The Influence of Hi-flux Powders Characteristics on the Performance of Magnetic Powder Cores

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Abstract

The influence of Hi-flux powders characteristics on the performance of magnetic powder cores was studied. It was found that different cooling rate and nozzle configuration could change the shape and microstructure of powders。 Smooth surface and spherical shape of powders were beneficial to improve DC bias performance and reduce core losses of magnetic powder core.

Keywords : Hi-flux, atomizing, magnetic powder cores

1. Introduction

As necessary inductance components, magnetic powder cores are widely used in the field of computer, telecommunication, and electronics. In recent years, with electronic devices applied for high frequency condition and miniaturized, magnetic powder cores with high performance was desired. Hi-flux powder cores have high saturation flux density and low core losses, so they are preferably applied to high frequency and high power condition. Hi-flux powders characteristics have obvious effect on the performance of magnetic powder cores. The paper investigated the influence of the shape and microstructure of gas atomized and water atomized powders on the performance of magnetic powder cores so as to improve their performance.

2. Experimental and results

By means of nitrogen gas atomization and water atomization, Hi-flux powders (50wt%Fe-50wt%Ni) were prepared. After atomizing finished, powders were dried (for water atomized powders only) and screened to suitable size. Subsequently, 2wt% silicone resin and 2wt% toluene were added into powders and mixed, then the mixture was dried in the air at 80℃ and 0.5wt% mica as lubricant was added. Finally, the above mixture was consolidated to form ring shape powder cores, and then powder cores underwent heat treatment for 1 hour at 550℃ in high pure argon atmosphere. The morphology and microstructure of powders were observed, DC bias of powder cores was measured under 50KHz frequency and 10mA current condition, and core losses were measured under 50KHz frequency and 0.1T flux condition.

The shape of powders is a crucial factor for eddy current losses. For powder cores, there should be good insulation between particles and insulation layer is as thin as possible [1,2]. Because of their smooth surface and spherical shape, gas atomized powders were easily coated with insulating compound, which caused lower current between particles, thus resulting in lower core losses (483mW/cm^3). However, water atomized powders had irregular shape, and there were sharp protrusions on the surface, so coating particles with insulating compound was difficult, which resulted in low resistance between particles. As a result, eddy current passed through a particle to the others, and the core losses cores were high (931mW/cm^3).

The stability of the permeability of powder cores in the DC magnetic field is an important parameter evaluating their performance, which determines maximum DC magnetic flux applied under normal operating state. As seen from Fig. 3, Dc bias of powder cores which were made of gas atomized powders was better than that of powder cores which were made of water atomized powders. On one hand, gas atomized powders were frozen by nitrogen gas at lower cooling rate so that crystal grains had relatively long time to grow up, while water atomized powders were frozen at higher cooling rate so that crystal grains had shorter time to grow up, which resulted them smaller, thus there were more grain boundaries and defects such as dislocation and vacancy in the grains. On the other hand, since permeability and coercivity are both sensitive to microstructure, grain boundaries and defects would prevent magnetic domain wall from moving, which resulted in magnetizing difficult and reduced permeability.

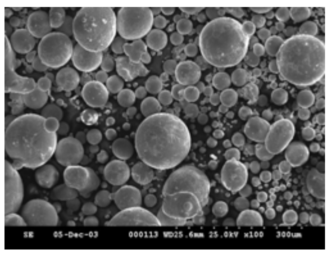

Fig. 1. Morphology of gas atomized powders.

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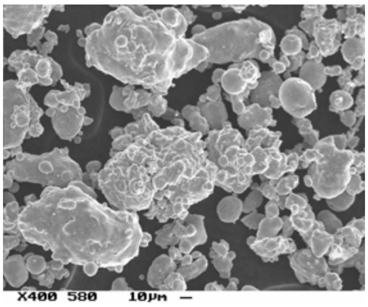

Fig. 2. Morphology of water atomized powders.

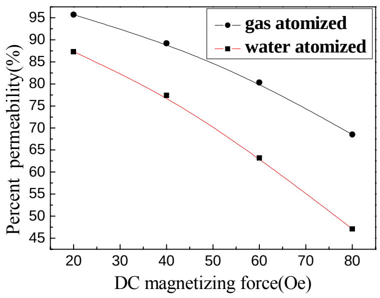

Fig. 3. Dc bias of cores.

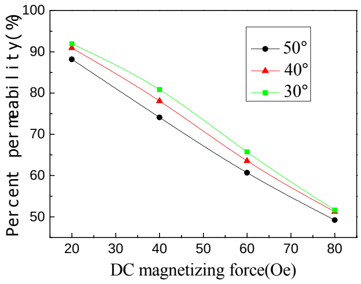

Fig. 4. Dc bias of cores.

Although gas atomization method could produce powders with spherical shape and smooth surface, it needs higher cost and long production cycle than water atomizing. In order to obtain desired shape of water atomized powders, the process of water atomizing should be improved.

There are varied factors affecting powder shape, including nozzle angle, atomizing pressure, water flow, melting temperature of metal, the height of container under nozzle. Atomizing nozzle (with "V" shape angle) is crucial component which determines the shape and size of powder. When atomizing, molten metal flows down through a guide tube, and then is smashed at focus of high pressure water to form powders instantly. With nozzle angle decreasing, the focus moves downwards, so impact force on the molten metal also become smaller, which is beneficial to form spherical shape. At the same time, decreasing atomizing pressure will further facilitate to the formation of spherical powder.

Adopting nozzles with angle of 50°, 40°, or 30° and corresponding atomizing pressure of 420bar, 380bar, 320bar, water atomized powders were produced. The shape of powders became more smooth and spherical with nozzle angle decreasing from 50° to 30°. Powders below 150μm were used to be consolidated to form powder cores. According to test results, the losses of powder cores were 739mW/cm^3 for 50°, 627mW/cm^3 for 40°, and 550mW/cm^3 for 30° respectively. Dc bias was shown in Fig 4. It is noted that core losses have decreased and DC bias have also be improved.

3. Summary

Hi-flux powders with preferable characteristics were produced, and the following results were obtained:

1. Powder cores made of powders with smooth surface and spherical shape had high performance.

2 Decreasing nozzle angle and atomizing pressure could make powders shape more spherical and surface more smooth.

4. References

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