TEMPERATURE DEPENDENCE OF FRACTURE RESISTANCE OF DIFFERENT ZONES OF HIGH-STRENGTH ALUMINIUM ALLOY WELDED JOINTS

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ABSTRACT

The experimental data of analysis of temperature dependences of characteristics of fracture resistance in different zones of welded joints of high-strength aluminium alloys AMg6 NPP 1201, 1420 are presented. It is shown that in all joint zones studied the test temperature reduction from 293 down to 20 K does not remarkably influence the value of the nominal rupture stress. The specific energy of crack propagation is reduced in alloy of Al-Li-Mg system, in particular. The metal fusion zone is characterized by minimum values of all indices of fracture resistance.

KEYWORDS

High-strength aluminium alloys, welded joints, different zones, fracture resistance, temperature dependence, examination.

The service reliability of welded structures of aluminium alloys at room and cryogenic temperatures largely depends upon their fracture resistance. The structure changes of metal, which occur under the action of thermal cycle of welding lead to the reduction of properties (Rabkin, 1986). The analysis of temperature dependence of fracture resistance of different zones of high-strength aluminium alloy welded joints will specify the temperature conditions of service of industrial high-strength aluminium-base light alloys.

The paper presents the results of studies of fracture characteristics of butt welded joints of thin sheet (δ = 4 mm) semiproducts of Amg6 NPP alloys (aluminium-magnesium), 1201 (aluminium-copper) and 1420 (aluminium-lithium-magnesium) in a wide range of temperatures (20...300 K). The studies of specimens of welded joints were carried out on flat specimens

at the 4 mm/min rate in the conditions of off-centre tension, when tensile and bending moment simultaneously affect the metal (Zinkevich and Dedrik, 1976). The specimens had a notch of 11 mm depth with 0.1mm radius in apex. The notch apex was located so that the fracture occurred along the weld axis (a), in fusion zone (b), in HAZ (C) located at 5 mm distance from the fusion boundary.

For comparison the specimens of parent metal (d), cut across the rolling direction were tested. The notch and, respectively, the effect of maximum levels of external load coincided with the welded joint zones being studied.

By coordinates of experimental points the fracture diagrams calculated the unknown characteristics of fracture resistance: nominal stress (σ_r) and specific energy of crack propagation (SECP) (Zinkevich and Dedrik, 1976). To increase the validity of numeric values of indices of fracture resistance the measurement of area of the non-linear part of the test diagram both in ordinate axes and in abciss axes were carried out with 95...98 % accuracy.

The welding was performed with a non-consumable electrode in argon. Wire SvAMg63 was used for welding alloys AMg6 NPP and 1420 as filler metal, while Sv1201 was used for alloy 1201. In all cases the wire diameter was 2 mm. The plates of alloys 1201 and 1420 being welded were heat-treated by the scheme: quenching and artificial ageing by the known conditions (Fridlyander, 1979). The quality of welded joints was satisfactory by the results of X-ray analysis of welds.

The comparison of levels of nominal failure stress at room temperature in different areas of welded joints of alloys studied showed that alloy 1420 is characterized by 15...20 % less values as compared to the alloys AMg6 NPP and 1201.

The values σ_r of weld metal in all three alloys at 293 K vary within 280...330 MPa, in HAZ the values are approximately similar in spite of different degree of material weakening. The metal of fusion zone has minimum level of nominal failure stress. The value for the given zone is 1.5 - 2 times less than in parent metal.

The notable differences between the alloys being investigated are distinguished in determination of specific energy of crack propagation (SECP). As compared to the parent metal the weld of alloys AMg6 NPP and 1201 at room test temperature is characterized by less values of SECP. The differences of temperature relationships of SECP value, observed in HAZ, are due to the chemical composition of alloys and nature of post welding structure state (Rabkin, 1986). The energy parameter of fracture SECP in the fusion zone of joints studied as well as value of nominal rupture stress is characterized by the least level (2.5...5.2 J/cm2).

With a decrease of test temperature down to 77 K the values of in all regions of welded joints of alloys being studied

are increased by 20...40 %. The strengthening is more notable in testing of the wrought metal. The nominal rupture stress of 1201 alloy is increased up to 550 MPa, of AMg6 NPP alloy - only up to 450 MPa. The value of 1420 alloy is 40...50 % lower as compared to the test conditions at room temperature. In the fusion zone the values σ_r are lower than in other alloys.

In case of cooling down to the temperature of liquid hydrogen (20 K), the values of nominal ruúpture stress in all studied zones of welded joints of alloys AMg6 NPP, 1201 and 1420 are increased by 10...20 %, as compared to the tests at 77 K. It is explained by the growth of stresses of disblocking of dislocations (Trefilov, 1989), that is caused by the reinforcing of interatomic bonds and by the narrowing of plastic deformations at cryogenic temperatures. The presence of such limitation of plastic deformations is experimentally proved by the reduction of fracture energy SECP in all zones of alloys being studied.The alloy 1420 differs from other ones by one order less values. However, this value of fracture resistance keeps approximately the same level as in the parent metal.

The higher values of characteristics of fracture resistance (σ_r and SECP) at 20 K are typical for the joints of 1201 alloy. This confirms the feasibility of 1201 alloy application and its welded joints for the operation in the conditions of superlow temperatures.

CONCLUSIONS

1. At all test temperatures the minimum values of fracture resistance and SECP in welded joints of three alloys being studied are typical for the fusion zone metal. In HAZ of welded joints of alloys AMg6 NPP and 1201 these characteristics are lower, and those of alloy 1420 are higher as compared to the parent metal in the initial state.

2. At low temperatures the welded joints of alloy 1420 differ from the joints of alloys AMg6 NPP and 1201 approximately by one order less values of SECP. At the same time this index keeps about the same level as that of the parent metal.

3. The welded joints of alloy 1201 in the 20...77 K temperature interval have the higher values of characteristics of rupture resistance as compared to other studied alloys.

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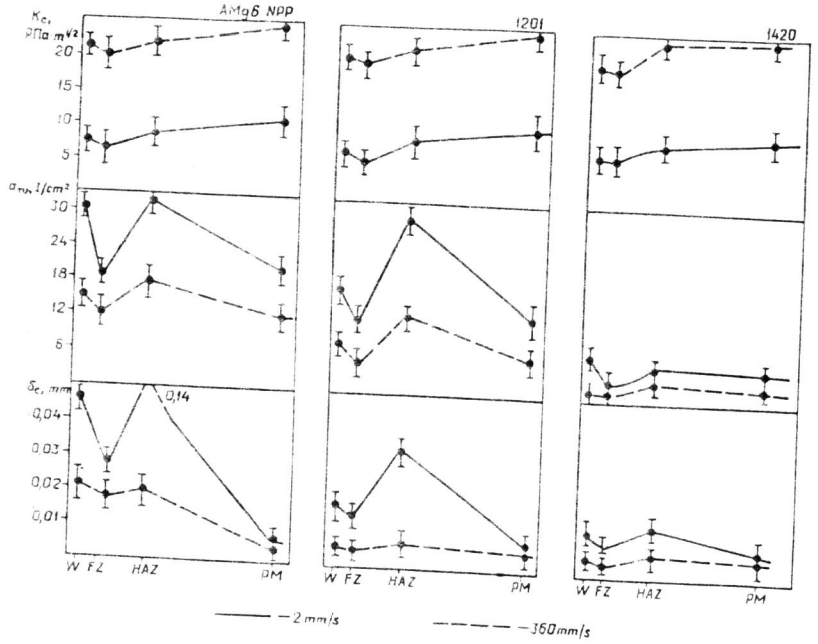

Fig.1. Effect of test temperature on the value of nominal rupture stress (σ_r) and specific energy of crack propagation (SECP) in different regions of welded joints of high-strength aluminium alloys.