ABSTRACT

Theses for the degree «Doctor of Philosophy» (Ph.D) in the specialty 6D072300 - Technical Physics

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Modification of Microstructure and Mechanical Properties of Steel Surface Coating 12Cr18Ni10Ti During Electrolytic Plasma Treatment

The relevance of the research

One of the main problems of modern stages of development and engineering industry is the development of energy-saving technologies, as well as improvement of the quality, reliability and durability of the working parts of items and assemblies of various machinery and equipment. In particular, for certain types of pieces in accordance with the features of loading during operation is necessary to provide a high hardness, wear resistance surface layer and sufficiently good toughness and ductility of the core. This applies to components that operate in harsh environments in contact with stringent conditions, high temperatures, abrasive substances that cause a significant deterioration of the surface and intensive corrosion.

Surface enrichment of low carbon austenitic steel 12Cr18Ni10Ti carbon and nitrogen in the electrolyte heating mode, as determined in the present work, allows to increase its microhardness, wear resistance and strength with the formation of resistant coatings by alloying and modification. Thus, applying the optimal mode of EPT, it is possible to improve the mechanical properties of the surface of the steel 12Cr18Ni10Ti and to increase the reliability and durability of the parts made from this steel.

Based on the above, the study and generalization of data on the impact properties of electrolyte solutions and modes of electrolyte-plasma treatment (EPT) on the structural-phase state and physico-mechanical properties of steel 12Cr18Ni10Ti is relevant.

The aim of the work is to study the structural-phase state, the mechanical properties and corrosion resistance of the modified surface layers of steel 12Cr18Ni10Ti after various modes of EPT, followed by quenching.

To achieve this goal it was decided the following **tasks:**

1) to develop technology for EPT and to establish the optimal processing conditions began to improve performance characteristics;

2) to explore patterns of change in structure and phase composition of the surface of the steel during processing in an electrolytic plasma;

3) to study the morphology of the resulting EPT carbide and density of the particles and the substructure of the modified surface layers of steel;

4) to establish the dependence of the structural changes, the surface micro hardness, wear resistance and corrosion resistance of hardened layers of steel from the modes of EPT;

The solution of the set tasks will be made a significant contribution to the physical basis of chemical heat treatment of steels, at least in the understanding of the basic regularities of the influence of electrolyte-plasma effect on the modification of surface layers of steel.

Research object - structural-phase state, mechanical properties and corrosion resistance of steel 12Cr18Ni10Ti before and after EPT.

The object of the research - steel 12Cr18Ni10Ti steel austenitic, structural type.

Methods of research. EPT samples was carried out on the developed experimental setup. To study the status and properties of the samples before and after treatment was applied the following analysis techniques: optical, scanning electron and transmission electron microscopy, x-ray analysis, determination of microhardness and wear resistance, the distribution of atoms of carbon and nitrogen in the modified layers were determined using optical emission spectrometer; roughness was determined on the profilograph method of measuring a surface profile.

Scientific novelty.

For the first time studied and described in the phase composition, structure, mechanical properties and corrosion resistance of modified surface layers of steel 12Cr18Ni10Ti, processed in an electrolytic plasma under different conditions.

The optimal regimes of plasma electrolytic carburizing, retracements and nitriding samples of steel 12Cr18Ni10Ti.

New results have been obtained about the regularities of structure formation of the modified layer at saturation steel with nitrogen and carbon, as well as phase composition of carbide and nitride layers depending on the mode of EPT.

In the modified surface layers of the steel 12Cr18Ni10Ti identified carbide and density of the particles and developed dislocation substructure, positive impact on the physico-mechanical properties of steel.

The main provisions for the thesis defense.

1. Technology EPT and optimum modes of plasma electrolytic carburizing, retracements and nitriding the surface of the steel 12Cr18Ni10Ti;

2. Basic regularities of changes in the microstructure, the substructure and the phase composition of the surface of the steel 12Cr18Ni10Ti after EPT predicting the kinetics of the processes of cementation, retracements, nitriding to obtain the modified layer with the specified technical characteristics and simultaneous fragmentation of the substructure, the formation of subgrain structure in which there is net dislocation substructure with particles of carbides and nitrides of iron on the boundaries of subgrains;

3. Peculiarities of changes in physical-mechanical properties and corrosion resistance of steel after plasma electrolytic carburizing, retracements and nitriding followed by quenching.

Scientific and practical value.

In this work it was found that EPT the surface of the steel 12Cr18Ni10Ti improves its physical and mechanical properties, which is a consequence of changes in the structural-phase state of the hardened layer. The emergence of stainless steel 12Cr18Ni10Ti such structural components as nitrides, carbides, acicular martensite becomes possible due to the saturation of the steel with nitrogen and carbon in the process of EPT.

In the work were developed innovative patents for inventions: "Installation of electrolyte-plasma processing", which is intended for modification and surface hardening of metal parts for various purposes; "Method of plasma electrolytic carburizing of stainless steel, which consists in heating the parts to a temperature 950-990 °C and subsequent quenching in an electrolyte containing 10 % Na_2CO_3 and 10 % $C_3H_8O_3$.

The methodology of the studies revealed the formation of hardening carbide and nitride phases and their influence on physical-mechanical properties, can be used by researchers in the modification of other types of steels.

Publication. Just on the topic of the thesis were published in 18 publications in co-authorship, of which: 6 works (3 article, 3 innovation patent) published in the publications recommended by the Committee for control in the sphere of education and science of the Republic of Kazakhstan; 1 article published in international journal with a non-zero impact factor included in the database of Thomson Reuters; 2 articles published in foreign journals included in Scopus database; 9 abstracts and papers in proceedings of international conferences.

The structure and scope of the thesis. The work consists of an introduction, four chapters, conclusion and list of used sources. She set out on page 120, contains 74 figure, 6 tables, and bibliography list of 181 titles.