Research on iron loss in SMCs considering frequency and temperature effect

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Soft magnetic composites (SMCs) enable to guide magnetic flux in 3-D structures that are difficult to achieve with non-oriented silicon steel(NOSS). The high resistivity of SMCs can effectively suppress the eddy current loss. However, the magnetic properties of SMCs are more complex than NOSS, the hysteresis loss of SMCs is relatively high, and the magnetic properties are also affected by its internal structure and moulding stress. In this paper, the magnetic properties of SMCs are investigated. Through ring sample testing experiments, the influence of different particle sizes and moulding stresses on the magnetic properties of SMCs is studied. An increase in particle size leads to a decrease in the saturation magnetic induction intensity and maximum permeability of SMCs, while an increase in pressing stress reduces the iron loss of the material. Meanwhile, considering the application environment of SMCs, the variation laws of the magnetic properties of SMCs and NOSS under the action of magnetic fields and temperature are comparatively analysed.

Keywords: SMCs; particle size; moulding stress; temperature; frequency

1. Introduction

Soft magnetic composites (SMCs), made from iron particle powders with insulating coatings, can be directly pressed into complex three-dimensional structures, which has aroused great interest among electric motors researchers. This also means that both the particles and the moulding stress can affect the magnetization characteristics of SMCs, and this cannot be ignored in SMCs applications[1]. The resistivity of SMCs is significantly higher than non-oriented silicon steel (NOSS), enabling them to suppress large eddy current loss in high frequency magnetic field. However, SMCs have high hysteresis loss, which may lead to greater core losses in low frequency field[2]. Moreover, service temperature is also an important factor [3]. In electric motors with special structures, the magnetic field and temperature coexist and are more complex. Therefore, this paper further studies the performance changes of SMCs under the coupled action of the magnetic field and temperature, and conducts a comparative analysis with NOSS, which is of certain value for the development and application of SMCs.

2. Results and discussion

Figure 1 (a) shows the variation of the loss of SMCs under different pressing stresses and particle sizes at 400 Hz and 1 T.

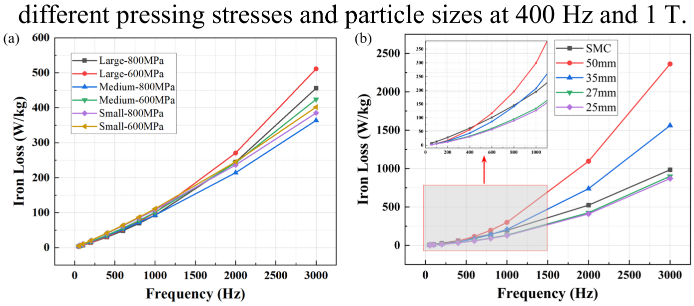

Figure 1: Iron loss of SMCs. (a) Different particle sizes and moulding stresses. (b) Comparison of SMCs and different grades of NOSS

It can be seen that at low frequencies, a decrease in particle size increases the loss of SMCs, while as the frequency rises, SMCs with smaller particle sizes exhibit a slower loss growth rate and gradually gain an advantage. This is because an increase in both the resistivity and hysteresis loss of the material. And the loss decreases with the increase in moulding stress. When the moulding stress rises from 600MPa to 800MPa, the loss of SMCs with large size particles decreases by 3.2%. The reason may be that the increase in moulding stress reduces the distance between iron particles, weakens the pinning effect, and thus reduces the hysteresis loss. Figure 1(b) shows the comparison of iron losses between SMCs and silicon steels with different thicknesses at various frequencies and 1.5T. It can be seen that the iron losses of SMCs are generally higher than those of NOSS. As the frequency increases, this gap gradually narrows. When the frequency reaches above 600 Hz, the loss of SMCs is smaller than that of the 0.5mm NOSS, and at 1000 Hz, it is smaller than the 0.1mm NOSS.

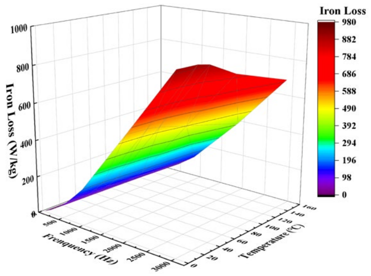

Figure 2: Iron loss of SMCs at different temperatures and frequencies.

Figure 2 shows the variation of the iron loss of SMCs under the combined influence of frequency and temperature at 1.5T. At a constant frequency, the iron loss decreases as the temperature increases. As the frequency rises, the impact of temperature on SMCs becomes more significant. The effect of the magnetic properties variation under this coupling on the electric motor performance is also further considered

References

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