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Effects of the lubricants on the magnetic properties of hot deformed NdFeB magnets

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1. Introduction

Anisotropic NdFeB magnets are obtained by hot working[1,2] rapidly quenched NdFeB powders, and some lubricants are known to improve their hard magnetic properties[3]. The single stroke hot deformation(SSHD) is a simple method for the fabrication of anisotropic NdFeB mangets [4, 5]. In order to improve the magnetic properties of NdFeB magnets, we added some lubricants to commercial NdFeB powders. The added materials were MoS_2, Al, BN, Sb, Zn, Si, C, oleic acid and diethylene glycol, etc. The effects of these lubricants on the magnetic products were studied in this work.

2. Experiments

Starting materials for the experiments were commercial isotropic NdFeB powders of MQPA, MQPB and MQPB+(Magnequench). In order to increase flow ability during plastic deformation, small amounts of lubricants with powder or liquid type were added to the magnetic powders. The lubricants MoS_2, Al, BN, Sb, Zn, Si, and C were in the state of powder with the particle size smaller than 45 micrometers. They were mixed with NdFeB powders mechanically. The lubricants of oleic acid and diethylene glycol were in liquid state. They were dissolved in acetone and mixed with MQPA (B, B+) powder and dried. The amount of the lubricants varied was in the range of 0.2 - 1.0 wt%. The mixed powders were filled into a copper tube then pressed in an argon gas atmosphere at 700 ℃ with a press speed of 0.7 mm/s. The magnetic properties were measured by a hysteresisgraph system under a maximum applied field of 1600 kA/m (~20 kOe) after premagnetization at 7200 kA/m (~90 kOe).

3. Results and discussion

Fig. 1 shows the dependence of the magnetic properties of NdFeB magnet made from MQPA on the amount of some lubricants. Among the lubricants mentioned above, MoS_2 and Al were the most effective to increase remanence. The largest increment in remanence and maximum energy product was observed at the amount of 0.6 wt% MoS_2 and 0.2 wt% Al. The increase of the remanence was about 10 % and that of maximum energy product was about 25 %. In addition, Al addition increases coercivity while MoS_2 decreases.

Zn was found the most effecctive for the increase of coercivity among the lubricants. The addition of 0.4 wt% zinc increased ${}_iH_c$ by about 60 %. Low melting point of Zn is considered to increase coercivity.

The effects of other lubricants, such as graphite, oleic acid and diethyene glycol were also examined. However, they did not improve the coercivity or remanence. The results are opposite with those obtained by K.Iwasaki, et al[5]. They reported that inorganic lubricants of BN, MoS_2, and graphite and the organic lubricants of oleic acid and diethyene glycol improve hard magnetic properties.

MQPB and MQPB+ powders have low Nd-content and anisotropy are not obtained by hot deformation. In order to know the effects of lubricants, we also mixed the lubricants with MQPB and MQPB+ powders and hot deformed. However, the hard magnetic properties obtained were poor with coercivity of 4~9 kOe, remanence of 7~10 kG and energy product of 11~15 MG.Oe. Obviously the lubricants did not endow the magnet with magnetic anisotropy. It is conjectured that the lubricants only help the particle sliding during hot deformation and do not penetrate into the grain boundaries.

4. Conclusion

Several kinds of lubricants have been investigated in this work. They have differents effects to the magnetic properties. MoS_2 and Al increase remanance and energy product effectively; Zn increases *i*Hc considerably. Graphite, gallium, oleic acid and diethyene glycol deteriorate the magnetic properties. Some results are different with those obtained from die upsetting process.

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Reference

[1] R. W. Lee, Appl. Phys. Lett., 46(1985)799

[2] J. J. Croat, V. Panchanathan, K. H. Sese, Proceedings of the 10th International Workshop on Rare-Earth Magnets and Their Applications, Tyoto, Japan, 1989, p.429

[3] K.Iwasaki , S. Tanigawa and M. Tokunaga, IEEE Transactions on Magnetics, Vol. 26(5),

[4] Li Ying, Y. B. Kim, M. J. Kim, M. S. song, J. H. Yang, T. K. Kim, C. O. Kim, J. Materials science & Technology, 2000(3), 129

[5] Ying Li, Y. B. Kim, M. J. Kim, D. S. Suhr, T K. Kim, C. O. Kim, Intermag2000, HR-01

Fig. 1 The effects of lubricants on magneti properties.