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INFLUENCE OF THERMAL CONDITIONS OF WELDING ON THE FEATURES OF CRACK INITIATION IN THE HAZ OF JOINTS OF ALUMINIUM ALLOYS V96 AND V96tss

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The influence of thermal impact in nonconsumable electrode and electron beam welding on the features of cracking in different sections of the HAZ of high-strength complex-alloyed aluminium alloys V96 and V96tss at off-center tension has been analyzed. It is shown that the used temperature-time parameters of the welding mode change the volume fraction of particles contained in the alloy, their dimensions, shape and morphology of inclusion location on the boundary between the grains have an essential influence on the local stressed state in the HAZ metal and determine the associated mechanism of fracture site initiation.

Keywords: *high-strength aluminium alloys, welding, nonconsumable electrode, electron beam, thermal impact, structure, heat-affected zone, off-center tension, crack initiation, fracture*

Development of aircraft construction is inseparably linked with application of new structural materials of an improved composition and mechanical properties, one of which is V96 alloy of Al--Zn--Mg--Cu alloying system. It was highly appreciated by specialists as a material allowing structure weight to be reduced without decreasing its rigidity, thus making it attractive for flying vehicle manufacture [1]. On the other hand, welded joints of this alloy are characterized by unsatisfactory ductile properties and low resistance to cold cracking in the HAZ of welded joints in fusion welding, which is associated with running of irreversible physico-chemical processes, accompanying the thermal cycle of fusion welding. The welded joint HAZ develops six characteristic structural sections, differing by grain and boundary dimensions, phase and inclusion composition [2--5]. Formation of final structures and physico-mechanical properties of the HAZ metal depend on decomposition kinetics of metastable phases and are determined by heat input into the used welding process [1].

V96 alloy mechanical properties are improved by adding scandium, which has a high (1814 K) melting temperature and minimum (3.05 N/m^3) specific weight [6--8]. Dispersed particles of Al_3Sc phase form not as a result of special strengthening treatment, but are a product of high-temperature decomposition of oversaturated solid solution of scandium in aluminium at melt solidification. Al_3Sc particles are coherent with the matrix, they are uniformly distributed in the grain bulk and preserve their stability at comparatively high temperature, and, thus, stabilize the structure and suppress recrystallization, which runs in the metal. The main factor, explaining the unique influence of scandium on the structure and properties of aluminium and aluminium alloys, is the dimensional-structural similarity of crystalline lattices of aluminium (4.405) and Al_3Sc phase (4.407). Owing to such a similarity, Al_3Sc particles formed at initial solidification are effective grain nuclei, thus ensuring a maximum refinement of the cast grains (down to the dendrite cell size).

The mechanism of decomposition of aluminium solid solution, formed at weld metal solidification, is also determined by the principle of the above dimensional-structural similarity, namely the decomposition products (Al_3Sc particles) precipitate by the homogeneous mechanism. They feature a high density and short distance between the particles, respectively. Here, the strengthening and anti-recrystallization impact of scandium compared to other transition metals is noted.

To determine the causes for lowering of ductility of V96 alloy welded joints (wt.%: 2.3 Mg, 2.1 Cu, 8.1 Zn, 0.2 Zr), it is necessary to study the influence of thermal conditions of welding on the structural features of different HAZ sections, establish the mechanism of crack initiation in them, and compare it with similar sections of V96tss alloy of the same composition, but with scandium additives (0.3 wt.%). Presence of the latter in the alloy composition accelerates solid solution decomposition during thermal operations and promotes formation of finely-dispersed particles of intermetallic phases [5], which, being located in the grain bulk and along grain boundaries, strengthen the alloy and prevent metal recrystallization at heating during welding, while mechanical properties of the alloy are improved [8].

The purpose of this work is determination of the influence of structural and physical inhomogeneity found in the welded joint HAZ, on crack initiation in nonconsumable-electrode (TIG) and electron beam (EB) welding [5]. Scanning electron microscope JSM-840 with «Link-860/500» microanalyzer system (at accelerating voltage of 15, 20 and 30 kV) was used for investigations, allowing determination of the features of crack initiation and nature of damage of welded joints in the studied alloys.

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