

Analysis of Key Points of Fault Diagnosis Techniques in Heavy-duty Truck Engine Maintenance

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Abstract: As the main force of logistics and transportation, the reliability of the engine of heavy-duty trucks directly affects the transportation efficiency and cost. Scientific fault diagnosis technology is the key to improving maintenance efficiency and reducing operating costs. Based on the analysis of the common types and causes of heavy-duty truck engine faults, this paper focuses on the key points of diagnosis of several types of major faults. Studies have shown that carbon deposition can be prevented through reasonable cleaning and improving fuel quality. Noise faults need to be carefully checked for parts and tear. If the engine oil deteriorates, the oil must be replaced in time and the working condition must be optimized. For start-stop faults, circuits and components should be repaired in a targeted manner. The application of these diagnostic technologies can greatly improve the accuracy and efficiency of heavy-duty truck engine maintenance, and provide a strong guarantee for the efficient operation of vehicles.

1. Introduction

As the heart of heavy-duty trucks, the performance of the engine is particularly critical. However, due to the fact that heavy-duty trucks usually operate for long periods of time under complex operating conditions, the engine is prone to a variety of failures, which not only reduces transportation efficiency, but also significantly increases operating costs. Therefore, mastering scientific engine fault diagnosis technology is crucial to the efficient maintenance and operation of heavy-duty trucks. Based on the analysis of typical faults of heavy-duty truck engines, this paper discusses the technical points to improve the efficiency of key fault diagnosis. By systematically sorting out the diagnostic ideas and methods, it provides practical reference for relevant practitioners, in order to improve the level of heavy-duty truck engine maintenance, reduce operating costs, and contribute to the development of the logistics and transportation industry.

2. Common Types of Engine Faults in Heavy-duty Trucks

2.1 Carbon Deposition Fault

In the high-temperature and high-pressure working environment of the engine, carbon particles generated by fuel combustion in the combustion chamber will gradually deposit on the combustion chamber wall, piston crown, valves and other parts, forming a carbon deposition layer. With the continuous accumulation of carbon deposits, the intake and combustion chamber volumes of the engine decrease, and the compression ratio decreases, seriously affecting the normal operation of the engine. Excessive carbon deposition can also lead to a decrease in fuel atomization quality, incomplete combustion, weakened engine power, increased fuel consumption, and excessive exhaust emissions ^[1]. In addition, the thick carbon deposits can spontaneously ignite at high temperatures, causing more serious engine failures such as detonation and knocking, and even damaging engine components.

2.2 Noise Malfunction

When the engine is working, the interaction between various moving parts will produce a certain amount of noise. But when the engine produces abnormal noise, it usually indicates that certain components have malfunctioned or worn out. Typical noise faults include knocking sounds, camshaft noise, timing gear noise, etc. Among them, the knocking sound is usually caused by the spontaneous combustion of carbon deposits, producing sharp metal impact sounds. Camshaft noise is often caused by wear of camshaft bearings, presenting a low humming sound. The timing gear noise is generated due to gear wear or improper installation, sounding like a “whooshing” friction sound. These abnormal noises not only affect the driving experience, but are also more likely to cause damage to other engine components, resulting in greater repair costs.

2.3 Engine Oil Deterioration Fault

The physical and chemical properties of engine oil will gradually change in harsh working environments such as high temperature, high pressure, and high shear, leading to oil deterioration. The color of deteriorated engine oil usually changes from translucent amber to black brown, accompanied by a pungent burnt smell. Deterioration of engine oil can significantly reduce its lubrication performance, accelerate the wear of engine components, and cause more debris and impurities. At the same time, the heat dissipation ability of deteriorated engine oil decreases, which can easily lead to high local temperatures in the engine, exacerbating the oxidation and deterioration of the oil, forming a vicious cycle. In addition, engine oil deterioration can also cause blockages in the oil circuit, resulting in insufficient lubrication and cooling of the engine, further exacerbating wear and overheating issues.

2.4 Start-stop Malfunction

Modern heavy-duty trucks commonly use electronic control engines, and their starting and stopping processes are precisely controlled by the electronic control system. When the electronic control system malfunctions, the starting and stopping process of the engine will be affected, manifested as difficulty or inability to start, unstable idle, stalling and other problems. These faults are caused by various reasons such as damage to the starting circuit, malfunction of the electronic control module, and abnormal sensor signals. For example, poor contact or damaged wiring harness in the starting circuit can result in insufficient starting current, making it difficult to start the engine. Program errors or hardware failures in the electronic control module can easily cause program interruptions or confusion during startup. If the sensor provides incorrect signals, it will cause the electronic control system to make incorrect judgments and controls, resulting in abnormal start-stop processes.

3. Analysis of the Causes of Heavy Truck Engine Malfunctions

3.1 Fuel Quality Issues

Heavy trucks typically perform long-distance transportation tasks and have a strong dependence on fuel quality. However, the domestic refined oil market is mixed with good and bad, and some unscrupulous merchants add inferior additives to diesel or purchase unqualified low-grade fuel in pursuit of profit, resulting in worrying diesel quality in the circulation field. These issues are often caused by the presence of harmful substances such as moisture, impurities, and gum in fuel, which pose hidden dangers to the normal operation of the engine. Among them, moisture can cause corrosion of fuel pipelines, condense into ice in cold weather, and block the oil circuit. Impurities can wear down the fuel injection pump and nozzle, affecting fuel atomization and injection. However, gum is prone to form carbon deposits at high temperatures, which can block the combustion chamber and intake/exhaust passages, leading to a decrease in engine performance and an increase in fuel consumption.

3.2 Wear and Tear of Engine Components

The material characteristics, processing technology, assembly quality, and other factors of engine components can all affect their ability to resist wear. Once the wear of components exceeds the allowable range of the design, the performance and reliability of the engine will be affected [2]. For example, the wear of piston rings can cause cylinder leakage and a decrease in compression ratio. The wear of valves and valve seats can easily lead to problems such as valve burnout and poor sealing. The wear of bearings will increase the clearance between the journal and the bearings, causing knocking and vibration. The wear of the camshaft and cam will affect the normal opening and closing of the valves, reducing the intake and exhaust efficiency of the engine.

3.3 Harsh Working Environment of the Engine

Heavy trucks typically operate in complex and ever-changing environments, such as extreme conditions such as high temperatures, extreme cold, humidity, and high dust, all of which can have a negative impact on the reliability of the engine. For example, high-temperature environments can accelerate the oxidation and deterioration of engine oil, reduce its lubrication performance, and soften engine components, exacerbating wear and tear. Severe cold environments can cause fuel to solidify, block fuel lines, and affect the normal starting and operation of the engine. Humid environments may cause corrosion and short circuits in engine electrical components, and even lead to electronic control system failure. Particles in a dusty environment can mix into the intake system, accelerate the blockage of the air filter, and enter the cylinder, causing wear and tear.

4. Key Points of Fault Diagnosis Technology in Heavy Truck Engine Maintenance

4.1 Cleaning and Prevention of Carbon Deposition Faults

Cleaning and prevention are two key technical steps for addressing carbon deposition faults in heavy-duty truck engines. Firstly, in terms of cleaning, it is necessary to choose a suitable cleaning method based on the location and degree of carbon deposition. For mild carbon deposits, chemical cleaning agents can be used to decompose the carbon deposits into small molecule substances that are easily discharged through high-temperature combustion or catalytic reactions. For severe carbon deposition, physical cleaning methods such as high-pressure water jet, shot blasting, etc. need to be used to remove the carbon deposition layer through mechanical action. Secondly, the cleaning process should strictly control parameters such as temperature, pressure, and time to avoid secondary damage to engine components. In terms of prevention, the first step is to optimize the combustion process of the engine. By improving the combustion chamber design, injection timing and atomization quality, etc. can be optimized to achieve full combustion and reduce the generation of carbon deposits. In addition, choosing high-quality fuel and engine oil can avoid the introduction of impurities and gum, and reduce the risk of carbon deposition. Finally, it is important to control the engine's operating conditions reasonably, avoid prolonged low load operation, and reduce carbon deposition.

4.2 Troubleshooting and Repair of Noise Malfunctions

The diagnosis of noise faults mainly relies on the experience and hearing of maintenance technicians. By distinguishing the type, frequency, and propagation path of noise, the fault source can be preliminarily determined. For suspected faulty areas, professional equipment such as stethoscopes and vibration testers are used to accurately locate the source of noise. Common sources of engine noise include camshafts, valve mechanisms, piston connecting rod mechanisms, timing gears, etc. The machining errors, assembly clearances, wear levels, and other factors of these components can all lead to abnormal noise. After identifying the source of the noise, it is necessary to further disassemble and inspect the faulty components, evaluate their wear or damage, and determine a repair plan. For mild wear, it can be repaired by adjusting clearances, replacing vulnerable parts, and other methods. For severe wear or damage, component remanufacturing or replacement is required. The entire repair process must strictly comply with technical specifications,

control assembly clearances and tightening torque, and perform dynamic balance correction if necessary. After the repair is completed, the engine needs to be run for noise re-inspection to verify the repair effect.

4.3 Methods for Handling Oil Deterioration Faults

Engine oil deterioration is one of the common faults in heavy-duty truck engines, and its treatment needs to follow scientific methods and processes. Once the problem of engine oil deterioration occurs, it is necessary to immediately stop using the deteriorated engine oil and replace it with new oil as soon as possible to prevent the continuous damage of the deteriorated engine oil to the engine. During the oil change process, it is necessary to thoroughly drain the old oil and use specialized flushing oil to clean the engine interior multiple times until the flushing oil color becomes clear, ensuring that residual oxides and impurities are fully removed. The selection of new engine oil must strictly match the engine model and operating conditions to achieve its optimal lubrication and heat dissipation effects. At the same time, it is necessary to conduct in-depth analysis of the causes of engine oil deterioration, and based on the analysis results, develop and implement targeted prevention plans, such as selecting high-quality engine oil, shortening oil change cycles, and improving engine maintenance.

4.4 Diagnosis and Elimination of Start-stop Faults

The diagnosis and elimination of engine start-stop faults in heavy-duty trucks require a systematic technical approach. The diagnostic process usually starts with the symptoms of the fault, such as difficulty in starting, inability to start, unstable idling, stalling, etc., combined with the environmental conditions and historical conditions of the vehicle where the fault occurred, to preliminarily determine the type and scope of the fault. On this basis, diagnostic instruments are used to read fault codes and obtain fault information of the electronic control system, further narrowing down the scope of investigation. According to the instructions of the fault code, it is necessary to focus on checking the relevant circuits, sensors, actuators, and electronic control units, and accurately locate the fault point through circuit testing, signal measurement, component inspection, and other means. After identifying the cause of the malfunction, targeted troubleshooting measures should be taken, such as replacing damaged components, cleaning blocked oil circuits, and flashing electronic control programs. The exclusion process must strictly follow the maintenance manual and circuit diagram to ensure the correct assembly and connection of each component. After the repair is completed, the start-stop test should be repeated and verified under actual working conditions to ensure the complete elimination of the fault.

5. Conclusion

In summary, the diagnosis and repair of engine failures in heavy-duty trucks involve multiple aspects such as fuel quality, component wear, working environment, carbon deposits, noise, engine oil deterioration, and start-stop systems. Each type of malfunction needs to follow the technical approach of “analyzing phenomena, detecting causes, clarifying solutions, implementing measures, and summarizing experience”, comprehensively using various diagnostic, repair, and maintenance techniques to fundamentally improve the reliability and durability of the engine. Only by constantly summarizing the practical experience of diagnosis and repair, absorbing and innovating relevant technologies, can we keep up with the pace of the development of heavy-duty truck engine technology and provide solid technical support for the safe and efficient operation of vehicles.

References

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