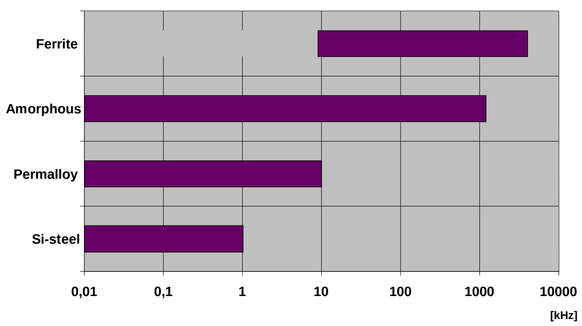
TRANSFORMERS WITH AMORPHOUS CORES MANUFACTURED BY ELHAND TRANSFORMATORY

Moshe Maor[1], Dariusz Koteras[2], Leszek Jasiński[3], Mirosław Machnik[3], Mirosław Łukiewski[3]

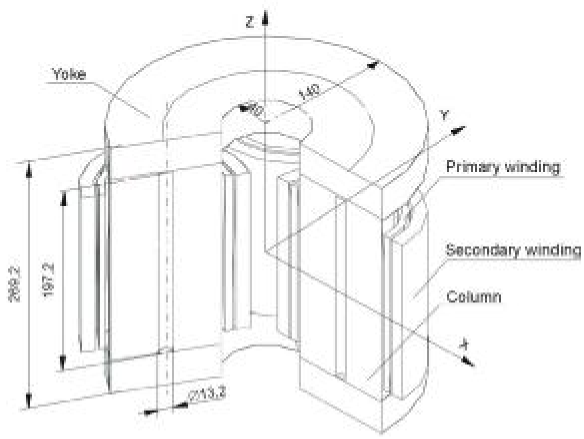
1 ADVANCED TRANSFORMER TECHNOLOGIES Ltd
2 THE OPOLE TECHNICAL UNIVERSITY
3 ELHAND TRANSFORMATORY

The history of amorphous magnetic material dates back to the 1950s. However, the main breakthrough in mastering the technology for these materials took place as late as the beginning of the seventies, when a method for producing amorphous magnetic material in continuous cycle was developed in the United States [1]. Apart from the well-known advantages of these materials and a sound knowledge of their production technology, they are not widely applied. The amorphous material advantages enable their successful application both for building distributive transformers operating at network frequencies and high-frequency transformers. The magnetic and physical parameters of the amorphous materials, with other ferromagnetic materials, are shown in Drawing 1.



Drawing 1. Frequency ranges for applying magnetic materials [2]

One of the companies that deals with the manufacturing and distribution of the amorphous transformers is the ELHAND TRANSFORMATORY Company from Lubliniec. In co-operation with the Israeli company: ADVANCED TRANSFORMER TECHNOLOGIES Ltd (ATT), producing amorphous cores, it has launched on to the market amorphous transformers with a symmetric core (Drawing 2).



Drawing 2. Axonometric sketch of the transformed described herewith

Description of the technology for manufacturing transformer amorphous cores

The method for the continuous production of metallic glasses involves directing a thin stable metal stream on to the external surface of a fast-rotating roller (a few thousand rotation per minute), manufactured from metal with good thermal conduction. This roller serves the purpose of rapid cooling of the liquid alloy, as a result of which magnetic material is formed with amorphous properties. The speed of this cooling ranges at 10^6 K/s. If cooled too slowly, the material will become partially crystallised and the amorphous structure will be lost. In practice, the liquid alloy is passed on to the cooling roller surface through a slotted nozzle placed very close to its surface.

Magnetic material properties	Traditional steel core	Ferrite 3F3	Ferrite 3E7	80 Ni perm alloy	Iron-based amorphous core	Cobalt-based amorphous core
Initial permeability μ_I	1500	3000	15000	40000	5000	60000
Maximum permeability μ_m	20000	6000	30000	200000	100000	1000000
Saturation induction B_s [T]	1,8	0,33	0,21	0,74	1,57	0,5
Coercion intensity at 50Hz H_c [A/m]	40	12,8	5,6	2,4	2,4	0,5
Resisitivity [μΩ*m]	50	20000	1000	60	130	120
Curie temperature [^{o}C]	750	200	130	500	415	255
Unit losses at 0,1T 100kHz [mW/cm^3]	---	80	230	213	380	45,6

Table 1. Comparison of magnetic materials parameters [2]

In effect, in this manner we can obtain an amorphous band, 12 cm wide and from 18 to 30 μm thick [2].

The band, manufactured in this way, is wound in a roll with the widths equal to the yoke and column diameter. The yokes obtained in such a way are fitted directly to the core structure and the columns are additionally cut lengthwise. In the place of the cuts, insulation is placed in order to reduce rotary currents. [2].

In this way, a ready-made symmetric core is obtained, comprising three roller columns and two yokes. Such a core is shown in Drawing 3. Primary and secondary cylindrical windings are placed on the columns. The whole item is assembled on glass and EP bases and is screwed in with four bolts. The transformer, produced in such a manner, is symmetric, both electric- and geometric-wise

Drawing 3. Symmetric amorphous core produced by ATT

It is very easy to assemble such a transformer. That is why the overhauls requiring windings replacement are profitable, even with small units. Drawing 4 presents an amorphous transformer with the power of 10 kVA, manufactured by ELHAND TRANSFORMATORY from Lubliniec.

Drawing. 4. 10kVA amorphous transformer, manufactured by ELHAND TRANSFORMATORY from Lubliniec

Conclusions

Due to the application of amorphous material for core construction, this transformer makes it possible to reduce idle losses by nearly five times when compared with the traditional transformer with the core made of electromagnetic steel sheets. For example, idle losses at the 10 kVA transformer with the steel core, also manufactured by ELHAND TRANSFORMATORY (from electromagnetic band of ET-52 type) of the same power and with amorphous core are 22W [4]. In order to realise the savings arising thereby, the following comparison may be used. Estimated annual losses in distributive transformers installed in the United States, as per the data from the beginning of the nineties, is 35 billion kWh, corresponding to 1.6 billion dollars. Replacing all the cores in these transformers with amorphous ones would allow savings of 23 billion kWh, the equivalent of 1.3 billion dollars [6].

The transformers with amorphous cores have another advantage, i.e. their wide range of work rated frequencies. On the basis of amorphous cores, it is possible to build both line transformers and transformers with the frequencies up to 1 MHz. The latter are used in electronic voltage converters of greater power, UPS and welding instrumentation. The possibility of manufacturing units with significant power permits the application of amorphous transformers in power electronic systems of great power, which is possible when applying ferritic cores.

Bibliography

[1] Praca pod red. Lachowicz H. K.: *Magnetyki amorficzne*. Instytut Fizyki PAN, Warszawa 1983

[2] ACP Ltd. *The best solution for power supply. Amorphous magnetic components*, Netania, Israel, 2000

[3] Soiński M.: *Materiały magnetyczne w technice*. COSiW, Warszawa, 2001

[4] AT3S Transformers Technical Documentation- ELHAND TRANSFORMATORY

[5] ET3S Transformers Technica lDocumentation- ELHAND TRANSFORMATORY

[6] Lachowicz H. K.: *Magnetyki amorficzne*. Wiedza i życie, Warszawa, 09/1997

[7] Lachowicz H. K.: *Zastosowania i perspektywy rozwoju współczesnych materiałów magnetycznych*. Elektronika (XXXI) 7-9/1990