UDK 669.15-194:621.785.5

**A.P. Cheiliakh[1], Y.A. Cheylyakh[1], Wu Kaiming[2]**

([1]SHEI "Pryazovskyi State Technical University", Mariupol, Ukraine

[2]Wuhan University of Science and Technology, Wuhan, China)

## CORROSION-RESISTANT NICKEL-FREE TWO-PHASE STEELS WITH METASTABLE AUSTENITE

In the world practice, Cr-Ni steels of type 18/8 (10Cr18Ni(9…10)Ti, 08Cr22Ni6Mo2, etc.) are widely used as effective corrosion-resistant steels. These steels are very expensive since they contain 9…11 % Ni. With the objective of adequate replacement of expensive Fe-Cr-Ni-stainless (corrosion-resistant) steels with nickel-free steels, in PSTU developed Fe-Cr-Mn steels for the ability to work in corrosive environments of low and medium aggressiveness [1].

To determine the optimal chemical composition of new nickel-free steels, the impact of chromium from ~14 % to ~22 % on the phase composition, microstructure, and mechanical properties was studied. An important feature and advantage of the developed Fe-Cr-Mn steels is the metastability of the austenitic phase, which undergoes a deformation induced martensite $\gamma \rightarrow \alpha'$ transformation that develops when testing the mechanical properties and operation DIMTT.

New nickel-free stainless steels, depending on the chromium content (from ~14 to ~22 %), belong to different structural classes: austenite-martensite (10Cr14Mn6SiV), austenite-ferrite (10Cr18MnSiV), and ferrite-austenite (08Cr22Mn6SiV). After quenching at 1050 °C, the microstructure of 10Cr14Mn6SiV steel consists of austenite and martensite. With an increase in the chromium content from ~14 % to ~18 %, the martensite component disappears from the structure, and ferrite appears. The microstructure of 10Cr18Mn6SiV steel consists of ~46 % ferrite in the form of closed regions and ~54 % austenite. With an increase in chromium content to ~22 %, the amount of ferrite increases to 68 %, and austenite decreases to 32 %. The mechanical properties of the investigated stainless steels after quenching at 1050 °C, tempering 200 °C are given in Table.

With an increase in the chromium content from 14 to 22 %, the tensile strengths (from 1520 to 900 MPa) and the yield strength (from 920 to 500 MPa) and torsion and yield strength (from 1430 to 800 MPa and from 760 to 200 MPa, respectively) decrease in steel at continuous increase in plastic properties (δ - from 5 % to 43 %; ψ - from 6 % to 65 %; relative shear (g) - from 60 % to 122 %).

| Grade of steel | Ultimate strength ($\sigma_в$), MPa | Yield strength ($\sigma_т$), MPa | Relative elongation (δ), % | Relative duration (ψ), % | Impact strength, MJ/м$^2$ | |
|---|---|---|---|---|---|---|
| | | | | | KCV | KCU |
| 10Cr14Mn6SiV | 1520 | 920 | 5 | 6 | 0,5 | - |
| 10Cr18Mn6SiV | 1100 | 480 | 32 | 28 | 3,8 | - |
| 08Cr22Mn6SiV | 900 | 500 | 43 | 65 | 3,3 | - |
| 10Cr8Ni9Ti [2] | 530 | 230 | 38 | 55 | - | 2,5 |
| AISI304 (ASTM A240) | 510 | 205 | 43 | - | - | - |

This is explained on the one hand by the disappearance of quenching martensite and an increase in the proportion of ductile ferrite. An additional and very significant factor in increasing strength and, at the same time, plasticity is the deformation metastability of austenite, which manifests itself in the development of γ→α' DIMTT with the formation of deformation martensite (Δα'). DIMTT causes, on the one hand, self-strengthening of steels, and on the other hand, relaxation of microstresses, it simultaneously increasing ductility and impact strength directly at testing of mechanical properties. The degree of the strengthening effect and increase of the ductility properties in steels is different and is determined by the kinetics of the γ→α' DIMTT. The more deformation martensite (Δα') is formed - the greater the self-strengthening effect ($\Delta\sigma=\sigma_в - \sigma_т$; $\Delta\tau=\tau_{пч} - \tau_{0,3}$), and the longer the DIMTT develops more smoothly in time - the greater the ductility properties (δ, ψ, g). It is noteworthy that in steel 08Cr22Mn6SiV the effect of superplasticity is manifested (g = 122 %) when a strength high enough for this class of steels is reached ($\sigma_в$=900 MPa, $\tau_{пч}$ = 800 MPa). In standard Fe-Cr-Ni steels, for example 10Cr18Ni9Ti, (steel type 18/8) (AISI 304), under similar conditions for testing properties, this effect is not realized.

A comparison of the mechanical properties of the developed nickel-free corrosion-resistant steels and well-known widely used Fe-Cr-Ni steels (10Cr18Ni9Ti, (steel type 18/8) (AISI 304) (see Table) shows that the new nickel-free steels have a significantly higher set of strength properties with similar ductility indices.

**References**

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.

UDK 621.785.6:669.018

**Y.A. Cheylyakh[1], A.P. Cheiliakh[1], G.F. Vander Voort[2]**

[1]SHEI “Pryazovskyi State Technical University”, Mariupol, Ukraine

[2]Consultant-Struers Inc., Wadsworth, IL, USA

## 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