IMPACT ANALYSIS OF THE STEEL GRADE ON ELECTROMAGNETIC CHARACTERISTICS OF ELECTRICAL MACHINES

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Introduction. The development of electrical engineering requires a constant improvement of the physical characteristics of soft magnetic materials, in particular, widely used electrotechnical steels. Therefore, the degree of sophistication of the chemical composition of steel is increasing in the process of manufacturing of modern anisotropic electrotechnical steels on the basis of Fe-Si by rolling and heat treatment. A number of engineers from major metallurgical complexes such as Azovstal, Zaporizhstal, etc. are engaged in improving the chemical composition of steel in Ukraine, as well as the engineers from Elektrotyazhmash.

The aim of the work. To analyze and draw conclusions on how the electromagnetic characteristics of electrical machines affect the used steel grade, as well as the dependence of electromagnetic properties on the chemical composition of steel.

Materials and research results. One of the main factors in the design of high-efficiency electrical machines is the right choice of steel grades when designing hydraulic units. For this purpose, special steel grades with certain chemical properties which influence on the electromagnetic properties of the electrical machines are used. In electrical machines it is used special electrotechnical steel - isotropic steel, with variable direction of magnetic flux (rotating machines) with a pronounced texture in a certain crystallographic direction. Electrotechnical sheet metal steels include eight grades: 10895, 20895, 10880, 20880, 10864, 10848, 20848, 20832.

In connection with the above-mentioned features, in order for electric machines to have high electromagnetic properties, electrotechnical steel should have a small degree of magnetization at low magnetic field strength in order to provide a small winding current. Losses for reversal should be minimal so that the smallest amount of electrical power is converted into the heat and the efficiency of the electric machine increases. With the increase of the power and the duration of continuous machine operation, there is a problem of heat dissipation and the increase of remagnetising losses.

The hysteresis loop shown in Fig. 1, in connection with this requirement, should have steep, high and very narrow curves, because the area of hysteresis corresponds to energy losses per cycle per unit volume.

Electrotechnical sheet steels are used for the manufacture of anchors and poles of electrical machines, magnetic cables, stators and rotors of electric motors, turbogenerators and hydrogenerators.

In the hydrogenerators SGC 538 / 160-70 the stator is made of steel grade E330P, which possesses increased mechanical and magnetic characteristics, due to the correct choice of steel grades, it is possible to achieve significant improvements in the characteristics of the hydrogenerator.

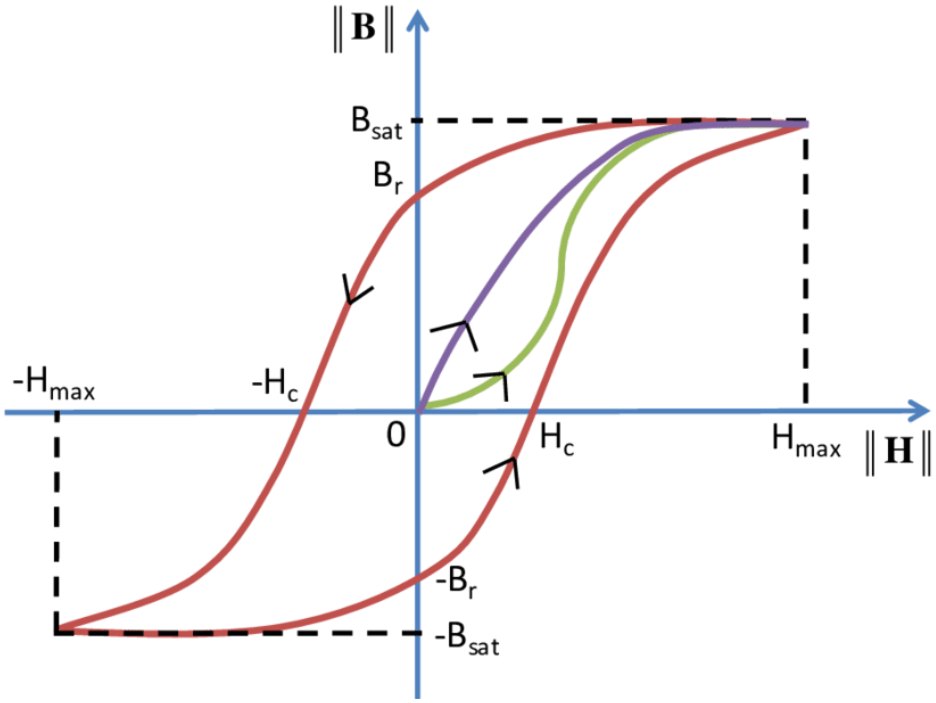

Figure 1 – The hysteresis loop

General requirements for electrotechnical steel to be used in electrical machines: high magnetic permeability, low coercivity and small remagnetising losses.

Table 1 – Magnetic induction of steel E330P

	Magnetic induction T, at the intensity of the magnetic field, A/cm					Specific losses at 50 Hz, at induction T, W/kg			Average specific electrical resistance, Ohm*mm^2/m
	10	25	50	100	300	1,0	1,5	1,7	
E330P	1,70	1,85	1,90	1,95	2,00	0,8	1,75	2,5i	0,50

In order to obtain the minimum coercivity and high permeability in electric machines, a ferromagnetic material of a homogeneous structure (pure metal or solid solution), cleared from the impurities and inclusions is used.

The most harmful impurities are carbon (Fe3C), oxygen and sulfur. carbon is one of the most harmful impurities in electrical steel, which extends the area of austenite existence, that has a negative impact on the electromagnetic properties of the machine.

Impact of impurities on the coercivity of iron of technical purity is shown in Fig. 2: 1 - nitrogen; 2 - carbon; 3 - sulfur; 4 - phosphorus; 5 - oxygen; 6 - manganese.

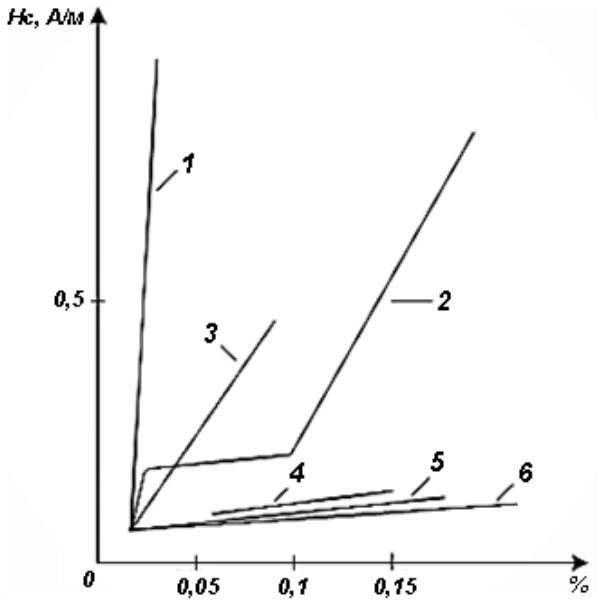

Figure 2 – Impact of impurities on the coercivity of iron of technical purity

The Fig. 3 shows the effect of carbon on the magnetization curve of iron. The 0.015% reduction of carbon content in steel in the investigated range of 0,03-0,05% contributes to reduction of unit costs by 0,5W/kg and increase of magnetic induction by 0,15T in electric machines. The degree of influence of carbon on the magnetic properties depends on the form of its excreting in the solid solution in the form of cementite (lamellar or globular) or graphite. The most unfavorable influence on the magnetic properties of the metal makes the excreting in the form of structurally-free carbides located inside the grains of the ferrite. The disengagement of carbon inside the grains in the form of graphite has little impact. The value of the coercive force with the same content of carbon in the metal, but with various forms of disengagement can vary by a factor of 1,5-2.

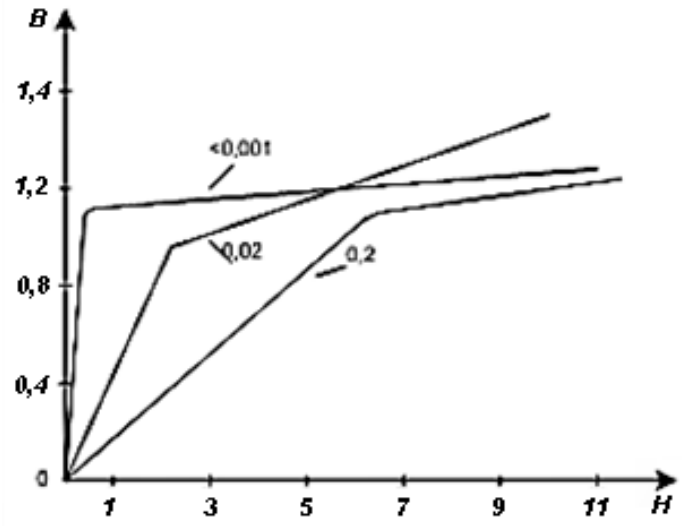

Figure 3 – Effect of carbon on the magnetization curve of iron

The adding of carbide-forming elements to the steel leads to the formation of stable carbides and deterioration of magnetic properties.

The smelting of isotropic electrotechnical steel with carbon less than 0,005% is important for the improvement of the magnetic properties of the plasticity of the metal. Other methods - for example, metal refining in the final thickness are less effective. Using this method, although a deep release of carbon (to 0.002-0.005%) is carried out, but annealing in a humid atmosphere leads to internal oxidation. The inclusion of silicon oxides, formed during internal oxidation in the process of getting rid of carbon, greatly worsens the magnetic properties of steel. Impact of pollution on hysteresis Influence of pollution on loss of hysteresis is shown in Fig. 4.

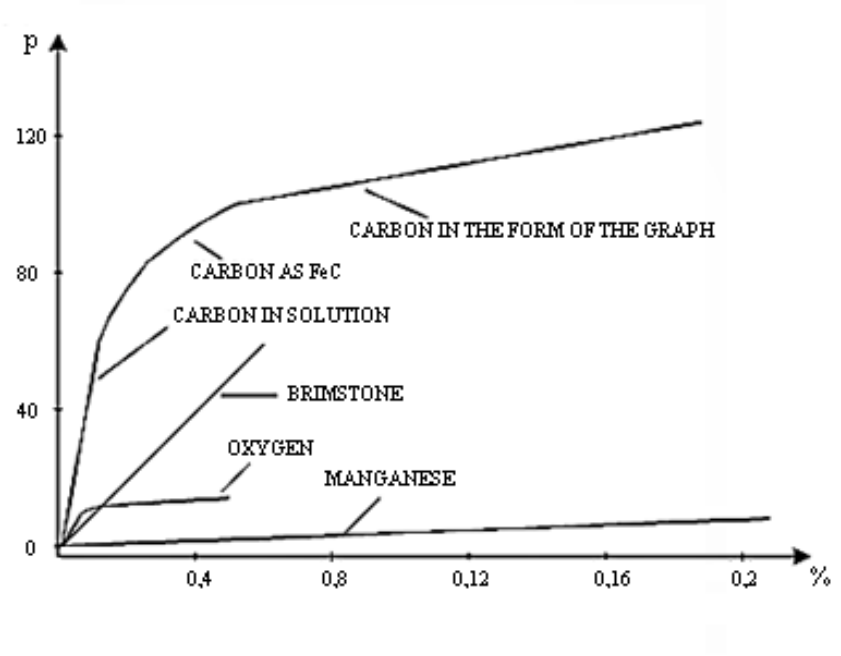

Figure 4 – Influence of pollution on loss of hysteresis of iron-silicon alloy with 4% Si, at B = 1.0 T

Magnetic permeability increases with increasing grain of ferrite. Defamation, even weak, reduces the magnetic permeability and increases losses, therefore, recrystallized metal applied, which is used to eliminate internal stresses, that in the future will lead to the improvement of the electromagnetic properties of the electrical machines and during its operation the material must be completely recrystallized.

Conclusions. The electromagnetic properties of electric machines are affected by the following quantities that are determined by the chemical properties of the steel: magnetic permeability, remagnetising losses (depend on the width of the hysteresis loop), induction of saturation. All these quantities combined with the correct selection of steel grades make the hydropower more efficient at operation and allow to make it more reliable and durable. For these reasons, the choice of steel grades is extremely important for obtaining the qualitative electromagnetic characteristics of the electrical machines.

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