HYBRID MAGNETIC ELEMENTS

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THE MAIN GOAL OF INVESTIGATION

Preparing new structure of magnetic circuits for electric machines – hybrid magnetic circuits

MAGNETIC CIRCUITS

Magnetic circuit is a part of electric machine and is a closed path containing a magnetic flux.

A magnetic circuit can contain soft and hard magnetic elements; may also contain air gaps.

Magnetic Circuit

Traditional

- permanent magnets
- electrical sheets as soft magnetic element

New

- permanent magnets from hard magnetic powders
- parts from soft magnetic powders

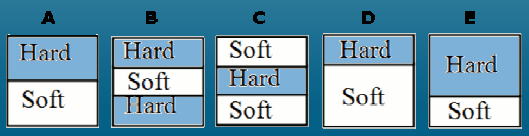
ADVANTAGES OF POWDER MAGNETIC CIRCUIT PREPARED BY BONDING MAGNETIC POWDER BY RESIN

- obtaining elements with good magnetic properties
- tailoring physical properties of elements
- making elements with complicated shapes and high dimensional precision
- preparing magnetic circuits with 3D distribution of magnetic flux
- preparing magnetic circuits with soft and hard magnetic layers in one technological process
- reducing costs of manufacturing electromagnetic transducers
- easier recycling process in the case of powder: waste is less substantial than in the case of remainders of cut out electrical steel
- reducing eddy current losses due to high resistivity of elements
- machining of elements for preparing models or elements in a very small series, instead of designing and preparing high cost dies

THE AIM OF FIRST STAGE OF INVESTIGATION IS TO ANALYZE POSSIBILITIES OF PRODUCTION AND MEASUREMENT FOR HYBRID ELEMENTS

HYBRID MAGNETIC ELEMENTS

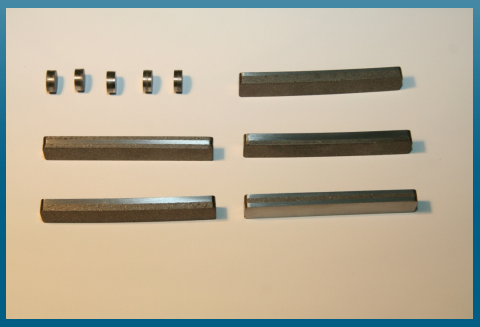
Hybrid magnetic elements were manufactured from:
- hard magnetic powder Nd-Fe-B from melt spun ribbon
- iron powder



Configurations of layers of hybrid magnetic elements

For preparing hybrid elements, compression molding technology can be used

HYBRID MAGNETIC ELEMENTS



PHYSICAL PROPERTIES OF HYBRID MAGNETIC ELEMENTS:

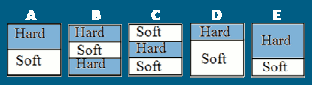
Measurements of magnetic properties

Measurements of mechanical properties:
- compressive strength
- transverse rupture strength
- tensile strength
- Brinell hardness

Measurements of electrical resistivity

MEASUREMENT OF MAGNETIC PROPERTIES

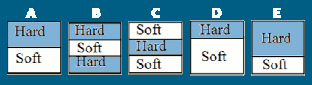
Configuration of layers	B_r	H_{cJ}	H_{cB}	$(BH)_{max}$
	[T]	[kA/m]	[kA/m]	[kJ/m³]
A	0.80	321	249	48.8
B	0.69	378	266	44.7
C	0.50	127	97	11.0
D	0.89	197	168	39.1
E	0.75	452	324	59.6
Hard magnetic powder	0.66	651	413	66.5



MEASUREMENT OF MECHANICAL PROPERTIES

compressive strength

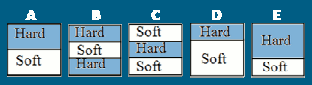
Configuration of layers	R_c [MPa]
A	175
B	189
C	209
D	184
E	168
Hard magnetic powder	146
Soft magnetic powder	260



MEASUREMENT OF MECHANICAL PROPERTIES

transverse rupture strength

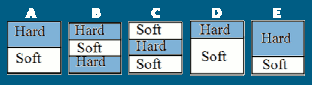
Configuration of layers	TRS [MPa]
A	79
B	81
C	82
D	89
E	80
Hard magnetic powder	61
Soft magnetic powder	108



MEASUREMENT OF MECHANICAL PROPERTIES

tensile strength

Configuration of layers	R_m [MPa]
A	16
B	41
C	38
D	23
E	13
Hard magnetic powder	32
Soft magnetic powder	48

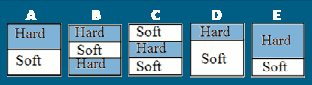


Samples of hybrid elements after tensile tests

MEASUREMENT OF MECHANICAL PROPERTIES

Brinell hardness

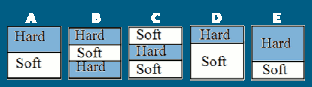
Configuration of layers	HB 2.5/62.5
A soft magnetic layer	72
A hard magnetic layer	66
B	59
C	73
D soft magnetic layer	76
D hard magnetic layer	59
E soft magnetic layer	76
E hard magnetic layer	64
Hard magnetic powder	61
Soft magnetic powder	81



MEASUREMENT OF ELECTRICAL PROPERTIES

electrical resistivity

Configuration of layers	ρ [μΩ·m]
A	81
B	46
C	124
D	130
E	60
Hard magnetic powder	40
Soft magnetic powder	3324



SUMMARY

- Hybrid elements are possible to prepare in one technological process
- Physical properties depend on the configuraction of soft and magnetic powder, and on their amount.
- Structure of hybrid magnetic circuits depends on the design of electric motor