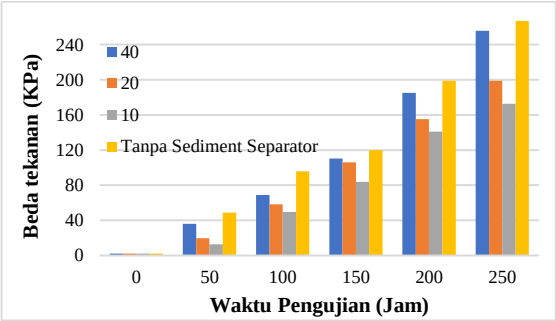

Figure 8: Comparison of fuel pressure difference

The fuel filter pressure difference increases as the test time increases. This condition is caused by the greater filter clogging that increases [23].

4. Engine power of Cat 16M grader

Figure 9 shows the decrease in power of the Cat 16M grader from 50 hours to 250 hours of use. The standard power of the engine is 530 Hp. At the number of sediment separator core holes 40 at the 250-hour test time, the power decreased significantly to 397 Hp which is equivalent to 26% of the standard value, at the number of sediment separator core holes 20, the power decreased to 439 Hp which is equivalent to 17% of the standard, at the number of sediment separator core holes 10, the power decreased to 455 Hp which is equivalent to 14% of the standard, and at the filter without sediment separator, the power decreased to 27%.

The decrease in Cat 16 M grader engine power is caused by filter blockage. Filter clogging can reduce fuel pressure in the injector, thus affecting the fogging

process [24,25]. The incomplete fogging process causes an incomplete combustion process and ultimately causes a decrease in engine power [26,27].

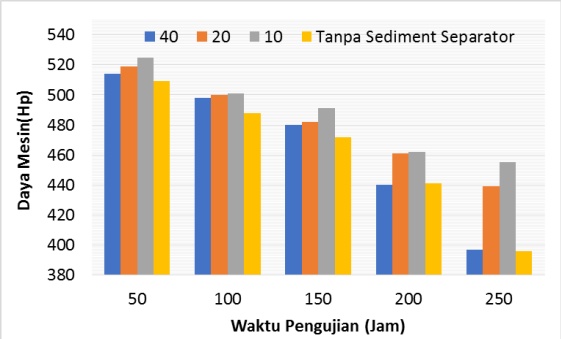

Figure 9. Engine power

5. Fuel filter clogging efficiency

Filter efficiency is the ability of the fuel filter to perform its function without excessive fuel flow resistance. The filter replacement time period is every 250 hours. In calculating the efficiency of the fuel filter life, data on the level of filter clogging is taken when the standard filter life is 250 hours, then the following equation is used:

$$\eta_f = \left(\frac{U_l}{S_l} - \left(\frac{ACP}{MCP}\right)\right) \quad (1)$$

Where:

η_f = Filter Efficiency
U_l = Usage Life
S_l = Standart Life
ACP = Actual Clogging Percentage
ACP = Maximum Clogging Percentage

Because the data collection schedule is the same as the standard age, the equation used is as follows:

$$\eta_f = \left(1 - \left(\frac{ACP}{MCP}\right)\right) \quad (2)$$

From the calculation results, then the results are presented in Figure 10, as follows:

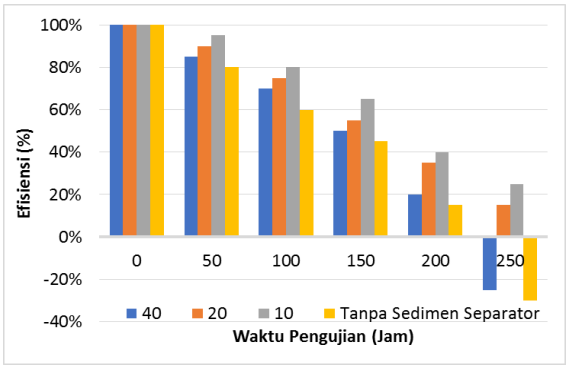

Figure 10: Filter clogging efficiency

The graph shows the correlation between the clogging efficiency of the fuel filter on the CAT 16M grader and its lifespan, especially during the 250-hour test period, with the analysis of three variations in the number of sediment separator core holes (40, 20, and 10). It can be seen that the most significant decrease in efficiency occurs when using a filter with a 40 core sediment separator of -25% and a filter without a sediment separator of -30%. The minus value is due to filter cloggings that exceed the maximum limit of 20% and filter damage. In the use of filters with a sediment separator core 20 produces the lowest efficiency at 250 hours of use of 15% and the use of filters with a sediment separator core 10 produces the lowest efficiency at 250 hours of use of 25%. A high efficiency value indicates a better clogging efficiency level because it prevents sediment from reaching the main engine filter.

6. Economic Analysis

The following is the calculation of the cost of replacing the CAT 16M grader filter in 1 year with a fuel filter replacement cost of 3 million.

Table 1. Calculation of filter replacement cost

Jumlah Lubang	Waktu Mencapai Kebuntuan Maksimal	Umur Kebuntuan Maksimal	Total Pergantian per Tahun	Biaya (Rp/tahun)
40	-50	200	30	90,000000
20	44	294	20	61,200000
10	83	333	17	54,000000
Tanpa Sedimen Separator	-58	192	31	93,600000

Table 1 shows the cost in 1 year when using a sediment separator core and without a sediment separator. Calculation of the cost of replacing the CAT 16M Grader fuel filter is carried out within a period of 1 year with a total of 6250 hours of operation. Using a core sediment separator with 10 holes requires the lowest filter replacement cost in 1 year, so it is recommended to be applied to CAT 16M grader machines.

Conclusion

From the results and discussion it can be concluded that using the number of holes of the sediment separator core 10 at 250 operating hours produces the highest sediment volume of 92 ml, the filter with the lowest clogging rate and the lowest fuel pressure difference. In addition, using the number of sediment separator cores 10 at 250 hours of operation produces the highest engine power, the highest filter clogging efficiency and has a high economic value.

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