Fault analysis of fuel system on Komatsu PC200-8 excavator (case studies at PT Kaltim Plantation)

Denny Hendra Cipta

Politeknik Negeri Nunukan, Nunukan, Indonesia
dennyhc.pnn@gmail.com

Abstract. Komatsu PC200-8 is a type of excavator that is widely used in the mining and plantation industries in East Kalimantan. Operational disruption of excavators can cause losses for the company considering its vital role in the company's production process. One of the Komatsu PC200-8 excavators owned by PT Kaltim Plantation experienced a problem with the symptom that the engine could not start. In order to restore the operational function of the excavator and obtain useful knowledge specifically in the field of heavy equipment engineering, it is necessary to analyze these disturbances. After inspection and testing, problems were found in the unit's fuel supply system. In order to determine the main source of interference, inspection and measurement as well as data analysis are carried out. Inspections were carried out on all the main components of the fuel system, in addition to that, electrical resistance measurements were also carried out on the two way valve components. The measurement results are then compared with the standard values in the manual book. The results of the analysis determined that the problem was caused by an internal leak in the injector, which was caused by impurities in the fuel getting into the components. To overcome this problem, replacement is carried out by replacing fuel system components that are no longer suitable for use, such as fuel filters and injectors..

Keywords: Excavator, Fault Analysis, Fuel System, Injector, Komatsu PC 200-8.

1 Introduction

The Komatsu PC200-8 is a hydraulic excavator that is widely used in various sectors such as construction, agriculture, and plantation[1]. The excavator is equipped with an engine system, electrical system, hydraulic system, and mechatronic system, and all actuator movements are controlled by the mechatronic system[1]. The hydraulic system of the excavator consists of several components, including the hydraulic tank, hydraulic pump, hydraulic valve, hydraulic motor, and hydraulic cylinder[2]. The excavator is designed to perform tasks such as digging, pushing, pulling, leveling, and excavating in rough terrain conditions[3].

The Komatsu PC200-8 excavator is equipped with the SAA6D107E-1 engine series as its power source. This engine employs a High Pressure Common Rail Fuel System

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(HPCR) for its fuel delivery system. The High-Pressure Common Rail (HPCR) is a fuel system designed to maintain high fuel pressure during the fuel delivery process to the combustion chamber. This system comprises various components that collaborate to ensure precise timing, quantity, and pressure of fuel delivery. The HPCR system consists of two circuits: the low-pressure circuit and the high-pressure circuit. The low-pressure circuit is responsible for transporting fuel from the fuel tank to the high-pressure pump, with standard pressure levels ranging from 0.15 to 0.03 MPa (1.5-3.0 kg/cm2). Components of the low-pressure circuit include a feed pump of the trochoid pump type, a priming pump, and a fuel filter. On the other hand, the high-pressure circuit involves the high-pressure pump regulated by the PCV solenoid valve, a common rail, and injectors, with a standard pressure rating of 140 MPa (1.430 kg/cm2) [6].

The problem discussed in this paper comes from a case study conducted on one of the excavator units PC200-8 owned by PT Kaltim Plantation whose maintenance and repair is handled by PT United Tractor site Separi. The unit owner reported that the company's Komatsu PC200-8 unit was experiencing an engine can't run problem. Previously, this unit had experienced symptoms of low power engine problems, then the next day the unit could not be turned on at all. Due to this situation, the unit experiences a breakdown which hampers the work process. To restore the unit to its optimal condition, fault analysis is required. This action is also taken to prevent the same fault from occurring again.

2 Methods

Data collection was carried out at PT. United Tractors site Separi East Kalimantan on a unit owned by PT Kaltim Plantation. The data collection methods used are as follows.

1. Literature study

Data collection at this stage is carried out by studying the PC200-8 shop manual [6] to understand in more depth the trouble detected on the monitor panel and also as a guide to subsequent measurement and inspection steps.

2. Interviews

The data collection is also conducted through direct interviews with mechanics and unit operators who have experienced the trouble in order to gain a deeper understanding of the issues that occurred during unit operation and how to address these problems

3. Observation

Direct field observations of the target objects were conducted to obtain the data or information required by the author for the preparation of this final assignment, specifically, the image data captured by the author directly from the research site. The aim was to acquire the necessary data for the author's final project writing, as well as for the

Trouble Shooting Report (TSR), Emergency Trouble Report (ETR), and unit history documentation.

4. Testing and Measurement

This research stage aims to examine and test the condition, function, and performance of each component that makes up the working system where the possible cause of the fault occurs. This step aims to eliminate the possible causes of the fault gradually and in detail so that in the end the root cause of the fault is found.

3 Result and Discussion

3.1 Result

The results of literature studies and observations regarding the excavator that experiencing problems are shown in Table 1.

Table 1. Unit information

No.	Item	Description
1.	*Unit Model*	PC200-8
2.	*Serial Number Unit*	C72110
3.	*Engine Model*	SAA6D170E-1
4.	*Serial Number Engine*	26597721
5.	*Hours Meter*	3.574 h
6.	*Trouble Date*	05 September 2022 (Start) 22 Oktober 2022 (Finish)
7.	*Customer*	PT Kaltim Plantation

An interview with the unit operator informed that on the previous day the previous unit had experienced a problem in the form of a low engine power, but before the mechanic had time to carry out an inspection, the unit had experienced a breakdown where the engine could not be started. from the process of further observation of the unit that is experiencing interference, it is known that the engine can be rotated (the starter motor can rotate the crankshaft) but there is no visible combustion smoke from the exhaust, then referring reference [8] there are several general causes of this fault, namely:

- Fuel is not being supplied
- Supply of fuel is extremely small
- Improper selection of fuel (particularly in winter)

By paying attention to these symptoms and refer to the troubleshooting chart in the unit shop manual, it is assumed that the problem originates from the fuel supply system.

To determine the cause of the problem, further testing and measurement of the fuel system needs to be carried out. The types of inspections carried out are as follows.

1. Monitor panel inspection

In every event of a breakdown on a heavy equipment unit, the first thing to check is the monitor panel (if any) on the unit. The monitor panel system on Komatsu units is relatively sophisticated and makes it very easy for mechanics to analyze and diagnose disturbances on the unit. For the reading and explanation of the fault code displayed on the monitor panel, is refered to [8]. For the case of a fault on this unit, the monitor panel does not show any problem codes, as shown in Fig. 1 . This indicates that the fault that occurs is outside the scope of the unit's sensors. For this reason, a detailed inspection of the fuel system components is required. The schematic of fuel system components needed to be checked is shown in Fig.2 [7].

Fig. 1. Monitor panel of the troubled unit

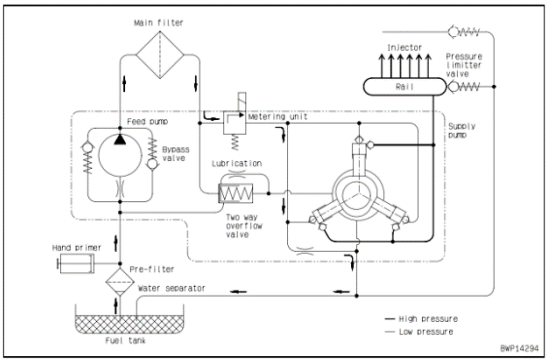

Fig. 2. Komatsu PC200-8 fuel supply system schematic

2. Fuel filter inspection

After checking the monitor panel, we proceeded to check the fuel system components. The first fuel system component to be checked is the fuel filter. Fuel filters play an

important role in maintaining engine function because they function to separate impurities mixed with fuel before flowing to the next fuel system component. From the results of the check, it was found that the fuel filter installed was a third party production with the brand "Donaldson" which is not recommended by Komatsu as shown in Fig.3. However, the impurities found in the fuel filter are still relatively normal.

Fig. 3. Fuel filter installed on the troubled unit

3. Internal leakage measurement at the fuel supply pump

After inspection of the fuel filter, proceed with inspection and measurement of the next fuel system component, namely the fuel line and supply pump from the low pressure circuit to the high pressure circuit. To determine the condition of the fuel line, a visual inspection is carried out of the pipes and pipe connections. The inspection results did not find any leaks in the fuel line.

Furthermore, the purpose of measuring internal leakage at the fuel supply pump is to ensure that the fuel injection pump is functioning properly and accurately delivering fuel to the engine. Any internal leakage within the fuel injection pump can cause a decrease in fuel pressure and a reduction in engine performance. By detecting and measuring internal leakage, any issues with the fuel injection pump can be identified and addressed, ensuring that the engine is running at optimal performance and fuel efficiency. Additionally, measuring internal leakage can help prevent damage to the engine and other components of the fuel system, which can be costly to repair [9][10].

Measurement of the fuel supply pump is done by connecting the hose to the fuel return hose that has been opened to the fuel reservoir tube, the engine is then started for ten seconds. The supply pump will work to pump fuel and fuel that does not flow to the high pressure pump will return through the fuel pump return hose. The volume of fuel collected is then measured and recorded. The result of internal leakage measurement is shown in Fig.4.

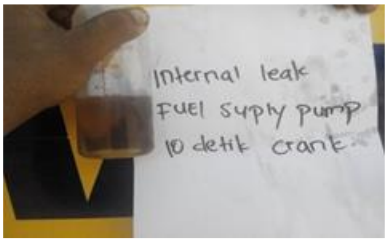

Fig. 4. Result of fuel supply pump internal leakage measurement

4. Measuring resistance on the two way valve

After the results of the internal leakage fuel supply pump measurement shows good condition results, the next possible root cause of the problem is the two way valve component. To ensure that damage occurs, continue by measuring the electrical resistance of the two way valve (TWV) using an AVO meter. Each cylinder is supplied by one injector and each injector has one two way valve, so there are six two way valves. The results of measuring the resistance of two way valve cylinders one to six are all still in good condition. Two way valve measurement process is shown in Fig.5.

Fig. 5. Two way valve resistance measurement

5. Measuring fuel return rate from injector

Measuring fuel return to the fuel tank rate can help detect issues with the injectors, such as clogging or leakage, which can cause poor engine performance, fuel economy, and emission. The fuel return rate from an injector can significantly affect engine performance in the following ways [11] [12]:

- Poor Fuel Economy: If the fuel return rate is too high, it can cause poor fuel economy as the engine is receiving more fuel than it needs
- Reduced Engine Power: If the fuel return rate is too low, it can cause reduced engine power as the engine is not receiving enough fuel to operate at its full potential
- Increased Emissions: If the fuel return rate is too high, it can cause increased emissions as unburned fuel is released into the atmosphere
- Injector Damage: If the fuel return rate is too high, it can cause damage to the injectors as they are not designed to handle excessive fuel flow

Therefore, it is important to measure the fuel return rate from injectors to ensure that the fuel system is functioning properly and that the injectors are delivering the correct amount of fuel to the engine

The injector fuel return rate is measured while the return hose of the pressure limiter is connected. Accordingly, before measuring the leakage from the injector, check that the leakage from the pressure limiter is normal. A hose is attached to the fuel return line

and forwarded to the measuring cup. the engine is cranked for 20 seconds and the amount of fuel contained in the measuring cup is counted and recorded. The result of injector fuel return is shown in Fig. 6.

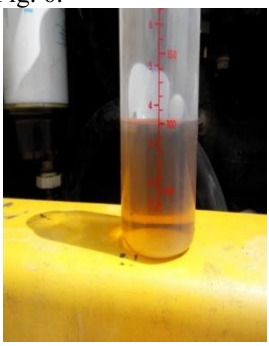

Fig. 6. Injector fuel return measurement

6. Faulty injector

Based on the results of the inspection and measurement process, it can be concluded that the faulty fuel system component is the fuel injector. The injector has too much internal leakage, so it cannot deliver high-pressure fuel into the combustion chamber. The lack of fuel supplied to the combustion chamber causes the engine to not start. The faulty injector is shown in Fig.7. For the problem solving, the injectors needed to be removed from the cylinder head, shown in Fig. 8.

Fig. 7. Faulty injector

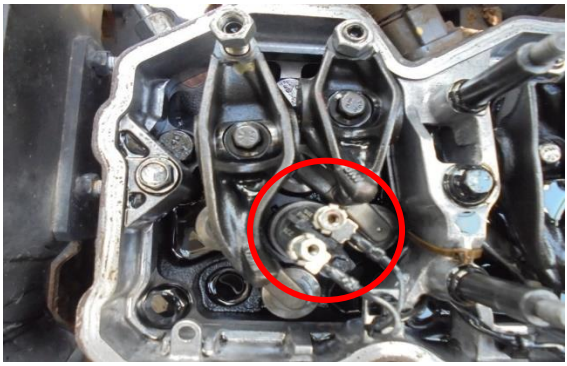

Fig. 8. Position of the injector in the cylinder head

7. Corrective Measures

To solve the engine cannot start problem that occurs, the following corrective measures are taken:

- Replace the fuel filter

To maintain the cleanliness of the fuel entering the fuel system, the fuel filter is replaced with a fuel filter that complies with the manufacturer's recommendations, as shown in Fig.9.

Fig. 9. New fuel filter

- Replace the injector assy

The damaged fuel injector cannot be repaired, so it is replaced with new injector assy, like shown in Fig. 10.

Fig. 10. New injector assy

After replacing the injector and fuel filter, the engine was started and monitored. The test went smoothly and as expected so that the unit was declared normal and could operate again.

3.2 Discussion

The results of the observation and visual inspection on the Komatsu PC200-8 excavator fuel system components that are experiencing problem are shown in Table II. These results indicate there are no problems with the fuel system, except for the problem of the brand of fuel filter used not according to the manufacturer's recommendations. for further action to use the fuel filter according to the manufacturer's recommendations.

Table 2. Results of Visual Inspection

Visual Inspection	Standard	Actual
Monitor panel	No errors allowed	No errors
Fuel line	No leaks allowed	No leaks
Fuel filter	Genuine parts	Donaldson

The results of the testing and measurement on the Komatsu PC200-8 excavator fuel system components that are experiencing problem are shown in Table III.

Table 3. Results of Testing and Measurement

Measurement	Standard	Actual
Internal leak supply pump per 10 second	Max 600 ml/ minutes	100 ml

Two way valve resistance, injector 1 to 6	Max 2 Ω	0,3 Ω
Fuel return amount per 20 second	Max 200 ml/ minute at rpm 200	100 ml

Measurement results show the volume of fuel returned from the injector is less than the standard. Low fuel return volume in diesel engine fuel injectors can be caused by several factors, such as:

- Clogged fuel injectors: Dirt, debris, or other contaminants can clog the fuel injectors, reducing the fuel flow and causing low fuel return volume.
- Faulty fuel pressure regulator: The fuel pressure regulator is responsible for maintaining the correct fuel pressure in the fuel system. If it fails, it can cause low fuel return volume.
- Leaking fuel injectors: Fuel injectors that are leaking can cause low fuel return volume by allowing fuel to escape from the system.
- Faulty fuel pump: The fuel pump is responsible for supplying fuel to the injectors. If it is not working properly, it can cause low fuel return volume.
- Fuel system restrictions: Restrictions in the fuel system, such as a clogged fuel filter or a kinked fuel line, can reduce the fuel flow and cause low fuel return volume

Further investigation revealed that the unit often ran out of fuel during operation, causing the injectors to run dry. This accelerated the damage to the injectors.

4 Conclusion

Fault analysis of fuel system on Komatsu PC200-8 excavator (case studies at PT Kaltim Plantation) has been carried out. It was found that the cause of the engine failure to start was due to damage to the injector which was unable to supply fuel into the combustion chamber. The main cause of injector damage is often running out of fuel when the engine is running, this causes the injector to work dry. This causes damage to the injector seal and causes a reduction in fuel injector spray pressure. To solve this problem, the fuel filter and injector assembly were replaced with new components.

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References

1. Sadono, Sri, N. Cuk Supriyadi Ali, Dena Hendriana, Henry Nasution and Gembong Baskoro.: “Modeling, Simulation, and Analysis of Auto Warming Up and Overheat Prevention System in Komatsu Hydraulic Excavator PC 200-8.” Conference on Management and Engineering in Industry (CMEI), Vol. 2 No. I, pp. 1- 6, 2020.
2. Pramudya, Ricko.: “Hydraulic Working System on the Komatsu PC 200-8 Type Excavator at PT United Tractors Tbk. Jakarta Branch”, “Sistem Kerja Hidrolik Pada Excavator Tipe Komatsu Pc 200-8 Di PT United Tractors Tbk. Cabang Jakarta,” unpublished.
3. Prayoga, Anggit Ganda, Djoko Suprijanto, Dandung Rudy Hartana and Daru Sugati.: “Komatsu Pc 200-8MO Excavator Hydraulic System Design”, “Perancangan Sistem Hidrolik Excavator Komatsu Pc 200-8MO,” Jurnal Cedekia Mekanika, Vol. 1 No. 1, March 2020.
4. Magfirotunnisa, Gunawan, and Puji Saksono.: "Comparative Analysis of the Use of Diesel Fuel with Biodiesel B15 and B20 on the Performance of the Komatsu Saa6d107e-1 Engine." “Analisis Perbandingan Penggunaan Bahan Bakar Solar Dengan Biodiesel B15 Dan B20 Terhadap Performansi Engine Komatsu SAA6d107E-1.” Prosiding SNITT POLTEKBA, Vol. 3, 2018.
5. Komatsu.: Shop Manual PC200-8. Komatsu America Corp. 2006. Unpublished.
6. Komatsu.: Shop Manual PC200-8: Section 30 Testing and Adjusting Part 1. Komatsu America Corp. 2006. Unpublished.
7. Komatsu.: Shop Manual PC200-8: Section 40 Troubleshooting. Komatsu America Corp. 2006. Unpublished.
8. L. Cheng, L. Shouyu, L. Yuhe, Z. Wanzhi, & R. Quanshi: “Internal leakage detection method of fuel injection pump.” 2015.
9. Moulis, Thomas N.: “When Supply Flow Rate (Discharge Flow Rate Of Pump) Is Low And Consumption Flowrate (Injection Flowrate Of Inector And Leakage Flow Rate) Shigh, Pal Cannot Operate And Mode Of Common Rai Pressure Staying In Abnormally.” (2017).
10. Moon, Seong-Joon, Soo-Jin Jeong, Sang-In Lee and Taehun Kim.: “A Numerical Study on the Geometry Optimization of Internal Flow Passage in the Common-rail Diesel Injector for Improving Injection Performance.” (2014).
11. Immonen, Eero, Mika Laurén, Lassi Roininen and Simo Särkkä.: “Neural Network Based Identification of Fuel Injection Rate Profiles for Diesel Engines.” 2020 9th International Conference on Industrial Technology and Management (ICITM) (2020): 138-143.