STRUCTURE AND PROPERTIES OF HIGH-MANGANESE DEPOSITED METAL

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Effect of charge materials, containing ultra-dispersed carbides, on properties of metal deposited by flux-cored wire PP-AN105 was investigated. It was found that application of ultra-dispersed carbides leads to refining of deposited metal structure and more uniform distribution of alloying elements, thus improving its cold workability and wear resistance.

Keywords: *arc hard-facing, flux-cored wires, high-manganese deposited metal, properties of deposited metal, microstructure, ultra-dispersed carbides*

The high-carbon high-manganese Hadfield steel 110G13 is widely used for casting teeth and buckets of excavators, dredge buckets, dredgers, jaws, crushing heads, railway frogs and other similar parts [1, 2], that is explained by its capability to undergo impact loads. As a result of cold working the hardness of a surface layer of steel is increased from *HB* 180–250 up to 450–500, thus this layer has a good resistance to abrasive wear at intensive impact loads. The purely austenite structure and cold workability are acquired by steel 110G13 after hardening (heating up to 950–1100 °C, cooling in water). Castings from steel 110G13 have, as a rule, a coarse-grain structure that has a negative influence on crack resistance, and also on mechanical and service properties of steel [3].

To perform hard-facing of parts of steel 110G13, the E.O. Paton Electric Welding Institute has developed a flux-cored wire of PP-AN105 type, which produces the deposited metal, almost similar by chemical composition to the parent metal, additionally alloyed by nickel for improvement of the austenite stability [4]. However, the heating and delayed cooling at 800–500 °C temperature in hard-facing (welding) of parts of steel 110G13 leads to the decay of austenite and precipitation of a carbide phase at the grain boundaries, that reduces its crack resistance and also mechanical and service properties [1, 2]. The application of a special technique of hard-facing (deposition of narrow beads with a minimum heat input and their subsequent peening) allows preventing the precipitation of a carbide phase at the grain boundaries, but it is not almost managed to avoid the formation of a coarse-grain columnar structure of the deposited metal.

It was found from the results of investigations carried out by us [5], that application of ultra-dispersed carbide compositions in charge of flux-cored wires contributes to refining of structure of the deposited metal corresponding to tool steels. The aim of the present work was the investigation of effect of ultra-dispersed carbide compositions, added to the charge of the flux-cored wire PP-AN105, on the structure and properties of austenite deposited metal of 110G13N type. The ultra-dispersed carbide compositions were produced by high-temperature treatment of mixture of powders of metallic manganese, iron powder and natural colloid graphite in CO_2. As a result the powder contained 3.7 wt.% C; 12.6 wt.% Mn; the rest – Fe.

Specimens for study of structure and wear resistance of the deposited metal were hard-faced by self-shielding flux-cored wire with a charge, containing the treated powder PP-AN105op (tested), and standard charge PP-AN105. Hard-facing was made in four layers using wires of 2 mm diameter at similar conditions (I = 230–240 A; U_a = 24–26 V).

In investigation of a cold workability of metal deposited by both wires, firstly the Brinell hardness of deposited metal was determined, and then the Rockwell hardness was measured in the made dent. It was established that the metal deposited by standard wire PP-AN105 had hardness *HB* 163–170 directly after deposition, and after cold working it was of *HRC* 34–36, and metal deposited by test wire PP-AN105op had, respectively, *HB* 179–187 and *HRC* 38–40.

The microstructure of metal, deposited by wires of both types, was also evaluated. Specimens for metallographic examinations were manufactured by a standard procedure. To reveal the microstructure, they were subjected to etching in 20 % water solution of chromic acid. Mircohardness of deposited metal was determined in the LECO hardness meter M-400 at 1 N load, the content of δ-ferrite was determined using the ferrite meter FERRITGEHALTME SSER-1.053.

It was found that in both cases the deposited metal has an austenite structure with a negligible content of δ-ferrite. Microhardness of austenite matrix of metal deposited by a test wire is *HV*01 264–292, and by a standard wire – *HV*01 258–285 MPa. Metal, deposited by the test wire (Figure 1, *a*) has the finer-

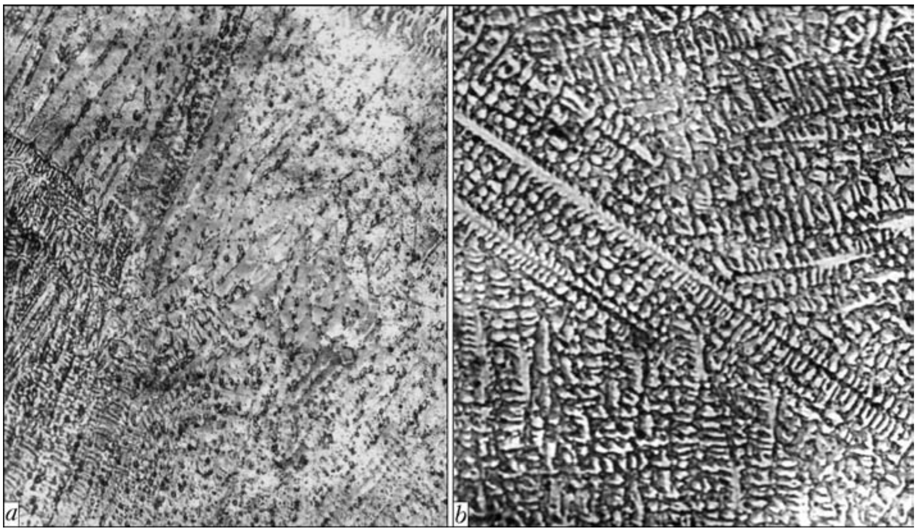

Figure 1. Microstructures (×200) of the forth layer of the deposited metal produced in hard-facing with flux-cored wires PP-AN105op (*a*) and PP-AN105 (*b*)

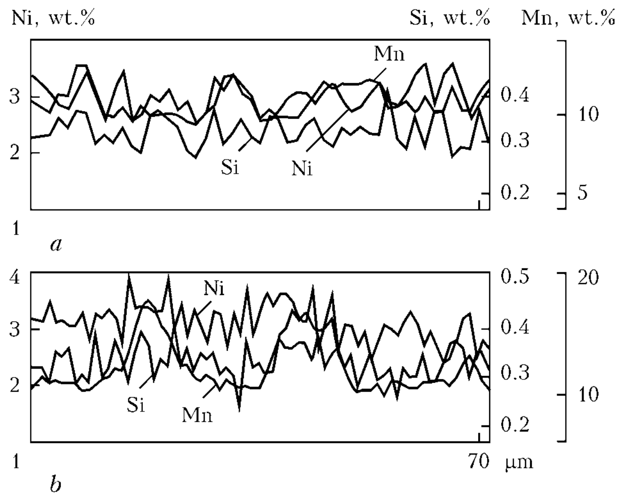

Figure 2. Distribution of alloying elements in metal deposited with flux-cored wires PP-AN105op (*a*) and PP-AN105 (*b*)

grain structure as compared with that deposited by the standard wire (Figure 1, *b*).

The metal, deposited by the test wire, contains 1.0–1.5 wt.% of δ-ferrite, while that by the standard wire — 0.2–0.3 wt.%. It is known that in welding of chrome-nickel austenite steels the presence of 2.0–3.0 wt.% of δ-ferrite in steel structure allows successful prevention of crystalline cracks [6]. Probably, in hard-facing the austenite steel 110G13 the δ-ferrite should play its positive role.

The uniformity of distribution of main alloying elements in the deposited metal was determined using X-ray diffraction microanalyzer Camebax SX50 at the depth of about 70 μm from the surface of deposited metal, parallel to it, in the automatic mode at the interval of about 1.01 μm (Figure 2).

The distribution of alloying elements in metal deposited by the test wire PP-AN105op (Figure 2, *a*) is more uniform than in metal deposited by PP-AN105 wire with a standard charge (Figure 2, *b*). This is clearly observed on the example of manganese, the main alloying element.

The wear resistance of specimens of metal, deposited by flux-cored wires PP-AN105op and PP-AN105, was determined at dry friction of metal on metal at room temperature by the shaft–plane scheme (Figure 3). Specimens of 3 × 15 × 25 mm size were cut out from the deposited metal so that the test plane entered the upper layers of the deposited metal. Shaft-mating body of 40 mm diameter was manufactured of steel 45 and hardened up to *HRC* 42 hardness. During

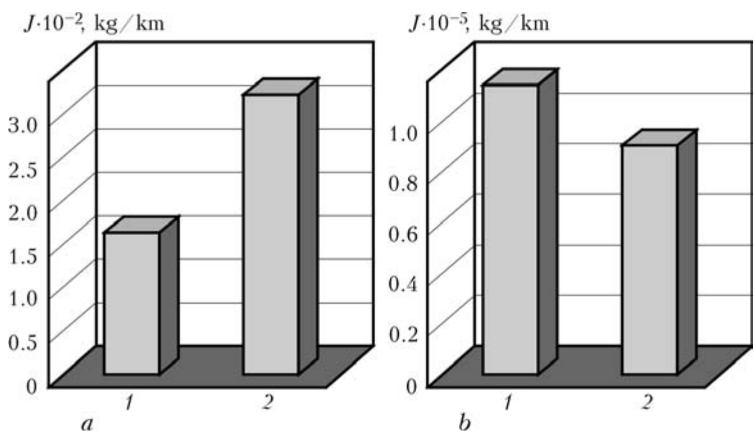

Figure 3. Wear *J* of specimens (*a*) and mating bodies (*b*) deposited by wires PP-AN105op (*1*) and PP-AN105 (*2*)

tests the specimen is pressed against the mating body by a plane which has 3 × 25 mm size. As a result, a dent is formed on the test plane, and a path is formed on the mating body. Here, the following test condition was selected: sliding rate — 1 m/s; load — 30 N; rotation frequency of mating body — 30 rpm. This condition provided stabilization of tribotechnical characteristics of all test specimens. The use of system of positioning allowed repeating tests of each deposited specimen not less than 3 times on new areas of friction of the specimen and on the path of mating body friction.

The tests showed that the wear of metal deposited by the test wire PP-AN105op is 2 times lower than that of metal deposited by the standard wire PP-AN105 (Figure 3, *a*). The wear of rings-mating bodies which were tested in pair with specimens deposited by the test wire PP-AN105op is 2 times higher than that in those which were tested with specimens deposited by a standard wire PP-AN105 (Figure 3, *b*). However, the total wear resistance of a pair of friction: test deposited metal–ring-mating body was higher than in pair of friction: standard deposited metal–ring-mating body.

Thus, the application of charge materials, containing the ultra-dispersed carbides in the flux-cored wire PP-AN105, leads to refining of structure of deposited metal of 110G13N type and more uniform distribution of alloying elements in it.

In dry sliding friction the metal deposited by flux-cored wire PP-AN105, whose charge contains ultra-dispersed carbides, is subjected to cold working to a larger degree and results in 2 times higher resistance than the metal deposited by the standard wire PP-AN105.

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