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Polymer Bonded Magnets

Sensor Applications

Barcode zu Ansprech-partner und Infomaterialien

Motivation

Polymer bonded magnets are composite materials consisting of a polymeric matrix with embedded hard magnetic filler particles. These magnets can be cost-effectively produced in injection molding, which enables the production of parts in high quantities with very narrow tolerances and, at the same time, the integration of functional parts such as shafts or bushings. In comparison to conventionally sintered magnets, polymer bonded magnets offer a high degree of freedom in geometry and magnetizing structure due to the injection molding process. Furthermore, by embedding particles in the polymer matrix, the risk of corrosion is significantly reduced.

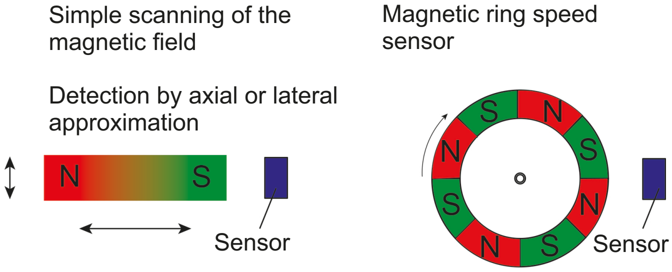

Fig. 1: Application example for polymer bonded magnet sensor applications

Application

Typical applications for polymer bonded magnets are sensor systems, actuators as well as holding magnets. In magnetic sensor systems, polymer bonded magnets are often used as multipolar encoders in combination with an electronic sensor, e.g. a hall sensor, in order to measure movement, such as turning direction, speed, angle or position of machine elements. In response to the magnets' linear or rotative relative movement, the sensor measures the changing magnetic field, which can be further evaluated digitally (Fig. 1). The demonstrator shown in Fig. 2 is a good example for the high potential that comes with the integration of polymer bonded magnets. The integrated magnetoresistive sensor generates an electric signal proportional to the rotation of the bipolar magnet in a range from 0° to 180°. The complete assembly is manufactured in one mold with different materials in order to generate a movable connection between carrier and magnet. Depending on the specific applications, certain requirements of the magnetic properties, such as a high peak flux density or an accurate pole length, have to be achieved.

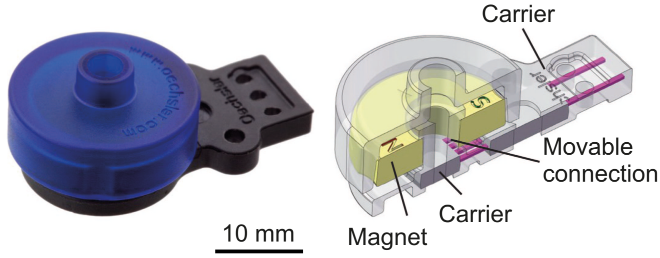

Fig. 2: Rotary encoder and specific construction (demonstrator developed in cooperation with Oechsler AG)

Injection Molding with Integrated Magnetic Field

In order to utilize the full potential of anisotropic filler materials, the particles have to be oriented during the injection molding process until the filler orientation is fixed by the re-solidified polymer (Fig. 3). Therefore, a magnetic field has to be integrated into the mold, which can be achieved by the integration of magnetic coils or sintered magnets. In order to achieve precise pole structures, both the design of the magnetic field inside the mold and precision during manufacturing are of major importance. The magnetic field orientation has to be exactly defined in regard to tits strength and direction.

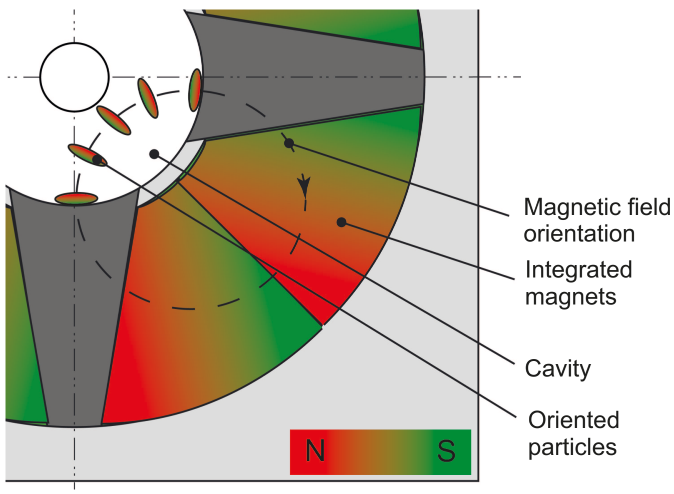

Fig. 3: Orientation of filler particels during the injection molding process

Influences during Injection Molding

The magnetic properties are defined by the filler type, e.g. ferrites (SrFeO) or rare earth fillers (NdFeB), the filler content as well as the degree of orientation of the fillers. Magnetically anisotropic fillers are aligned during the injection molding process, which leads to a higher degree of orientation and thus significantly increased magnetic properties. The degree of orientation depends on the strength of the field, the melt viscosity and the process parameters. An anisotropic filler material has a preferred direction regarding its orientation in a magnetic field and depending on the shape of the filler material (Fig. 4). Therefore, the alignment and orientation of the anisotropic filler during injection molding is also affected by the shape of the filler. For multipolar magnets, different quality criteria, such as the peak flux density or the pole length accuracy are of major importance (Fig. 5). The pole length accuracy is influenced by different factors, such as compound composition, processing parameters or part design, desired pole length or gating system. Current research activities deal with the elaboration of the fundamental influencing factors during the injection molding process on the properties of polymer bonded magnets. For this, the entire process chain is considered, including all previously mentioned influencing factors. Furthermore, there is an attempt to differentiate between the influence of different processing parameters in the injection molding process by investigating in alternative production techniques. For example, the influence of the holding pressure can be examined using the pressing method. In this way, the impact of the holding pressure on the part properties can be isolated and examined separately.

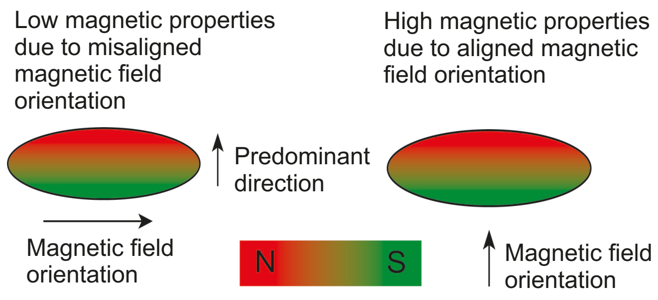

Fig. 4: Dependence of magnetic properties on predominant direction of anisotropic filler material

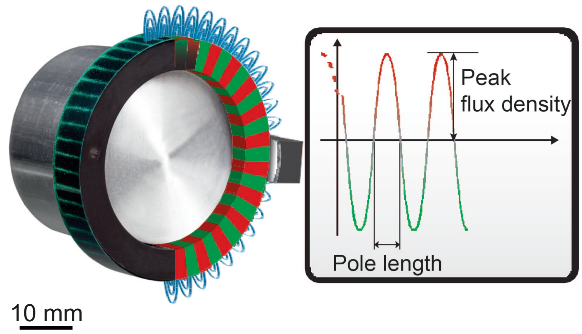

Fig. 5: Injection molded signal transmitter with flux density curve

Simulation

The aim of the simulation is the prediction of the final magnetic properties of the injection molded parts as a result of the mold and part design as well as the material properties of the compound. The simulation can be used for mold design as well as the design of the final parts and its magnetic properties. For the simulation, the magnetic properties of the integrated sintered magnets and the mold materials (e.g. magnetic conductivity) are implemented. In the first simulation step, the directional field strength and direction is calculated for each finite element in the cavity. Based on the magnetic properties of the compound as a function of the field strength, in a second simulation step, the resulting magnetic properties of the molded part are calculated. Fig. 6 shows the influence of the filler material on the flux density in the cavity using the same integrated magnetic field. The modeling and simulation of the entire process chain and thus the improvement of the understanding of each single influencing factor is a comprehensive objective for all work. The correlation between material properties, such as the compound, the process parameters and the part design have to be portrayed within the simulation. Though even there is the opportunity to simplificate the issue, the real state of the case of the application has to be depicted as accurately as possible. Although, it is possible to reduce the complexity by simplifications, th eactual state of the case must be portrayed as accurately as possible. Current research activities focus on a realistic representation of the entire process chain, taking the interrelationships and the representation of various attributes such as magnetic or thermal properties into account.

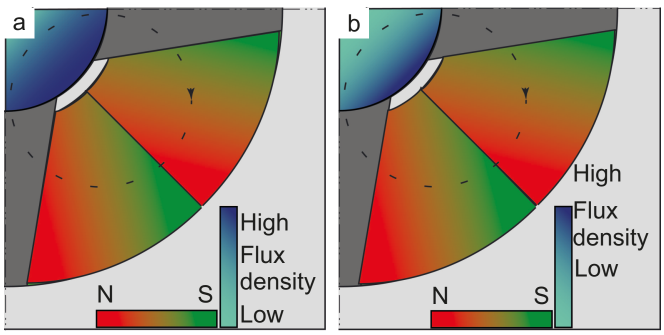

Fig. 6: Simulated flux density in the cavity with different filler materials (a) NdFeB, (b) SrFeO)

Research Objects and Service for Industry

- Thermoplastic and thermoset injection
- Molding of magnets
- Development of magnetic compounds
- Simulation of magnetic molds
- Testing of polymer bonded materials/ parts
- Failure analysis

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