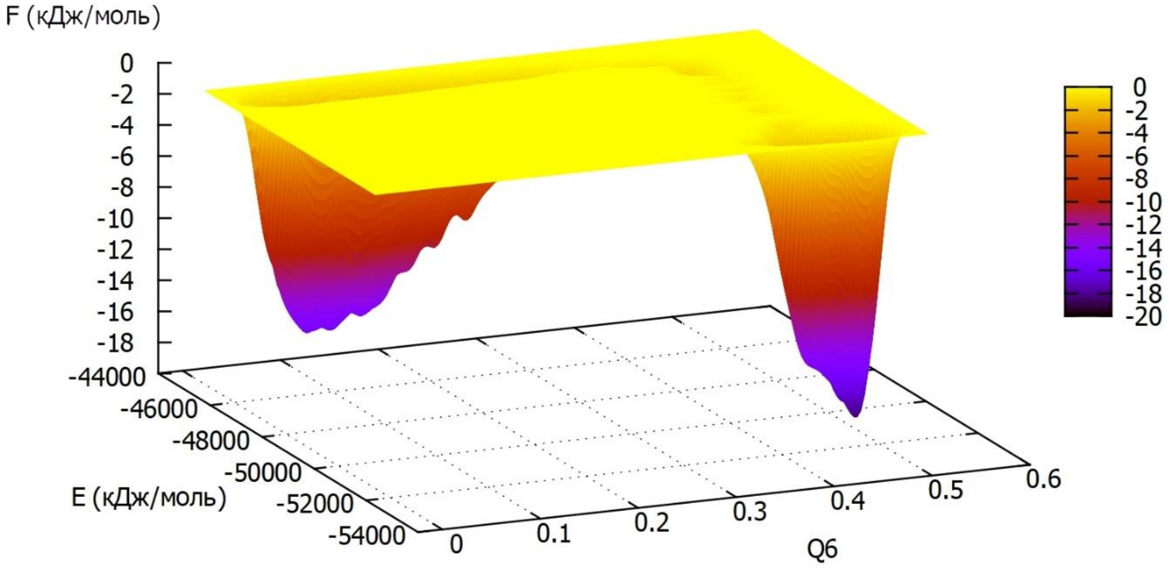

Рис. 1 – Ландшафт свободной энергии в зависимости от выбранных параметров порядка для температуры 0.75 T_m. Левая яма соответствует метастабильному жидкому состоянию, а правая – кристаллу

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SURFACE MODIFICATION OF STEEL INDUCTOR AS AN APPROACH TO ENCHANCE ITS DURABILITY IN HIGH PULSED MAGNETIC FIELDS

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Abstract. The work concerns both a theoretical analysis of magnetic and thermal effects in conductor with inhomogeneous initial conductivity and realization of this approach on steel, oriented on inductors production, by steel surface modification. Monotonically changing specific resistance of steel was suggested to be realized via steel pack chromizing.

The relevance of the research is due to the use of high-field coils in the technology of magnetic pulse welding of metals. Consideration and reduction of the ohmic heating of the current-carrying layer of the inductor and the thermal stresses and strains associated with it is of key importance for increasing inductor durability.

A promising approach is the realization of an inductor material with initial inhomogeneous resistivity in the current-carrying layer. Here, an analysis of the stress state of the surface layer of a cylindrical inductor made of medium-carbon steel with an internal diameter of 10 mm was carried out taking material heating into account and the parameters of the surface modification of two types (see *Fig. 1a*), which allows well reducing the influence of thermal effects (*Fig. 1b*), have been determined: the degree of resistance increase on the surface (γ_{00}) and the depth of modification (δ_M). We used magnetic field pulse as one half-period (15 μs) of damped sinusoid with amplitude 50 T. It was concluded that more efficient thermal unloading of the inductor surface is achieved using type *I* modification. At both modification types the reasonable values of the modification parameters are: $\gamma_{00} > 1.2$, $\delta_M \sim 0.2$–0.3 mm. Practically, the approach was applied on steels of three grades: 30KhGSA, 40Kh, and U8A, which were subjected to pack chromizing at 1000°C in Ar for 20 to 100 h, using chromium pack (wt.%): 5Cr+0.5NH_4Cl+Al_2O_3 (*bal.*).

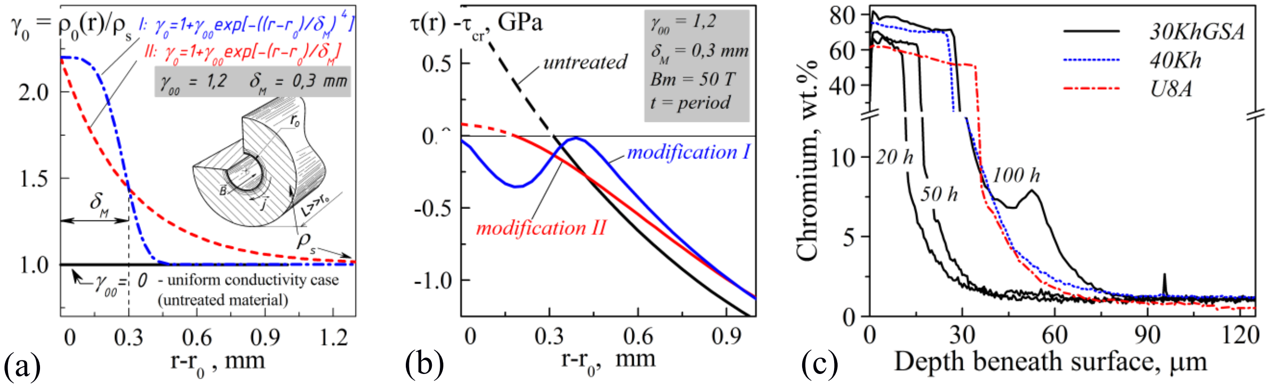

Fig. 1. (a) – model profiles of initial resistivity *$\rho_0(r)$*, inset – modeled concentrator; (b) – mechanical stresses intensity *$\tau(r)$* as compared to yield stress τ_{cr}; (c) – chromium profiles at different process duration.

Modified surface consists of the external "Cr-C" carbidic layer with thickness 10 to 40 μm depending on conditions and steel grade (*Fig. 1c*). The diffuse layer located beneath the external coating is characterized with an exponential decrease in chromium concentration and resistivity, as a consequence. It meets the resistivity distribution shape being modeled. This layer is likely a chromium-rich ferrite (or martensite after quench) with maximum concentration of chromium at about 10 wt. %. After chromizing for 100 h, the diffuse layers of 56, 70, and 94 μm in thickness were obtained for the steels 40Kh, 30KhGSA and U8A, respectively. Thus, to increase the diffuse layer thickness and eliminate the formation of the external carbidic layer for successful steel application further optimization of chromizing procedure is needed.

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