Rubber Isostatic Pressing (RIP) for Ferrite Magnets

M. Sagawa, H. Nagata, T. Watanabe, O. Itatani

J. PHYS. IV FRANCE 7 (1997)
Colloque C1, Supplément au Journal de Physique III de mars 1997

Rubber Isostatic Pressing (RIP) for Ferrite Magnets

M. Sagawa, H. Nagata, T. Watanabe and O. Itatani

Intermetallics Co., Ltd., Erie 401, 22-1 Oiagecho, Matsumuro, Nishikyo-ku, Kyoto 615, Japan

Abstract. Applying RIP (Rubber Isostatic Pressing) to the ferrite sintered magnets, the following have been developed:
(1) Ferrite sintered magnets having energy product as high as 5.12 MGOe
(2) RIP setup for arc-segment magnets

1. Introduction

RIP has been proposed as a new technique of pressing powder for the rare earth and ferrite sintered magnets[1][2]. The combination of high packing density of the powder in the rubber-mold cavity and magnetic alignment by a high, pulsed magnetic field was shown to be essential for obtaining good compacts for sintered magnets having very high energy products[1]. This technique is being introduced lately in the industrial production of the sintered NdFeB magnets.

If RIP is used in the production of the ferrite magnets, the following effects are expected: (1) The degree of orientation in the green compacts is improved remarkably, leading to substantial improvement in remanence of the sintered magnets. (2) Because a very fine powder can be used in RIP, ferrite magnets with very high coercivity can be produced.

Apart from the improvement in the magnetic properties, an important subject in applying RIP to the ferrite magnets is to develop a setup of RIP for producing arc-segment magnets, because the arc-segment is the most important shape in the ferrite sintered magnets.

The purposes of this paper are: (1) to develop ferrite sintered magnets with high remanence by improving the degree of orientation, (2) to develop ferrite sintered magnets with coercivity as high as possible by using very fine powder, and (3) to develop RIP setup for the arc-segment ferrite magnets

2. Results

The starting material was $SrO \cdot 6Fe_2O_3$ with small addition of SiO_2 and $CaCO_3$. For the high remanence magnet, 1 wt% of calcium stearate was mixed in the powder during milling. The average grain size was 0.7μm as measured by the Fisher subsieve sizer. For the high coercivity magnets, powder with an average grain size of 0.3 μm was prepared by the method of Taguchi et al [3]. 2 % of calcium stearate was mixed during milling. Both the powders were then dried by flowing air.

A RIP set described before [1] was used. The packing density was 2.0 g/cm^3, pulsed magnetic field for alignment was 3T, and the pressing pressure was 0.3 to 0.8 ton/cm^2. Both the two powders could be compacted easily in good shape by RIP. The density of the compacts was 2.8 g/cm^3 when the pressure was 0.5 ton/cm^2. Compacts were then sintered in air at 1240℃ for the high remanence magnets and 1200℃ for the high coercivity magnets both for 2h. Density reached 5.0 g/cm^3.

In Fig. 1 are shown demagnetization curves of the high remanence magnet and high coercivity magnet measured on cylindrical specimens, 20 mm in diameter and 13 mm long. The high remanence magnet has surprisingly high remanence. The degree of orientation, which is estimated from the ratio of the remanence and the highest value of magnetization in the first quadrant of the hysteresis curve, reaches 99 %.

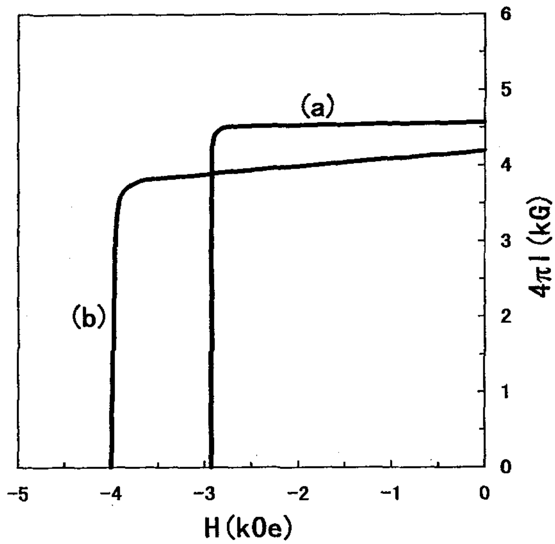

Fig. 1 Demagnetization curves for (*a*) the high remanence magnet [Br = 4.57 kG, Hci = 2.93 kOe, (BH)max = 5.12 MGOe] and (*b*) the high coercivity magnet [Br = 4.19 kG, Hci = 4.00 kOe, (BH)max = 4.26 MGOe]

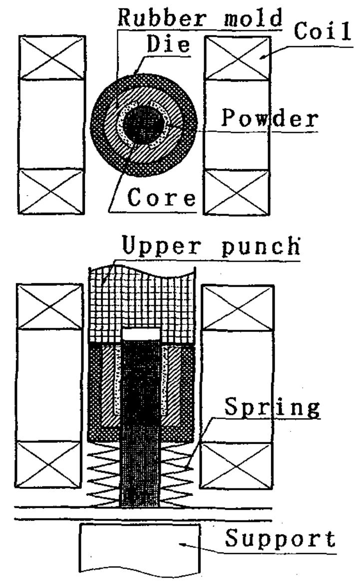

Fig. 2 RIP setup for arc-segment ferrite magnets

The degree of orientation for the high coercivity magnet was 96 %. It is likely that agglomeration of the powder was not completely eliminated during drying. Even so, the level of the magnetic properties of the high coercivity magnet is extremely high considering that this magnet is prepared by dry pressing. In addition, it should be noted that a dry powder as fine as 0.3 μm was compacted easily in perfect shape by RIP. By ordinary die pressing, compaction of such fine dry powder of ferrite would be impossible without mixing a large quantity of organic binder. If wet pressing is used, compaction of such powder may be possible, but filtration problem would be serious.

In Fig. 2 is shown an RIP setup for arc segments that was developed for ferrite magnets. In this setup, the magnetic field for the alignment is applied perpendicular to the direction of the pressing axis. The core, that contacts the internal curvature of the arc segments, has to consist of hard material like metal: if this part is made of rubber, the compacts would always have vertical cracks. If the die is made of non-magnetic metal and the core of magnetic metal, the arc segments have radial orientation. It has proved that arc-segment ferrite magnets having excellent magnetic properties can be produced in good shape by the setup shown in Fig. 2 in the laboratory, and development of automated RIP apparatus installing this setup is in progress.

Acknowledgment

We thank H. Taguchi of TDK and H. Nobuhara of MATE Co.,Ltd for providing ferrite powders used in our experiments in the present paper.

Reference

[1] M. Sagawa, H. Nagata, *IEEE Trans MAG*,29 (1993) 2747
[2] M. Sagawa, H. Nagata, O. Itatani, T. Watanabe, *Proc. of 13th International Workshop on Rare Earth Magnets and their Applications,* (1994) supplement 13
[3] H. Taguchi, F. Hirata, T. Takeishi, T, Mori, *Digests of 6th International Conf. On Ferrite* (1992) 306