THE USE OF RARE EARTH FLUORIDES AS FLUX COMPONENTS IN TIG WELDING OF TITANIUM

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The paper presents the results of investigations of the influence of rare-earth metal fluorides on structural changes in weld metal of titanium alloy VT22 for the purpose of using them in the flux filler of experimental flux-cored wire for welding this alloy. It was shown that refinement of β-grains is observed in welds made by argon-arc welding of VT22 alloy over a layer of flux, consisting of rare-earth metal fluorides. Addition of LaF_3 to the core of experimental flux cored titanium wire PPT-22 in combination with heat treatment allowed increasing the impact toughness of welds in argon-arc welding of VT22 alloy 2 times up to 30.6 J/cm^2.

Keywords: titanium alloy VT-22, TIG welding, flux-cored wire, rare earth fluorides

One of the advantages of welding titanium with flux application is presence of molten flux skin covering the welding zone and protecting it from harmful influence of O_2, H_2 and N_2. From the technological effectiveness viewpoint, none of the fluorides of alkali and alkali-earth elements is suitable as a one-component flux. Therefore, multicomponent systems, consisting of fluorides of alkali, alkali-earth and rare-earth metals, as well as alkali-earth metal chlorides are applied as fluxes in titanium welding [1]. Application of fluoride fluxes at argon arc welding of titanium leads to reduction of weld pool dimensions, shortening of the time of metal being in the molten state, and also binds hydrogen into TiF_xH_y compounds insoluble in the metal, that lowers the probability of initiation of gas phase nuclei in the weld pool and inhibits pore formation in liquid titanium.

Reference [1] is a study of the possibility of weld metal refining by adding to flux such elements active to oxygen and nitrogen, as cerium, lanthanum, yttrium in the form of fluorides. The most active refining action is produced by yttrium, the least active is produced by cerium, with lanthanum taking an intermediate position. It is found that not more than 10% of these fluorides should be added to the flux to refine the weld metal. Then, oxygen content in the weld metal will be equal to 0.09% and with further increase of LaF_3 or YF_3 content in the flux, it will remain constant.

The authors of [2] studied the possibility of modifying the weld metal using fluxes containing fluorides of rare-earth metals. The work shows that in welding of VT15 β-titanium alloy using flux, containing LaF_3, refinement of weld structure, improvement of mechanical properties of weld metal and lowering of oxygen content in it are observed. Increase of its ductile properties and impact toughness is noted. Chemical-spectral method showed that metallurgical interaction of liquid metal and molten flux, having LaF_3 in its composition, is accompanied by lanthanum transition into the weld metal.

This work is a study of the influence of rare-earth metal fluorides on structural changes in weld metal of VT22 alloy, in order to use them in the composition of flux filler of flux-cored wire PPT-22 [3].

Studies were conducted on welded samples 6 mm thick from VT22 alloy, produced by TIG welding over flux in one pass and without flux application. Experiments were performed with fluorides of LaF_3 and YF_3 rare-earth metals in the following regime: I_w = 200 A, V_w = 8 m/h; L_a = 2 mm, U_a = = 12.5…13.0 V.

It should be noted that in welds made by TIG welding over flux consisting of fluoride of a rare-earth metal (LaF_3 or YF_3), refinement of β-grains is observed in as-welded condition, compared to TIG welding without flux application. Analysis of grain distribution in welds over their cross-sectional area showed that the microstructure of the metal of a weld made by TIG welding without flux application, consists of a small number of large b-grains, and in welds, made with application of fluorides of both yttrium and lanthanum, the number of small grains is much higher than in the weld made without flux application. For instance, in the weld, produced with rare-earth metal fluoride, 10 times more grains of up to 0.1 mm^2 area appear, compared to a similar region of the weld, produced without lanthanum or yttrium participation.

Microhardness values of welds made with LaF_3 and YF_3 are on the level of 3450 MPa that is 150 MPa higher than those of welds made without addition of rare-earth elements and is closer to microhardness values of base metal (3800 MPa).

Thus, application of rare-earth elements in welding of two-phase (α+β)-titanium alloy VT22 at weld microhardness values close to those of base metal, leads to refinement of β-grains in the weld, that, in its turn, creates prerequisites for increase of weld ductility.

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