Development of Heavy-Rare-Earth-Free Hot-deformed Nd-Fe-B Magnets and Their Practical Realization for Traction Motors

Keiko Hioki : Daido Steel Co., Ltd.

Nd-Fe-B magnets exhibit the highest maximum energy product, $(BH)_{max}$, of all the permanent magnet materials. They have been mainly used in motors and made a significant contribution to clean energy technologies. Especially, the demand for traction motor of hybrid electric vehicles (HEVs) and electric vehicles (EVs) has been rapidly increasing in recent years. Since the magnets for the traction motors are used in high temperature environment, they are required to have both the high remanence and high heat resistance. In general, heavy rare earth elements (HREEs) such as Dy and Tb are added to improve coercivity for high temperature applications. However, HREEs' supply is unstable because they are not abundant and are distributed unevenly. Taking the increase of the production of HEVs into consideration, it is important and urgent problem to reduce HREEs consumption in Nd-Fe-B magnets.

In order to improve the coercivity without adding HREEs, it is known that to modify the microstructure is effective because there is a strong correlation between magnetic property and microstructure. It was proved that the fine microstructure brings both the reduction of HREEs content and better heat resistance[1]. Besides, some microstructure observations and calculations indicate that magnetically isolating the main phases also improve coercivity[2].

Hot-deformed Nd-Fe-B magnet has fine (200~500 nm) and highly orientated crystal grain microstructure due to its unique production process. We optimized its chemical composition and hot-deformation process, and consequently succeeded in obtaining well-controlled fine microstructure which shows excellent magnetic properties (Fig. 1). New motor design was also conducted to realize the traction motor with HREE-free Nd-Fe-B magnet[3] (Fig.2). I will mainly present the details of the development of HREE-free magnets in the conference.

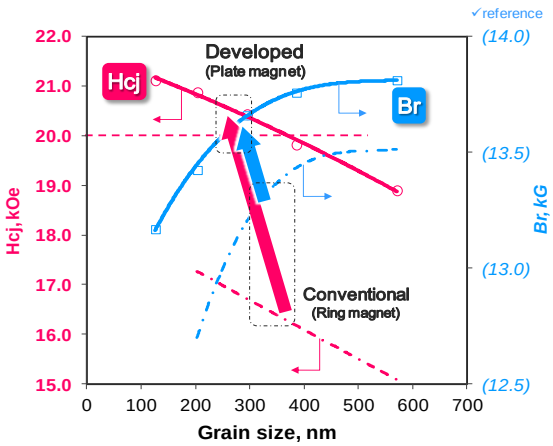

Fig. 1 Magnetic properties of conventional and developed magnets.

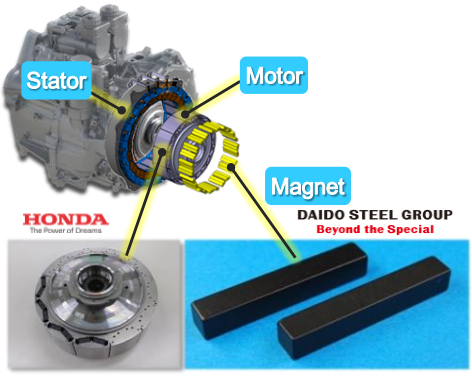

Fig. 2 Newly-designed motor.

Bibliography

[1] K. Hioki, et.al; J. Magn. Soc. Jpn, **38**, 79 (2014).

[2] J. Liu, et.al; Acta Mater., **61**, 5387 (2013).

[3] S. Soma, et al; SAE Int. J. Alt. Power. **6(2)**, 290 (2017).