Friedrich-Alexander-Universität
Erlangen-Nürnberg

LEHRSTUHL
FÜR KUNSTSTOFFTECHNIK
Prof. Dr.-Ing. Dietmar Drummer

Polymer Bonded Magnets

Motivation

Polymer bonded magnets are composite materials consisting of a polymeric matrix with embedded hard magnetic fillers. The filler grade defines the maximum of the magnetic properties and is limited by the viscosity of the compound up to 60 vol.-% in terms of a thermoplastic and 70 vol.-% in terms of a thermoset matrix. The injection molding process enables polymer bonded magnets to be realized with a high degree of freedom in geometry and magnetization structure, a high size accuracy even for small and thin shaped samples and an integration of function elements. Thermoset based polymer bonded magnets further obtain a higher chemical permanence and thermal resistance relative to a thermoplastic matrix. Due to the lower viscosity of thermosets, higher filler grades and a more homogenous orientation can be reached.

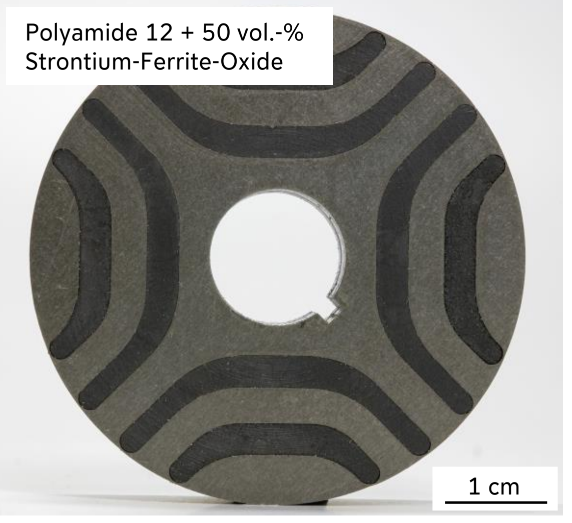

Fig. 1: Rotor of a reluctance motor based on polymer bonded magnets

Application

Polymer bonded magnets are mainly utilized in the fields of sensor and drive technologies, whereby the main application within the drive technology is the magnetic excitation of synchronous or direct current (DC) machines (Fig. 1 and Fig. 2). Thermoset based polymer bonded magnets expand the application field by meeting the demands of cooling water pumps or the chemical industry.

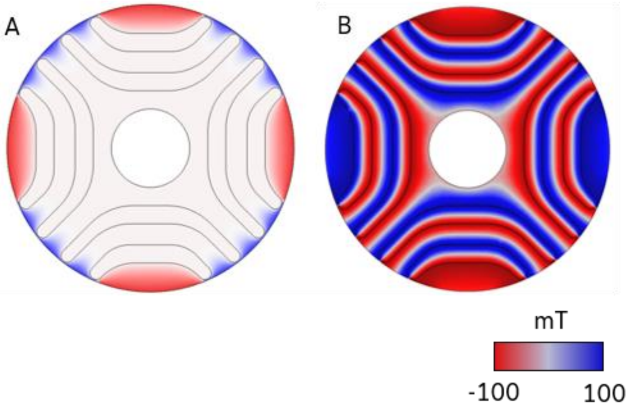

Fig. 2: Magnetic flux density in the rotor reached by:
A) standard reluctance motor
B) polymer bonded magnets

| Institute of Polymer Technology
| Am Weichselgarten 10 | 91058 Erlangen-Tennenlohe, Germany
| Phone: +49 9131 85 710 00 | Fax: +49 9131 85 710 07
| Mail: lkt-info@fau.de | https://www.lkt.tf.fau.eu/

Research focus

To extend the application fields of polymer bonded magnets by using a thermoset based matrix, a detailed study of the flow and curing behavior as well as the reaction kinetics is required. Therefore, investigations are held in terms of the influence of the matrix type, the hard magnetic filler type and grade on the viscosity of the compound with respect to time and temperature. These results are further correlated with the magnetic and mechanical properties of polymer bonded magnets.

Main research results

The reaction kinetics is mainly influenced by the heat capacity of the matrix and the thermal conductivity of the hard magnetic filler leading to a lower specific enthalpy and a shift of the reaction to higher temperatures. The minimum of the viscosity is significantly reduced by using a thermoset matrix relative to a thermoplastic one (Fig. 3). Within the thermoset based magnets, mainly the filler and the filler grade influence the viscosity with respect to the network structure. This network structure is based on the integration of fillers into the three dimensional chemical thermoset network (Fig. 4) and relies on the presence and possibility of reaction between functional groups of the filler and the matrix as well as the cross linking density of the matrix. The influence of the material system onto the mechanical and magnetic properties correspond with the network structure as for example a high filler integration in the network hinders the orientation of particles by an outer magnetic field and reduces the elastic properties leading to high stiffness and less elongation at break.

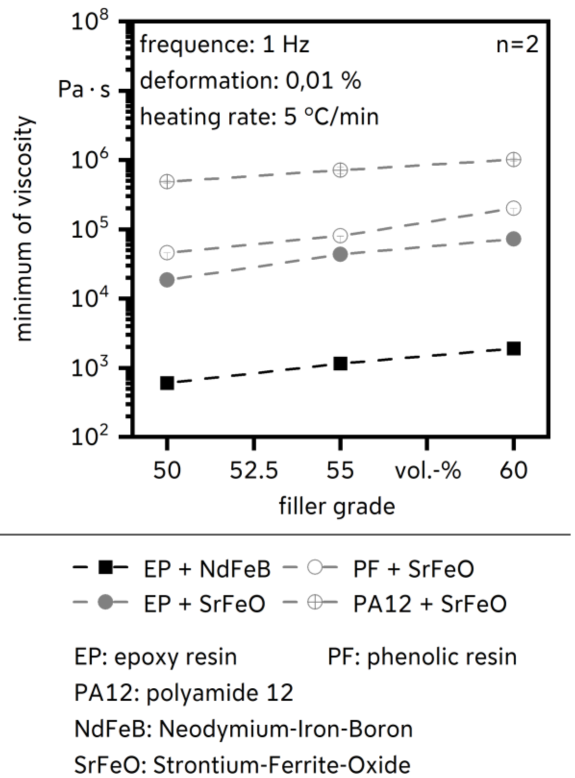

Fig. 3: Minimum of viscosity relativ to material system

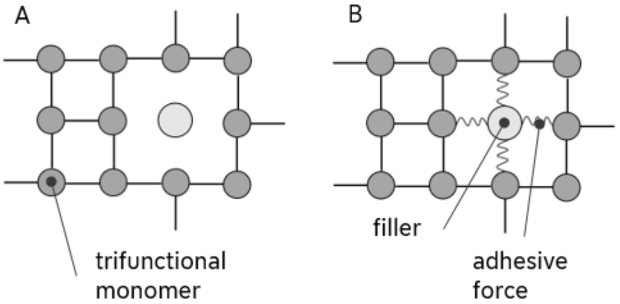

Fig. 4: Network structure:
A) without adhesive force
[example: Neodymium- Iron-Boron]
B) with adhesive force
[example: Strontium-Ferrite-Oxide]

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