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Practice Analysis of Metal Wear Self-Repair Technology in Automobile Engine Maintenance

Xingyu Liu

Xihua University, Chengdu 610039, China.

Abstract: With the high temperature and high speed of the automobile engine working environment, metal wear has become the main factor of engine failure. This paper explores the application of metal wear self-repair technology. Through nanomaterials addition, chemical reaction repair and other methods, tiny cracks are filled, protective film is formed, and self-repair of metal is realized. This study provides innovative solutions for engine maintenance and provides an important reference for automobile maintenance engineering.

Keywords: Automobile Engine; Metal Wear; Self-Repair Technology; Practical Analysis

Introduction

In the automobile industry, the long running of the engine inevitably causes metal wear. In order to solve this problem, the metal wear self-repair technology has emerged. Its application in the field of automotive engine maintenance has become a cutting-edge solution to improve the life of parts and reduce maintenance costs.

1. Failure causes of automobile engine and the application principle of metal wear self-repair technology

1.1 Cause of automobile engine failure

1.1.1 Frictional wear

Friction wear refers to the engine operation, internal parts such as piston ring, crankshaft, connecting rod gradually lose surface material due to long time high speed friction and extreme high temperature environment, forming wear. This stems from the constant friction of the piston ring and the cylinder, crankshaft and connecting rod, which bears the huge friction and high temperature pressure in the engine work. The surface of the piston ring, crankshaft and connecting rod gradually wear, affecting the engine performance.

1.1.2 Metal fatigue

Metal fatigue refers to the phenomenon of gradual damage and final failure of metal materials under frequent stress changes. In automotive engines, parts experience constant stress changes in tens of thousands of reciprocating movements, leading to small stress concentration of metal materials and fatigue cracks. Especially under high load, high speed, such as crankshaft, connecting rod and other core components to bear greater pressure and vibration, accelerate the formation of fatigue crack. These cracks may eventually lead to component failure, so the monitoring and prevention of fatigue cracks is critical.

1.1.3 Particulate matter erosion

Particulate erosion refers to the engine internal combustion process, small particles in the air enter the engine with the intake air, causing small and frequent impact and friction on the surface of key components. This tiny particle erosion occurs on rapidly rotating components, such as cylinder walls, pistons, crankshaft, etc. In a high temperature and high pressure environment, these particles cause local wear on the surface and accumulate into tiny wear areas over time. Especially in the combustion environment, particles interact with lubricating oil and combustion products to produce acidic or corrosive substances, aggravate surface erosion.

1.2 Application principle of metal wear self-repair technology

1.2.1 The nanomaterial addition

Nanomaterials addition is an advanced engine maintenance technology that introduces nanoscale materials such as nanoparticles and

nanolubricants into engine oil to cope with wear and tiny cracks in parts. These nanomaterials have an extremely small particle size and a high specific surface area, allowing them to go deep into the microscopic wear areas during the engine work. Once added to the engine oil, these nanomaterials form a uniform and wear-resistant protective film on the wear surface. This nanoprotective film acts like a microscopic layer of a shield, which can fill and cover tiny cracks, wear areas and uneven surface, slowing or even preventing further wear processes. These nanomaterials also exhibit excellent lubrication properties, helping to reduce friction between parts and reduce heat and energy losses.

1.2.2 Chemical reaction for repair

Chemical reaction repair technology is an innovative engine repair method to deal with the wear of parts by introducing special chemicals. When the engine parts wear, these special chemicals act on the damaged surface and achieve the effect of automatic repair by chemical reaction with the surface metal. These chemicals often contain components such as organic synthetic materials, surfactants, and metal ions[1]. When the engine runs, these substances will form a solid layer of repair on the damaged surface. The formation process of this repair layer involves various chemical reactions, which may include reaction mechanisms such as ion exchange, deposition, and chemical bonding. These reactions allow the originally damaged metal surface to be repaired, enhancing the surface hardness, and also improving the smoothness of the surface.

1.2.3 Magnetic field-assisted repair

Magnetic field-assisted repair technology is an innovative engine repair method that uses magnetic field technology to repair metal wear surfaces. By introducing a magnetic field in the engine, the distribution of metal particles on the wear surface can form an orderly wear repair structure. Under the action of the magnetic field, the metal particles in the engine are guided by the magnetic force to form an orderly arranged structure on the worn surface. This ordered metal particle structure not only fills tiny areas of wear, but also can form a uniform wear repair layer. The effect of magnetic field regulation improves the adhesion of metal particles on the wear surface, and then enhances the adhesion and stability of the repair layer[2]. Magnetic field-assisted repair technology also has the characteristics of regulating the morphology of the wear surface, which helps to improve the flatness of the surface and slow down the development of further wear.

2. The application importance and specific application methods of metal wear self-repair technology

2.1 The application importance of metal wear self-repair technology

The application of metal wear self-repair technology in automotive engineering is of significant importance in improving vehicle performance, reducing maintenance cost and enhancing maintainability. By effectively filling tiny cracks and wear areas, metal wear self-repair technology is expected to significantly extend the service life of engine parts. This repair mechanism can not only prevent further wear, but also repair the already damaged surface, thus improving the reliability of the vehicle. Extending the life of parts not only meets the economic benefits, but also improves the long-term stability of vehicles and reduces the potential faults caused by the aging of parts. In terms of maintenance, the metal wear self-repair technology has obvious cost advantages over the traditional methods of replacing parts. By realizing automatic repair, the replacement frequency of expensive parts can be reduced, effectively saving the maintenance cost of car owners. This provides car owners with an economical and efficient maintenance option, but also helps to promote the automotive maintenance industry to a more sustainable direction. Self-repair technology helps to improve the engine's maintainability. By reducing the possibility of sudden failure, car owners can more easily perform regular maintenance, reducing maintenance time and costs. This not only improves the maintainability of the vehicle, but also increases the owners' confidence in the performance of the vehicle, bringing a better user experience for the entire vehicle operation cycle.

2.2 Specific application methods of metal wear self-repair technology

Using advanced technologies such as nanomaterials addition, chemical reaction repair, magnetic field assisted repair, intelligent monitoring system and regular maintenance and detection, metal wear self-repair technology has shown multi-level and all-round application in

engine maintenance.

First, By adding nanomaterials such as nanoparticles and nano-lubricants to the engine oil, the system can form a protective film to fill the tiny wear area, thus achieving the self-repair of the metal. The added nanomaterials have excellent filling and lubrication properties, effectively preventing further wear and improving the overall performance of the engine parts.

Second, the use of chemical reaction repair technology, by introducing special chemical substances, make the chemical reaction with the damaged surface, forming a solid repair layer, restore the surface hardness and smoothness of the parts. At the micro level, the automatic repair of the metal is realized, providing a more lasting and more comprehensive protection for the engine.

Third, the magnetic field assisted repair technology through the application of magnetic field to regulate the distribution of metal particles on the wear surface, form an orderly wear repair structure, improve the adhesion of metal particles on the surface, and realize the self-repair of wear. It makes the repair effect more orderly and stable, and improves the adhesion and persistence of the repair layer.

Fourth, the introduction of intelligent monitoring system enables the system to monitor the operating state of the engine in real time, and obtain the actual wear situation through the sensor, so as to dynamically adjust the self-repair strategy[3]. It is helpful to achieve the best repair effect under different working conditions, and improve the intelligence and adaptability of the whole system.

Fifth, the implementation of regular maintenance and testing procedures is an important link to ensure the reliability of self-repair technology. Through regular maintenance and testing, the effects of self-repair technology can be monitored, and potential problems can be found and solved in time to ensure that the system can maintain efficient self-repair effect in long-term operation. The comprehensive application means provide a comprehensive support for the successful application of metal wear self-repair technology.

3. Conclusion

Metal wear self-repair technology has shown great potential in automobile engine maintenance. In the future, with the progress of science and technology, combined with intelligent monitoring system and more advanced repair methods, a more efficient and intelligent self-repair system will be realized, improve engine reliability, and promote automotive engineering to a more sustainable future.

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