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Development of a "top-down" production route for Nd-Fe-B magnets

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Abstract

The goal of the Pioneer Fund project is the validation of this process for further implementation in industrial production. The manufacturing process for permanent magnets offers varied advantages compared with the conventional sintering process, such as a lower number of manufacturing steps, higher efficiency as well as lower energy consumption. Achievements in this project include increasing the level of market readiness and discovering new development opportunities for more targeted commercialization.

Project description

Permanent magnetic materials play an increasingly important role for technologies in the fields of energy generation, mobility, as well as in automation and entertainment industry. The production of permanent magnets has taken a strong upturn in the last decade, and the demand for magnets has increased dramatically due to the increasing automation, as well as the change from combustion engines to electromobility.

Due to their high magnetic energy density, the neodymium-iron-boron (Nd-Fe-B) alloys are among the most important permanent magnet materials. However, this alloy is permanent-magnetic only if it has a specific microstructure (e.g. as small as possible grain-size and magnetic texture). The conventional Nd-Fe-B magnets production nowadays takes place via a powder metallurgical route through sintering, which is a complex manufacturing process and associated with high costs in the value added.

In the project „New top-down synthesis methods" of the LOEWE RESPONSE project at the TU Darmstadt, a forming process route was developed and patented by the departments PtU, PhM and FM starting from Nd-Fe-B castings. The goal of this process route is a cheap and efficient production of Nd-Fe-B permanent magnets compared to the classical powder route by means of a continuous forming process. The previous results have demonstrated the high potential of this process route by achieving significant magnetic hardening (increase in remanence and coercivity).

Results

Two main objectives were achieved within the project: The influence of different alloy compositions was investigated. Upsetting in combination with ultrasonic treatment was used as a successful post-treatment. The starting point of the project was an observed mechanism of grain refinement during rotary swaging, which was scientifically proven (patent: DE 102018105250.2 and publication: Fansun Chi et al, Towards manufacturing of Nd-Fe-B magnets by continuous rotary swaging of cast alloy, Journal of Magnetism and Magnetic Materials 490, 165405 (2019)), i.e., the process possessed a TRL between 3 and 4. The development in the project increased the magnetic properties of the products and made it possible to better control the process and increase the reproducibility of the results. Therefore, a TRL of 5 can now be applied. In addition, possibilities for upscaling the process volume were investigated, also in order to develop the possibility of continuous production.

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