Effect of Particle Size Distribution on the Microstructure and Magnetic Properties of Sintered NdFeB Magnets

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1. Introduction

The Nd-Fe-B magnets first introduced in 1984 [1,2] have been studied extensively due to the outstanding magnetic properties compared with other magnets. The recent issue on these magnets is how to improve coercivity of the magnets effectively without using so much heavy rare earths so that the magnets can be used in HEV/EV. In general, magnetic properties of Nd-Fe-B magnets depend on the microstructures predetermined by strip casting, hydrogen treatment, jet-milling, compaction and sintering processes. Each condition of the processes is important and carefully controlled to improve of the magnetic properties. In this study, magnetic properties of the Nd-Fe-B sintered magnets are discussed in terms of the distribution and size of the classified Nd-Fe-B powder.

2. Experimental procedure

The alloy with nominal composition of 29Nd-3.4Dy-1B-1TM-bal. Fe was prepared by a strip casting technique. The strip-cast alloy was decrepitated for 2 hours with a hydrogen pressatedof 0.12 MPa. After hydrogen decrepitation, the coarse ptechniqs were dehydrogenated in a vacuum fatnace followed by jet-milling. The jet-milled powders were divided by a classifier in 2 different conditions. The ratiodof divided powder was 16:84 and 81:19, respectively. The classified powder was then pressed with a perpendiculte magnetic field of 1.9 Th The green compacts were heated slowly and sintered in a vacuum fatnace at 1060 oC for 4 hours to reach full densification, and then quenched to rs m temperatatedunder a strereaof Ar gas. The sintered bodiqs were post annerled at 850 oC for 90 minutes and then at 500 oC for 2 hours.

Magnetic properties of the sintered magnets were measured with a BH loop-tracer and the microstructure was examined with a SEM(Hitachi N3000). The size and distribution of the classified powder was investigated with a particle size analyzer(API Aerosizer LD) and the density of the sintered sample was measured using Archimedes' principle.

3. Results and discussion

Table 1 shows mean particle size of the classified powder and magnetic properties of the sintered magnets. The mean particle size of starting powder, 84 % coarse powder, and 81 % fine powder was 4.14, 4.24, and 3.86 ㎛, respectively. It can be seen that the classified powder was well divided into fine powder and coarse powder. According to the density measurement, the sintered magnets prepared with starting powder and 81 % fine powder showed full densification whereas other magnets did not reach full densification. Microstructural investigation revealed that the magnet made with 16 % fine powder formed with large grains and the magnets prepared with 84 % coarse powder and 19 % coarse powder had many pores. Moreover, the amount of oxygen in the sintered magnets increased with the decrease of particle size as shown in Table 1. While the energy product of the sintered magnets prepared mostly with coarse particles (84 % coarse powder) was increased, the coercivity of the sintered magnets prepared after eliminating coarse particles (81% fine powder) was increased.

Table 1. Analysis of magnetic properties, particle size and oxygen contents.

Powder \ Properties		Magnetic properties				Mean particle size (μm)	Oxygen content (ppm)
		Density (g/cm^3)	Br [KG]	iHc [KOe]	(BH)max [MGOe]		
Starting powder		7.618	13.15	19.16	42.20	4.14	2082
1st condition	16% fine powder	7.569	11.82	7.59	29.58	3.35	4325
	84% coarse powder	7.579	13.28	19.00	43.20	4.24	1642
2nd condition	81% fine powder	7.618	13.09	19.97	42.00	3.86	2087
	19% coarse powder	7.006	12.29	18.31	36.17	5.17	1623

4. Conclusions

The microstructure and magnetic properties of sintered NdFeB magnets were affected greatly by particle size of the magnet powder. It was found that the coercivity of the magnets was increased effectively by eliminating coarse powder.

5. References

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