Influences of self-bonding, dispensing, and welding process on the magnetic properties of electrical steel lamination

Weizhou Li [a], Yulin Li [a], Ze Xie [a], Lubin Zeng [b], Ruilin Pei [a, b]

[a]*Department of Electric Engineering, Shenyang University of Technology, Shenyang, China.*
[b]*Suzhou Inn-Mag New Energy Ltd., Suzhou, China.*

Self-bonding, dispensing, and welding processes are the more common core lamination processes. The magnetic property analysis and comparison of the three lamination processes can help to guide the precise design and selection of the motor. This paper explores the magnetic performance effects of the self-bonding, dispensing, and welding processes on electrical steel lamination, which were determined from tests on circular samples and measurements of stator lamination stacks. The experimental results are based on three different lamination processes for the same base material common to electric machines and are investigated at different frequencies. Finally, simulations and experiments verify the effects of the three lamination processes on the performance of electric machines.

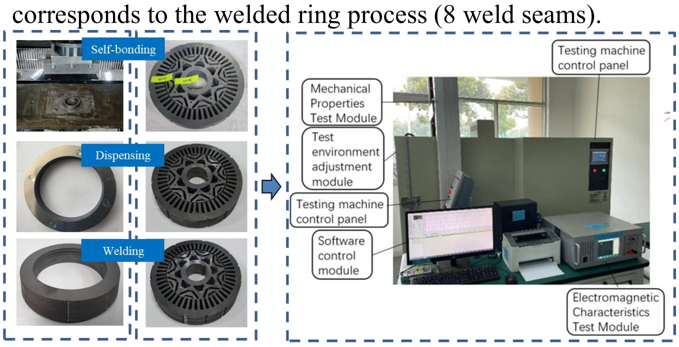
Keywords: Magnetic property; Self-bonding; Dispensing; Welding; Electrical steel

1. Introduction

Motor's core lamination forming process is one of the necessary process of motor manufacturing, core lamination way, being widely used, is worth to cite the clamping, welding or gluing technologies, these have a greater impact on the core and motor performance [1]. Ref. [2] studied the effect of Welding on the performance of the core, and Ref. [3] investigated the application of self-bonding material with a thickness of 0.35 mm, which has made great improvements in coating in recent years, in an external rotor permanent magnet synchronous motor with a speed of 1500 rpm. At present, the effect of different core lamination processes on the magnetic properties of materials over a wide range of variable frequencies has rarely been investigated.

2. Results and discussion

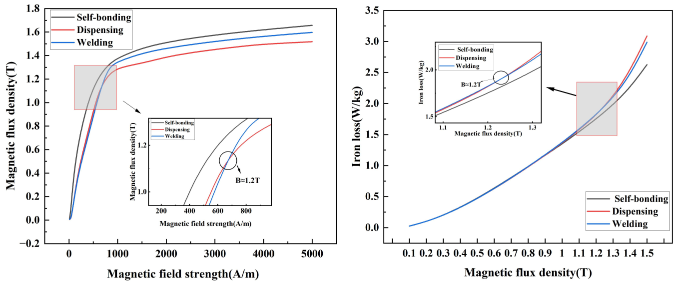
Tests were performed to fabricate three rings and three cores, as shown in Figure 1. Circle 1 is based on a self-bonded core (ZZ25WV1300), which is stacked by placing it under 1.5 MPa pressure for 1h at 180°C; circle 2 is made of the same material with a conventional coating (25WV1300), which is applied by dispensing; and circle 3 is made of the same material as circle 2, but it is welded, with 5 weld seams set up. Core 1 corresponds to the self-bonding process, core 2 corresponds to the dispensing ring process, and core 3 corresponds to the welded ring process (8 weld seams).



Ring samples Iron core Magnetic properties test

Figure 1: Test equipment, rings and cores of different processes

The magnetic performance tests of three process rings at 50Hz-1000Hz were completed, and the Magnetic field strength-Flux density curves (B-H curves) and Flux density-Iron loss curves (B-P curves) at 50Hz are shown in Figure 2.



a) B-H curves at 50Hz b) B-P curves at 50Hz

Figure 2: Self-bonding, dispensing, and welding process performance

In Figure 2 , it can be seen that the magnetic density of the self-bonded sample is about 1.32 T at 800 A/m, which is higher than the values of dispensing and welding samples of 7.32% and 1.54%, respectively. It is worth noting that the B-H and B-P curves of the two processes of dispensing, and welding produce an intersection point at a flux density of about 1.2 T, which is just the intersection point between the irreversible magnetic domain wall movement and the dominant phase of domain rotation (the migration behaviour of the magnetic domain wall decreases gradually), which will be analysed in the full paper.

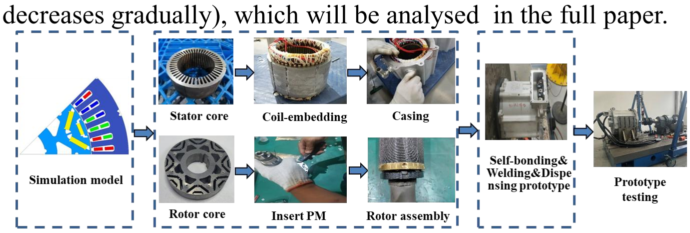


Figure 3: Prototype production

Based on the research above, a 13000rpm permanent magnet synchronous motor model is developed and three prototypes are fabricated for validation, and the machining of the basic parts of the prototype has been completed, as shown in Figure 3, to verify the effects of the three lamination processes on the performance of the motor by testing the motor.

References

[1] Z. Gmyrek, and A. Cavagnino, Influence of punching, welding, and Clamping on magnetic cores of fractional kilowatt motors. IEEE Transactions on Industry Applications, 54 (5): 4123-4132. (2018).

[2] H. Wang and Y. Zhang. Modeling of Eddy-Current Losses of Welded Laminated Electrical Steels. IEEE Transactions on Industrial Electronics, 64(4), 2992-3000 (2017).

[3] Z. Yu, J. Wan, Y. Li, et al. Application analysis of self-bonding electrical steel sheet in high power density PMSM for all-electric aircraft. Energy Reports, 9, 514-521 (2023).