CHOICE AND JUSTIFICATION OF THE METHOD OF TITANIUM WELDING WITH PLATINUM

Anatolii Sanin
ORCID: https://orcid.org/0000-0002-5614-3882
Oles Honchar Dnipro National University, Dnipro, Ukraine

Igor Mamchur
ORCID: https://orcid.org/0000-0002-9957-5685
Oles Honchar Dnipro National University, Dnipro, Ukraine

Tatyana Nosova
ORCID: https://orcid.org/0009-0009-1591-8811
Oles Honchar Dnipro National University, Dnipro, Ukraine

Stella Mamchur
ORCID: https://orcid.org/0009-0004-1600-6068
Oles Honchar Dnipro National University, Dnipro, Ukraine

INTRODUCTION

Protection of marine objects from corrosion is the main condition for their operation. Platinum and titanium in the form of foil (bimetal) are chosen as electrode materials. The manufacturing of electrodes for antifouling protection, which are based on the process of seawater electrolysis with a large area (more than 1000 mm²), is a challenge. Modern requirements to electrodes: the design should be non-disassembling; the strength of connection of Pt foil with Ti base should be not less than 0.9 strength of platinum foil; partial non-welding of platinum foil with titanium is not allowed; depth of penetration of titanium into platinum at any point of contact surfaces is not more than 10% of foil thickness; electrode corrosion should not exceed 0.5 mm along the entire length of the electrode; cracks, melting and displacement of foil is not allowed [1].

OBJECTIVE AND TASKS

The purpose of this work is the choice of technology for joining platinum foil and titanium, as well as the development of welding modes. The analysis has shown that diffusion welding of platinum foil with titanium alloys on the contact area of more than 1000mm² with ensuring a continuous weld and preserving the original dimensions of platinum foil requires additional research [2]. Regularities of distribution of welding temperature and pressure, their influence on equal strength and quality of the joint at all points of contact, influence of technical parameters on the mechanism, structure and physical and mechanical properties of the given joint were investigated on samples with contact welding surface area not more than 1000 mm².

MATERIALS AND METHODS

Analysis of platinum-titanium system shows insignificant solubility of titanium in platinum of low-temperature modification and higher solubility in high-temperature modification of titanium. Ti3Pt, TiPt, and TiPt3 intermetallides are also formed. The use of fusion welding will lead to the formation of all the above phases in the molten zone. It is not possible to regulate their extent. Application of diffusion welding in vacuum allows to regulate the phase composition by changing the welding parameters. The following methods were used to study the phase composition of the platinum-titanium diffusion zone: metallographic analysis; X-ray diffusion analysis; X-ray diffusion analysis; micro-X-ray spectral analysis; electron microscopic analysis. Diffusion welding requires heating the parts to be joined to a certain temperature [3,4]. Factors such as welding temperature, structural shapes, dimensions of the products to be welded determine the choice of heating source. In this work we designed and manufactured a unit for pressure transfer by rotating rolls and investigated the possibility of obtaining welded joints between foil and substrate without thinning the foil. The influence on the strength of the welded joint of the main welding parameters, which determine the technological process: welding temperature; welding pressure in the welding zone; welding time; the amount of vacuum in the welding zone, was investigated on the designed unit with a fixture for pressure transfer by a flexible membrane.

RESULTS

Microstructural studies were carried out on samples in cross-section at magnifications x500, x4000 (fig. 1). The detailed structure of the diffusion zones was studied using a scanning electron microscope REM (fig. 2). Determination of the phase composition of the diffusion zones was carried out on the DRON-1.5 unit. The analysis was carried out to identify phases and mixture of phases. Since the diffusion zone of bimetallic compound platinum-titanium is a multiphase system, the X-ray diffraction pattern of this zone will have a continuous diffraction pattern. The intensity of the maximums of the X-ray diffraction pattern is proportional to the number of phases and is represented by one or two of the most intense lines, which were preliminarily recorded for the initial joined metals. The most intense reflections fall in the angle range 20°-65°. The accuracy in determining the true value of the identity periods is approximately 0.0002 Angstrom.

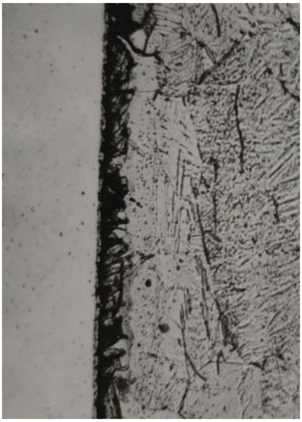

Figure – 1 Microstructure of the diffusion zone of platinum-titanium compounds (x500)

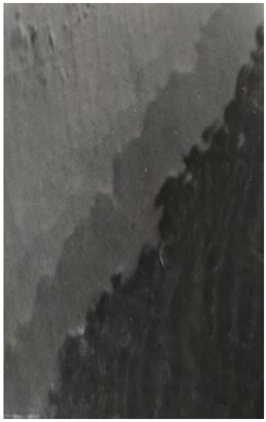

Figure 2 - Structure of transition zone of platinum-titanium diffusion junction in reflected electrons (x4000)

Figure – 3 Transition zone with probe traces at spot analysis of platinum-titanium compound obtained on the MS-46 instrument (Cameca, x500)

The micro-X-ray spectral analysis was carried out on a Comeca instrument by scanning and determining the composition by elements with a distance between points of 2μm in the direction perpendicular to the welding surface (fig. 3). The formation of the weld zone is determined by diffusion processes and affects the strength of the joint. Dwell time is the most significant factor determining the degree of development of diffusion processes. Welding was performed at the following regimes: T = 1138K, P = 6.37 MPa, τ = 900, 1800, 2700 s (fig. 4 a, b, c).

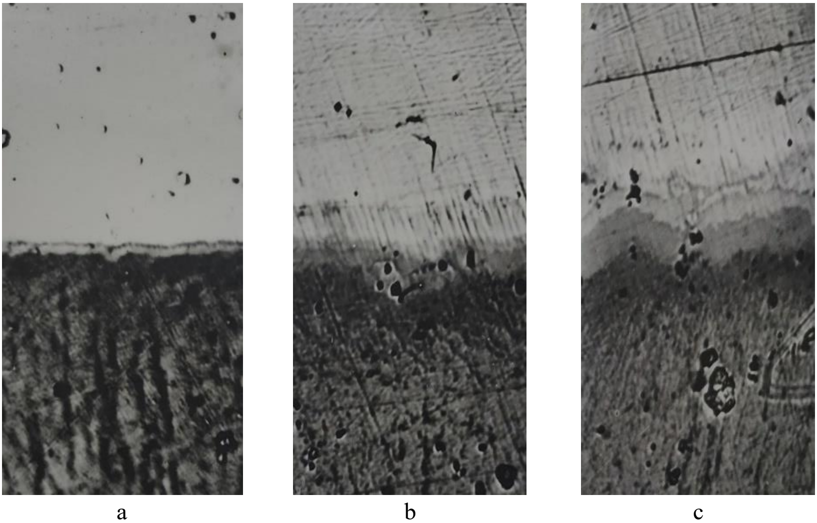

Figure - 4 Microstructure of the welded platinum-titanium joints obtained at the T = 1138K, P = 6.37 MPa, (a: τ = 900s, b: τ = 1900s, c: τ = 2700s, x500)

The microstructure shows etched titanium and platinum. On the titanium side, a diffusion zone is observed, which is of equal thickness throughout the weld. On the platinum side there are deflections towards titanium. It testifies that it is platinum that promotes intensive development of physical contact on the surface as the most plastic material and fills all microroughnesses on the surface of titanium. So with the increase of welding time up to 1800c the diffusion zone expands, there are areas of diffusion penetration into both platinum and titanium (Fig. 4b). The thin layer in the middle of the diffusion zone is primary, detectable at a welding time of 900c (Fig. 4a). With increasing dwell time, mutual diffusion of Ti -> Pt and Pt -> Ti takes place through it. Thus, the increase of welding time up to 1800s leads to the increase of the zone of diffusion interaction of components. At welding time 1800s the shape of the primary zone of diffusion interaction changes (Fig. 4c).

Here three zones of diffusion interaction are distinguished, their thickness is not uniform. The thickness of diffusion interaction zones determined by microstructure at 900s, 1800s, 2700s was 8.1 μm, 25 μm, 34 μm respectively. The data of micro-X-ray spectral analysis confirm the formation of mixtures of phases in the diffusion zone at τ = 900s phase composition: α + Ti3Pt; Ti3Pt; Ti3Pt + TiPt; TiPt; TiPt + TiPt3; TiPt3; γ (platinum) with a total width of 10.33μm. Similar composition but different phase layer extents are formed at τ = 1800 and 2700s.Mechanical strength tests have shown that the fracture point of the welded platinum-titanium joint is the zone of intermetallide TiPt3. The optimum phase composition has a diffusion zone obtained at holding time 1800s. Optimal strength is determined by intermetallides Ti3Pt and TiPt, zones of solid solutions and an insignificant amount of intermetallic phase TiPt3 not isolated in a continuous intermetallic layer.

Conclusions

A method of diffusion welding in vacuum is proposed for joining dissimilar metals platinum and titanium.

Equipment for welding platinum-titanium electrodes with large contact surfaces has been designed and manufactured.

According to the experimental results, the method of increasing the reliability of the welded joint on large contact surfaces, which consists in increasing the welding pressure above 6.37 MPa, has been substantiated.

It has been established that the formation of the welded joint of platinum-titanium occurs by diffusion and sequential growth of intermetallic layers Ti3Pt, PiPt and TiPt3, as well as zones of solid solutions.

The optimum welding mode is: T = 1138K, P = 6.37 MPa, τ = 1800s, at which the total width of the diffusion zone is 30 μm with the thickness of intermetallide layers Ti3Pt and TiPt - 4.2 μm.

It was found that the fracture of the welded joint during mechanical testing occurs along the boundary of TiPt3 intermetallide.

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