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INVESTIGATION AND EXPERIMENTATION IN THE USE OF TITANIUM AS A STRUCTURAL MATERIAL FOR HYDROMETALLURGICAL APPARATUS

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V. B. Zhilkin

The high aggressiveness of the technological media with respect to the majority of structural materials due to the simultaneous presence of sulphates and chorides in them of metals, dissolved gases (oxygen, chorine, sulphur dioxide), solid particles of precipitants and residue, as well as increased temperatures of up to 80° (Table 1) is a specific feature of hydrometallurgical production of nickel and cobalt. In these media, as extended industrial testing and investigation disclosed, all stainless steels and alloys, the majority of synthetic polymers (capron, polyethylene, vinyl plastic, various brands of resin), wood cellulose, natural and certain synthetic rubbers (capron, chlorine, etc.) are unstable. Stainless steels, which are the basic design material for the majority of hydrometallurgical and chemical production devices, are the most susceptible to corrosion deterioration under these conditions.

The corrosion resistance of stainless steels (brands EI401, EI402, EI403, EYalT, Kh23N, Kh55N), as well as nichrome, nickel, and cupronickel in a synthetic solution corresponding to the composition of industrial anolyte was studied. All these materials proved to be unstable. Kh23N23M2, EYalT, Kh23N steels, Hastelloy alloy B, and electrolytic copper were tested in industrial media. They also deteriorated rapidly in anolyte, and in a bath after removal of iron, i.e., in the most aggressive media with regard to the metallic structural material media of the nickel electrolysis plant. Later on, multifaceted tests were conducted on Kh23N28M3D3T and Kh18N12M2T steels, as well as on titanium for the purpose of determining their suitability and quality as a structural material for manufacturing centrifuges. Under laboratory conditions the samples were tested by boiling in a solution after removal from iron, and then under production conditions - in a flowing anolyte for 110-120 hours. It was clear that titanium has high resistance whereas the stainless steels experienced strongly expressed localized corrosion.

Table 1. Characteristics of the basic technological media for the hydrometallurgical production of nickel.

Medium	Solid phase content, g/m^3	Liquid phase characteristics: T, °C; pH	Remarks
1. Anolyte	Practically none	70; 2.5*	-
2. Ferrous sinter cake suspension	≤ 2	70; 3.5	The suspension is aerated and contains active chlorine compounds
3. Cement copper suspension	≤ 1	70; 2.5	The suspension is mixed hydrodynamically and contains copper and nickel metallic particles
4. Cobalt sinter cake suspension	≤ 4	70; 4.0	The suspension is aerated and contains active chlorine compounds
5. Catholyte	Prohibited	70; 2.6	-

*~70 g/l of nickel.

Below are some of the results of testing titanium alloys for corrosion in industrial media and under laboratory conditions. The tests were conducted by screening in flowing media (see Table 1), directly in the technological apparatus, samples of titanium alloys belonging to different alloying systems. The samples were prepared from various semifinished products - sheets, forged rods, pipes, casts, foils with different kinds of technological treatment. Welded samples were also tested. Corrosion control was accomplished a) by internal features (visually); b) by changing the weight (the absence of signs of localized corrosion was the basis for calculating the deep-seated indicator); c) by changing the mechanical properties for exposing the intercrystalline corrosion (for testing discontinuous samples and Menage samples were used). The test time for the samples was not less than 1000 hours. All the samples proved to be stable - stability, according to GOST 5272-50 [ГОСТ = GOST = All-Union State Standard], was 1 point. The test results, given in Table 2, permitted the following conclusions to be drawn:

1. In conditions of basic technological media of a nickel electrolysis plant, all titanium samples tested were found to be in the stable, passive state and are completely stable (1 point on the GOST 5272-50 scale).

2. All alloys tested showed no disposition to intercrystalline corrosion.

3. The strength of weld seams is equivalent to the strength of the base metal.

4. Technological working (casting, hot deformation, mechanical treatment) does not reduce the corrosion resistance of titanium alloys under test conditions.

Table 2. Results of testing titanium alloys for corrosion under working conditions.

Brand or alloys system	Nominal chemical composition, %	Sample characteristics	Proposed purpose of the alloy, test purpose	Test site (working medium according to Table 1	Test time, hours	Corrosion inspection method: Visual	Corrosion inspection method: Weight depth index, mm/yr	Corrosion inspection method: Change of mechanical properties
				α-alloys				
VT1	Technical titanium	Ingots, rods, sheets, pipes welded samples	Basic structural material for manufactured apparatus	1, 2, 3, 4	1000-4000	Without changes	≤0.001	Not observed***
IMP-1	The same	Sheets, rods	The same, comparison with VT1	1	1000	The same	≤0.001	Not observed
VT5	5Al	Rods, castings	Cast formed products	1, 2, 3, 4	1000	"	≤0.001	Not observed**
VT5-1	5Al; 2.5Sn	Sheets	Comparison with VT1	1, 2, 3, 4	1000	"	≤0.001	Not observed*
VTL1	5Al; 1.0Si	Ingots	Production of cast formed products	1, 2, 3, 4	1000	"	≤0.001	Not observed
Ti-3Al	3.4Al	Sheets, forged rods	Comparison with VT1	1	1000	"	≤0.001	Not observed***
Ti-Al-Zr	3Al; 2.5Zr	Pipes, rods	Production of heat exchange and other pipe apparatus	1, 2, 3, 4	1000	"	≤0.001	Not observed**
				α + β-alloys (β-stabilizers up to 2%)				
OT4-1	2Al; 5Mn	Sheets, rods	Comparison with VT1	1, 2, 3, 4	1000	"	≤0.001	Not observed***
OT4	3Al; 1.5Mn	The same	The same	1, 2, 3, 4	1000	"	≤0.001	Not observed***
VT4	4Al; 1.5Mn	Sheets	"	1, 2, 3, 4	1000	"	≤0.001	Not observed*
AT3	3Al; 1.5% (Fe + Cr + Si + B)	Rods	"	1, 2, 3, 4	1000	"	≤0.001	Not observed**
				α + β-alloys (β-stabilizers more than 2%)				
VT3	5.5Al; 2.5Cr	Rods	Comparison with VT1	1	1000	Without changes	≤0.001	Not observed
VT14	4Al; 3Mo; 1V	Sheets, foil, rods	Reinforcing products, pickup parts	1, 2, 3, 4	1000	The same	≤0.001	Not observed
VT16	2.5Al; 7.5Mo	The same	The same	1, 2, 3, 4	1000	"	≤0.001	Not observed
				β-alloys				
VT15	2.5Al; 7.6Mo	"	"	1, 2, 3, 4	1000	"	≤0.001	Not observed

*On discontinuous sheet samples. **On Mesnager samples from rods or ingots. ***On these and other samples.

5. For manufacturing technological apparatus - pumps, the locking conduit armature, filters, as well as for parts and subassemblies in regulation-measuring apparatus, which function under test conditions, it is recommended that we use technical titanium VT1 brand) since it is sufficiently strong, the most technological, unique, and feasible for economic representations of titanium alloy.

6. Using melted alloys, alloyed with aluminum (VT5) and aluminum and silicon (VTL1) is recommended for improving the melt properties. It is advisable that the preparation of the melt-formed parts of the equipment be determined by structural requirements and economic feasibility.

7. Using thermal resistant VT14, VT15, and VT16 alloys in the strong structural elements (mounting parts), in KIP instrument parts and automatics (diaphragms and other elements), as well as in friction subassemblies is recommended.