

ELECTROSLAG SURFACING OF HIGH-CHROMIUM CAST IRON WITH 110G13L STEEL

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The paper presents the results of metallographic examination of metal at test surfacing of 110G13L steel samples with high-chromium cast iron shot in current-supplying mould. Possibility of producing sound bimetal joints and features of formation of metal fusion zone at minimum and maximum penetration of base metal are shown. 10 Ref., 1 Table, 6 Figures.

Keywords: *electroslag surfacing, current-supplying mould, surfacing shot, high-chromium cast iron, 110G13L steel, metal structure*

Steel 110G13L has become wide spread at manufacture of different parts of ore mining and smelting equipment subjected to abrasive wear. However, if wear forces are not big in process of operation or thickness of strengthened layer is comparable with abrasive wear, the advantages of this steel do not become apparent and its wear resistance is the same as in common low-alloy steel. Therefore, in this case in order to increase life of worn parts produced from steel 110G13L it is desirable not simply restore their sizes, but replace worn part by the materials of increased wear resistance. Among such materials are, in particular, high-chromium cast irons (15–30 % of Cr) [1–4]. And, regardless the fact, that they are characterized with not only increased abrasive wear resistance, but sufficiently high mechanical properties (Table), deposition of such materials with arc surfacing methods is virtually impossible. Such a problem can be solved with the help of electroslag surfacing (ESS).

Numerous works on development of an optimum technology for restoration of parts of steel 110G13L were carried out at Donetsk National Technical University applicable to ESS with high-chromium cast of excavator bucket teeth [5–7]. At that, classical scheme of surfacing of located in the mould billet with electrode melting in slag was used. The authors of developed ESS technology have got a large experience of operation of parts deposited with high-chromium cast iron and have carried out sufficiently detailed study of fusion zone of steel 110G13L and high-chromium cast iron [8, 9]. Based on the results of this experience and investigations it can be concluded that, firstly, producing the sound bimetal joints of steel and cast iron is sufficiently difficult problem even at electroslag surfacing; secondly, the parts restored using such

a technology are good to be used only in absence of significant impact loads [6, 8].

Developed at the E.O. Paton Electric Welding Institute technology of electroslag surfacing with discrete material in current-supplying mould (CSM) has specific advantages of effect on the conditions of metal fusion and formation of their crystalline structure in comparison with the surfacing methods in conventional moulds using large-section consumable electrodes. These advantages are determined by the possibility to vary surfacing technological parameters in wider limits as well as by processes of molten metal inoculation (metallic pool) with material being deposited and rotation of the metallic pool caused by CSM design [10].

Therefore, aim of present work was investigation of the structure of deposited high-chromium cast iron and its fusion zone with steel 110G13L at ESS in CSM using discrete filler, namely cast iron shot as a surfacing consumable.

Surfacing was performed in CSM of 180 mm diameter. The base metal was the billets of 40 mm thick steel 110G13L. The discrete filler was shot of 2.5–3.5 mm diameter from high-chromium cast iron (wt.% 2.4 C; 27Cr), received by air spraying of liquid metal jet. Surfacing efficiency is around 30 kg/h.

Properties of deposited and cast high-chromium cast iron (~3 % C, 16 % Cr)

Material	Mechanical properties				Hardness HRC
	σ_r , MPa	KCU_{20^*} , MJ/m ²	σ_{bend^*} , MPa	Bending deflection, mm	
Deposited cast iron	820	1.3	1650	2.9	~ 50
Cast iron	420	–	280	1.7	~ 50



Figure 1. Microstructure ($\times 100$) of deposited high-chromium cast iron of sample No.1

The samples cut out from the bimetal billets of different level of base metal penetration was investigated. Sample No.1 was of minimum penetration (1–2 mm) and sample No.2 with the maximum (5–7 mm) penetration. A microstructure of deposited layer (high-chromium cast iron) was revealed by electrolytic etching in 20 % water solution of chromium anhydride at 15 V voltage during 5 s. The microstructure of base metal (steel 110G13L) was revealed by etching in 4 % alcoholic solution of nitrogen acid. The metallographic examinations were carried out using «Epikvant» microscope. Microhardness was measured on PMT-3 device at 100 g loading. Hardness was measured on TK-2M device on Rockwell method.

Examination results. Sample No.1. Microstructure of the deposited metal is primary austenite grains with chromium-carbide eutectic located along their boundaries (Figure 1). Hardness of deposited metal is HRC 44–46. There are also single zones with different structure from 0.5 to 2–3 mm, located approximate-

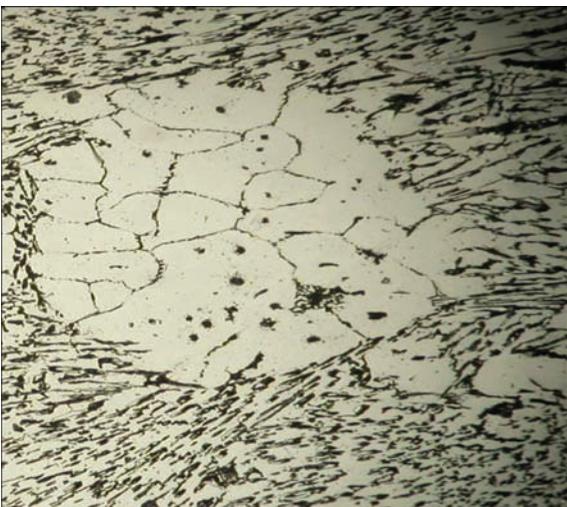


Figure 2. Microstructure ($\times 100$) of inclusions with coarse austenite grains in deposited high-chromium cast iron of sample No.1

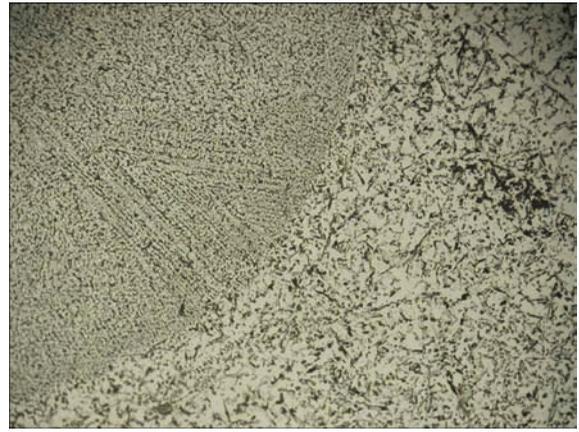


Figure 3. Microstructure ($\times 100$) of inclusions with fine-crystalline structure in deposited high-chromium cast iron of sample No.1

ly at 5–6 mm distance from the surface of deposited layer and 1–3 mm from fusion zone. Apparently, these zones have similar reasons of origin. The zones with coarse austenite grains (Figure 2) appear due to presence in the shot of significant amount of granules of relatively big size (≥ 3 mm), structure of metal of which is preserved at their melting in the case of insufficient amount of heat coming to their surface.

The zones with microcrystalline structure (Figure 3) are molten shots of rather small diameter, metal of which does not have time to spread and mix with the rest deposited metal. Appearance of the zones of both types is related with disagreement of mass rate of surfacing shot feeding with its fractional composition and electrolytic mode of surfacing.

The microstructure of base metal is coarse elongated austenite grains, boundaries of which include carbide precipitations. With distance from the fusion line the size and amount of carbides reduce. It can be assumed that such structural changes are related with thermal surfacing cycle as well as mixing the base and deposited metals.

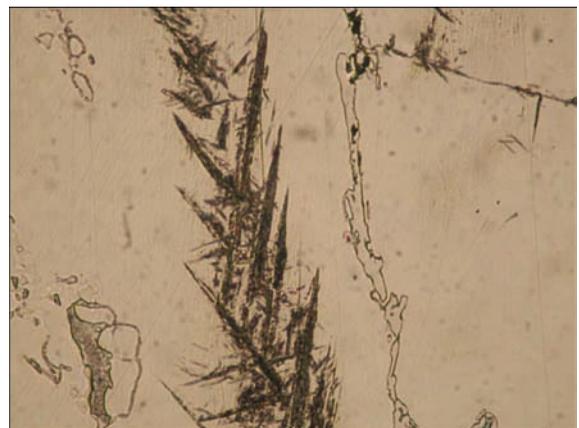


Figure 4. Acicular structure phase in fusion zone of base and deposited metals of sample No.1 ($\times 500$)

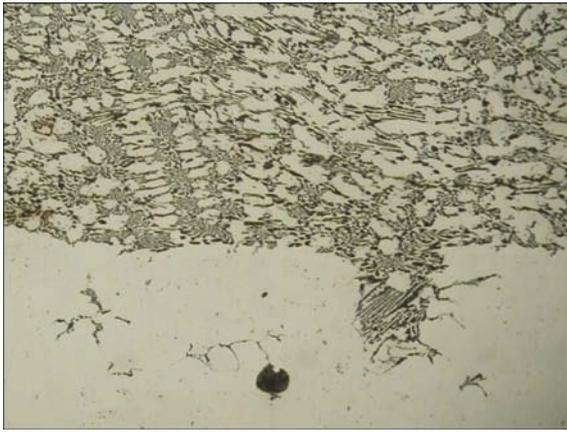


Figure 5. Microstructure ($\times 100$) of fusion zone of sample No.2 (without etching of base metal)

Bimetal joint is formed by means of smooth transfer of deposited metal to base one, however, there are disordered precipitations of acicular phase (Figure 4) in separate places. Hardness of the fusion zone is low and makes only *HRC* 18–22 (at base metal hardness *HRC* 12–15). This assumes absence of significant accumulations of hard and brittle constituents as well as allows considering this zone resistant to increased impact loads. Comparison of the results of this investigation with the results, obtained on the samples deposited by large-section electrode of approximately same composition in conventional mould [10] shows that in the second case increased strength properties of the joints is possible only at additional alloying of cast iron with manganese (to 8 %) that deteriorates its wear resistance.

Sample No.2 Microstructure of the deposited metal (at thickness of deposited layer around 20 mm) is similar to microstructure of sample No.1 metal. Significant changes are observed in the fusion zone of base and deposited metals. This zone contains local inclusions of different size structural constituents of high-chromium cast iron in the metal of base (Figure 5). Also there are defects of cast steel in form of pores (round dark color inclusions). Large amount of various phases (Figure 6) is formed due to significant mixing of steel and cast iron in the fusion zone. Nevertheless, hardness of this zone is relatively low, i.e. *HRC* 17. Therefore, bimetal joints with rather plastic transition zone can be received even at significant mixing of the base and deposited metals.

Carried investigations show that ESS of parts from 110G13L steel with shot of high-chromium cast iron



Figure 6. Microstructure ($\times 125$) of fusion zone of sample No.2 (after etching)

in CSM provides the minimum penetration of metal of the base and allows getting quality bimetal joints with a plastic transition zone from steel to cast iron.

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