Magnetic properties of Fe-Co alloy under stress-magnetic field coupling

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After a long period of research, it has been found that some new soft magnetic materials with high saturation magnetic density have become a breakthrough for improving motor torque. For example, Fe-Co alloys(1J22) has high saturation magnetic induction strength and high Curie temperature, which means that it is highly adaptable to high temperature and can maintain good magnetic energy at high temperature. However, 1J22 has problems such as low yield strength after annealing and susceptibility of magnetic permeability to external physical factors such as stress. Therefore, this paper investigates the changing law of magnetic properties of 1J22 under stress-magnetic field coupling, so as to propose some modifications for future motor design.

Keywords: 1J22; stress fields; Magnetic properties

1. Introduction

At present, motor stator core materials are still dominated by Conventional Silicon Steel (CSS). However, the performance of CSS has encountered a bottleneck with the continuous improvement of requirements on motor performance. It has been found that 1J22 have higher saturation magnetic density [1], which means that 1J22 motors have higher output torque at the same current [2]. However, the magnetic properties of soft magnetic materials are susceptible to stress when applied to motors, which can affect the accuracy of the motor design [3].

Nevertheless, the magnetic changes of 1J22 under the coupling of stress field and electromagnetic field have not been sufficiently verified. Therefore, in this paper, the stress-field-induced magnetic changes of 1J22 and CSS are analysed by constructing a stress-magnetism coupling experimental platform and conducting coupled field experiments.

2. Results and discussion

In this paper, a coupled stress field and electromagnetic field test system of iron core material is established. The coupled test system includes a magnetic field module and a stress field module, and the test principle is shown in Figure 1. The stress measuring range is -100~100MPa, and the frequency measuring range is 50~1000 Hz.

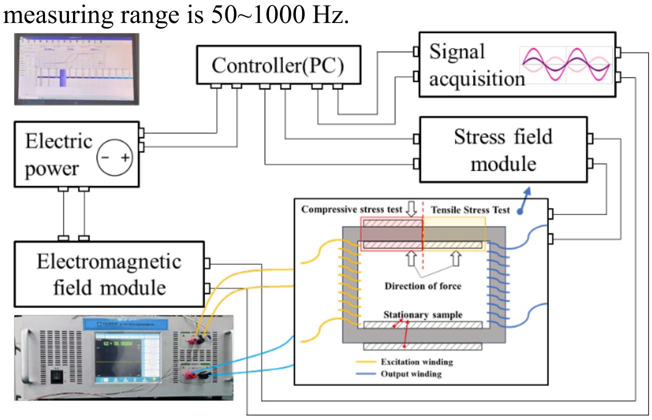

Figure 1: Experimental equipment.

When a tensile stress of 0~60MPa is applied to the upper and lower ends of the specimen, the corresponding test results are shown in Fig.2. As the tensile stress increases, the losses of 1J22 and CSS begin to show a decreasing trend. This trend is more obvious for 1J22, where the loss decreases the most at a flux density of 1T, reaching 48.6%, and CSS decreases by 36.4%. However, the stress sensitivity of the loss decreases with increasing stress.

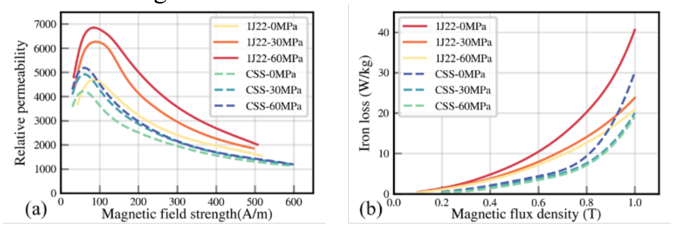

Figure 2: (a) is B-P curve of 1J22 and CSS under different stress@400Hz. (b) is Relative permeability curves of 1J22 and CSS under different stress@400Hz

Figure 2(b) shows the effect of stress on the magnetic flux density of 1J22 and CSS. The results show that when the tensile stress is increased to 30 MPa, the relative permeability of 1J22 at a magnetic field strength of 100 A/m increases by 36.7%. The increase in relative permeability is 9.6% when the stress is increased from 30 MPa to 60 MPa. The relative permeability of 1J22 starts to become less sensitive to stress and the same phenomenon occurs in CSS.

Although the sensitivity of the magnetic properties of 1J22 is decreasing with increasing tensile stress, the trend is remains favourable. In addition, we will illustrate in a subsequent paper a wider study of the interaction of stress (including compressive stress) and magnetic field, which shows that compressive stress deteriorates the magnetic properties of 1J22. Finally, we verify the above test results by fabricating a motor core.

References

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