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NEW APPROACHES TO DESIGNING STRENGTHENING TREATMENTS WITH THE CONTROLING PHASE-STRUCTURAL ALLOYS EVOLUTION AT OPERATION

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The problems of improving physical, mechanical and operational properties of many steels, cast irons and others alloys present great interest to many countries as well.

The work is devoted to the generalization of studies on the implementation of a new approach to the design of innovative strengthening treatments of alloys of various functional applications based on the accounting and control of the evolution of the phase-structural state during operation.

The proposed approach is based on the principle of controlled phase-structural evolution at the stages of testing and operation, providing self-improvement of the microstructure and, as a result, the properties directly under the influence of the operating environment itself. This evolution is realized due to the “programmed” initially or controlled (optimal) development of deformational, in some cases thermo-deformational induced phase transformations during testing or operation (DIPTT, TDIPTT): martensitic $\gamma \rightarrow \alpha'$; $\gamma \rightarrow \varepsilon'$; $\gamma \rightarrow \alpha' \rightarrow \varepsilon'$ transformations (DIMTT); dynamic strain aging (DSA); transformation of the compositions and structure of dispersion hardening phases, etc. These transformations are accompanied by the effects of self-strengthening, self-relaxation of microstresses due to the formation of martensite deformation and precipitation of dispersed particles of solid phases, self-adaptation to operating conditions, absorption of part of the energy due to the self-organization of the phase-structural state.

Obtaining metastable states of austenite is possible in any phase-structural modifications: austenite as a main and second γ-phase; primary (A_{pr}); eutectic (A_e); retained (A_{ret}); secondary or reversed (A_{rev}); satiated; powder in steels, cast irons, deposited metal, powder alloys. For this, it is necessary to use all possible mechanisms of stabilization and destabilization of austenite in order to rationally manage DIPTT (TDIPTT, DIMTT, DSA, etc.) while developing new and improving traditional methods and strengthening technologies.

Pure structural transformations are possible (TWIP – Twinning Induced Plasticity), the evolution of which during operation should initially be controlled not only by alloying, but also by processing. The implementation of the DIMTT or (and) TWIP effects with the optimal evolution of the alloy during testing of the properties ensures the achievement of an abnormally high strength complex (ultimate tensile strength 1600…2000 MPa), ductility (percent elongation 15…25%), impact strength (KCU = 1.0…1,6 MJ/m^2) structural steels, increased (1,5…4 times) relative wear resistance (of dry sliding friction ($\varepsilon_{s.f.}$), abrasive ($\varepsilon_{a.}$) and impact-abrasive ($\varepsilon_{i.a.}$) wearing) of metastable cost-saving steels, cast irons and deposited metals.

The highest value of impact-abrasive wear resistance ($\varepsilon_{i.a.}$= 9,8) and impact strength (KCU=15,4 MJ/m^2) of deposited Fe-Cr-Mn metal was achieved after quenching at 1150 °C, when the microstructure is mainly austenite (with small quantity of quenching martensite and carbides). The highest value in sliding friction wear resistance ($\varepsilon_{s.f.}$ = 4,2) with satisfactory impact strength value (KCU = 8,5 MJ/m^2) was achieved after quenching at 950 °C, when the structure of deposited metal is martensite-carbides with metastable retained austenite, which realized $\gamma_{ret}\rightarrow\alpha'$ DIMTT.

A new direction in the design of hardening treatments is the use of the principle of austenite heterogenization for the implementation of subsequent martensitic transformations during cooling and DIMTT, on the basis of which new methods and technologies for hardening steels and cast irons are created. Thermo-chemical methods have been created (carburizing, nitro-carburizing, high-speed thermo-cyclic cyaniding with induction heating, decarburizing treatment, etc.) in combination with the original methods of heat treatment (quenching from differentiated temperatures, high temperature thermo-cyclic treatment, low temperature thermo-cyclic treatment, plasma or electron beam treatments, etc.), providing the formation of gradient structures with differentiation of the number of A_{res} and the degree of its metastability along the depth of the layer, taking into account the subsequent evolution of the phase-structural state during operation.

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EFFECT OF DECARBURIZATION QUENCHING ON THE PROCESS OF DESTABILIZING AUSTENITE TO INCREASE THE WEAR RESISTANCE OF HADFIELD'S STEEL

The decarburization process, characterized by a decrease in the carbon content in the surface layers of most high-carbon alloys (steels and cast irons), parts and tools, when heated in oxidizing environments, is a negative phenomenon that reduces mechanical properties, because decarburization is a significant problem in heat treatment of steels as decarburization is detrimental to wear life and fatigue life of components. At the same time, for low-carbon transformer and stainless steels, of ferritic and austenitic classes, decarburization can be used as a kind of chemical-thermal treatment that improves their properties. However, to enhance the mechanical and operational properties of high-carbon alloys, decarburization as a technological process of strengthening processing is not considered in the literature and is not applied in practice. Decarburization of high-carbon steels in the process of heat treatment is considered a very undesirable phenomenon, which one usually tries to prevent. Meanwhile, a new method of thermo-chemical treatment – for decarburizing hardening of Hadfield Mn high-carbon steels is proposed, which is shown that it is possible to increase its wear resistance.