Influence of manganese phosphating on wear resistance of steel piston material under boundary lubrication condition

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Influence of manganese phosphating on wear resistance of steel piston material under boundary lubrication condition

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Abstract：The forged steel piston material of 42CrMoA will generate a non-metallic and non-electric conversion film on the surface after the manganese series phosphating (Mn-P) treatment. Compared to the traditional zinc series phosphating (Zn-P) treatment, this type of film is thicker, the coverage rate is higher and the arrangement of crystal particles is better distributed. In order to study the friction and wear characteristics of 42CrMoA after Mn-P under boundary lubrication condition, an abrasion tester was used to simulate the working state of the forged steel piston, the wear surfaces was observed with electron microscope, and finally obtained the friction coefficient, wear rate and wear morphology of the specimens under different conditions. The results show that the friction coefficient and wear rate decrease significantly after Mn-P in poor lubrication conditions, especially under high normal pressures, they decrease by nearly 1 time, and the variation amplitude also decreases obviously with the normal pressure or relative speed changes. The phosphating film can also change the wear mechanism of the matching surface, particularly, in some bad conditions. The adhesive wear may change into slight abrasive wear, and the wear degree of the material was reduced. The surface roughness of metal has a great influence on the effect of phosphating, the smooth surface can form a well-distributed and dense phosphating film, which plays a good role in oil storage and wear resistance.

Key words: steel piston material; conversion film; manganese series phosphating treatment; wear characteristics; boundary lubrication condition

1 Introduction

To achieve high emission efficiency, the maximum detonation pressure of modern diesel engines has exceeded 20 MPa with a trend of continuous increment [1,2]. To ensure its reliability, integrated thin-wall forged steel piston has been used in commercial, car diesel and other engines to replace traditional aluminum-alloyed piston [3-5]. Besides high strength, the thermal expansion coefficient of forged steel material is also better than aluminum alloy and closer to that of cast iron cylinder sleeve, which means smaller cylinder clearance can be set to minimize the panting of lower skirt, especially with high work load [6,7]. However, there are also some disadvantages of forged steel piston, e.g. much worse thermal conductivity and severer abrasion of skirt resulting from smaller cylinder clearance. Therefore, how to reduce the friction loss and enhance the wear resistance under different working conditions becomes an important scientific research project.

Nowadays, black phosphating process has been widely used in engine part and piston to optimize its surface wear resistance and overall efficiency [8-10]. Black phosphate process the steel matrix with phosphate, formation a layer of film of

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