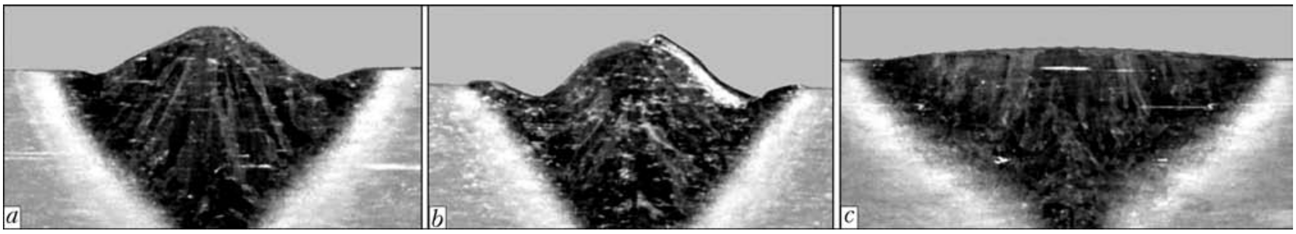

Figure 6. Macrostructure (×8) of welded joints of VT20 alloy with incomplete penetration and weld face bead: *a, b* — EBW by horizontal beam by upward schematic at v_w = 8 and 32 mm/s, respectively; *c* — downward schematic, v_w = 8 mm/s

have passed X-ray inspection. No defects in the form of cavities, pores, undercuts or lacks-of-fusion were found.

Defect-free formation of welded joints of titanium alloy VT20 (δ = 17 mm) produced in EBW with complete penetration, is achieved by the schematic of welding with a horizontal electron beam with EBG movement downwards, upwards and horizontally.

Thus, the recommended welding schematics and developed modes of EBW of titanium alloy VT20 allow eliminating machining of the face and reverse weld beads.

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INFLUENCE OF MAIN TECHNOLOGICAL PARAMETERS OF THE PLASMA CLADDING PROCESS ON PROPERTIES OF COMPOSITE DEPOSITED METAL

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The paper presents results of experiments on determination of the influence of technological parameters of the process of plasma cladding of composite alloys using filler material in the form of flux-cored strip consisting of a metal sheath and core, on formation and wear resistance of deposited metal. The strip core contained hard-alloy grains based on fused tungsten carbides.

Keywords: *plasma cladding, filler material, wear resistance, composite alloy, reinforcing particles, strip tungsten carbide (relite)*

The process of plasma cladding of composite alloys [1, 2] using filler material in the form of the flux-cored strip, which consists of a metal sheath and core of grains of fused tungsten carbide and fine-dispersed charge of alloying and deoxidizing components (strip relite), should provide a wear-resistant layer with optimal geometry at a high quality of formation and wear resistance (Figure 1).

It is well-known that wear resistance of composite alloy is determined by the concentration and wear resistance of reinforcing particles (fused tungsten carbide) in deposited metal and ability of its matrix to hold these particles. As a rule, the said properties of the wear-resistant layer depend on the cladding technology and level of dissolution of a reinforcing particle in the process of cladding. Dissolution of grains of tungsten carbides results in reduction of the concentration of the wear-resistant phase and increase of saturation of the matrix with tungsten and carbon, this increasing the probability of its embrittlement and decreasing wear resistance of alloy as a whole [3].

The paper presents results of investigations into the influence of main technological parameters of the plasma cladding process on the quality of formation, structure and wear resistance of the composite deposited metal.

Ranges of the main technological indicators of the plasma cladding process were as follows:

transferred arc current I_a, A	180–340
cladding speed v_{cl}, m/h	4–20
filler metal feed speed v_f, m/h	10–50

Cladding was carried out on low-carbon steel samples measuring 150 × 70 × 20 mm. The following conditions were used as the initial ones: I_a = 220 A, U = 34 V, v_{cl} = 8 m/h, v_f = 20 m/h, plasma gas flow

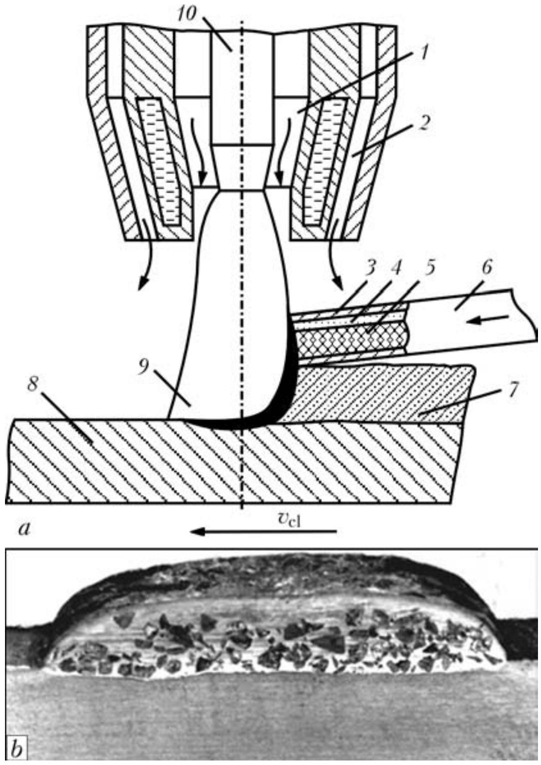

Figure 1. Scheme of plasma cladding of composite alloys using strip relite as a filler material (*a*) (*1, 2* — plasma and shielding gas, respectively; *3* — sheath; *4* — fine charge; *5* — reinforcing particles; *6* — filler material; *7* — deposited layer; *8* — sample; *9* — plasma arc column; *10* — electrode) and macrosection of the deposited bead (*b*)

rate — 2 l/min, shielding gas flow rate — 6 l/min, amplitude of oscillation of the plasma torch — 25 mm, and frequency of oscillation of the plasma torch — 35 min^{-1}. Strip relite AN-LZP-9-8 [4] was used as a filler material.

The evaluation of the influence of parameters of the cladding process on properties of the deposited metal was carried out at several values of each parameter, the rest of the parameters being kept constant.

The quality of the deposited metal was evaluated by the wear test procedure for composite alloys over a fixed abrasive (sliding path 30 m, sliding speed 0.5 m/s) at one value of the contact pressure equal to 1.055 MPa [3]. Three samples of each deposited metal obtained at fixed conditions of the process of cladding were tested, and the arithmetic mean of the value of wear of the tested samples was taken as an indicator.

It was determined experimentally (Figure 2) that the plasma arc current has the greatest influence on wear W of composite metal. Increase in the current is accompanied by increase in the time of existence of molten pool and its volume.

The time of contact of the molten matrix phase of alloy and reinforcing particles increases with increase in the time of existence of the molten pool, this resulting in growth of the degree of their dissolution, decrease in concentration of the wear-resistant phase, and, hence, reduction of wear resistance of the composite alloy as a whole.

The cladding speed in the investigated range of the process parameters has no noticeable influence on wear resistance values. However, its further increase leads to deterioration of formation of the deposited bead, resulting in the lack of fusion, disappearance of the common molten pool, reduction of the level of base metal penetration, and impossibility of performing the process.

Minimal values of the filler material feed speed lead to low performance of the deposited metal. In this case, the molten pool of a big volume is formed at a fixed cladding current value, this resulting in dissolution of the reinforcing particles and reduction of wear resistance of the alloy.

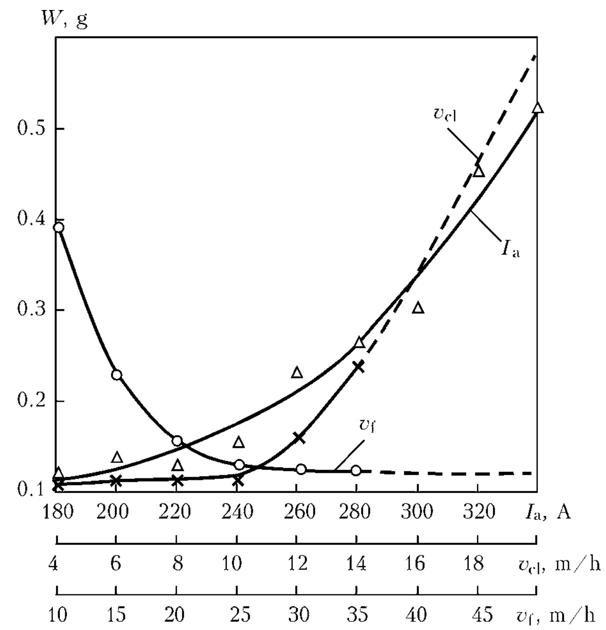

Figure 2. Influence of main technological parameters of the plasma cladding process on wear of composite metal

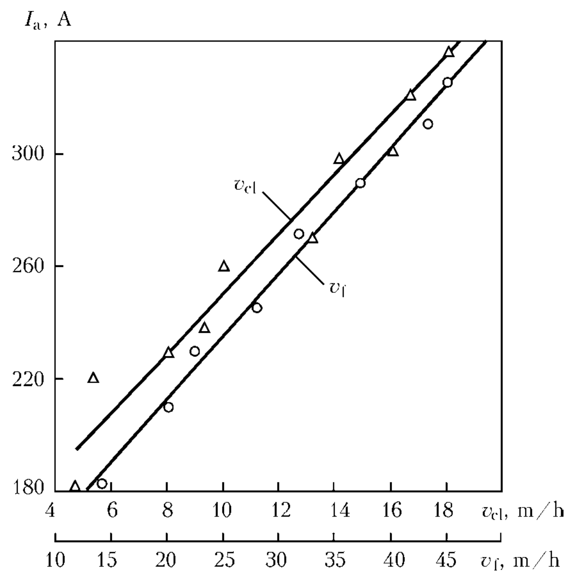

Figure 3. Dependence of cladding speed and filler material feed speed on plasma cladding current

Increase of the filler metal feed speed leads to increase of the amount of the filler material fed to the plasma arc, which is to be melted, this requiring a higher amount of heat.

As a result, dissolution of the reinforcing particles decreases, formation of the deposited bead improves, and its wear resistance grows. Exceeding the optimal filler metal feed speed leads to reduction of the efficiency of melting of the incoming filler metal and the base metal, this resulting in termination of cladding process (see Figure 2, the region is shown by dashed line).

Thus, for every standard size of the filler material (width and thickness of the strip relite) there is an optimal range of main technological parameters of the cladding process (current intensity, cladding speed and filler metal feed speed), which are interrelated to each other, and are of critical importance for formation and geometry of the deposited beads.

There is a close connection between the cladding speed, filler material feed speed and plasma arc current (Figure 3). Increasing the cladding speed is usually accompanied by growth of the filler material feed speed for maintaining constant size of the deposited bead. For this, it is necessary to increase the plasma arc current in order to provide melting of a bigger amount of the filler material.

Therefore, selection of optimal conditions for plasma cladding is reduced to determination of the current, cladding speed and filler material feed speed. Values of the rest of the process parameters (plasma gas and shielding gas flow rates, arc voltage etc.) have a minor influence on formation of the wear-resistant alloy and are to be maintained within the above ranges.

The influence of main technological parameters of the process of plasma cladding on dimensions and shape of the deposited beads is shown in Figure 4.

According to the experience, thickness of the layer of the deposited beads should be no more than 4–5 mm, otherwise a sudden decrease of the cladding quality will take place, which shows up in insignificant dissolution of the reinforcing particles. The minimal thickness of the deposited metal, which has been obtained by using the strip relite with the reinforcing grains of 0.40–0.63 mm size, is around 0.7 mm. However, it is very difficult to perform such a cladding process, the main role being given to the quality of the filler material.

Thus, the main technological parameters of the plasma cladding process by using the strip relite and their influence on the quality of composite deposited metal were determined. It was found that the plasma arc current has the highest influence on wear resistance of the composite alloy.

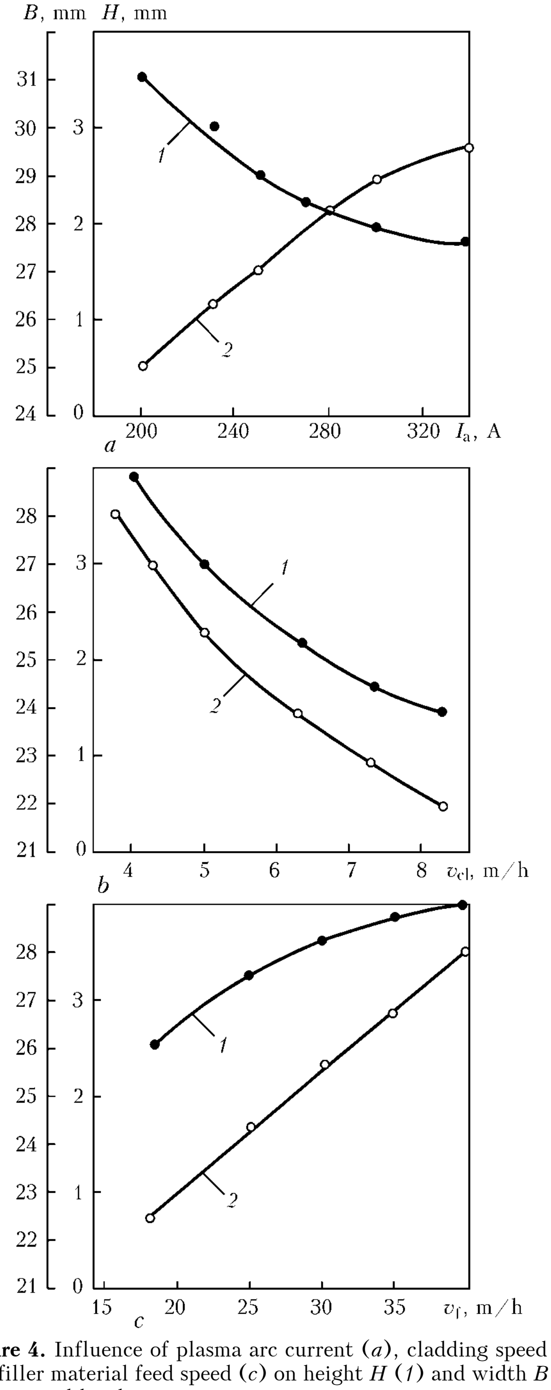

Figure 4. Influence of plasma arc current (*a*), cladding speed (*b*) and filler material feed speed (*c*) on height *H* (*1*) and width *B* (*2*) of deposited bead

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