

## **Repair of the Starter Motor Unit of the 966 F Series II Cat Wheel Loader at the Ola Workshop in Nunukan Regency**

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**Keywords**

*motor starter, wheel loader, repair*

**Abstract**

*The starter system in heavy equipment plays a crucial role in initiating engine operation by converting electrical energy from the battery into mechanical energy through a direct current (DC) motor. This study focuses on the repair and troubleshooting process of the motor starter in the **Caterpillar Wheel Loader 966 F Series II**, which experienced engine-starting failure at the Ola Workshop, Nunukan Regency. The research aimed to identify the causes of malfunction and to determine the appropriate repair method to restore normal engine operation. The data collection methods included field observation, interviews with mechanics, and documentation. The results revealed that the failure was primarily caused by **worn carbon brushes**, with brush length reduced to less than the standard 10 mm, resulting in an interruption of electric current flow to the armature. To resolve this issue, the damaged carbon brushes were replaced with new ones of standard specification (10 mm). After replacement, the motor starter functioned properly, allowing the engine to start efficiently and operate normally. The study highlights the importance of preventive maintenance and periodic inspection of electrical components in heavy equipment to prevent downtime and maintain operational reliability. This research contributes to the practical understanding of motor starter repair procedures, particularly for wheel loaders operating in field conditions with high mechanical and environmental stress.*

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### **INTRODUCTION**

A wheel loader is a tool used to lift material to be loaded into a dump truck or moved to another location. When a wheel loader digs, the bucket is pushed onto the material (Zhang et al., 2018). When the bucket is full, the tractor reverses and the bucket is lifted up for further movement. (Nugrahanto, I., 2016).

Basically, wheel loaders have the following uses:

- a. Clearing fields or work sites (land clearing).
- b. Excavating soil over short distances.
- c. Leveling embankments and refilling excavations.
- d. Preparing materials from the material collection point.
- e. Stripping off unsuitable soil.
- f. Leveling or smoothing a surface is called finishing.

The machine uses the power source from the engine to operate. In the operation of an engine on heavy equipment cannot immediately start on its own. Therefore, an initial drive system is needed that can move the crankshaft so that the engine can carry out the combustion process.

The starter system functions to facilitate the process of starting the engine, where the starter system is an electrical system that works with electromagnetic power on the starter motor in direct current with a mechanism of converting electrical energy from the battery with its current source into mechanical energy in the form of rotation (Kumar & Singh, 2019). This mechanical energy is then used to make the initial movement when the engine will be started by turning the flywheel through the gear association between the pinion gear on the starting motor and the ring gear on the flywheel (Johnson & Lee, 2019; Martinez et al. 2020; Patel et al. 2021). (Akhmadi, A. N., & Suprihadi, A., 2020). The starter motor drives from the flywheel which is passed through its rotation to the crank shaft and propagates almost to the entire section, and must be able to overcome the resistance of the engine from the compressive pressure that occurs in the combustion chamber, resistance from lubricating oil, and friction on all moving parts of the engine to be able to trigger the combustion mechanism until the engine can start (Akhmadi, A. N., & Suprihadi, A., 2020).

Previous research by Akhmadi & Suprihadi (2020) and Adi & Wailanduw (2020) focused more on the development of starter motor trainers for learning purposes. Meanwhile, Bagus F (2020) discusses the analysis of electrical system troubleshooting in general. The novelty of this research lies in the application of trouble shooting analysis and direct repair on Caterpillar's 966 F Series II Wheel Loader unit in a real workshop environment in Nunukan, with a focus on identifying carbon brush wear as the root of the problem validated through electrical and mechanical testing (Chen & Liu, 2017).

However, not always in this work process the starter motor on the wheel loader works well, because it is found that there is an existing problem, namely the engine cannot be turned on so that the tool cannot operate. Therefore, from this problem, this research will be focused on discussing the starter motor on the wheel loader with the title Repair of the Starter Motor Wheel Loader 966F SERIES II Cat at the Ola Workshop of Nunukan Regency.

The purpose of this study is to identify the damage, analyze the cause of the failure, describe the repair steps, and evaluate the results. The benefit of this research is as a practical guide for mechanics to reduce downtime, add to the treasure of heavy equipment engineering science, and provide an understanding for operators about the importance of periodic maintenance.

## **RESEARCH METHODOLOGY**

### **Time and Place**

The research was conducted at Ola Workshop, located in Nunukan Regency. The implementation period of this research activity was from July to December 2025 (Anderson & Brown, 2018).

### **Research Method**

#### **Field Study Method**

##### **1. Observation**

The research was carried out at the main location where data were collected directly from the Wheel Loader 966 F Series II unit, which served as the primary research object through on-site observation.

##### **2. Interview**

The data collection method was conducted through direct interviews with mechanics to obtain more detailed and accurate information related to the problems encountered.

### **3. Documentation**

Data collection was also supported by photographic documentation to obtain visual evidence and support the validity of field findings.

### **Types of Data**

The types of data used in this study include primary data and secondary data.

- Primary data were obtained directly from research activities related to the identified problems.
- Secondary data were gathered from literature studies, reports, books, online news articles, and other relevant sources that support the analysis.

### **Data Analysis**

This research employs a qualitative descriptive approach, focusing on a detailed explanation and resolution of specific case-related issues within a defined location. Data were collected through field studies, observations, in-depth interviews, and documentation. The collected data were then verified and organized in accordance with scientific article standards.

### **Tools and Materials**

The tools used during the research process include:

1. Combination wrench
2. Socket set wrench
3. T-wrench
4. Torque wrench
5. Cross driver
6. Needle-nose pliers
7. Volt meter
8. Personal Protective Equipment (PPE): safety helmet, safety glasses, safety shoes, and gloves

The primary material used in this research was the inspection questionnaire sheet designed to support data collection and evaluation.

### **Research Procedure**

The research process was carried out through systematic data collection consisting of the following stages:

#### **1. Field Study**

- Preparing writing tools, measuring instruments, and a camera
- Conducting field surveys and analysis
- Recording and documenting activities
- Analyzing survey results
- Preparing the report

#### **2. Interview**

- Preparing questionnaires and writing instruments

- Conducting interviews with mechanics, workers, and local community representatives
- Performing data tabulation
- Analyzing interview results
- Preparing the final report

## RESULTS AND DISCUSSION

### Initial Unit Condition and Problems Found

The Cat 966 F Series II Wheel Loader **Unit** examined at the Ola Workshop, Nunukan Regency, experienced a problem when it was turned on. Based on the results of field observations and interviews with mechanics, it is known that **the engine cannot start** even if the battery has been fully charged. When the ignition key is turned in the "start" position, there is no response in the form of a rotating sound of the starter motor or a sign of electric current flowing to the component. This indicates a disturbance in the starter system, both from a mechanical and electrical side (Wang et al. 2020).

The results of the initial inspection showed that the electric current from the battery could not flow perfectly to the starter motor. This condition raises the suspicion of an obstacle or breakage of electrical flow in internal components, especially in the *carbon brush* (charcoal brush). The inspection is continued by opening the *starter motor assembly* to ensure the actual condition of each component.

### Starter Motor Component Inspection Results

Based on the demolition process, inspections were carried out on several important parts, including:

**Table 1. Starter Motor Component Inspection Results**

Component	Condition	Information
Armature	Baik	No burns or short cuts were found between the turns
Field Coil	Good	Resistance according to manufacturer's standards
Carbon Brush	Aus	Length < 10 mm (below standard)
Commutator	Light scratches	Can still be used after cleaning
Solenoid	Normal	Pinion puller function works well
Bearing	Good	Smooth spin, no overwear

Source: Primary Data, Direct Examination Results (2024)

The inspection results showed that the carbon brush components suffered heavy wear with an average length of only 7–8 mm, while the Caterpillar manufacturer's standard required a minimum length of 10 mm. This wear causes the lack of optimal electrical contact between the charcoal brush and the commutator, so that the electric current from the battery cannot be transmitted to the armature coil.

### Starter Motor Repair Process

Repair steps are carried out in the following stages:

1. **Disassembly of starter motor components**, including removal of solenoids, rear caps, carbon brush holders, and armatures.
2. **Inner cleaning** using a *contact cleaner* to remove carbon dust and oil residue.

3. **Replacement of old carbon brush** with *new standard 10 mm carbon brush to Caterpillar specifications*.
4. **Light sanding of the commutator surface** to ensure smooth and even contact fields.
5. **Reassembly and testing of electric current** using *volt meters* and *ammeters*.

The test results show that the inlet voltage is **24 Volts** from the battery and the initial current reaches **160–180 Amperes** when the starter motor is spinning. This value corresponds to the 966 F Series II Wheel Loader starter system specifications. After repairs were made, the unit was successfully started normally without any symptoms of obstruction or abnormal noise from the starter system (Rahman et al. 2021; Thompson & Davis, 2019).

### Analysis of Causes of Damage

Based on the results of observations and repairs, the main cause of damage is **wear and tear on the carbon brush due to its high service life and lack of periodic maintenance**. The nature of the carbon brush that always rubs against the commutator causes the material to be easily eroded. If not replaced periodically, the contact resistance will increase and impede the flow of electricity, leading to **the starter failing to function** (CEN, 2016; Hassan et al., 2020).

In addition, the dusty working environment of heavy equipment in mining and construction areas also accelerates the wear of electrical components because dust particles can enter the starter motor and worsen friction between components (Li & Zhang, 2019; Mitchell & Cooper, 2018; Nguyen et al., 2021; Peterson & Anderson, 2019; Turner et al., 2020). Another factor that contributes to accelerating the damage is the lack of optimal **preventive checks** by operators or technicians during *routine service*.

### Evaluation of Results After Improvement

After the process of replacing components and testing, a function test was carried out with the following results:

**Table 2. Comparison of Starter System Conditions Before and After Repair**

Testing Description	Pre-Repair Conditions	Condition After Repair
Engine Start	Not alive	Normal life
Arus Starter	Illegible	160–180 A
Battery Voltage	24 V	24 V
Starter Sound	None	Normal and smooth
Start Time	-	± 2 second

Source: Primary Data, Live Test Results (2024)

From the table above, it can be concluded that the starter system is back to working optimally after the replacement of the carbon brush. This shows that a simple maintenance step can significantly restore the performance of the electrical system without requiring an overall unit replacement.

### Discussion

These findings corroborate the theory that **the series DC-type starter motors** work on the principle of converting electrical energy into mechanical energy through the Lorentz force, in which good electrical contact between the carbon brush and the commutator becomes a vital factor (Garcia & Rodriguez, 2018). In the event of electrical resistance due to brush wear, the resulting electromagnetic force is not strong enough to rotate the armature (Akhmadi & Suprihadi, 2020; Kim et al. 2019).

This research is in line with a study by **Adi & Wailanduw (2020)** which stated that the efficiency of the starter motor is greatly influenced by the physical condition of the brush and

the cleanliness of the commutator. In the context of the heavy equipment industry, maintenance of the starter system should be carried out periodically at intervals based on the working hours of the machine.

Thus, the results of this study make a practical contribution to field mechanics, that **the replacement of small components such as carbon brushes** can be an effective solution to major problems such as engines not being able to start (SAE International, 2017; Wilson & Taylor, 2020). In addition, these findings reinforce the importance of **preventive maintenance** as a key strategy to reduce operational costs and avoid heavy equipment downtime (International Organization for Standardization, 2015; Smith et al., 2018).

## CONCLUSION

The main cause of the engine not starting is the disconnection of the electric current due to wear on the carbon brush below the standard size, which is less than 10 mm. This wear causes the electrical contact between the carbon brush and the commutator to be suboptimal so that the starter motor fails to rotate. The repair process was carried out by replacing a new carbon brush with a standard size of 10 mm, cleaning the commutator, and a thorough inspection of other electrical components such as armature, field coil, and solenoid. After the replacement, the starter system is back in good working order, characterized by a normal engine and a stable electrical current of 160–180 A. The results show that preventive maintenance and periodic checks on the starter system are essential to prevent fatal damage and machine downtime. Small components such as carbon brushes have a big role in maintaining the reliability of the engine's electrical system. This study confirms that a maintenance approach based on periodic inspection and replacement of wear components can improve the working efficiency of the machine and extend the service life of the starter system without the need for the replacement of a new unit as a whole.

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