Magnetic Properties of Laser-processed Ring-shaped Laminated Cores

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Abstract

In this study, we evaluated the magnetic properties of ring-shaped laminated cores manufactured by laser machining, which are used in prototype motor development. As a result, it was found that the magnetic properties of the specimens manufactured by laser machining were degraded due to the distortion of the B-H loop caused by the thermal stress generated during the machining process. It was also found that hysteresis loss increased by about 113% when the excitation frequency was 50 Hz and the magnetic flux density was 1.0 T.

1 Introduction

In recent years, global economic development has led to an increase in global electricity consumption and greenhouse gas emissions. However, in order to prevent global warming, it is essential to reduce greenhouse gas emissions. The way to solve this problem is to reduce electricity consumption. For that, it is essential to increase the efficiency of products that use electricity. In particular, motors consume about half of the world's total electricity, and higher efficiency is desirable. In the prototype stage of motor development, laser processing is generally used. The effects of laser processing on magnetic properties have been reported mostly for single steel sheets, but not for laminated cores [1]. Therefore, the purpose of this paper is to clarify the effect of laser processing on the magnetic properties of laminated cores by evaluating the magnetic properties of laser-processed non-oriented electrical steel sheets, and to contribute to the reduction of motor losses.

2 Laminated cores to evaluate magnetic properties

A ring-shaped laminated core made from a non-oriented electrical steel sheet, 35A300, manufactured by laser processing was used as a specimen. Figure 1 shows the ring-shaped laminated core used for the measurement. As shown in Table 1, a steel sheet, 0.35 mm thickness, 7650 kg/dm^3 material density, 80 mm outer diameter, and 70 mm inner diameter was laminated to a laminated core of thickness of 5 mm, and the excitation coil and B coil were wound in this laminated core. The number of excitation coil was 100 and the number of B coil was 80, respectively.

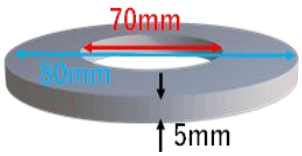


Figure 1: Laminated ring core

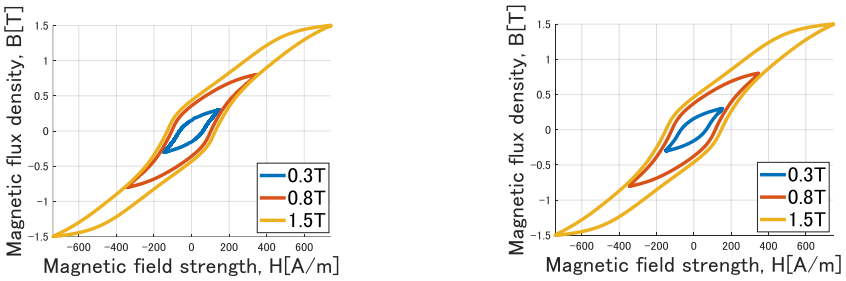
Table 1 Specimen for evaluation

Grade	35A300
Thickness	0.35mm
Material density	7.65kg/dm^3
Inner diameter	70mm
Outer diameter	80mm
Number of excitation coil	100turn
Number of B-coil	80turn
Processing method	Laser processing

3 Magnetic properties and discussions

To clarify the effect of laser processing on magnetic properties, they are evaluated from B-H loops and iron losses. Figure 2 (a), (b) show the B-H loops at 50 Hz and 100 Hz, respectively, and it is shown that the B-H loops are distorted. This is considered to be due to the thermal stress caused by the laser processing, which affected the magnetic properties.

Figure 3 shows the hysteresis loss and eddy current loss at 1.0 T derived from iron loss by frequency separation. From Figure 3, the eddy current loss and hysteresis loss of the laminated core are 0.27 W/kg and 1.92 W/kg, respectively, while the catalogue values of the 35A300 steel sheet are 0.18 W/kg and 0.90 W/kg, respectively. It was found that laser processing increased hysteresis loss by 113% and eddy current loss by 50%. In other words, the laser processing imposes thermal stress on the non-oriented electrical steel sheet, which increases hysteresis loss and eddy current loss, leading to distortion of the B-H loop. The full paper will report the results of a detailed study of the relationship between other processing conditions and magnetic properties.



(a) 50Hz (b) 100Hz

Figure 2: B-H loops of laminated core

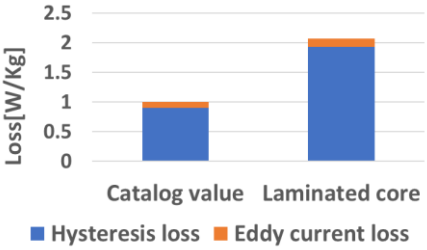


Figure 3: Separation of iron loss

4 Conclusion

In this paper, we showed that laser processing caused the distortions in the B-H loops. It was also found that the hysteresis loss increased by 113% and the eddy current loss increased by 50% at a magnetic flux density of 1.0T. In other words, the laser processing applied thermal stresses into the specimens, which degraded their magnetic properties. Therefore, the degradation of magnetic properties by laser processing should be considered in the design for motor prototyping.

References

[1] A. Kutsukake, Y. Kido, T. Ikeda, T. Todaka and M. Enokizono, Influence of machining method of single sheet specimen on magnetic properties, *The Papers of Technical Meeting on Magnetics*, **MAG-13-148**, IEE Japan, (2013), pp. 39-44.