CORROSION OF WELDED JOINTS IN AK-1 AND AK-2 ALLOYS UNDER STRESS

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Titanium is a relatively expensive material for chemical machine building. Cheaper alloys based on titanium-production wastes can be employed in the manufacture of chlorine salts. Titanium alloys of types AK-1 and AK-2 are rather stable in mineral and organic acids [1]; in the present investigation, we studied their tendency toward corrosion cracking under stress. As can be seen from Table 1, the alloys and welded joints in them exhibited satisfactory mechanical properties. The specimens were subjected to automatic single-pass argon-arc welding without bead removal, using a nonconsumable tungsten electrode. Cut specimens 115 × 15 × 4 mm in size (including the seam in the center) were placed in special titanium retainers and a screw was used to set up a stress equivalent to 90% of the yield strength; the specimens were then immersed in the test solutions. As can be seen from Table 2, the AK-1 and AK-2 alloys and welded joints in them had high stability in chloride solutions. Visual examination of the specimens revealed no cracks or surface crazing. Metallographic studies made with a magnification of ×300 also failed to reveal any destruction in saturated $CaCl_2$ and $MgCl_2$ solutions; however, superficial corrosion occurred in the zone of thermal influence in welded joints in AK-1 and AK-2 alloys exposed to saturated NH_4Cl solutions. According to [2], titanium alloys with a coarse-grained structure tend to corrode under stress in 10% hydrochloric acid at 35°C with holding times of more than 100 h. However, we did not observe any signs of cracking either visually or metallographically after testing for 500 h in 10% HCl (Table 2).

The alloys investigated and the welded joints in them thus exhibited no tendency toward surface crazing in 10% HCl even under the maximum permissible loads. A tendency toward corrosion cracking under stress in 99% gaseous HNO_3 was previously observed for VT-1 titanium and welded joints in it. In our experiments, no cracks were detected after specimens of AK-2 alloy and welded joints in this alloy were exposed to the conditions in question for 600 h. No cracking occurred in the liquid phase. Slight damage was observed over the zone of thermal influence. Failure did not occur in specimens of AK-1 alloy

TABLE 1. Chemical Composition and Mechanical Properties of AK-1 and AK-2 Alloys

Type of alloy and thickness, mm	Material tested	Chemical composition, wt. %				Mechanical properties							
		Al	V	O_2	H_2	σ_S, kg/mm²	σ_B, kg/mm²	δ, %	ψ, %	α, deg	a_n, kgm/cm², seam	a_n, kgm/cm², zone of thermal influence	Strength of welded joint and failure site
AK-1 6	Base metal	—	2,0	0,23	0,005	90,6	93,9	23,7	41,7	48	4,7	—	—
	Weld metal	not determined		0,23	0,006	91,8	94,3	12,7	23,1	40	3,1	4,1	92.1 kg/mm², zone of thermal influence
AK-2 6	Base metal	2,9	2,0	0,28	0,005	92,1	96,7	16,7	36,1	27	3,1	—	—
	Weld metal	not determined		0,31	0,005	98,3	102,2	8,1	17,1	25	2,2	2,5	106.3 kg/mm², zone of thermal influence

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TABLE 2. Corrosion Rate of Ak-1 and AK-2 Alloys and Welded Joints in Them in Different Media

Alloy	Metal	Corrosion rate, mm/year					
		99% HNO_3 50°		10% HCl 35°	NH_4Cl, saturated, 116°	$CaCl_2$, saturated, 127°	$MgCl_2$, molten, 154°
		liquid phase	gaseous phase				
		1000 h	600 h	500 h	900 h	900 h	1000 h
AK-1	base	0.001	0.003	0.0053	0.0008	0.0006	0.0002
	seam	0.001	0.003	0.0059	0.0002	0.0002	0.0003
AK-2	base	0.003	0.066 crack	0.0086	0.0006	0.0006	0.0003
	seam	0.003	0.009 crack	0.0068	0.0002	0.0008	0.0004

and welded joints in this alloy when tested in both liquid and gaseous media.

Alloying of titanium with vanadium thus substantially raises the resistance of the alloys to corrosion cracking in aggressive media in comparison with unalloyed titanium. Alloying with aluminum reduces the resistance to corrosion cracking.

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