Performance analysis and research of high-speed motor with dual-phase reinforcement based on rotor local carburizing

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The drive motor of electric vehicles shows the development trend of high-speed and high-power density, and the iron core urgently needs to be made of silicon steel with higher strength and better magnetic properties. The current method of increasing the yield strength will deteriorate the magnetic properties of the silicon steel, resulting in a decrease in the efficiency and torque of the motor. In this research, a new method to improve the strength of the rotor is proposed. The rotor is made of Non-Grain Oriented (NGO) silicon steel, which is carburized locally at the flux barrier and rib, thereby increasing the strength of the rotor and the speed of the motor. By comparing the magnetic properties and mechanical properties of silicon steel before and after carburizing, the influence of its characteristics on motor speed and torque is discussed. The test results show that the strength of the flux barrier is obviously increased after carburizing, the magnetic leakage of the motor is also reduced, and the torque and maximum speed of the motor are increased.

Keywords: Local carburization; Flux barrier; Yield strength; Silicon steel; Motor

1. Introduction

Carburizing is a heat treatment process to increase the carbon content of the alloy surface and improve its strength. Carburizing process is generally applied to the process of alloy, and there are few cases in literature describing the application of NGO silicon steel to motors after carburizing [1]. Some dual-phase materials are used in synchronous reluctance motors by nitriding [2]. In this research, NGO silicon steel was carburized and innovatively used in the rotor, and its magnetic and mechanical properties were further investigated. Based on vacuum carburizing furnace, the local carburizing of flux barrier and rib in rotor was completed. As a result, the magnetic leakage at the flux barrier is reduced and the strength of the rotor is increased, thereby increasing the torque and maximum speed of the motor. The research is aim to apply this method to the high-speed drive motor of electric vehicles.

2. Results and discussion

Carburizing is a process in which the alloy is put into a closed carburizing furnace, and methane or ethane is introduced. These gases can decompose active carbon atoms at high temperatures and penetrate into the surface of the alloy, making the surface layer of the alloy have a higher carbon content. In this research, NGO silicon steel was tried as the target of carburizing to change part of the ferrite into martensite and improve the strength of the rotor. In addition, metallographic tests, hardness tests, magnetic properties tests and tensile tests were also completed.

In order to further explore the influence of the locally carburized rotor on the motor performance, the flux barrier and rib are divided in the rotor topology. In the finite element simulation, the material in the purple area (flux barrier and rib) is set into the carburized NGO silicon steel. The stator and other areas of the rotor are not carburized and are therefore defined as the magnetic properties of un-carburized NGO silicon steel. The area where the stress is most concentrated, such as the flux barrier and the rib of the rotor, are taken as the targets of carburizing to improve the strength. At the same time, other areas of the rotor are coated with stop-off paints (Thurckon PAC) to maintain the original properties. So as to improve the speed of the motor while preventing the decline of the motor performance.

Through the test results, it was found that due to the increase of carbon content, the magnetic permeability of NGO silicon steel after carburizing is reduced, which can reduce the magnetic leakage of the motor. In addition, the higher strength of the rotor can increase the maximum speed of the motor.

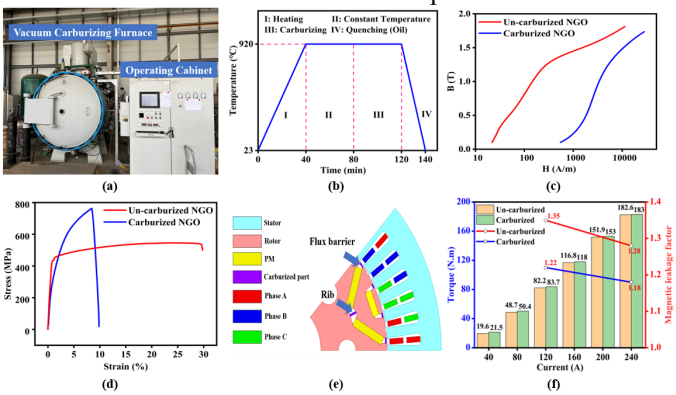

Figure 1: (a) Carburizing equipment; (b) Carburizing process; (c) B-H curve; (d) Stress-strain curve; (e) Finite element model of motor; (f) Torque and magnetic leakage factor of motor.

The results show that the rotor can withstand greater centrifugal force after local carburizing. As a result, the maximum speed of the motor is increased by 2,000 r/min, and the torque of the motor is slightly improved. According to the test results of the motor, the speed can be greatly improved without sacrificing the torque of the motor. The rationality and feasibility of this research have been verified. In the future, different methods of controlling yield strength are also studied, and their properties are analysed and compared.

References

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