1. Чейлях А.П. Экономнолегированные метастабильные сплавы и упрочняющие технологии. – Мариуполь: ПГТУ, 2009. – 483 с.

2. ГОСТ 7350-77 Сталь толстолистовая коррозионно-стойкая, жаростойкая и жаропрочная. Технические условия.

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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 [1]. 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 [2], which is shown that it is possible to increase its wear resistance.

In this work the method of surface hardening based on the destabilization of phase-stable austenite in austenitic grade Hadfield steel as a result of the decarburization during high-temperature austenitization and destabilization during quenching is experimentally presented and justified. The features of the formation of a microstructure in the surface

layers during decarburization quenching of Hadfield steel, which gradually varies in depth with a change in the ratio of α'- and ε'- martensites and metastable austenite, are studied in detail. Signs of ε- and α-martensite and metastable austenite can be observed in the microstructure of the decarburized layer of 110Mn13 steel. Microstructure of ε–martensite is characterized by the system of straight sliding lines, crossing at the angle ~60º, whilst α-martensite possesses lath (package) structure.

As the holding time at elevated temperatures (1150 °C) increases, the depth of the decarburized layer increases, and in the surface layer of the 110Mn13 steel samples the carbon content decreases, which causes destabilization of the austenite, the degree of which depends on the depth of decarburization in accordance with the actual distribution of the carbon content. The carbon distribution along the depth from the (x) surface as a function of the time of decarburization (t) can be solved by means of the following equation:

$$C(X,t) = C_S + (C_o - C_S) erf\left(\frac{x}{2\sqrt{D\tau}} \right),$$

where C_o and C_s are the initial and the ultimate (on the surface) carbon concentration, $erf\left(\frac{x}{2\sqrt{D\tau}} \right)$ is an error function from the value of $\left(\frac{x}{2\sqrt{D\tau}} \right)$ which is determined by means of special tables; D is the coefficient of carbon diffusion in γ-iron which could be determined for the applicable temperature of decarburizing austenitization with regards to mutual influence of alloying elements upon the thermodynamic activity of carbon. Dependences of the carbon concentration on the depth of the decarburized layer at different times of austenitization of 110Mn13 steel at a temperature of 1150 °C was shown experimentally.

The destabilization of excessively stable austenite during decarburization causes a significant increase in the wear resistance of 110Mn13 steel (optimally by a factor of ~ 4) due to the activation of the mechanism of deformation induced $\gamma{\rightarrow}\varepsilon'$ and $\gamma{\rightarrow}\varepsilon'{\rightarrow}\alpha'$ martensite transformations in the surface layer during the wear process (DIMTW). The contribution of the mechanism of deformation induced $\gamma{\rightarrow}\varepsilon'$ and $\gamma{\rightarrow}\varepsilon'{\rightarrow}\alpha'$ DIMTW to an increase in wear resistance exceeds and significantly supplements the role of the traditional hardening mechanism and the formation of packing defects in Hadfield's steel under sliding friction conditions.

References

1. Vander Voort, G. F. "Measurement of Decarburization," Advanced Materials & Processes, February 2014, Vol. 173, pp. 22-27.

2. Чейлях А.П., Чейлях Я.А. Поверхностное упрочнение высокомарганцовистых сталей закалкой с обезуглероживающей аустенитизацией // Строительство, материаловедение, машиностроение // Сб. научн. трудов.- Вып.42, ч. 1, Дн-ск: ПГАСА, 2007. - С. 41-46.

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MATHEMATICAL MODELLING VACUUM DEGASSING OF STEEL IN ARGON-STIRRED LADLE

The article presents a mathematical model of a non-stationary process of denitrogenation and dehydrogenation of steel melt in vacuum chamber with argon stirring. Vacuum degassing is a technology that is widely used in metallurgical plants to achieve extremely low concentrations of hydrogen and nitrogen in the metal melt, which is needed to improve the quality of steel products [1]. According to the well-known hypothesis, initially the gas in the melt is in the dissolved state. Hydrogen and nitrogen bubbles are formed from a solution on the surface of the ladle lining provided that the pressure of metal melt is sufficiently low. The pressure required for the bubble to appear is determined in accordance with Sieverts' law. To a large extent, the degassing is also affected by the argon stirring, when bubbles collect hydrogen and nitrogen in their paths, floating through the melt and flying off the free surface. It is also important to reduce the duration of degassing to keep the melt temperature at a sufficiently high level, as well as to speed up overall process. Conducting numerical studies of the above process on a mathematical model reduces the cost of time and financial resources, so building a model is an actual task. The description of the melt flow and gases in the ladle is based on the mass and impulse conservation laws for a continuous medium, which is justified by the small size of the bubbles and their large number. Given the complexity of finding the analytic solution of nonlinear differential equations in partial derivatives in three-dimensional formulation, it is proposed to use the central difference method, which is sufficiently accurate and widely used for similar