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Development of Superior Fe-Si Sintered Magnetic Cores Equivalent to Wrought Si-steels

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Abstract

Wrought Si-steels are generally used for electromagnetic valves, which are needed good response. To date, Hitachi Powdered Metals Co., Ltd. have produced Fe-Si base sintered magnetic material, EU-52, which shows a magnetic flux density of more than 1.25T at 2000A/m and a maximum permeability of more than 3500. However these magnetic properties are lower than that of wrought Si-steels. Because EU-52 has a low density of 7.2Mg/m^3. For improving the magnetic properties, it is necessary to increase the density of sintered cores. To increase density, a new mixing method of coating fine Si powders on atomized iron powders was developed, for avoiding the Kirkendall effect. As the result, developed P/M Fe-Si magnetic cores shows higher density of 7.38Mg/m^3, higher magnetic flux density of 1.48T at 2000A/m and higher maximum permeability of 6800.

Keywords : sintered magnetic cores, fine Si powder, high magnetic flux density, high permiability

1. Introduction

Fe-Si soft magnetic materials are used as many types of magnetic cores used in AC magnetic field. These soft magnetic parts are produced by Fe-Si base sintered magnetic materials, which show magnetic flux density more than 1.25T at 2000A/m and maximum permeability more than 4000.

Recently, units for automobiles are changing to electromagnetic drive systems from mechanical drive systems. In these fields, various types of actuator are required higher magnetic flux density and higher permeability. To improve these properties, it is necessary to increase the density of sintered cores. However, higher density is difficult to use Fe-Si mixed powder by conventional mixing method. Because coarse pores are produced by the Kirkendall effect.

To avoid the effect, a new coating method of fine Si powders on atomized iron powders was developed, as using fine Si powders is seemed to be most effective. As a result, developed Fe-Si sintered magnetic cores show higher density and higher magnetic properties. This report describes the new coating method of fine Si powders and magnetic properties of developed Fe-Si sintered magnetic cores.

2. Experimental Method

2.1 Preparation of specimens

The main powder used was a water atomized iron powder. Chemical composition of this powder is Fe-0.6mass%P. An addition Si powder was a fine powder under 10 μm. of particle size.

The fine Si powder was coated on iron powder by a new developed coating method[1)]. This method applied as a granulating method using the rolling flow granulation system[2)]. Then, coated powders were mixed with 0.5mass% of amide-wax for 30min by using V-type mixer. And also, the mixed powder by conventional mixing method was used to compare the effects.

These coating powders were compacted at ring shape specimens, of which sizes are ϕ20 x ϕ30 x 5mm, at a pressure of 686MPa. Then, these compacts were dewaxed in dissociated NH3 gas at 1023K and sintered at 1423~1523K for 60min in vacuum (at about 5Pa).

2.2 Evaluation of properties

The ring shape specimens were wound 100 turns as the primary winding and 20 turns as the secondary winding. D.C. magnetic properties were evaluated by measuring the B-H curve at a maximum magnetizing force of 2000A/m.

3. Experimental Results and Discussions

Figure 1 shows the relationship between the sintering temperatures and sintered density. At 1523K, the developed material applied new coating method shows high density of 7.38Mg/m^3. This density is higher than that of conventional material by 0.15Mg/m^3 at the same sintering temperatures.

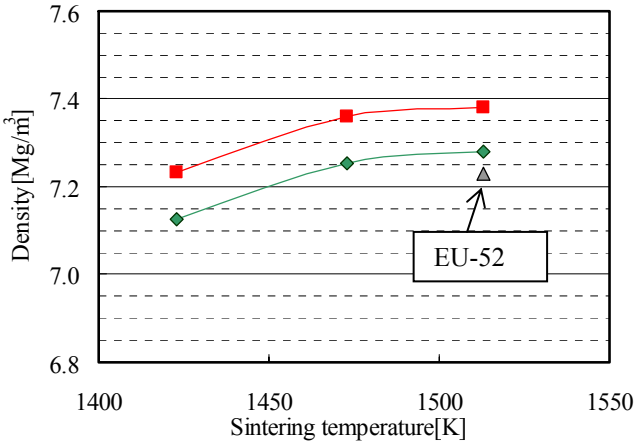

Fig. 1. The relationship between the sintering temperatures and sintered density.

According to the increase of the density, the magnetic flux density increases greatly. Figure 2 shows the relationship between the sintering temperatures and magnetic flux density at 2000A/m. The developed material has a high magnetic flux density: 1.48T.

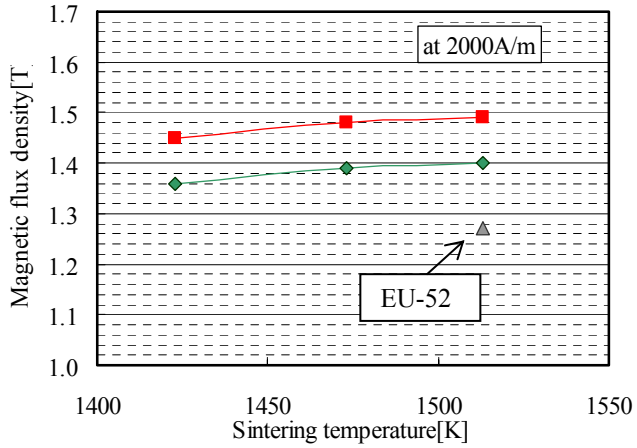

Fig. 2. The relationship between the sintering temperatures and magnetic flux density at 2000A/m.

In addition to magnetic flux density, other magnetic properties improved. Figure 3 shows the relationship between the sintering temperatures and permeability. The developed material shows 6800, exceeding the conventional material by 3000. The reason for their higher magnetic properties is coating state of Si powder. It is thought that the growth of the crystal grain is promoted as for the developed material, because coating the fine Si powders on atomized iron-powders uniformly improves the diffusion of Si into iron particles.

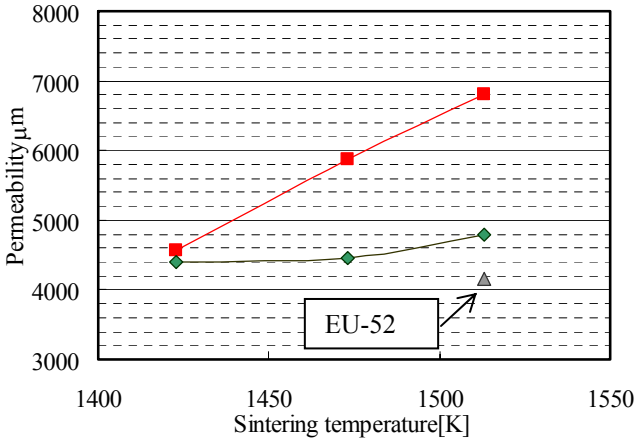

Fig. 3. The relationship between the sintering temperatures and permeability.

4. Conclusions

In order to achieve a high magnetic flux density and high permeability in Fe-Si sintered magnetic cores, increasing the density of cores were studied using fine Si powder and a new coating method of fine Si powders. The following conclusions were obtained.

1) The developed material applied finer Si powders and a new coating method showed higher density than conventional material at the same sintered conditions.
2) Using the developed material, it is possible to obtain Fe-Si sintered magnetic cores with high magnetic flux density of $B_{2000A/m}$: 1.48T and high permeability of μm 6800.

5. References

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