DIELECTROMAGNETS FROM MIXTURE OF HARD MAGNETIC POWDERS FOR SMALL ELECTRICAL MOTORS

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Abstract Dielectromagnets are permanent magnets made from resin-bonded hard magnetic powders. Magnetic properties of dielectromagnets depend on kind of used hard magnetic materials as chemical compound, shape, size of grain and applied technology. Comparison of advantages and disadvantages of dielectromagnets made from different kind of magnetic powders induced us to try to prepare dielectromagnets from mixture of hard magnetic powders, not only one of them. The purpose of investigation on this kind of dielectromagnets is to find formula to prepare permanent magnets with properties adequate to different kind of electrical motors requirements. As hard magnetic materials we used powders of ferrite, melt-spun ribbon Nd-Fe-B and Alnico. Papers present results of investigation on technology of this kind of dielectromagnets. It shows also influence of kind of mixture and used technology on magnetic properties of dielectromagnets.

I. INTRODUCTION

Dielectromagnets are permanent magnets made from hard magnetic powder bonded by resin.

Magnets of this kind have many advantages. One of them is easier technology of production in comparison with sintering magnets. This technology permits also to eliminate final treatment of magnets. Technology of dielectromagnets enables to form more complicated shapes of magnets, giving in result that magnetic energy is used more effective in motors using this types of magnets.

This is a reason why dielectromagnets are more economic than sintering magnets. Their magnetic properties are worse than magnetic properties of sintering magnets but sufficient to many applications.

Properties of dielectromagnets depend on kind of hard magnetic powder, used technology and kind of resin.

As hard magnetic powders are mainly used: powders of strontium ferrite, powders of barium ferrite, powders of Sm-Co alloys and powders of melt-spun ribbon Nd-Fe-B.

Dielectromagnets from this kind of powders have different properties. Dielectromagnets prepared from powdering melt-spun ribbon Nd-Fe-B have high value of magnetic properties, but their weakness is value of temperature coefficient of H_{cJ}. They are high in price on the market.

Dielectromagnets prepared from ferrite powders have low value of magnetic properties, but their advantages is positive value of temperature coefficient of H_{cJ} and of course low price level.

Different kind of permanent magnets is Alnico. They are mainly casted. Their advantage is high value of remanence and high thermal stability.

Comparison of properties and analyse of advantages and faults of different kinds of permanent magnets generated idea

of preparing dielectromagnets from mixture of hard magnetic powder not only one of them.

Paper presents initial research on this kinds of dielectromagnets.

II. EXPERIMENTAL

There are two methods of preparing bonded by resin magnets. One of them is pressing powder and then impregnating samples in vacuum with two-component exposy resin. The second method is pressing mixture of hard magnetic powders with one-component resin, and then curing compacts.

The second method of preparing dielectromagnets was used in our experiments; this method is described in [1, 2,3].

As hard magnetic material were used powder of melt-spun ribbon Nd-Fe-B, made by General Motors - MQP-D, strontium ferrite powder, and powdered Alnico.

Mixture of melt-spun ribbon Nd-Fe-B and strontium ferrite powders have following composition:

75 wt.% MQP-D + 25 wt.% strontium ferrite
50 wt.% MQP-D + 50 wt.% strontium ferrite
25 wt.% MQP-D + 75 wt.% strontium ferrite

Mixture of melt-spun ribbon Nd-Fe-B powder and Alnico powder have following composition:

75 wt.% MQP-D + 25 wt.% Alnico powder
50 wt.% MQP-D + 50 wt.% Alnico powder
25 wt.% MQP-D + 75 wt.% Alnico powder

As resin was used one-component epoxy-resin Epidian 100.

The magnetic properties were measured with Permagraph-Hysteresisgraph made by Electro-Physic, at room temperature.

The structure was determined with scanning electron microscope type JSM-5 of JEOL production and metallographic microscope type MeF-2 of Reichert production.

III. RESULTS AND DISCUSSION

Table 1. shows magnetic properties of dielectromagnets prepared from mixture of melt-spun ribbon Nd-Fe-B and strontium ferrite powders at room temperature.

Table 1 Magnetic properties of dielectromagnets prepared from mixture of melt-spun ribbon Nd-Fe-B and strontium ferrite powders.

Composition	Br kGs	H_{ci} kOe	H_{cb} kOe	$(BH)_{max}$ MGsOe
75 wt.% MQP-D + 25 wt.% strontium ferrite	4,4	11,0	3,8	4,4
50 wt.% MQP-D + 50 wt.% strontium ferrite	3,0	9,1	2,4	1,96
25 wt.% MQP-D + 75 wt.% strontium ferrite	2,0	5,0	1,6	0,9

Figure 1 shows the demagnetization curves of these kind of dielectromagnets at room temperature.

For comparison figure 1 shows the demagnetization curves of dielectromagnets prepared from only one component: melt-spun ribbon Nd-Fe-B (curve 1a) and strontium ferrite (curve 1e)

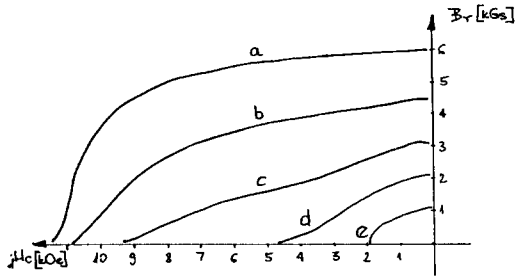

Fig. 1 Demagnetization curves at room temperature of dielectromagnets from hard magnetic powders: a- MQP-D, b- 75 wt.% MQP-D + 25 wt.% strontium ferrite, c- 50 wt.% MQP-D + 50 wt.% strontium ferrite, d- 25 wt.% MQP-D + 75 wt.% strontium ferrite, e- strontium ferrite.

Table 1 and figure 1 show changes of magnetic properties of dielectromagnets from different contents of melt-spun ribbon Nd-Fe-B and strontium ferrite powders in mixture. Of course magnetic properties decreases with decreasing content of

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melt-spun ribbon Nd-Fe-B powder in dielectromagnets, but decreasing of H_{ci} is relatively slow. All dielectromagnets with MQP-D powder have magnetic properties better than dielectromagnets prepared from strontium ferrite only.

Table 2 lists magnetic properties of dielectromagnets from mixture of melt-spun ribbon Nd-Fe-B powder and Alnico powder measured at room temperature.

Table 2 Magnetic properties of dielectromagnets prepared from mixture of melt-spun ribbon Nd-Fe-B powder and Alnico powder.

Composition	Br kGs	H_{ci} kOe	H_{cb} kOe	$(BH)_{max}$ MGsOe
75 wt.% MQP-D + 25 wt.% Alnico	5,4	8,0	3,2	4,0
50 wt.% MQP-D + 50 wt.% Alnico	4,2	4,0	1,9	1,68
25 wt.% MQP-D + 75 wt.% Alnico	3,3	1,6	1,1	0,72

Figure 2 shows the demagnetization curves of dielectromagnets prepared from these powders. Demagnetization curves of dielectromagnets from MQP-D and Alnico powders permit to compare magnetic properties of these dielectromagnets with properties of dielectromagnets prepared from mixture of these powders.

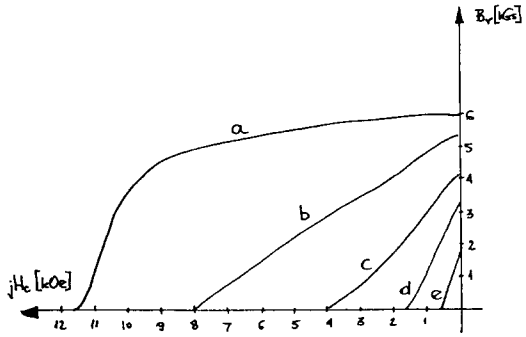

Fig. 2 Room temperature demagnetization curves of dielectromagnets from hard magnetic powders: a- MQP-D, b- 75 wt.% MQP-D + 25 wt.% Alnico powder, c- 50 wt.% MQP-D + 50 wt.% Alnico powder, d- 25 wt.% MQP-D + 75 wt.% Alnico powder, e- Alnico powder.

Table 2 and figure 2 show the change of magnetic properties with the change of mixture composition. In this case decreasing of remanence with increasing Alnico powder contents is relatively slow. Alnico casted magnets have high value of remanence and very low value of coercivity.

The metallographic investigations show changes of dielectromagnets structure with changes of their composition. Figure 3 shows a scanning electron micrographs of the fracture surface dielectromagnets from mixture of MQP-D powder and strontium ferrite.

Long, flat grain of MQP-D powder are surrounded by fine grain of ferrite.

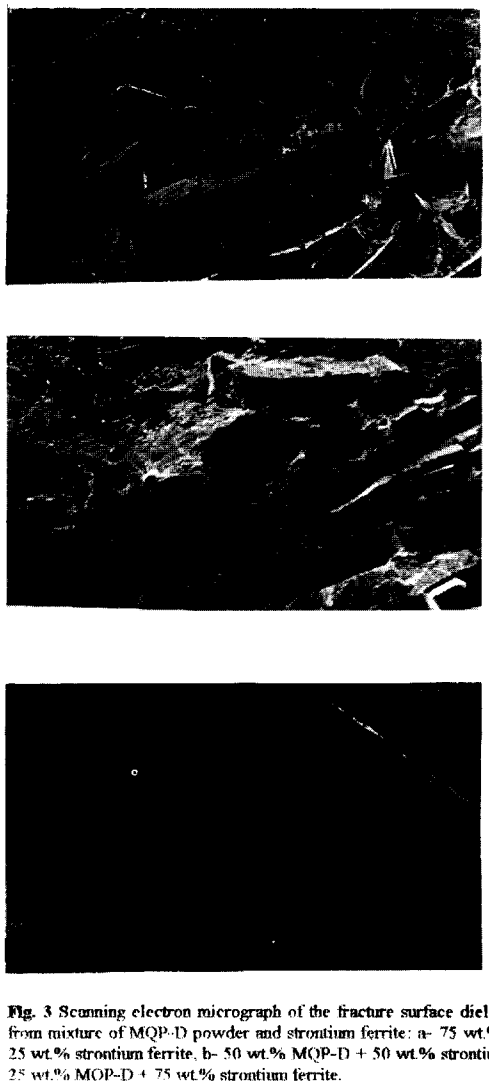

Fig. 3 Scanning electron micrograph of the fracture surface dielectromagnets from mixture of MQP-D powder and strontium ferrite: a- 75 wt.% MQP-D + 25 wt.% strontium ferrite, b- 50 wt.% MQP-D + 50 wt.% strontium ferrite, c- 25 wt.% MQP-D + 75 wt.% strontium ferrite.

Figure 4 shows a scanning electron micrographs of the fracture surface dielectromagnets from mixture of melt-spun ribbon Nd-Fe-B powder and Alnico powder. These micrographs show long, flat grain of MQP-D powder surrounded by grain of powdered Alnico.

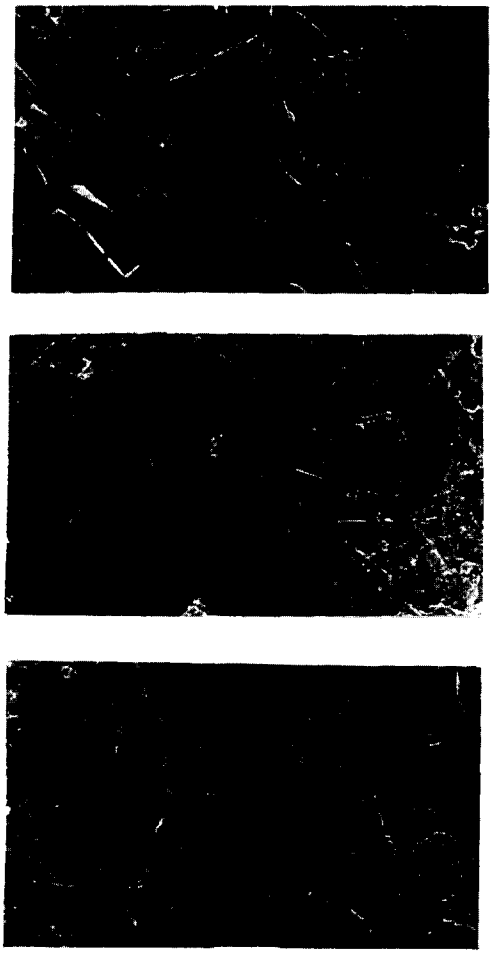

Fig. 4 Scanning electron micrograph of the fracture surface dielectromagnets from of MQP-D powder and Alnico powder: a- 75 wt.% MQP-D + 25 wt.% Alnico powder, b- 50 wt.% MQP-D + 50 wt.% Alnico powder, c- 25 wt.% MQP-D + 75 wt.% Alnico powder.

To summarize we have to state that dielectromagnets prepared from mixture of melt-spun ribbon Nd-Fe-B and strontium ferrite show very promissing magnetic properties. Increasing of strontium ferrite contents in mixture induce decreasing of coercive force as we expected but relatively slow. All kinds of dielectromagnets of different proportions in mixture of powders have magnetic properties better than dielectromagnets from strontium ferrite only.

Dielectromagnets from mixture of Nd-Fe-B and powdered Alnico have higher value of remanence B_r than dielectromagnets made from mixture with strontium ferrite. Decreasing of remanence with increasing of content of powdered Alnico in mixture is relatively slow.

Magnetic properties of dielectromagnets from both kinds of mixtures are very promissing. These kinds of dielectromagnets can enrich market offer of permanent magnets and permit to choose permanent magnets with magnetic properties suitable for small electrical motors and other applications. Additional advantage of this kind of dielectromagnets is their lower cost level on the market due to low price of ferrites.

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