INVESTIGATE CORE LOSS OF PM MICRO-MOTOR MADE BY MIM TECHNOLOGY

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Abstract

Research has been conducted into the effects of "particle size" on the core loss of soft magnetic materials. Various types of PM micro electric motors, which produced through solid hog-out stainless steel, laminated stainless steel and Metal Injection Moulding (MIM) stainless steel powders have been studied. The results shown that, the core loss of PM micro-motor through MIM technique is comparable with laminated core motor.

Introduction

In electric machines, lamination is normally used to reduce the core loss produced in the machine operation. However, they are limited to rectangular geometry with flux in the plane of the sheet, and low frequency applications [1].

The alternative of low loss related to the most important alternating current requirement of low magnetic hysteresis couple with the highest possible electrical resistance to minimize eddy current in a magnetic materials [2]. If the frequency of the alternating current is high, it is necessary to make the silicon steel so thin that the motor core become very expensive, and it is difficult in fabricating the lamination to form the motor cores. Though lamination is the most effective way to reduce the core loss in electric machine [3], it is generally difficult to produce grain-oriented silicon steel sheet thinner than 160 µm by secondary recrystallization with inhibitors [4]. With MIM technique, the cost of the motor core can be reduced and the core loss will be controlled in acceptable level.

Experimental Procedure

The experiments have been conducted in two parts. First, measured the core loss for pole piece rings, which produced through 430h stainless steel solid hog-out materials and MIM materials. Spherical stainless steel particle of 15 to 25 µm, 100 to 110 µm and 200 to 220 µm in diameter were used in the fabrication of pole piece rings through MIM process. Second, fabrication of PM micro-motors from solid hog-out materials, conventional lamination method and MIM technique, which with different stainless steel particle sizes. Table 1 shows the dimensions of the PM micro-motor stator, which under the investigations.

For the pole piece rings, dynamic hysteresis loops has been measured under controlled sinusoidal induction waveform at frequencies between 50 Hz to 300 Hz. The corresponding power losses were determined.

The core loss for the various PM micro-motor has been measured through AIO Tester, a motor tester which has been developed in Data Storage Institute for in-house use.

The power loss, P_B, consisted of hysteresis loss, P_h, eddy current loss, P_e and unknown loss factor or residual loss, P_r. The hysteresis loss can be measured independent of P_B, but it is impossible to obtain others separately [5]. Thus P_h and $(P_B - P_h)$ usually been analyzed.

Conclusion and Discussions

Figure 1 shown the total core loss measurement results in pole piece rings for solid hog-out materials and MIM techniques produced materials. The results show the hysteresis and eddy current losses, which produced through MIM technique is much smaller compared with solid hog-out materials. For MIM materials with 200 to 220 µm in diameter of powder particles shown less core loss compared with smaller particle sizes, which from 15 to 25 µm and 100 to 110 µm.

Figure 2 shown the various result through the PM micro-motor testing. The total core loss for such PM micro-motor produced through MIM technique with 200 to 220 µm of powder size is comparable with the loss of lamination PM micro motor. Hence, it is possible to produce low core losses PM micro motor through MIM technology. Stainless steel particles with bigger size in diameters will show less core losses in PM micro motor. By implementing this MIM technique, the cost of producing PM micro motor will be reduced drastically [6].

By using the Steinmetz equation [1], the total core loss can be expressed as,

$$P_{Loss} = P_h + P_e = \eta B^a f + \varepsilon B^b f^2 \tag{1}$$

Where P_h is the hysteresis loss and P_e is the eddy current loss.

From the experimental results and mathematical analysis, the following equation can be obtained by using (1),

$$P_{Loss} = \eta B^{1.9} f + \varepsilon B^{3.5} f^2 \tag{2}$$

Table 1: Dimension of Stator Motors under investigation

Outer Radius	13.78mm	Inner Radius	8.01mm
York Height	2.95mm	No. of Slots	12-slots
No. of Pole Pairs	4	No. of wire Turns	50 Turns

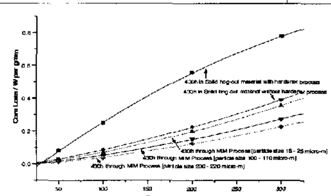

Fig. 1. Total core loss for 430h pole piece rings correspond to frequencies

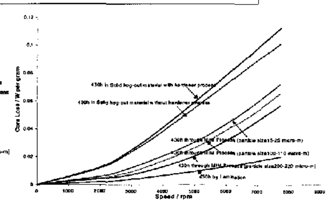

Fig 2. Total core loss in PM micro-motor test correspond to speed (rpm)

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