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Effects of Injection Conditions on the Mechanical Properties of Nd-Fe-B Dielectromagnets

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Injection molding is one of the methods to prepare dielectromagnets - permanent magnets made from hard magnetic powder (or from mixture of powders) bonded by dielectric materials. Magnetic properties of dielectromagnets are worse than those of sintered magnets made from the same hard magnetic powders, but this type of the permanent magnet has many advantages. One of them is simpler technology - easier in comparison to the technology of sintered magnets. The injection molded dielectromagnets do not need any final treatment. This technology permits to control magnetic, thermal and mechanical properties of dielectromagnets. The main characteristics of dielectromagnets are magnetic properties, however mechanical properties have serious influence onto a range of their applications. The main factors shaping mechanical properties of dielectromagnets are the kind and quantity of resin and the technology. The injection molded dielectromagnets from melt-spun ribbon Nd-Fe-B were used in research. The purpose of this investigation was to find the correlation between injection conditions and the mechanical properties of dielectromagnets. Influence of two parameters of injection, temperature and pressure on mechanical and magnetic properties were analysed. In the range of injection temperature and pressure magnetic properties of dielectromagnets were not significantly changed. Increasing of pressure of injection also does not influence on mechanical properties of analysed samples, however increasing of temperature of injection significantly improved both compression and bending strength.

1. Introduction

In the last years, a considerable spreading of applications of permanent magnets is observed. It is connected with development of the electrical micromachines and electronic equipments such as cameras, faxes, loud-speakers, where permanent magnets are used. Development of the electric and electronic equipment depends directly on the development of magnetic materials with different magnetic, thermal, mechanical and technological properties. The price of magnets is also important, and it often decides the application of the magnets. High price is a weakness of sintered magnets based on rare earth metals. It is connected with high price of components and complicated technology. The sintered magnets require also the final treatment due to shrinkage after sintering, and they are brittle.

Permanent magnets which allow partly to avoid disadvantages of the sintered magnets are dielectromagnets-permanent magnets prepared from hard magnetic powder bonded by resin. Dielectromagnets are also known as bonded magnets. Advantages of dielectromagnets spread their applications constantly. This kind of dielectromagnets meets needs of many applications due to their characteristics: good magnetic properties, corrosion resistance and the price lower than that the sintered magnets. The technology of dielectromanets enables to control magnetic, thermal and mechanical properties of the product [1-3]. Magnetic properties of all magnetic materials are very important feature, but very often, in many applications, mechanical properties are also important. Sometimes it is impossible to use the magnet with very good magnetic characteristics due to its bad mechanical properties. Mechanical properties depend on used materials and technology. Very good hard magnetic material for dielectromagnets is a powder from melt-spun ribbon Nd-Fe-B and technology of injection molding.

The aim of this investigation is to find a correlation between parameters of the technology of dielectromagnets made from Nd-Fe-B prepared by injection molding and its magnetic and mechanical properties.

2. Experiments

The kind and quantity of hard magnetic powder, the kind and quantity of resin and parameters of technological process determine the properties of the dielectromagnets made by injection molding. In experiment, influence of parameters of technology process, the temperature and the pressure of injection molding onto magnetic and mechanical properties of dielectromagnets was analysed.

In this experiment, mixture of hard magnetic powder with

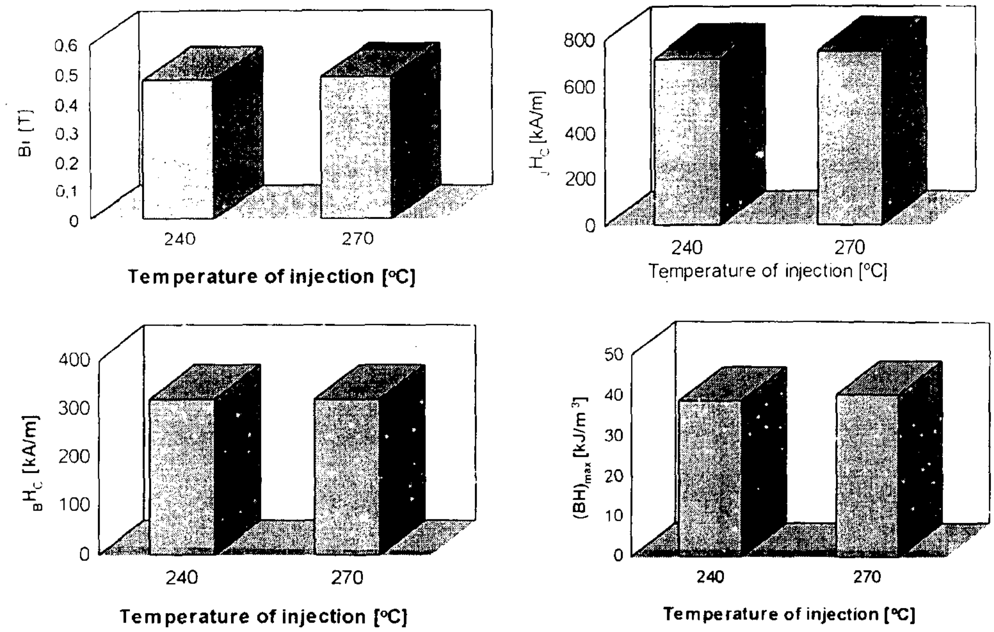

Fig. 1. Influence of the temperature of injection on magnetic properties of the injection molded dielectromagnets.

resin Grlamid XE3591 by EMS-CHEMIE AG, was used. Ready to use mixture is based on Nd-Fe-B as hard magnetic powder and Polyamid 12 as a resin [4]. Samples were prepared on a piston injection machine under following parameters of processes:

- temperature of injection 240 °C and 270 °C,
- pressure of injection 60 MPa and 80 MPa.

The magnetic properties of the injection molded dielectromagnets were measured with Permagraph - Hysteresisgraph at room temperature. The mechanical properties of samples, compressive strength and bending strength, were measured on laboratory testing machines.

3. Results and Discussion

The magnetic properties of injection molded dielectromagnets made from Grilamid XE3591 under different temperatures of injection, were measured. Results are shown in Fig. 1. As shown in Fig. 1, the increase of the temperature of injection from 240 °C to 270 °C does not cause the

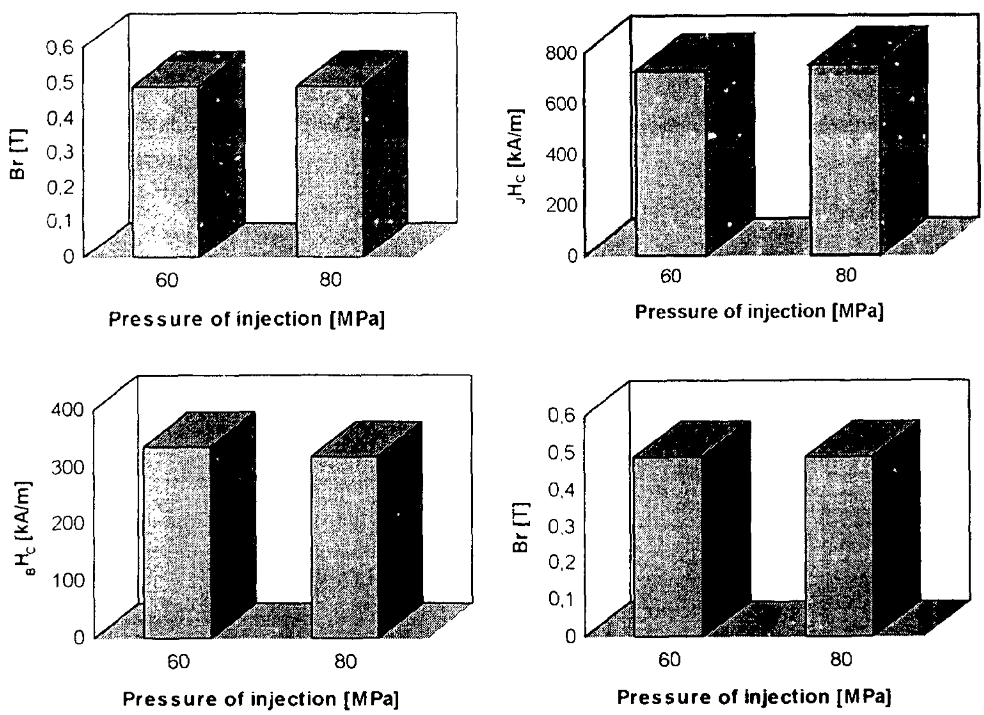

Fig. 2. Influence of the pressure of injection on magnetic properties of the injection molded dielectromagnets.

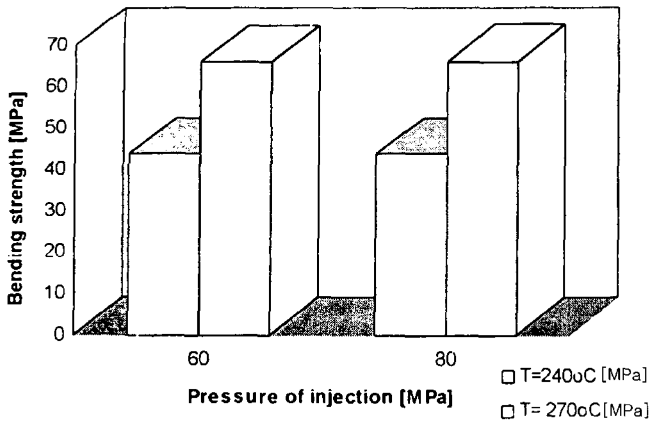

Fig. 3. Influence of the temperature and the pressure of injection process on bending strength of the injection molded dielectromagnets.

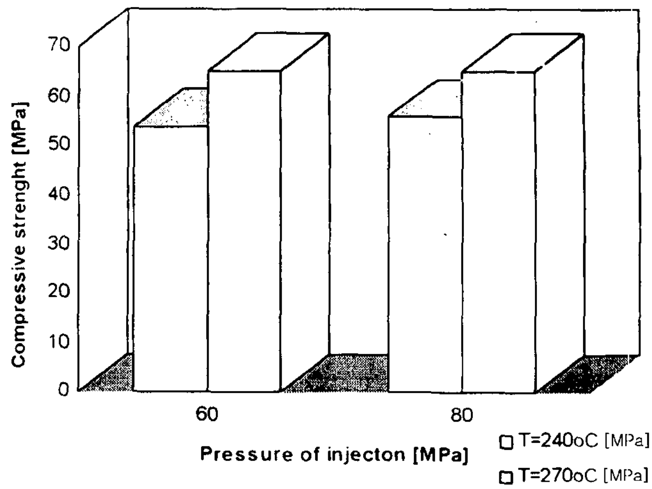

Fig. 4. Influence of the temperature of injection and the pressure of injection on compressive strength of the injection molded dielectromagnets.

essential change in magnetic properties: remanence, coercivity and energy product.

Figure 2 shows the influence of the pressure of injection on magnetic properties of the samples. Value of remanence B_r, coercivity $_JH_C$ and $_BH_C$ and maximum energy product $(BH)_{MAX}$ of the injection molded dielectromagnets are not showing essential changes with increasing the pressure of injection from 60 MPa to 80 MPa.

Three points bending test of prepared samples was performed. The influence of temperature and the pressure of injection process on the bending strength of the dielectromagnets was investigated, and the result is shown in Fig. 3. Figure 3 shows essential improvement of bending strength of injection molded dielectromagnets with increasing the temperature of the injection process. However, influence of the pressure of injection on bending strength of samples was not observed.

The results of measurements of compressive strength of samples prepared under the same conditions is shown in Fig. 4. Compressive strength of the injection molded dielectromagnets increase with increasing the temperature of injection, but increase of pressure of injection does not change the compressive strength of the samples.

4. Summary

The investigation indicated that, for the Nd-Fe-B dielectromagnets made by injection molding, the essential changes of the magnetic parameters of the samples with change of the temperature from 240 °C to 270 °C and the pressure from 60 MPa to 80 MPa of injection have not been found. Also the increase of the pressure of injection has not increased bending and compression strength of the injection molded samples. However, increasing of the temperature of injection improved the bending and compression strength of the Nd-Fe-B dielectromagnets by 50% and 20%, respectively.

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