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Comparative Studies of the Properties of Heat-Treated Welded Joints of AA2219 Alloy

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Comparative studies of welded joints of AA2219 alloy after corrosion tests in amyl (which is used as rocket fuel) are carried out. No changes in the morphology and dimensions of structural parameters in metal of seams and in heat-affected zone are revealed after exposure in amyl. Corrosion resistance of the AA2219-T81 and AA2219-T62 alloys in amyl corresponds to the standard metal resistance group—'resistant'. Welded joints are also resistant against intergranular and exfoliating corrosion as well as corrosion cracking: no local corrosion defects are detected. Strength coefficient of AA2219-T62 welded joints is by 30% higher than for AA2219-T81 joints, and, for both types, it is equal to 0.96 and 0.65, respectively. After soaking in amyl, T62 joints have higher ultimate strength and yield stress compared to T81 ones. Strength coefficient of AA2219-T62 welded joint after corrosion tests remains higher (0.94) than the strength coefficient of AA2219-T81 welded joint (0.65). At the same time, decrease in relative elongation of both joints may point to embrittlement of structural components in corrosive environment. As established, the heat-treatment conditions do not affect the values of resistance against uniform and local corrosion, mechanical strength and plasticity of the base metal. However, for welded joints, strength and plasticity are affected by heat-treatment conditions: AA2219-T62 joints have more uniform structure

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of weld metal and heat-affected zone; so, smaller difference in mechanical properties between welded joint and base metal is provided.

Key words: aluminium alloy AA2219, welded joint, heat treatment, corrosive environment, mechanical tests, corrosion resistance.

Проведено порівняльні дослідження зварних з'єднань стопу АА2219 після корозійних випробувань в амілі (який використовувався як ракетне паливо). Зміни морфології та розмірів структурних параметрів у металі швів і в зоні термічного впливу після витримування в амілі не відбуваються. Корозійна тривкість стопів АА2219-Т81 і АА2219-Т62 в амілі відповідає стандартній групі опору металу — «стійкий». Зварні з'єднання також є стійкими до міжкристалітної та відшарувальної корозії і корозійного розтріскування: локальних корозійних дефектів не виявлено. Коефіцієнт міцности зварних з'єднань АА2219-Т62 на 30% вищий, аніж для з'єднань АА2219-Т81, і становить для обох 0,96 і 0,65 відповідно. Після експонування в амілі з'єднання у стані Т62 мали вищу границю міцности та границю плинности порівняно зі з'єднанням у стані Т81. Коефіцієнт міцности зварного з'єднання АА2219-Т62 після корозійних випробувань залишився вищим (0,94), ніж коефіцієнт міцности зварного з'єднання АА2219-Т81 (0,65). У той же час зменшення відносного подовження обох з'єднань може свідчити про окрихчення елементів конструкції в корозійному середовищі. Встановлено, що умови термооброблення не впливають на значення стійкости до рівномірної та локальної корозії, механічну міцність і пластичність основного металу. Але для зварних з'єднань на міцність і пластичність впливає режим термічного оброблення: з'єднання АА2219-Т62 мають однорíднішу мікроструктуру металу шва та зони термічного впливу, завдяки чому забезпечується менша різниця механічних властивостей між зварним з'єднанням і основним металом.

Ключові слова: алюмінійовий стоп АА2219, зварне з'єднання, термооброблення, корозійне середовище, механічні випробування, корозійна стійкість.

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1. INTRODUCTION

Aluminium alloy AA 2219 is one of widespread light structural materials used in welded elements, units and assemblies of boosters (Saturn V, Apollo, Space, Shuttle, *etc.*) [1]. The alloy is characterized by a unique combination of properties: weldability, high strength and plasticity at a sufficiently low specific gravity, as well as significant cryogenic resistance. At the same time, the alloy is very sensitive to thermal welding cycle; therefore, during melting and crystallization of seams, the metal strength in heat-affected zone (HAZ) decreases due to the formation of heterogeneous structure during segregation of alloying elements and impurities along crystallites boundaries and grains.

Seam microstructure is determined by temperature gradient on distribution surface of solid solution, liquid metal and phases, the value of crystallization rate, as well as the nature of distribution of alloying elements in the volume of the seam metal. In addition, brittle layers of supersaturated phases can form between the grains, especially at the border fusion of weld and base metal. Sometimes, the layers form a dense frame around the grains [2, 3]. In addition, during argon arc welding of an alloy, individual pores may form in the seam structure. To prevent their formation [2] special activating fluxes (AlF_3, LiF, $KF–AlF_3$, K_2SiF_6) are used and DC welding is applied [4, 5].

Strength and plasticity indicators of welded joints of AA2219 alloy, obtained by argon arc welding with a non-fusible electrode, depend on metallurgical, technological and structural factors [4–6]. Particularly, they effect on the width and depth of the melting, the geometric dimensions of technological reinforcement and root of seam. The weakest part of butt-welded joints is heat-affected zone [6]. Heat treatments of joints after welding reduces the share of θ-phases in the seam structure, and regulate the size of eutectic layers [7, 8]. This makes the morphology of weld structure similar to the structure of other joint zones and make possible to increase strength, but with a decrease in plasticity [8–10].

The effect of increasing of plastic properties of AA2219-T8 alloy welded joints in production of large-sized fuel tanks is achieved, for example, by using multipass welding with tensile strength coefficient of 70% relative to the strength of the base metal and relative elongation more than 4% [8].

It should be noted that after welding, welded structural elements, aggregates and assemblies made of AA2219 alloy are usually subjected to heat treatment [8] according to various modes, which depend on the level of physical and mechanical properties required for the product's operating conditions in difficult conditions. The most widely used of them are as follow: artificial aging for 18 hours at 177°C (state T81), heat treatment followed by 8% deformation (T37), artificial ageing at 163°C for 24 hours to state T87, *etc*. In the work [8], it is emphasized that the implementation of artificial aging conditions for 36 hours at the temperature of 190°C (T62 state) allows simultaneously increasing strength and plasticity indicators.

Study of influence of cyclic heat treatment of welded joints of AA2219 alloy performed by arc welding with non-fusible electrode with an alternating polarity current on their properties showed that areas with different hardness are formed in HAZ [9], which lead to increase in the yield stress, but the plasticity of welded joint decreases.

A significant difference in physical and mechanical properties and local corrosion resistance of heat-stabilized after ageing AA2219 alloy was observed between coarse-grained and ultradispersed structures of

AA2219 alloy in the work [10]. The hardness and strength of the ultradispersed alloy were higher, and the susceptibility to intergranular corrosion (IGC) was lower compared to the alloy with a coarse-grained structure. At the same time, the resistance against exfoliating and electrochemical corrosion of the ultradispersed alloy was lower than that of the coarse-grained one. In addition, compared to the coarse-grained structure, the ultra-dispersed structure was less sensitive to local corrosion, which also depends on the ageing conditions. The difference in mechanical properties and the metal susceptibility to local corrosion of these alloys are mainly due to the complex interaction between alloying elements and impurities, the number of dislocations, and the peculiarities of the mechanism of separation of secondary phases' inclusions at the grain boundaries during the artificial aging operation [11].

More uniform microstructure of seams and an increase in strength by 44% at the rupture of welded joints of the AA2219 alloy, obtained by argon arc welding with a non-fusible electrode in an inert gas with a current of alternating polarity, was achieved due to use of the following parameters of heat treatment: heating at 535°C for 30 minutes, quenching in water, artificial aging at 175°C for 12 hours [12]. At the same time, the coefficient of strength of the joints was 76% of the level of the base metal. It is also noted that corrosion resistance of the joint after such a treatment is higher than for the joint after welding. Nevertheless, HAZ metal remains sensitive to the influence of a corrosive environment, which is explained by the dissolution of some structural components and segregation of Al_2Cu phase along grain boundaries.

Artificial ageing leads to the release of a finely dispersed metastable θ' phase in the weld metal, which contributes to an increase in the hardness of the weld metal by 20%. At the same time, destruction of joints during the tensile test occurred in the weld seam and the heat-affected zone.

Thus, summarizing the above-mentioned examples demonstrate the practical feasibility of further, comprehensive and thorough research of physical and mechanical properties of AA2219 alloy welded joints by various scientists. Our previous works have discussed in detail the properties of the base metal and welded joints obtained by fusion welding along and across rolled heat-treated joints in different modes [13, 14]. It is of practical importance to compare their operational properties in order to determine the most acceptable for operating conditions

Therefore, the following goal was formulated in this work—to conduct a comparative analysis of a complex of corrosion and mechanical properties of heat-treated welded joints of AA2219 alloy with thickness of 3 mm, obtained by argon arc welding with a non-fusible electrode along the rolling direction.

2. EXPERIMENTAL DETAILS

Aluminium alloy AA2219-T31 of Al–Cu alloying system with a thickness of 3 mm was the object of research. Chemical composition of that alloy (Table 1) was determined on Spektrovak-1000 spectrometer of the Baird Company, and according to the content of main alloying elements, this alloy corresponds to AMS-QQ-A-250/30A [13].

The plates were welded in a horizontal position along the rolling direction in argon shielding gas. A non-fusible tungsten electrode with a lanthanum coating and filler wire 2319 with a diameter of 1.6 mm were used. Power source was welding machine MW-450 (Fronius), alternating current, 200 Hz with a rectangular waveform; $I = 280$ A, $V = 20$ m/h, wire feed speed 117 m/h. To melt completely the welded edges in one pass, a stainless-steel substrate with a rectangular groove 4 mm wide and 1 mm deep was used, which made it possible to obtain high-quality formation of butt seams with technological reinforcement. Seams quality was assessed by the x-ray method on the RAP-150/300 device; the density of the seam metal was evaluated on the Densitometer DP-30 device. The geometric parameters of the seams were measured with an ART-34460-150 electronic calliper with division value of 0.01 mm. Test specimens were made from the welded blanks. The specimens were heat treated as described in Fig. 1.

Corrosion tests were carried out in amyl at 50°C for 45 days at the base of the testing laboratory of Design Office 'Pivdenne'. After that, the values of corrosion resistance, including resistance against local corrosion, as well as the nature of changes in mechanical properties were evaluated. Specimens were placed in the test stand (Fig. 2). The specified duration of tests in amyl corresponds to the calculated service life of the rocket-fuel storage capacity—1 year. In this regard, it is interesting to evaluate and compare the peculiarity of changes in mechanical properties of welded joints of AA2219 alloy during various

TABLE 1. Chemical composition of AA2219-T31 alloy [13].

Specimen or standard requirement	Weight part of the elements, %									
	Cu	Mn	Zr	V	Ti	Fe	Si	Zn	Mg	Other elements: even in hole
Specimen	6.7	0.34	0.18	–	0.05	0.16	0.09	0.03	0.02	0.01 (Ni)
AMS-QQ-A-250/30A	5.8–6.8	0.20–0.40	0.10–0.25	0.05–0.15	0.02–0.10	≤ 0.30	≤ 0.20	≤ 0.10	≤ 0.02	≤ 0.05/≤ 0.15

heat treatment operations and to choose the most effective one.

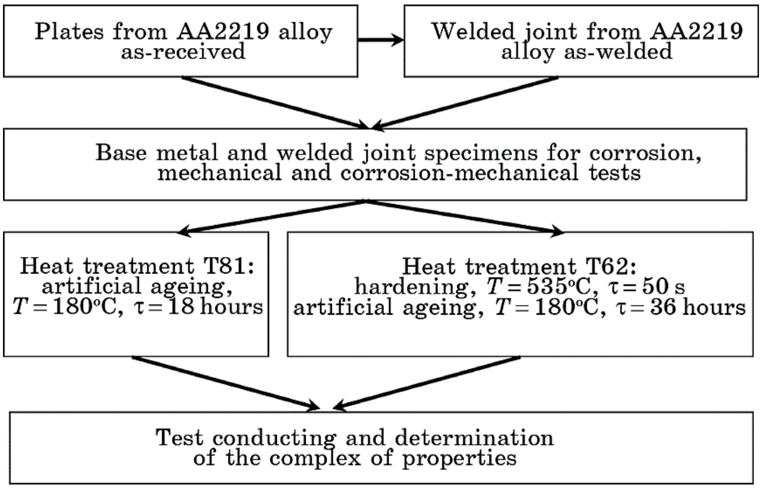

Fig. 1. Specimens preparing procedure for testing.

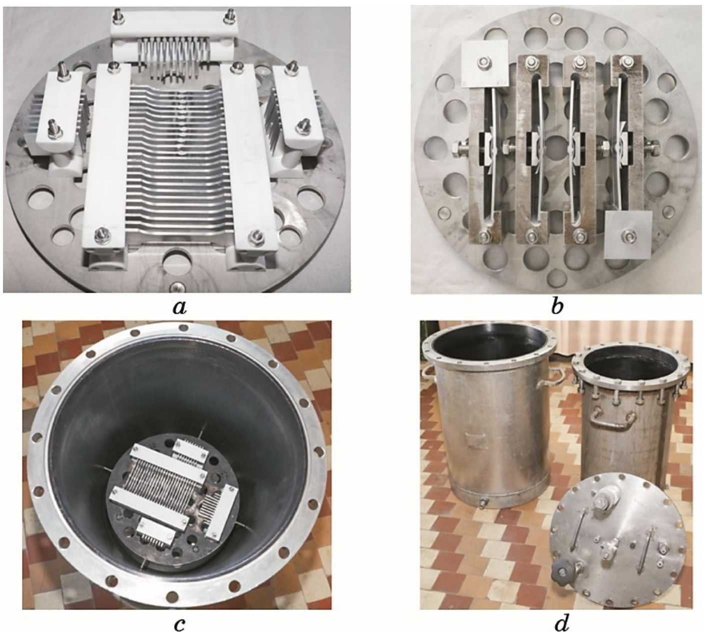

Fig. 2. Appearance of specimens prepared for tests: for determination of mechanical and corrosion properties (*a*), for determination of resistance against corrosion cracking (*b*), replacement of specimens in a test container (*c*), appearance of the test container (*d*).

Corrosion resistance of the base metal is estimated by massometry, and the corrosion rate in mm/year is calculated using the formula

$$\prod = \frac{8760\Delta m}{dST}, \quad (1)$$

where $\Delta m = m_1 - m_2$ is corrosion losses of the specimen [g], m_1 is mass of testing specimen [g], m_2 is mass of the specimen after corrosion tests, S is specimen surface area [m^2], T is duration of research [hours], ρ is aluminium alloys density equal to 2.7 g/cm^3, 8760 is the number of hours in a year.

Evaluation of resistance against exfoliating corrosion, intergranular corrosion and corrosion cracking (CC) was carried out after corrosion tests of specimen in amyl. The level of permanent deformation of specimens according to the four-point bending scheme for assessing durability against corrosion cracking, which was agreed with Design Office 'Pivdenne' was 957 kgf/cm^2. As one of the criteria for the influence of corrosive environment, the change in mechanical properties after corrosion tests was evaluated. Mechanical properties were determined on flat specimens with technological reinforcement on the front and back surfaces of the seam on an Instron-1126 machine at a speed of 6 mm/min. The relative elongation of the specimens was determined using extensometer No. G-51-12-M-A.

Metallographic studies were carried out on MMT-1600V microscope. The microstructure was detected by etching in a solution of such a composition: perchloric acid of 1000 cm^3 + glacial acetic acid of 75 cm^3.

3. RESULTS AND DISCUSSION

3.1. Investigation of Resistance against Uniform and Local Corrosion

Analysis of tests results of resistance of the base metal of AA2219 alloy against uniform corrosion in amyl indicates that corrosion rate of specimens is equal to 0.00362 mm/year for T81 stat and 0.00429 mm/year for specimens in T62 state. After tests, uneven darkening of the surface and corrosion spots formation of different planes were observed on specimens' surface. After removing of corrosion products, specimen's surface is shiny, no deep local defects are observed. Corrosion is identified as uniform and uneven; damages type is corrosion spots. According to the corrosion resistance scale [6], corrosion resistance of AA2219 alloy in T81 and T62 states in amyl is rated as 2, which corresponds to the resistance group—'resistant'. No significant difference in the corrosion resistance values of AA2219 alloy depending on the heat treatment (T81 and T62 condition) was established.

Resistance against exfoliating corrosion in amyl of base metal and welded joint of AA2219 alloy in both T81 and T62 state is rated as 2 in accordance to ГОСТ 9.904. The nature of change in the appearance of the specimens is a slight darkening of the surface with changing colours and corrosion spots.

Welded joint specimens of AA2219 alloy, heat-treated to T81 and T62 states, after corrosion tests in amyl, are resistant to intergranular corrosion and corrosion cracking. No destruction along grain boundaries and corrosion cracks was detected (Table 2).

3.2. Investigation of Macro- and Microstructures

The macrostructure of joints welded with a non-fusible electrode, consists of characteristic structural zones: the cast metal of the weld, the

TABLE 2. Corrosion and mechanical properties of heat-treated base metal and welded joint of AA2219 alloy: * is hardness of the weld metal, ** is hardness of HAZ.

Indicator	Base metal		Welded joint	
	Before corrosion tests	After tests in amyl	Before corrosion tests	After tests in amyl
		T81		
Ultimate strength σ_{ul}, MPa	463–462 463	466, 466, 464 465	293–308 301	315–314–309 313
Yield stress $\sigma_{0.2}$, MPa	365–367 361	373, 373, 355 367	234–241 238	230–257–232 240
Relative elongation δ, %	17.3–18.1 17.7	16.5–15.7–14.6 15,6	0.6–0.8 0.7	1.0–0.7–1.0 0.9
Corrosion rate, mm/year	–	0.00362	–	–
IGC resistance (breaking depth)	0	0	0	0
Exfoliation corrosion resistance, point	–	2	–	2
CC resistance (the presence of cracks)	–	No cracks	–	No cracks
Hardness HRB_{600}	99–101	100	80.5–96* 70–72**	77–97* 72–73**

Continuation of Table 2.

		T62		
Ultimate strength σ_{ul}, MPa	422–425 424	424–423–421 423	409–415 407	411–391–347 383
Yield stress $\sigma_{0.2}$, MPa	297–295 296	303–330–305 313	317–301 309	287–284–297 289
Relative elongation δ, %	17.6–19.1 18.4	17.0–15.5–14.4 15.6	4.0–5.8 4.9	4.8–3.5 3.8
Corrosion rate, mm/year	–	0,00429	–	–
IGC resistance (breaking depth)	0	0	0	0
Exfoliation corrosion resistance, point	–	2	–	2
CC resistance (the presence of cracks)	–	No cracks	–	No cracks
Hardness HRB_{600}	100–101	100	94–100* 95–96**	97–100* 97–98**

border of its fusion with the base metal, heat affected zone (HAZ). The structure of the metal weld is dendritic (Fig. 3, *a*, *c*).

Near the fusion border, dendrites have a columnar structure and directed from the fusion border to the centre of the seam; in the centre of the seam, dendrites are disposed along welding direction. Eutectic separations, the size of which does not exceed 15 μm, are located along the dendrite's borders. The uniform porosity, which is characteristic for alloys of this alloying system, is noted. Pores size do not exceed 50 μm, their density is 7–12% per 1 mm^2. Individual pores up to 0.4 mm in size are present in separate parts of the weld, which is acceptable according to the requirements of EN ISO 10042. Fusion zone separates the dendritic structure of the cast weld metal and the grain structure of the deformed metal of the heat-affected zone.

Intensive recrystallization processes were not detected in heat-affected zone, the grain size in this zone does not differ significantly compare with the grain size of base metal (Fig. 3, *a*, *c*). In contrast to other structural zones of joints, the precipitation of low-melting eutectics is observed along the grain boundaries.

At temperatures 350–370°C, that is, higher solidus temperatures,

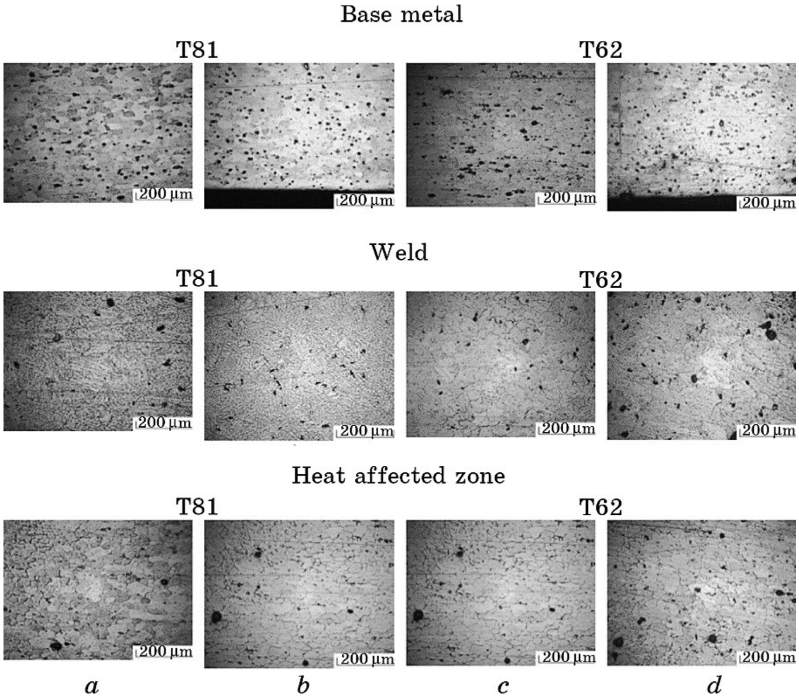

Fig. 3. Microstructure of different zones of welded joints of AA2219 alloy at T81 and T62 states before corrosion tests (*a*, *c*) and after tests in amyl (*b*, *d*).

alloying elements interact with each other, which contributes to the redistribution of structural components of the alloy and leads to a decrease in the hardness of the metal in this zone. It should be noted that a similar structural section is a component of any welded joint of aluminium alloys obtained by fusion welding. When moving away from the fusion line to the base metal, there is an area of annealing and aging in the structure, which was formed because of the action of the welding arc. In their structure, there are intermetallic precipitations of up to 25 μm in size, formed because of coagulation of insoluble intermetallic phases. The total width of the heat-affected zone of T81 welded joints on each side of the seam is 6 mm, and in T62 welded joints mode it is reduced to 2 mm (Fig. 3, *a*, *c*).

After corrosion tests in amyl, there are no changes in the morphology of the microstructure and grain sizes in the weld metal and HAZ (Fig. 3, *b*, *d*). This is quite natural, since, according to the results of the assessment of corrosion durability, no local corrosion defects were found on the surface of the welded joints (Table 2).

Hardness of T81 and T62 base metal specimens is almost the same, it is equal to 100–101 HRB_{600} (Fig. 4). So, exposure the specimens in cor-

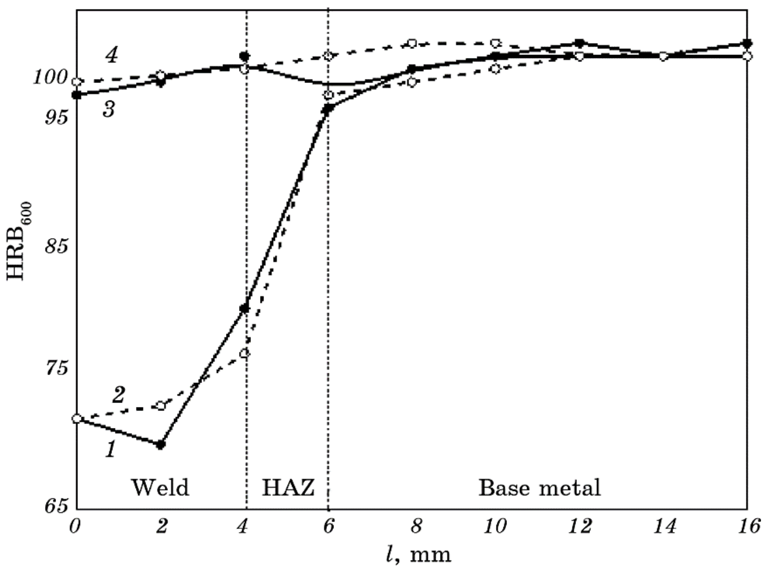

Fig. 4. Hardness of different zones of welded joints of AA2219 alloy heat-treated according to T81 (*1*, *2*) and T62 (*3*, *4*) regimes before corrosion tests (*1*, *3*) and after corrosion tests in amyl (*2*, *4*).

rosive environment did not significantly affect this indicator. Weld hardness differs more significantly depending on the heat treatment, and it is of 80.5–96 for T81 state and of 94–100 for T62 state, and for heat-affected zone, 70–72 and 95–96 HRB_{600}. However, as for the base metal, exposure to a corrosive environment practically did not change the hardness index. Therefore, it can be considered that the mode of heat treatment is a more significant factor affecting the hardness of the welded joint than the corrosion factor.

3.3. Mechanical Properties Investigation

Breaking diagrams of the studied specimens before and after corrosion tests are presented in Figs. 5, 6, *a*, in Figs. 5, 6, *b* the appearance of the destruction zone of specimens is shown. It should be noted that the rupture of both heat-treated welded joint occurred at a significantly lower value of relative elongation and at lower level of load.

The nominal yield stress of T81 welded joint specimens is 234–241 MPa, which is lower compared to the yield stress of the base metal, 365–367 MPa (Fig. 7, *a*). The ultimate strength of welded joints is 293–308 MPa, which is also less than the ultimate strength of base metal, 462–463 MPa (Fig. 7, *b*). Strength coefficient of as welded specimens was 0.65 relative to the strength coefficient of base metal. Expo-

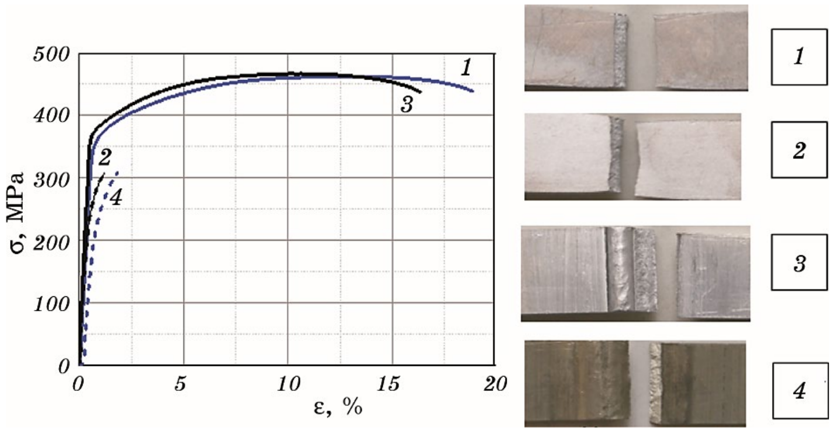

Fig. 5. Breaking diagrams (*a*) and the view of the fracture area of specimens (*b*) of base metal (*1*, *3*) and welded joint (*2*, *4*) of AA2219-T81 alloy as-received (*1*), as-welded (*2*) and after tests in amyl (*3*, *4*).

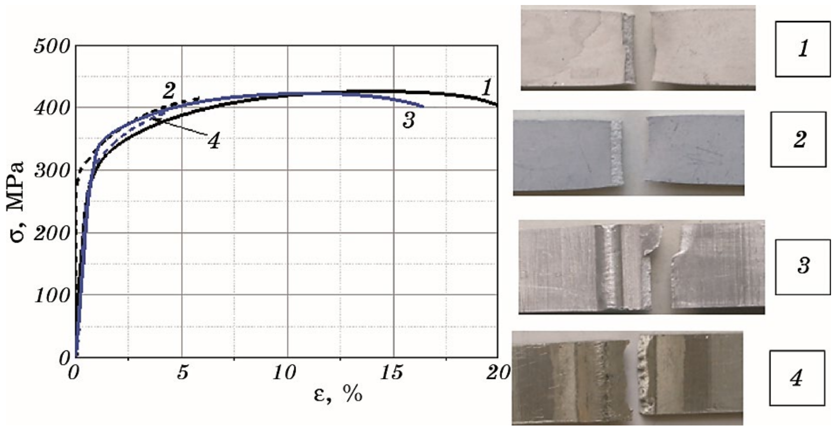

Fig. 6. Breaking diagrams (*a*) and the view of the fracture area of specimens (*b*) of base metal (*1*, *3*) and welded joint (*2*, *4*) of AA2219-T62 alloy as-received (*1*), as-welded (*2*) and after tests in amyl (*3*, *4*).

sure of welded joints in amyl caused near 1% increases in the yield stress of the AA2219-T81 alloy to 230–257 MPa.

At the same time, the ultimate strength of joints also increased by 4%, up to 309–315 MPa. However, the relative elongation of base metal decreased from 17.7 to 15.6% (Fig. 7, *c*), while for welded joint this indicator increased from 0.7 to 0.9%. It is likely that an increase in strength indicators and a decrease in relative elongation may point on embrittlement of individual components of the metal structure during its stay in amyl.

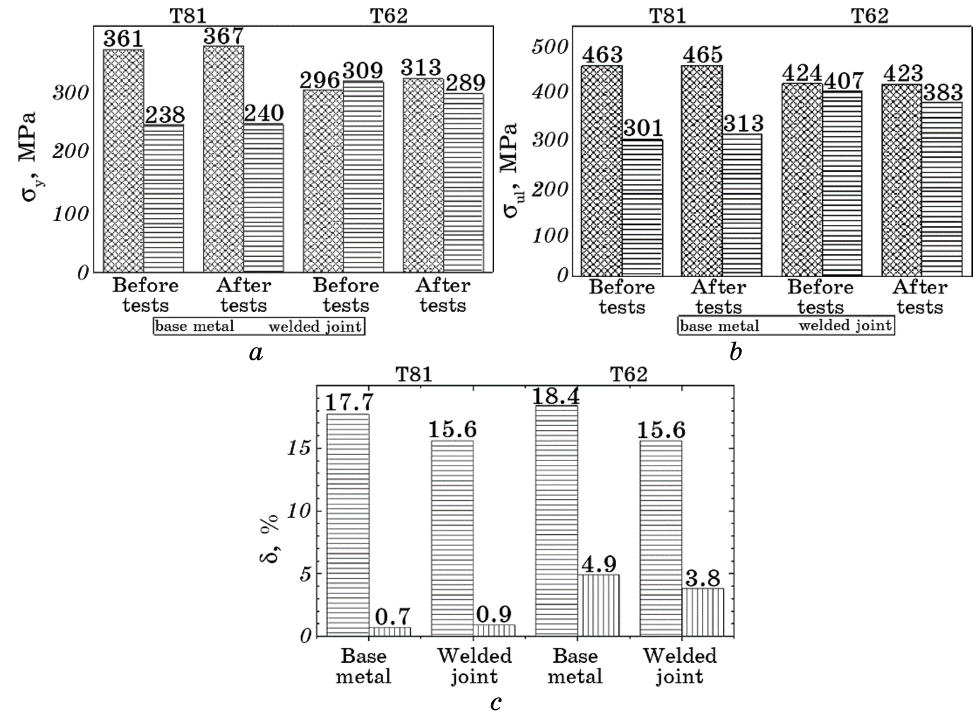

Fig. 7. Changes in mechanical properties of base metal and welded joint specimens of 2219A alloy in T81 and T62 condition along (*a*, *b*) the rolling before corrosion tests and after corrosion tests in amyl: yield stress (*a*), ultimate strength (*b*), relative elongation (*c*).

Conducting a quenching operation before artificial aging (mode T62) slightly increases the level of the yield stress of control samples of alloy joints to 301–317 MPa, which even slightly exceeds the value of the base metal indicator 295–297 MPa. The level of strength in this case is equal to 409–415 MPa, which also exceeds the strength of the base metal 422–425 MPa. The calculated strength coefficient of control samples of welded joints in the T62 state is 0.96 relative to the level of the base metal.

After exposure of the specimens of AA2219-T62 welded joints in amyl, a decrease of 6% of yield stress and ultimate strength is noted (Table 2). Relative elongation decreases by 22%. On the contrary, the yield point of base metal increases by 6%, and ultimate strength decreases slightly, by only 0.2%. At the same time, the relative elongation increases by 15%. The coefficient of welded joint strength of is 0.92.

When analysing the character of breaking of welded joints in T81 and T62 conditions, differences were found, namely, the rupture of

T81welded joints occur along the fusion zone, but T62 welded joints break along the HAZ at a distance of 4–5 mm from fusion line of the weld with base metal. As mentioned above, precipitation and coagulation of strengthening phases of insoluble elements of iron and silicon, as well as centre of the formation of low-melting eutectics at grain boundaries at temperatures higher than solidus temperature, and the course of coagulation processes with the formation of strengthening phases, which led to an increase in size of intermetallic precipitation, caused a decrease in hardness and destruction in this zone.

Analysing obtained results, it should be noted that base metal in both heat treatment state have higher indicators of mechanical properties compare to welded joint: AA2219-T81 base metal remain 30% higher than those of welded joints, AA2219-T62 base metal have by 10% higher properties than those for welded joints. At the same time, the values of ultimate strength and yield stress of T62 base metal are lower by 8 and 18% compared to such indicators for T81 base metal. On the contrary, ultimate strength and yield stress of T62 welded joint specimens is higher by 35 and 30% compared to similar indicators in the T81 condition. Strength coefficient of witness specimens of welded joints in the T62 state is greater than in the T81 state and is equal to 0.96 and 0.65, respectively. Hardness of base metal, weld and HAZ are equal: for T62 welded joint 100, 94–100 and 95–96 HRB_{600}, and for T81 welded joint 100–101, 80.5–96 and 70–72 HRB_{600}.

Study results of properties of heat-treated specimens of base metal and welded joint of AA2219 alloy after corrosion tests in amyl are given in Table 2.

It is noteworthy that the relative elongation of T81 base metal is 4% lower than T62 base metal, and the relative elongation of T62 welded joint is significantly higher compared to T81 welded joint—by 86%. That is, after T62 heat treatment, base metal has lower ultimate strength and plasticity, but had a slightly higher level of relative elongation.

It should also be noted that the difference in ultimate strength, yield stress and relative elongation between T81 base metal and welded joint is 35, 34 and 96%. For T62 base metal and welded joint, this difference is smaller by 4, 4, and 73%, respectively. Therefore, T62 welded joint has a more uniform structure compared to the T81 welded joint. This is precisely the result of a smaller difference in properties between base metal and welded joints.

4. CONCLUSIONS

Comparative studies of complex properties of base metal and welded joints of AA2219 alloy after corrosion tests in amyl environment were carried out.

1. It was established that microstructure of base metal of AA2219 alloy, heat-treated to the T81 and T62 states, does not changes after corrosion tests in amyl, neither in the central parts of metal, nor in surface layers. No change in the morphology and dimensions of structural parameters in metal of seams and in heat-affected zone was detected.
2. No differences in the corrosion resistance of welded joints of AA2219 alloy after exposure in amyl depending on the heat treatment mode were found. The rate of uniform corrosion of AA2219-81 specimens is 0.00362 mm/year; AA2219-T62 is 0.00429 mm/year, the corrosion resistance is rated as 2, which corresponds to the standard metal resistance group as 'resistant'. Corrosion is identified as uniform and uneven, the type of damage is corrosion spots. The resistance against exfoliating corrosion of base metal and welded joint was rated as 2 balls; change in their appearance is slight darkening with changing colours and individual corrosion spots. That is, welded joints of AA2219 alloy are resistant against intergranular corrosion and corrosion cracking in amyl, there no local dissolution were found along the boundaries of weld crystallites or HAZ grains, as well as no corrosion cracks were detected.
3. It was established that, under both conditions of heat treatment, mechanical properties of base metal are higher than those of welded joints are. AA2219-T62 base metal has lower ultimate strength and plasticity compared to AA2219-T81 state, and the relative elongation, on the contrary, has the opposite trend. The structure of T62-welded joints is more uniform than that of T81-welded joints, which causes a smaller difference between the values of mechanical properties of base metal and welded joints of AA2219 alloy. Strength coefficient of welded joint specimens in T62 state is 30% higher than in T81 state and is equal to 0.96 and 0.65, respectively.
4. After soaking in amyl, T62-welded joints are characterized by higher ultimate strength and yield stress compared to T81-welded joints. Strength coefficient of T62-welded joint specimens after corrosion tests in amyl, although decreased, remained significantly higher (0.94) than strength coefficient of T81-welded joint (0.65). At the same time, decrease in relative elongation may point to the probability of slow embrittlement of separate structural components of the metal in corrosive environment. Relative elongation of AA2219-T62 base metal is 3–4 times higher, in contrast to relative elongation of AA2219-T81 metal.
5. It has been confirmed that welding thermal cycle and heat treatment conditions do not affect the values of resistance against uniform and local corrosion, mechanical strength and plasticity of AA2219 base metal. Ultimate strength and plasticity of welded joints of AA2219 alloy with the same welding method is determined by heat treatment conditions: welded joints in T62 condition have a more uniform struc-

ture of weld metal and HAZ than in T81 condition. This ensures a smaller difference in mechanical properties between the joints and base metal.

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