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The tendency of high-strength aluminum ALLOY 1933 to Corrosion Resistance

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ABSTRACT

The use of aluminum alloys is limited due to their tendency to local corrosion (delaminating, pitting, corrosion cracking and corrosion fatigue). Corrosion, which leads to cracking, appears primarily in high-strength alloys, where they are subjected to prolonged tensile stress in the presence of a corrosive medium

This article presents the results of studies of the tendency to intergranular corrosion and corrosion cracking of high-strength aluminum alloy 1933. It is established that the tendency to intergranular corrosion does not depend on cooling conditions during quenching. The experimental data are summarized in a table from which it follows that the material of the selected forgings in almost all cases exhibits a tendency to intergranular corrosion, regardless of the temperature of the water during quenching. In order to obtain data, structural studies of intergranular corrosion have been carried out, which can be used to predict the structure and properties of alloy products after heat treatment to establish the correspondence between the tendency to MKC and KR in order to reduce the time for conducting control tests.

Key words: High strength aluminum alloy 1933, intergranular corrosion, anodic oxidation1.

1. INTRODUCTION

Under operating conditions, aviation materials are exposed to aggressive atmospheric factors. A moisture film formed as a result of dew or atmospheric precipitation on the surface of the metal material initiates the occurrence of electrochemical reactions, which can result in the nucleation of corrosion centers [1].

In modern airplanes, in order to obtain a high weighted design efficiency in combination with a long service life and operational reliability, it is necessary to use alloys with a high level of strength, fracture toughness, fatigue resistance, and corrosion resistance [2-5].

Aluminum alloys are characterized by the formation of pitting on the surface, which in the future may cause the development of intergranular corrosion (MCC). This type of corrosion damage is especially dangerous because it cannot be detected visually. MCC from the surface can spread to a critical depth and lead to the destruction of critical parts and structures.

Despite the fact that there is a comprehensive system of anticorrosive protection of aircraft - corrosion damage is the most common defects.

Over the years, high-strength aluminum alloys of the Al – Zn – Mg – Cu system have occupied a dominant position in aerospace engineering designs thanks to a successful combination of service and technological characteristics. These characteristics are possessed by the Russian alloy 1933, created at VIAM (All-Russian Institute of Aviation Materials) [6–9]. High-strength alloy 1933 is intended for large-sized forged and pressed semi-finished products as applied to the details of the internal power set - such as fittings, frames, spars [9]. Due to the chemical composition and technological conditions for the manufacture of semi-finished products, with a strength of 480–540 MPa, high fracture toughness values (K1s = 40–45 MPa) and a reduced fatigue crack growth rate (SRTU: dl / dN = 1.6–2.0 μm) were obtained / cycle) [10]. Alloy 1933 is superior in these indicators to foreign analogues in use - alloys 7050, 7175, 7085.

2. RESEARCH

Alloy 1933 belongs to the group of high-strength aluminum alloys based on the A1 - Zn - Mg - Cu system with the addition of Zr (the chemical composition of the alloy according to OST 1. 90073-80 is shown inTable 1).

Table 1: Alloy Chemical Composition

The basis	Cu	Mg	Mn	Zn	Fe	Si	Ti	Cr	Zr	Be
Al	0.8-1.2	1,6-2,2	<0,1	6,35-7,20	0,06-0,15	<0,1	0,03-0,06	<0,05	0,1-0,18	0,0001-0,02

The alloy is supplied according to OST 1. 90073-96 in the form of forgings and stampings, including large ones with a thickness of 200 mm or more.

High-strength alloy 1933, which meets the requirements of designers for strength, resource and reliability, is one of the main materials for the manufacture of parts of the airframe's power frame (frames, spars, fittings, etc.) for modern promising aircraft (SSJ, MS-21, etc.)

An analysis of the scientific and technical literature indicates that information on the tendency to intergranular corrosion has been little studied. Resistance to corrosion cracking is known for alloys of this group, however, this control, unlike tests for susceptibility to MCC, requires special devices and, in addition, takes a long period of time.

The relevance of this work was an attempt to establish a correspondence between the propensity for MKK (figure 1) and KR in order to reduce the time for conducting control tests.

For research, we took material from serial forgings manufactured at one of the metallurgical plants in MTMO mode. Heat treatment was carried out in furnaces of the thermal workshop, on templates with sizes 80x80 according to T2 mode:

-quenching with T = 465-475 ° C, cooling in cold (20 ° C) or hot (60-70 ° C);

-aging: 115 ± 5 ° C, holding for 8 hours, rising to T = 170 ± 5 ° C, holding for 8 hours, cooling in air.

The quality of the heat treatment was controlled by KSP-3 devices, control flexible thermocouples, hardness, electrical conductivity measurements, as well as determination of mechanical properties by samples cut from each template.

Fivex20x40 mm samples were cut from the templates, which were tested for a tendency to MKK according to GOST: 3 pcs. - in solution No. 1 (NaHl) and 3 pcs. - in solution No. 2 (with H2O2), as well as samples for testing for KR according to GOST 9.019-74, size 2x15x90 mm, 3 pcs each.

The intergranular corrosion depth was determined by metallographic analysis at a distance> 5 mm from the end face.

Because the parts made of the material under study are subjected to anodic oxidation, it was also interesting to find out whether the parts protect the anode film from the occurrence of MCC. For this, part of the samples was tested for their tendency to MCC after anodic oxidation according to the technology at the factory.

3. RESULTANDDISCUSSION

The research results are summarized in table 2, from which it follows that the material of the selected forgings in almost all cases exhibits a tendency to MCC, regardless of the temperature of the water during quenching

Table 2: Test results for the tendency to MKK and KP alloy samples 1933

Cipher code - about the party	T of water when cooling	MCC without anode film				MCC after anodizing				KP
		Solution № 1 (s NaCl)		Solution № 2 (s H_2O_2)		Solution № 1 (s NaCl)		Solution № 2 (s H_2O_2)		
2688-2100/3	64	1	0,26	4	0,07	7	0,17	10		not carried out
		2	0,3	5	0,043	8	0,24	11		
		3	0,2	6	0,05	9	0,24	12		
2688-2093/3	67	13	0,35	16	0,05	19	0,38	22		not detected
		14	0,19	17	0,07	20	0,26	23		
		15	0,35	18	0,13	21	0,23	24		
2700-2111/3	65	25	0,23	28	0,03	31	0,23	34		not detected
		26	0,23	29	0,012	32	0,19	35		
		27	0,18	30	0,04	33	0,19	36		
2688-2100/4	67	37	0,38	40	0,14	43	0,38	46		not carried out
		38	нет	41	0,14	44	0,4	47	not detected	
		39	0,38	42	0,09	45	0,38	48		
2698-2109/3	20	49	0,12	52	0,05	55	0,04	58		not detected
		50	0,19	53	0,02	56	0,07	59		
		51	0,09	54	0,05	57		60		
2695-2098/4	20	61	0,17	64	0,07	67	0,28	70		not detected
		62	0,24	65	0,07	68	0,19	71		
		63	0,24	66	0,07	69	0,19	72		
2695-2098/1	20	73	0,28	76	0,07	79	0,45	82		not detected
		74	0,19	77	0,16	80	0,35	83		
		75	0,21	78	0,03	81	0,28	84		
2698-2109/1	20	85	0,42	88	0,05	91	0,33	94		not detected
		86	0,38	89	0,04	92	0,38	95		
		87	0,38	90	0,05	93	0,19	96		

Table 2 also shows that for alloy 1933, solution No. 1 (with NaCl) is more rigid, since the samples tested in this solution (anodized and non-anodized) had an MCC from 0.09 to 0.42 mm, while the tested in solution No. 2 (with NaCl), the samples had an MCC from 0.012 to 0.16, while non-anodized samples showed no tendency to MCC.

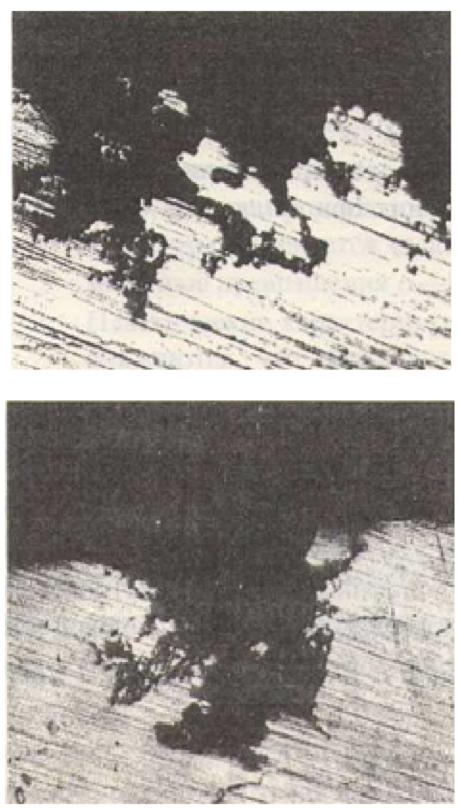

Figure 1: MKK view on thin sections. x500

4. CONCLUSION

Thanks to the research we have come to the conclusion:

1. When tested in solution No. 1, a tendency to MSC alloy 1933 was found both on samples that underwent anodic oxidation and on non-anodized samples.
2. When tested in solution No. 2, a tendency to MKC was found only on samples that were not subjected to anodic oxidation.
3. The depth of the MCC when tested in solution No. 1 is significantly less (3-7 times) than when tested in solution No. 2.
4. The tendency to MKK does not depend on cooling conditions during quenching.

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