

Analysis of Damage to Fuel System Components of Engine 4-390 Case Backhoe-loader Unit

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Abstract— The fuel system is one of the vital components of an engine, including the 4–390 CASE engine. This system functions to regulate and deliver fuel from the tank to the combustion chamber with the appropriate pressure and spray pattern. The effectiveness of the fuel system greatly affects the combustion process, power generated, fuel consumption, and the service life of the engine itself. The purpose of this study is to determine the damage and the causes of damage to fuel system components. In this study, data collection was carried out using observation, interview, and literature study methods, namely collecting data directly during field practice on fuel system components, consulting with related parties to complete existing data, and, as a reference, especially the party responsible for the unit, and collecting data with literature studies. For the implementation of the study, removing, disassembling, visual inspection, measurement, assembly, testing on components, and the fuel system were carried out. The results of the visual inspection and testing on the fuel system found a blockage in the fuel filter, and weak pressure on nozzle no. 3. The author made repairs by replacing the fuel filter, disassembling the FIP, replacing the vane on the feet pump in the FIP, and adding a shim to nozzle no. 3 so that the engine can run normally.

Keywords— Engine, fuel filter, fuel system, 4–390 CASE engine.

I. INTRODUCTION

The fuel system is a vital component of any engine, including the 4–390 CASE engine. This system regulates and delivers fuel from the tank to the combustion chamber at the appropriate pressure and spray pattern. The effectiveness of the fuel system significantly impacts the combustion process, power output, fuel consumption, and engine lifespan.

Damage or disruption to fuel system components can significantly impact engine performance. Some common problems include clogged injectors, reduced fuel pump pressure, fuel contamination, or failure of filters and other components. This can result in difficulty starting the engine, reduced power output, vibrations, and abnormal noises (knocking), and can even lead to more serious damage if not addressed promptly.

Various fuel system-related complaints often arise with the 4–390 CASE engine, such as reduced power, difficulty starting, and unstable combustion patterns. Based on these issues, a more in-depth analysis is necessary to identify and understand the cause of the damage and provide appropriate repairs to restore fuel system performance to engine specifications and standards.

Based on the above, this research focuses on "Fuel System Component Damage Analysis on the CASE 4–390 Engine," with the aim of identifying the types of damage that occur, analyzing their causes and impacts, and formulating maintenance and repair steps to maintain engine reliability and performance.

II. RESEARCH METHODS

A. Data Collection Methods

1. Observation Method: Collecting data directly during field practice on fuel system components.
2. Interview Method: Consulting with relevant parties to supplement existing data and serve as references, especially those responsible for the unit.
3. Literature Study: Collecting data through a literature review, which involves searching for information and previous research, then using all of this information as a theoretical basis for determining the research results. The author drew on literature from various sources, including journals, modules discussing fuel systems, and modules on engine specifications.

B. Research Object

The research object can be seen in the image below:



Figure 1. CASE 4–390 Engine

C. Tools and Materials

The tools used in this research include personal protective equipment (PPE), including safety shoes, a safety helmet, safety goggles, safety gloves, and other safety equipment. The main tools used include a socket set, combination spanner, torque wrench, and others. The materials used include packing

gaskets, O-rings, gasket glue, and other materials as the research progresses.

D. Types and Techniques of Data Collection

1) Types of Data Collected:

a. Qualitative Data: This information is a factor in data related to conversations, whether verbal or recorded as hard copy.

b. Quantitative Data: This information is in the form of numbers, representing the side effects of the adjustments and inspection calculations in this composition.

Quantitative information is information visible on the estimation instrument.

2) Data Collection Techniques

Several data collection methods used in this study include:

a. Direct Observation

The researcher observed the physical condition and function of fuel system components, noted any abnormalities or damage, and documented the visuals (photos/videos).

b. Texture Interviews

Conducted with technicians or machine operators to obtain information regarding damage history, maintenance frequency, and user habits.

c. Literature Review

Reviewing literature, machine manuals, and technician journals as a theoretical basis and for comparing analysis results.

d. Simple Tests (if possible)

For example, fuel pressure testing or injector leak testing using tools such as a manometer or injector tester.

III. RESULTS AND DISCUSSION

In this study, we conducted an inspection and analysis of the fuel system components of the Case 4-390 engine. Several key components, such as the feed pump, fuel filter, fuel injection pump, and nozzle, were inspected and analyzed. The inspection revealed wear on the FIP component, causing a misfire, while the nozzle experienced blockages or low power. This prevented fuel flow to the nozzle, resulting in difficulty starting the engine during cranking. Dirt was found in the fuel filter, causing blockages. A dirty filter impedes fuel flow, causing difficulty starting and excessive smoke. This indicates the fuel being used is not clean enough and that the fuel system has not been regularly maintained. The injection pump experienced wear on internal components such as the rotor and plunger. As a result, the injection pump was unable to pump fuel into the nozzle. This was due to a lack of lubrication within the FIP, which resulted in friction within the blades/vanes entering the rotor head, causing the precision-shaped rotor head to jam due to contaminants in the vanes, which are made of carbon from friction and fuel particle contaminants.

A. Fuel filter, FIP, and injector analysis

1. Check and clean the fuel filter, FIP, and nozzle

2. Visual inspection of the fuel filter, FIP, and nozzle

Information regarding damage to the Case 4-390 engine's fuel system components:

1. According to information from the workshop, this unit has not been used for 10 years.

2. Problems with the fuel filter, FIP, and injectors

B. 7-step troubleshooting process




1. Confirm the customer's problem, namely, the engine won't start

2. Perform initial inspection

a. Ensure the engine is safe and perform proper disassembly procedures

b. Perform a visual inspection around the unit

TABLE 1. Initial examination

Fuel Filter Condition	
Condition of the FIP pipe leading to the injector: Is there a fuel leak	
Condition of the fuel after draining	

Possible causes of the problem

a. Dirty fuel filter

b. Jammed FIP

c. Low pressure and clogged nozzle

Analysis & Testing of Possible Causes

In the previous step, we listed several causes of the problem. In step 4, we identified the cause of the engine's difficulty starting: damage to the fuel filter, FIP, and injector.

Here are the results of the inspection of several causes.

Correcting the Root Cause

a. Replace any contaminants in the fuel filter.

b. Replace any jammed FIP components.

c. Add shims to the nozzle components and clean the nozzle tip assembly.

Ensuring Repair Accuracy

After replacing and repairing the components in step 5, it is necessary to perform a performance test on the injector and test the fuel injection pump to ensure there is no persistent damage after the replacement.

TABLE 2. Examination of Causes




o	Inspection	Image	Hasil
1.	Checking the condition of the fuel filter		Not Good (filter condition is not good, there are contaminants in the filter)
2.	The FIP is jammed.		Not Good (When the FIP calibration was carried out, it got stuck in the rotor head section).
3.	Fire filter nozzle is stuck		Nozzle 1,2,4 (good) low pressure occurs on nozzle 3



Fig. 3. valve seat condition



Fig. 4. injector tip condition



Fig. 5. Condition of the fuel



Fig. 6. Fuel filter condition in the fuel filter



Fig. 7. Head pump rotor condition

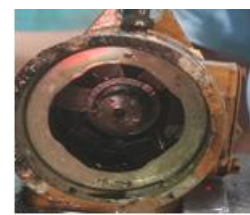


Fig. 8. Condition of the rotor head pump liner

Visual Inspection

A visual inspection of the injector components is performed to identify any physical damage or wear that could affect fuel system performance. The inspection process includes observing the condition of the injector body and any buildup of scale or carbon around the nozzle holes.

Several things to consider when conducting a visual inspection include:

- a. Providing references related to the visual inspection process to facilitate understanding of any indications found.
- b. Cleaning the components beforehand to clearly identify any signs of damage.

A. Providing references related to the visual inspection process to facilitate understanding of any indications found.



Fig. 1. Injector assembly

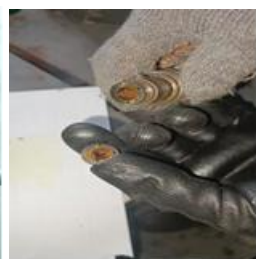


Fig. 2. Stop valve condition



Fig. 9. Fuel and contaminant conditions

B. Cleaning the components beforehand to clearly identify any signs of damage.

Cleaning and Inspecting the Nozzle

Use the OEM 1068 Nozzle Cleaning Kit to clean the vise. A brass wire brush should be used to clean the outside of the tip body. Use a cleaning wire to remove carbon from the spray vise. Use a cleaning wire 0.0127 to 0.0254 mm smaller in diameter than the vise or vise. Place the cleaning wire on the vise pin; the wire tip should extend 0.79 mm beyond the tip of the vise pin. A longer pin will hit the opposite side of the vise hole and break.



Fig. 10. Nozzle tip cleaning

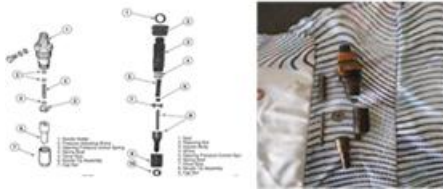


Fig. 11. Assembly stage



Fig. 12. Shims



Fig.13 Injector springs



Fig. 14. Spring mount



Fig.15. Valve stop



Fig. 16 Nozzle tip assembly



Fig. 17. Valve stop



Fig. 18. Tip assembly



Fig. 19 Rotor head condition



Fig. 20. Caming conditions

IV. CONCLUSION

A Based on this research, it was concluded that during the troubleshooting process, the cause of engine failure on the Case 4-390 backloader unit was:

The fuel filter was blocked due to corrosion and accumulated dirt in the filter.

The fuel filter was no longer able to draw fuel and pump fuel. The blockage occurred due to carbon dust, caused by wear between the carbon blades and the foot pump/transport pump housing. This dust clogged the rotor of the distributor pump head.

The nozzle was experiencing low pressure due to a weakened nozzle spring. To achieve the specified pressure, a shim was added to increase the spring tension.

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