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RESTORATION SURFACING OF PARTS OF TITANIUM ALLOY VT22

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The article gives the results of investigations of application of a flux-cored wire of PPT-22 grade as a filler material and magnetically-impelled arc in argon arc surfacing of worn-out parts of alloy VT22. It is shown, that in restoration of geometric sizes of worn-out surfaces using surfacing, the feasibility appears to control the shape of deposition and to produce the deposited metal with properties at the level of base metal after the standard heat treatment. 6 Ref., 1 Table, 10 Figures.

Keywords: *alloy VT22, surfacing, titanium flux-cored filler wire, magnetically-controlled arc*

One of the significant drawbacks of the most titanium alloys, in particular alloy VT22, is a low wear resistance. Therefore, during service of components and parts the defects of surface are occurred, caused by its wear. These defects are observed in some parts of present passenger and transport aircrafts, in particular in wing mechanization rails of aircraft «AN». Depth of worn-out regions reaches 2 mm (Figure 1). Due to occurrence of these defects it is necessary to replace the worn-out part by a new one, thus leading to large expenses for its manufacture.

One of the methods, which is used for restoration of geometric sizes of surface worn-out zones, is a thermal spraying of coatings [1]. The main drawbacks of these methods are the limiting of thickness of the sprayed coatings, which in many cases is not sufficient for restoration of deep damages, as well as a low adhesion of the sprayed layers, leading to their fracture under the conditions of high contact dynamic loads.

Figure 1. Working surface of rail with worn-out regions

The processes of restoration include also a technological process of surfacing. It possesses a high adhesion and allows avoiding those drawbacks which are typical for the above methods. Therefore, it was suggested to apply the process of surfacing by an arc, burning in argon at the tungsten electrode and impelled by the magnetic field for producing the deposited layer [2].

The effect of external transverse variable magnetic field allows controlling the depth of penetration, width and height of deposited layer, and also redistributing the arc heat energy so, that the most part of energy input was consumed for melting of the filler wire.

Probably, due to high content of β-stabilizers, the alloy VT22, is very sensitive to internal stresses, which occur in the heat-affected zone during welding with filler wires, the composition of which is differed from that of alloy VT22 [3,4]. Therefore, it was interesting to use the filler material for surfacing with the same composition of alloying elements, as in base metal, and to apply a standard mode of annealing after surfacing to the entire region of the deposited joint.

The important element of effect on alloy VT22 properties is a heat treatment (HT). Annealing for welded joints of this alloy serves simultaneously as a hardening HT. Depending on the temperature of heating, duration of annealing and cooling rate it is possible to obtain different combinations of strength and ductility. Annealing of alloy VT22 is performed in a two-phase region (750–850 °C) with a subsequent single- or multistep cooling [5]. Such heat treatment leads to maximum heterogeneity of structure with approximately equal amount of α and β phases.

Procedure of investigations. Surfacing on 12 mm thick plates of alloy VT22 was performed by a magnetically-impelled arc. As a filler material, the experimental solid wire VT22 (3 mm diameter) and experimental filler flux-cored wire of PPT-22 (3 mm diameter) were used [6]. Coming from the analysis of literature data, the HT mode was selected, recommended for welded joints: furnace heating up to T = = 750 °C, 1 h holding, air cooling.

Using microscope Neophot the quality of deposited joints was evaluated after HT on macro- and microsections, on which the deposited metal structure was examined.

Surfacing with a filler wire VT22. Results of metallographic examinations of the filler wire VT22 showed that the quality of its surface is poor, there are local defects in the form of cracks, tears and rolling laps on it (Figure 2). These defects occurred in the process of wire manufacture and can be a source of the deposited metal contamination and, as a consequence, of reducing its quality.


Figure 2. Microdefects of VT22 wire surface (×200)

In the metal, deposited by wire VT22, as well as in the fusion zone a large amount of different kinds of macro- (Figure 3) and microdefects (Figure 4) are observed. Mainly, these are discontinuities, cracks, lack of fusion, pores of up to 0.3 mm size. The presence of the mentioned defects can be referred to a poor

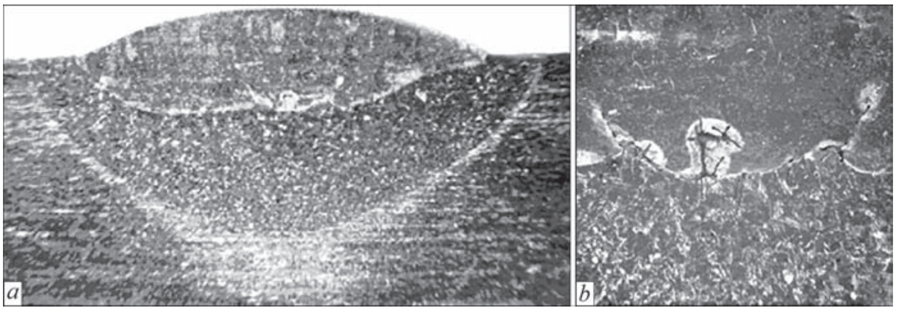

Figure 3. Macrosection of joint, deposited by a filler wire VT22 on substrate of VT22 alloy (*a*) and macrodefects in fusion zone (*b*)

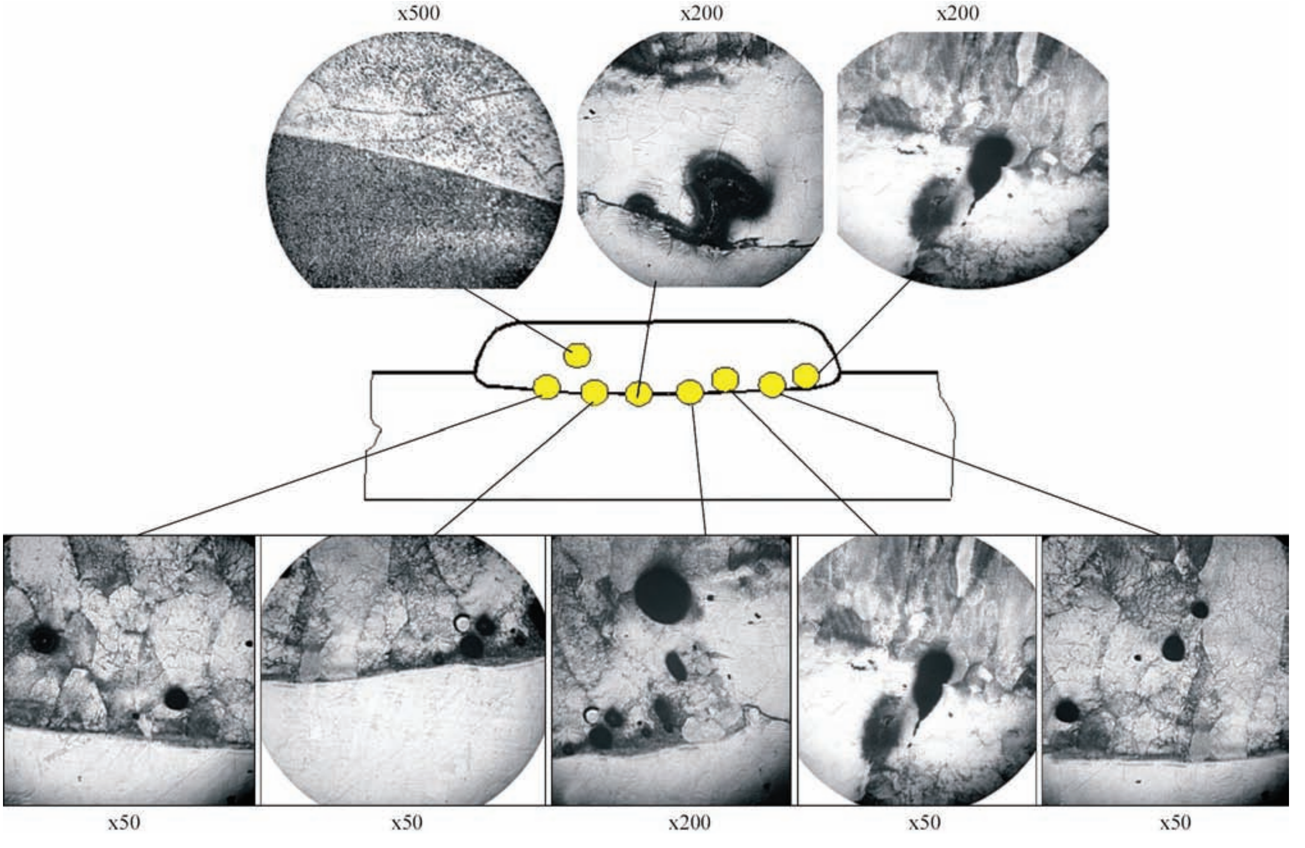

Figure 4. Regions of microstructure of deposited metal VT22 near fusion zone

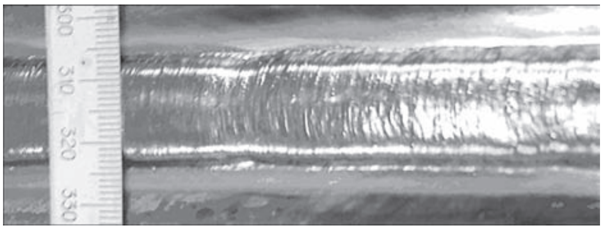

Figure 5. Nature of formation of surface of metal, deposited by a flux-cored wire PPT-22 on alloy VT22 plate

Figure 6. Macrosection of joint, deposited by a flux-cored wire PPT-22 on VT22 alloy plate in as-surfaced state

Figure 7. Radiogram of metal, deposited by a flux-cored wire PPT-22 in as-surfaced state

quality of manufactured filler wire VT22.On the basis of analysis of data, obtained from investigations, the conclusion was made about the non-rationality of application of this wire as a filler material for surfacing.

Surfacing with a filler flux-cored wire PPT-22. For making deposits the experimental filler flux-cored wire of PPT-22 grade was used as a filler material. Its design represents a tubular sheath of commercial titanium of VT1-00 grade. Inside the sheath there is a metallic core, consisting of granules of alloy VT22. Appearance of deposited metal is given in Figure 5, macrosection is shown in Figure 6. The made radiographic analysis of deposited specimens showed the absence of pores in them (Figure 7).

Metallographic analysis of the deposited metal did not reveal pores and other defects in it, no microdefects were revealed also in the fusion zone (Figure 8). In the deposited metal a fine-acicular homogeneous structure is formed, the decay of β-phase in grain volume during cooling occurs uniformly (Figure 9).

To stabilize the structure and obtain optimum mechanical properties the joints after surfacing were subjected to HT on the mode: furnace heating at T = = 750 °C, 1 h holding, air cooling.

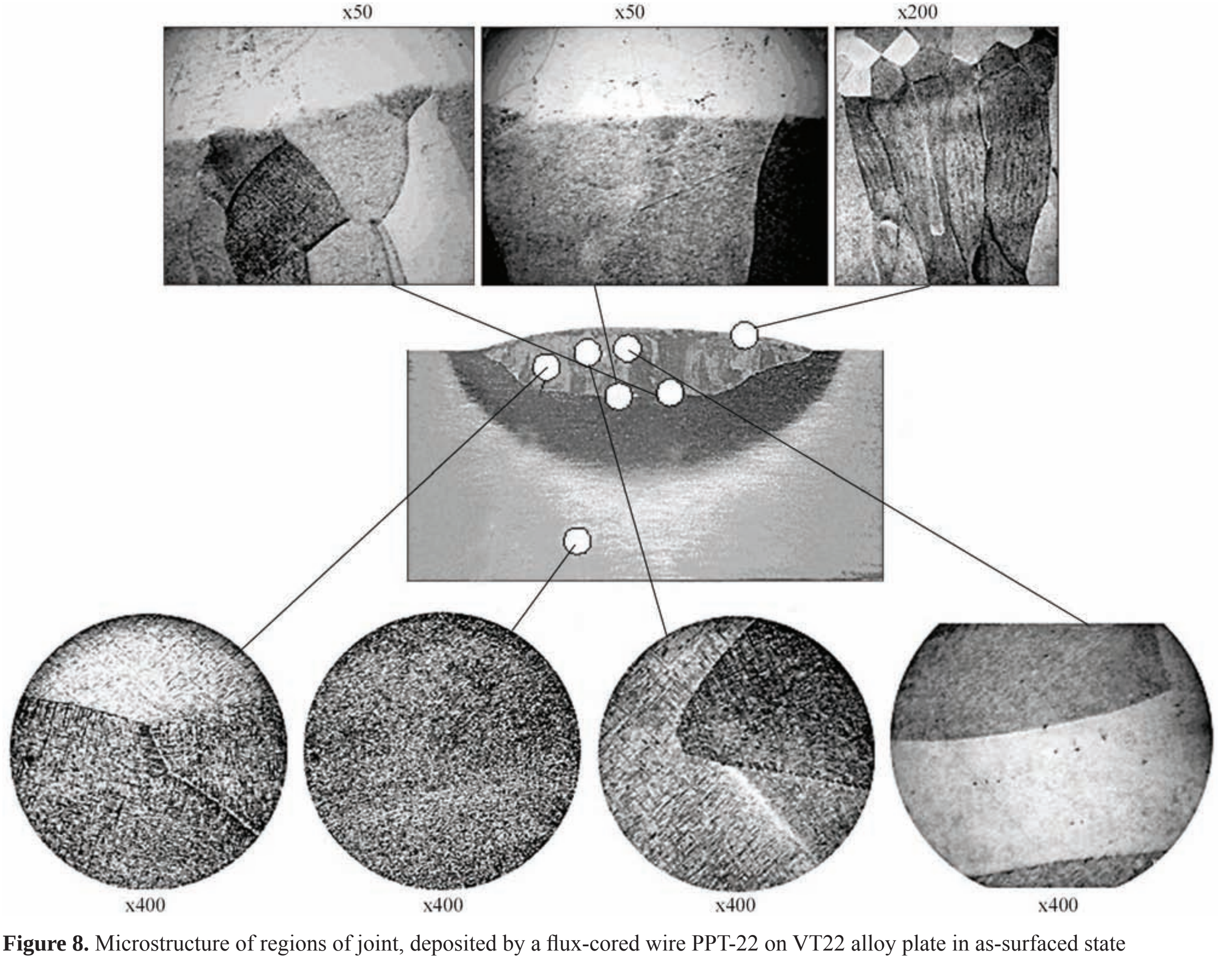

Figure 8. Microstructure of regions of joint, deposited by a flux-cored wire PPT-22 on VT22 alloy plate in as-surfaced state

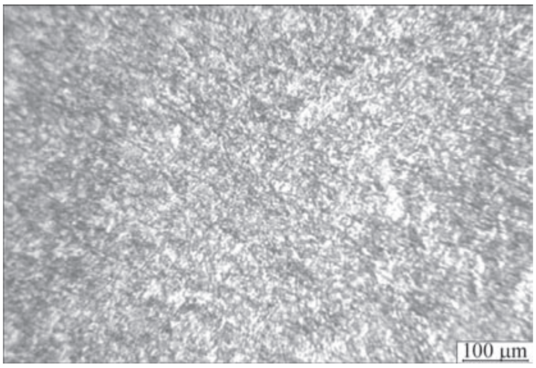

Figure 9. Microstructure of metal, deposited by wire PPT-22 in as-surfaced state

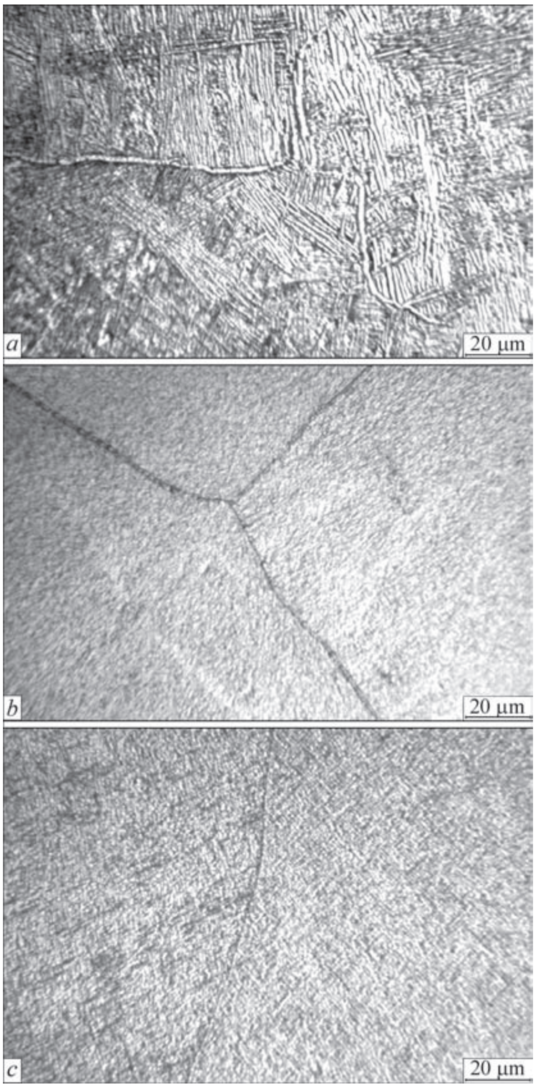

Figure 10. Microstructure of metal of joint, deposited by wire PPT-22

The carried out HT caused the change in structure of all the regions of welded joint. In base metal the waviness between α-plates was observed (Figure 10, *a*). In the heat-affected zone a sufficiently uniform decay of metastable β-phase with precipitation of dispersed particles of martensitic α´/α″-phase was occurred. Single fine recrystallized grains, partial recrystallization of β-grain were noted, a subgrain structure was retained (Figure 10, *b*). Annealing contributed to the formation of more homogeneous and uniform structure of metal in height of deposit (Figure 10, *c*), than that in a non-annealed specimen.

Mechanical properties of deposited and base metal after HT

Metal	σ_t, MPa	*KCV*, J/cm^2
Deposited metal	1066.0–1133.9 1099.9	13.4–14.1 13.7
Base metal	930.2–991.5 960.85	32.6–35.4 34.0
Note. Results of 5 tests are given.		

Analysis of results of mechanical tests (Table) showed that the strength of metal, deposited by the titanium filler flux-cored wire of PPT-22 grade, exceeds negligibly the strength of the base metal, which can exert a positive effect of wear resistance of deposited metal at the tribological tests.

The results of investigations showed that the combined application of filler flux-cored wire of PPT-22 grade and magnetically-impelled arc in argon arc surfacing allow controlling the shape (width and height) of deposit and producing the deposited metal with properties at the level of the base metal after the standard HT. The obtained data allow wire PPT-22 to be recommended for use as a filler material for the restoration surfacing.

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