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INFLUENCE OF RADIATION-TECHNOLOGICAL TREATMENT LOW-CARBON STEELS ON THEIR PHYSICAL-MECHANICAL PROPERTIES

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An experimental research of changes in physical-mechanical properties of low carbon steels after radiation-technological treatment with the use of electron irradiation with energy of 3.0 and 5.0 MeV are carried out. There is possibility of using radiation-technological treatment for controlled changes of the surface properties and the volume of low carbon steel with the use of different irradiation modes.

Keywords: the low carbon steel, radiation-technological treatment, process of electron irradiation, controlled changes of physical-mechanical properties of metal

Entry. Physic-technologic bases of modification of solids with the use of ionizing radiation are studied for creation of the applied methods of affecting on materials, substantially changing them properties [1]. Development and application of radiation-technological processes characteristic for all industries, including metallurgy [2].

Literary review. The methods of the radiation-thermal strengthening of products from steel, which the durability of deforming technological equipment of metallurgical plants rises due to, are presently worked out, in particular, technology of the radiation-thermal strengthening of worn-out and new rollers of the cold rolling, allowing in one and a half-two time to increase their durability as compared to roller by the hard-tempered currents of high-purity is offered [4].

Problem definition. The purpose of the real work is a preliminary estimation of fundamental possibility of the use of radiation-technological treatment (RTT) for the controlling change of physic-mechanical properties of the radiation-irradiate surface and volume of low-carbon steel at the different modes of irradiation.

Basic part of researches. In work samples from steel 45ХН2МФА, 09ГСА and St3bs, which exposed to the irradiation the bunch of electrons with different characteristics are investigated.

On the first stage of experiment (energy of electrons ≈ 5 MeV, current of bunch of electrons ≈ 1,0 mA, diameter of bunch ≈ a 400 mm, duration of impulses – 210-410 s) at the thickness of sample ≤ a 6 mm all volume of material in the area of destruction exposed to rays. We are measured the limits of fluidity σ_T, the limits of durability σ_B and shock viscidity of KCU for metal-roll of steel 45ХН2МФА of standard form before and after an irradiation.

As results of tests showed, looked the substantial decline of mechanical durability (σ_T, σ_B) of samples at the fluency of electrons ($\Phi_c \geq 4\cdot10^{15}$ sm^{-2} (tabl. 1).

Table 1 - Change of physic-mechanical properties of samples of metal-roll steel 45ХН2МФА after an irradiation the stream of electrons with energy 5.0 MeV

Rate of quality	Value of rate of quality of metal at the dose of irradiation the stream of electrons, 10^{15} sm^{-2}:					
	3.3	3.8	4.2	5.2	5.6	6.4
Limit of fluidity, N/mm^2	588.4	568.8	578.6	519.8	510.0	500,2
Tensile strength, N/mm^2	755.1	745.3	755.1	716.0	726.02	716.0
Specific viscidity, $kJoul/mm^2$	12.6	12.5	10.7	21.4	13.4	15.4
Hardness on Bryunel′, HB units	215	214	219	203	207	207

In the range of irradiation of electrons Φ = 3.3-4.2·1015 sm^{-2}, we looked the noticeable increase of hardness of samples from initial ≈ 208 to 220 HB units, id est. on 5.77 % at the practically stable values of parameters $\sigma_T \approx 578$ N/mm^2, $\sigma_B \approx 608$ N/mm^2. The got results do not conflict with data of work [4], in which the maximally attained level of increase of strengthening consist 1.5-3.0 HRC for rollers with superficial durability 62 HRC or 4,83 %.

Microstructure 45ХН2МФА can be modified in a near-surface area at diminishing of energy of bunch of electrons to 0.32 MeV and increase of strength of current to 2000 A (direction of impulse - $5 \cdot 10^{-6}$ s, a diameter of bunch ≈ a 50 mm). Experimental results confirm that the change of microstructure at the action of irradiation results in substantial growth of superficial microhardness HV of samples.

From the point of view of the technological use of irradiation, besides achievement of maximally high superficial microhardness is needed, maintenance of its at effectively high level on a possibly greater depth from the surface of metal.

From the technological point of view of influence on HB most effective is radiation treatment of the unalloyed steel of St3bs : displacement of distribution to the right - toward the large values of the mentioned parameter. An effect is substantially weaker expressed for steel 09Г2, foremost, because of higher content of manganese (1.70 % as compared to 0.65 % in St3bs) and silicon (0,80 % as compared to 0.15 % in St3bs). For steel 45ХН2МФА there is a reverse effect, id est. displacement of distribution toward the less values of parameter of HB, that logically to bind with the presence in the mentioned steel of vanadium (0.18 %), molybdenum (0.30 %), chrome (1.10 %) and nickel (1.80 %).

The choice of energy of irradiation electrons was executed with the use of data, presented in-process [5] about the extrapolated run of electrons to the environment of «STATISTICA».

The quantitative estimation of the chosen technological mode can be executed with the use of coefficient of technological efficiency, id est relation of weight-average values HB after an irradiation to the initial value Tech_Eff :

$$Tech_{Eff} = \frac{\int_0^{1000} f\rho_{\Phi\, 10^{15}_{09\tilde{A}2(HB)}} \cdot HB \cdot dHB}{\int_0^{1000} f\rho_{\Phi 0_{09\tilde{A}2(HB)}} \cdot HB \cdot dHB}\ , \quad (3)$$

which practically arc wise depends on the depth of treatment of samples of h_{max}.

Thus, for the making of the strengthening layer the use of current of bunch of electrons, the exact meaning of which must sneak up coming from the demand of providing of the sufficient heat affecting on material for achievement of temperature of martensite transition at absent of damage of surface, is possible. At implementation of this condition it is necessary to choose energy of irradiation, providing achievement higher h_{max} is possible for the increase of integral microhardness.

Conclusions. Possibility of the use of radiation-technological treatment (RTT) for the technological change of physic-mechanical properties of metals with the different level of alloying is confirmed.

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