International Scientific-Technical and Production Journal

The Paton WELDING JOURNAL

March 2009 # 3

English translation of the monthly «Avtomaticheskaya Svarka» (Automatic Welding) journal published in Russian since 1948

Founders: *E.O. Paton Electric Welding Institute of the NAS of Ukraine International Association «Welding»*

Publisher: *International Association «Welding»*

Address:
E.O. Paton Electric Welding Institute,
International Association «Welding»,
11, Bozhenko str., 03680, Kyiv, Ukraine
Tel.: (38044) 287 67 57
Fax: (38044) 528 04 86
E-mail: journal@paton.kiev.ua
http://www.nas.gov.ua/pwj

State Registration Certificate
KV 4790 of 09.01.2001

Subscriptions:
$324, 12 issues per year,
postage and packaging included.
Back issues available.

CONTENTS

SCIENTIFIC AND TECHNICAL

Maksymova S.V. Formation of brazed joints on titanium aluminide 2

Skulsky V.Yu. Thermokinetic peculiarities of formation of cold cracks in welded joints on hardening heat-resistant steels 8

Kuchuk-Yatsenko V.S., Shvets V.I., Sakhatsky A.G. and *Nakonechny A.A.* Features of resistance welding of titanium aluminides using nanolayered aluminium-titanium foils 11

Shonin V.A., Mashin V.S., Murashov A.P., Zelenin V.I., Demianov I.A., Pashulya M.P. and *Teplyuk V.M.* Role of protective coating of aluminium alloy welded joints in fatigue resistance 15

INDUSTRIAL

Titarenko V.I., Tkachenko O.V., Matiko D.Yu., Pilipko V.I., Mudraninets I.F. and *Mudraninets I.I.* Experience in designing and manufacture of welding-and-surfacing instalations 18

Shatan A.F., Andrianov A.A., Sidorets V.N. and *Zhernosekov A.M.* Efficiency of stabilisation of the alternating-current arc in covered-electrode welding 21

Shalomeev V.A., Tsivirko E.I., Petrik I.A. and *Lukinov V.V.* Welding repair of surface defects in Ml-10 alloy castings by using scandium-containing material 23

Litvinov A.P. Development of inert-gas welding (Review) 28

BRIEF INFORMATION

Onatskaya N.A. and *Demidenko L.Yu.* Electrohydraulic-pulsed treatment for strengthening the surfaces of 110G13MLS steel frogs 32

Thesis for a scientific degree 34

News 35

Developed at PWI 36

FORMATION OF BRAZED JOINTS ON TITANIUM ALUMINIDE

S.V. MAKSYMOVA
E.O. Paton Electric Welding Institute, NASU, Kiev, Ukraine

Studied were the features of formation of brazed joints on titanium aluminide, produced by radiation heating in vacuum using brazing filler metals based on the Ti--Zr system and alloyed with other elements. It is noted that utilisation of copper and nickel containing filler metals does not allow producing a homogeneous structure of metal of the brazed seams. Alloying the Ti--Zr system with iron, manganese and other elements provides structure and properties of the brazed seams close to those of the base material.

Keywords: *vacuum brazing, titanium aluminide, brazing filler metal, adhesion-active alloys, structure, eutectic, chemical heterogeneity*

Compositions based on the Ti--Al system are typical representatives of a new generation of high-strength and heat-resistant intermetallic alloys [1]. They hold promise for application in aircraft engineering to manufacture a number of parts of the hot section of gas turbine engines [2]. In their heat-resistant characteristics at 700--750 °C, they can compete with high-nickel alloys owing to their low specific weight [3]. This can provide a 30 % decrease in weight of a gas turbine engine.

Extensive research has been conducted in the last decades to study properties of heat-resistant titanium alloys on the intermetallic base and develop technological processes for production of permanent joints. Traditional welding methods (heating with a high heat input, application of pressure) are unacceptable in many cases.

The preferable method for joining intermetallic alloys is brazing. However, it involves a number of difficulties. On the one hand, the brazing process allows avoidance of high residual stresses in the joints, melting of the base metal and formation of cracks, as well as maintaining of mechanical properties of the base metal without violation of its structural state. On the other hand, production of brazed joints on γ-TiAl and selection of composition for brazing filler metals are limited to narrow ranges of contents of alloying elements, within which mechanical properties and performance of the base metal do not deteriorate. In this case, the rate of diffusion of many components of filler metals may be substantially slowed down because of formation of intermetallic phases with aluminium. In addition, intermetallic alloys differ in composition, and each alloy requires an individual approach to selection of filler metals and brazing temperature.

Reportedly [4, 5], components of the Ti--Al system differ much in their electronic structure of atoms and form a range of alloys, such as Ti_3Al, TiAl and $TiAl_3$. Mechanical properties of alloys based on the Ti--Al system depend upon their aluminium content. Hypostoichiometric alloys Ti--(46--49)Al (further on --- at.%), rather than single-phase γ-TiAl alloys, have maximal ductility. They belong to the two-phase ($\alpha_2 + \gamma$)-region, and the α_2-phase is represented by intermetallic Ti_3Al [4]. Alloys with the α_2-phase content of 10--15 vol.% are characterised by the maximal level of ductility [6]. Alloys with a fully lamellar coarse-grained structure (α_2 lamellae in the γ-matrix) have maximal creep resistance at increased and low temperatures.

The key drawback of the Ti--Al system based alloys under consideration, having an ordered lattice of the $L1_0$ type, is their low ductility (δ = 0.2--0.5 %) at room temperature, which is caused by specific displacement of dislocations in a face-centred tetragonal lattice. Yield stress grows with increase in temperature to about 800 °C.

So far only the first steps have been made in the field of the technology for joining intermetallic alloys by brazing. Criteria for selection of this joining method or the other have not been developed as yet. In this connection, we can speak only about individual studies. Moreover, these studies do not always answer the main goal, which consists in providing high performance of the joints under service conditions.

Vacuum brazing [7] of intermetallic titanium alloy Ti--37.5 % Al, whose structure is represented by the lamellar γ(TiAl)- and α_2(Ti_3Al)-phases, is performed by using the 15 μm thick aluminium foil, and by applying a compressive force and holding at a temperature of 700 or 900 °C, this favouring the diffusion processes and formation of intermetallics $TiAl_2$ (or $TiAl_3$) in the brazed seam metal. Long-time heat treatment of the brazed joints at 1300 °C with holding for 3.84 ks failed to provide formation of the lamellar γ/α_2-phase and strength of the brazed joints at a level of the base metal. Tensile strength σ_t at a temperature of 20 °C was approximately 220 MPa [7]. A drawback of this technological process is that it is labour- and time consuming. In addition, application of the compressive force is determined by design features of a specific brazed part. Hence, it cannot be considered a versatile method for production of permanent joints.

ŋqdqγeY bɆ dəqƐbYɜə d ɛɑɑbɔγ Ɉqdqγqγè