Conference Paper

Surface Hardening Low Alloy Structural Steel By Laser Welding

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Abstract

The paper studied the degree of surface hardening of various low-alloy structural steels by laser weld overlays. Laser welding carried out on the "Scanner" and «Huffman HC-205." Studies have been conducted microstructure and elemental composition of built-up layers and the heat-affected zones on steel substrates selected by scanning electron microscopy and X-ray microanalysis. There were also measured the microhardness and built according to the changes in the thickness microhardness themselves claddings and heat-affected zones. As a result, the optimal modes of application of the laser weld overlays on the substrate, allowing to minimize the size of the heat-affected zones and differences in microhardness values, which reduces the likelihood of cracks and discontinuities.

Keywords: surface hardening, nickel alloy, laser cladding

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Received: 21 December 2017
Accepted: 15 April 2018
Published: 6 May 2018

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the MIE-2017 Conference Committee.

1. Introduction

A large number of parts and machinery fails in operation due to abrasion, shock, erosion. Modern technology has different methods of hardening and restoration of details to improve their service life. One of the methods of restoration and hardening of details is laser surfacing. Surfacing – This metal coating layer on the surface of the workpiece or article by fusion welding. There are surfacing weld and reducing.

Surfacing is performed by applying a molten metal on the surface of the product has been heated to the melting temperature or to the wetting liquid reliable weld metal. Alloy layer is integrally formed with the base metal. Thus, typically (except in some cases a repair surfacing, used to restore the original dimensions of parts), chemical composition of the deposited layer may differ significantly from the composition of the base metal. As a rule, welding task - getting quite homogeneous in the required specifications (specifications) layer of the most efficient and productive methods. Thus, in various cases, in surfacing must be comprehensively address complex issues:

- material selection, ensuring appropriate conditions of use properties;
- the possibility of deposition of the material directly on the base metal parts, or selection of material for the cladding sublayer;
- choice of the method and mode of deposition, shapes and surfacing materials manufacturing methods;
- cladding mode, form, and fabrication method of surfacing materials;
- choice of thermal regime to carry out welding.

Compared with other methods, laser processing methods do not require vacuum. No contact of the processed sample with extraneous materials with lasers handled well hard, brittle and refractory materials. Lasers produce high power density without, whatever that may be, the additional heater. When using laser surfacing products can be made from cheap, tech materials with a high viscosity and are expensive and scarce components are spent only on the creation of the hardened surface layer.

2. Materials and Experimental Methods

Laser welding carried out on the flat and cylindrical samples. When laser surfacing on the flat parts can be supplied as a powder followed, and the side opposite to the motion (**Figure 1**).

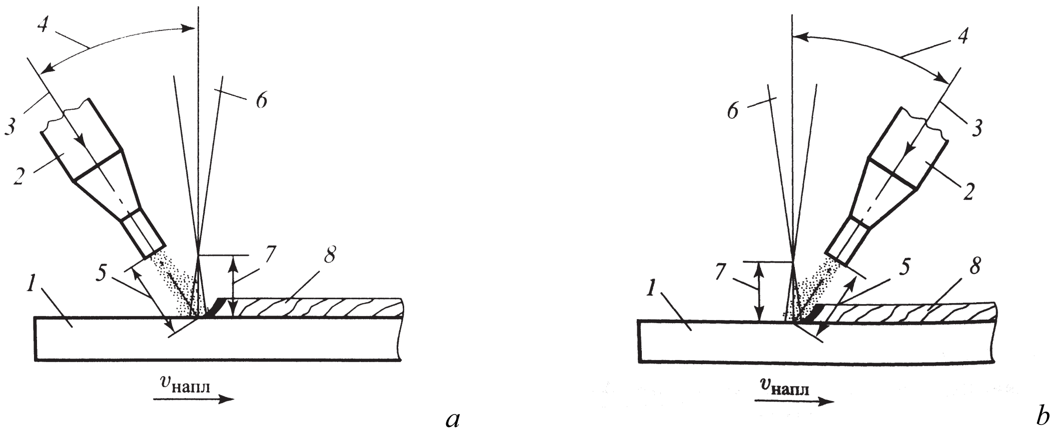


Figure 1: Laser cladding scheme forced feeding powder following (*a*) and to meet (*b*) the movement of the workpiece [1]. 1 – detail, 2 –powder supply, 3 –the direction of powder feed, 4 – angle of powder feed, 5 – distance of powder feed, 6 – laser ray, 7 – defocusing, 8 – roler.

In the case of the powder feed motion is achieved after the formation of a satisfactory weld beads. In this case the powder stream under pressure action the liquid metal is pressed against the cured surfacing parts. The process of formation becomes stable. Fluctuations of the geometric dimensions of the rollers along the length of the deposited layer are negligible [2].

Figure 2: Laser machine Huffman HC-205.

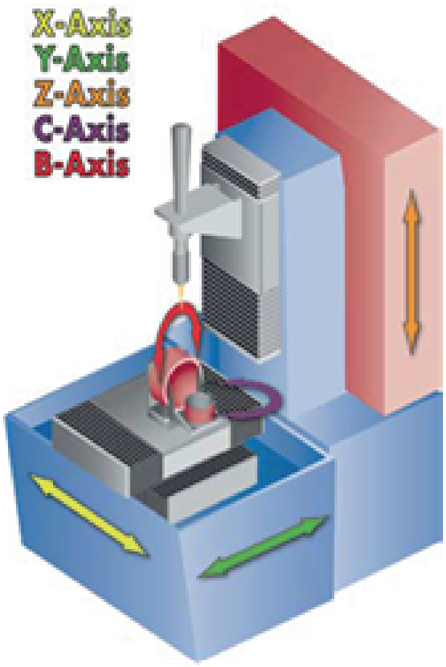


Figure 3: Coordinate system.

When applying powder movement towards the formation of a flat sample rolls occurs differently. Powder jet acting on the molten metal in a direction opposite the direction of travel the forming roller, whereby the molten metal is spread on the substrate surface. Increasing the area of the molten metal leads to an increase of the powder particles entering the melt. With this method, there is a minimal melting of the substrate, since the presence of the liquid interlayer effect complicates the laser beam on the base metal. In this regard, the coefficient stirring is reduced as compared with the value of the first parameter and the powder feed process practically to zero [3]. Laser surfacing conducted using powders of different grades based on iron, nickel and cobalt produced by Hoganas, Germany.

As substrates for laser surfacing were selected ordinary medium-low-alloy structural steel: Ст.10, Ст.20, 38Х2Ю, which are widely used in engineering for manufacturing, such as: gears, gear shaft, worm, claw couplings, rollers, fingers, sleeves and so on. For laser surfacing used fine powders rounded shape (**Figure 4, 5**) ranging from 50 to 100 mkm in diameter.

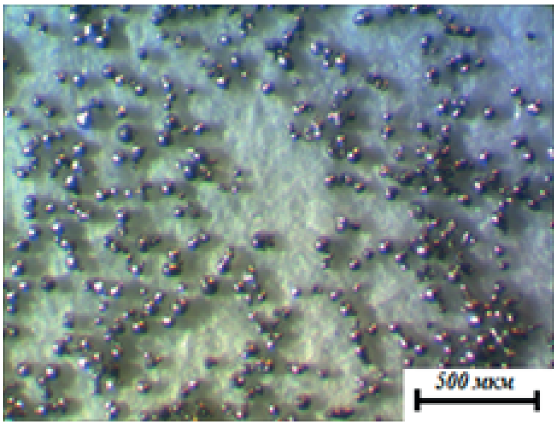


Figure 4: Fraction of the starting powder used for laser surfacing.

Table 1: The chemical composition based on powder **Ni**.

	The chemical composition, mas.%					
	Ni	C	Cr	Si	Fe	B
Hoganas 1350	Based	0,45	11,0	3,9	2,9	2,3

Powder brand Hoganas 410L, which are based on iron, hardened by heat treatment and has high wear resistance, good ductility, high toughness, good corrosion and heat resistance.

Table 2: The chemical composition based on powder **Fe**.

	The chemical composition, mas.%			
	Fe	C	Cr	Si
Hoganas 410L	Based	0,03	12,5	0,5

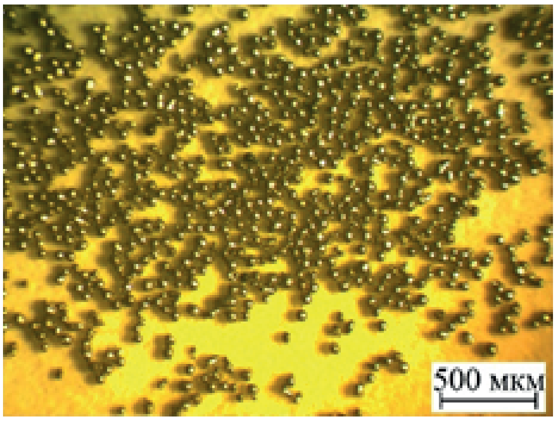


Figure 5: Larger image Powder Hoganas 410L.

Hoganas 2537 brand powder is made on the basis of cobalt is used for protection against corrosion and oxidation, as well as have high hot hardness.

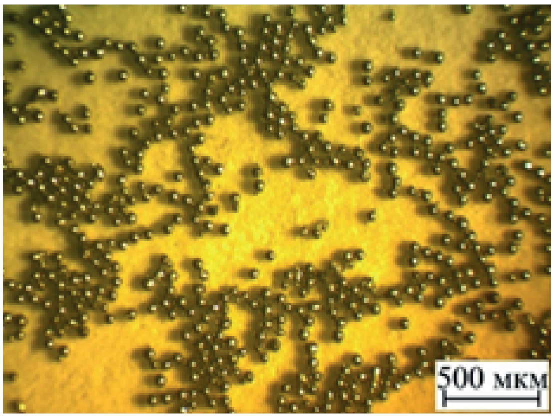


Figure 6: Larger image Powder Hoganas 2537.

Table 3: The chemical composition based on powder **Co**.

	The chemical composition, mas.%						
	Co	Fe	C	Cr	W	Si	Ni
Hoganas2537	Based	3	1,1	28,5	4,5	1,1	3

3. Results and Discussion

Microstructure themselves claddings and heat affected zones investigated in the back-scattered electrons in a scanning electron microscope.

The surface of the samples studied pre-ground and polished to a class of surface cleanliness ∇12, and degreased in the ultrasonic disperser brand "Сапфир".

Mechanical properties were investigated by microhardness measurement.

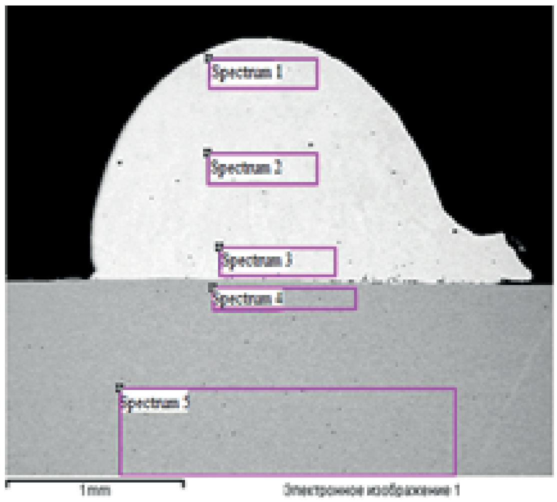


Figure 7: Area elemental analysis surfacing **№1** based on **Ni**.

TABLE 4: Elemental analysis surfacing based on **Ni**.

Elemental	Si	Cr	Mn	Fe	Ni
Spectrum 1	3,32	0,43	–	0,22	96,02
Spectrum 2	3,36	0,52	–	0,19	95,93
Spectrum 3	3,24	0,47	–	0,33	95,97
Spectrum 4	–	–	0,83	99,17	–
Spectrum 5	–	–	0,90	99,02	–

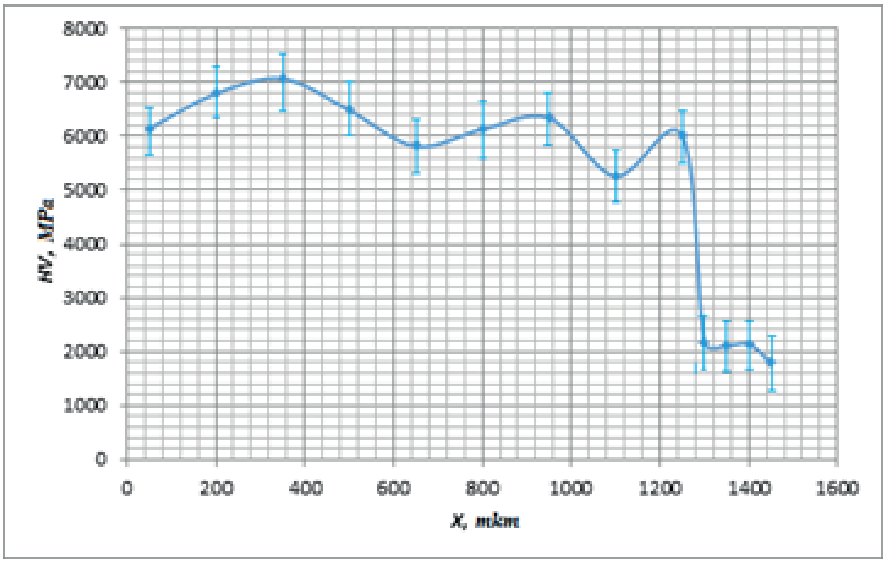
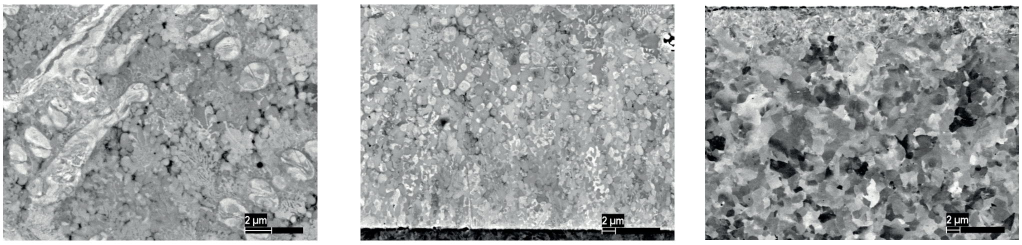


Figure 8: Microhardness surfacing **№1**.

3.1. Interim findings of the Ni-based surfacing

1. The maximum thickness of the surfacing of 1300 mkm.



a *b* *c*

Figure 9: Microstructure surfacing **№1** based on **Ni**. a – Top part surfacing, b – Middle part surfacing, c – Sample.

2. The zone of thermal influence is virtually absent.

3. Surfacing structure - dendritic-cell.

4. The structure of the substrate - polyhedral (equiaxed) grains of ferrite and pearlite. Phase composition - ferrite with a small layer of perlite.

5. The boundary of the substrate and facing a clear, no peeling, cracking and porosity.

6. Microhardness changes sharply at the boundary of cladding and the substrate 6000 MPa (surfacing) to 2200 MPa (substrate material)

7. Adhesion to substrate deposition satisfactory.

Coatings of iron-based powders by addition of alloying elements such as chromium, manganese, tungsten and formation of the corresponding carbides exhibit good wear resistance. We investigated the coating metal powder based on iron grade Hoganas 410L on a substrate made of structural steel of Article 20 in order to develop modifications to the surface of the technology.

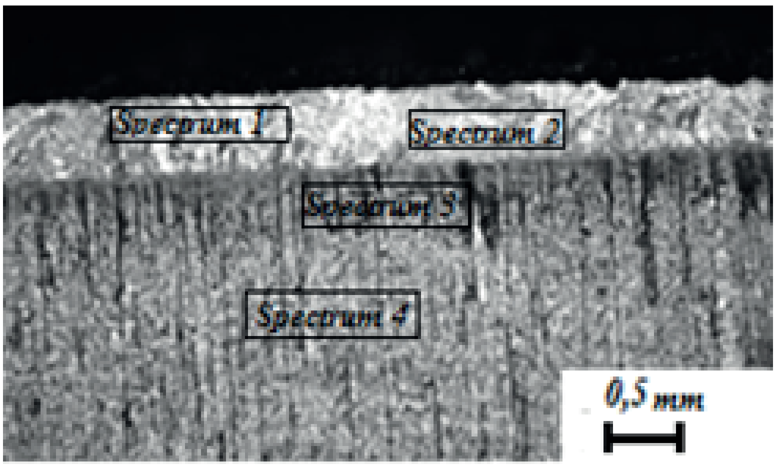


Figure 10: Area elemental analysis surfacing **№2** based on **Fe**.

Table 5: Elemental analysis surfacing based on **Fe**.

Elemental	Si	Cr	Mn	Co	Ni
Spectrum 1	0,46	12,14	0,50	0,25	0,50
Spectrum 2	0,46	12,18	0,50	0,31	0,69
Spectrum 3	0,36	2,58	0,49	0,05	0,13
Spectrum 4	0,34	0,05	0,50	0,01	0,04

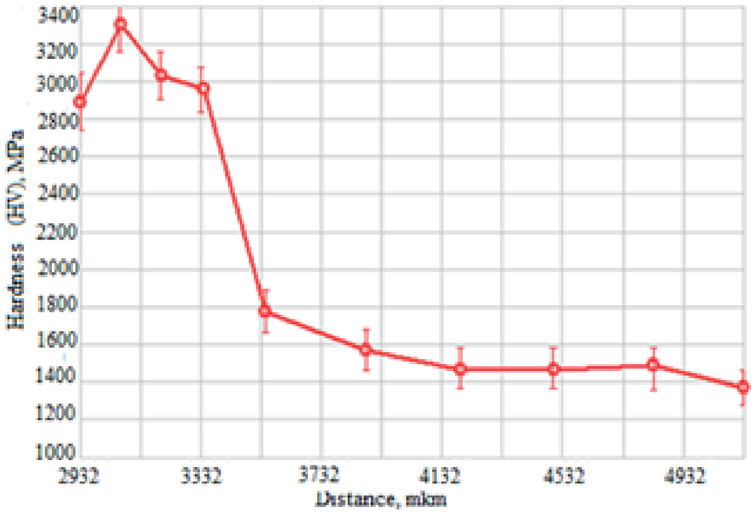


Figure 11: Microhardness surfacing **№2**.

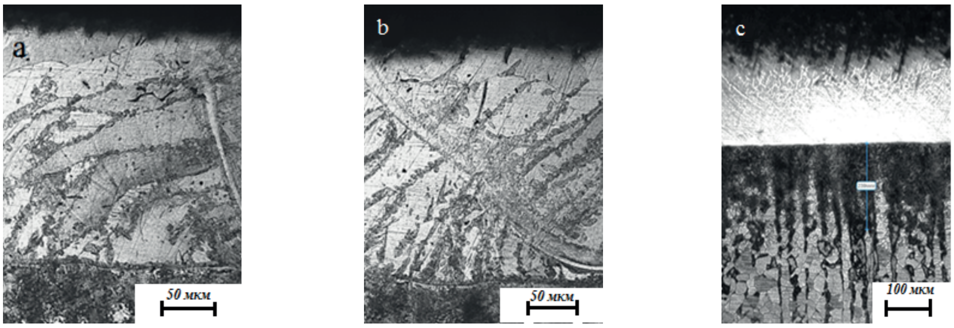


Figure 12: Microstructure surfacing **№2** based on **Fe**. a – Top part surfacing, b – Middle part surfacing, c – Thermal effect area.

3.2. Interim findings of the Fe-based surfacing

1. The maximum thickness of the surfacing of ~460–620 mkm.

2. Thermal influence zone of up to 350 mkm.

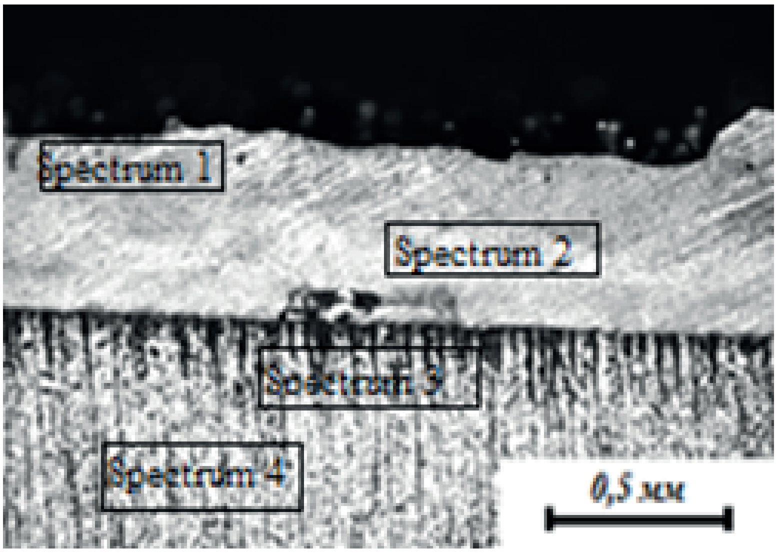


Figure 13: Area elemental analysis surfacing **№3** based on **Co**.

TABLE 6: Elemental analysis surfacing based on **Fe**.

Elemental	Si	Cr	Fe	W	Ni
Spectrum 1	0,46	26,30	2,58	3,48	2,45
Spectrum 2	0,46	25,82	1,86	3,10	1,62
Spectrum 3	0,36	7,85	54,56	0,08	0,04
Spectrum 4	0,34	–	98,56	–	–

3. Surfacing structure - mesh, visible grain refinement of ferrite and pearlite. There is the beginning of martensitic transformation. The microstructure of the deposited layer consists of a large elongated ferrite grains.

4. The structure of the substrat e - polyhedral grains of ferrite and pearlite. Phase composition - ferrite with a small layer of perlite and martensite.

5. The boundary of the substrate and facing a clear, no peeling, cracking and porosity.

6. Microhardness changes sharply at the boundary of cladding and the substrate 3000 MPa (surfacing) to 1800 MPa (substrate material).

7. Adhesion to substrate deposition satisfactory.

Heat-resistant coatings based on cobalt powders containing elements such as nickel, chromium, tungsten, molybdenum and carbon have working surfaces to improve wear resistance of parts in corrosive environments. Chromium is added for the formation of carbides to ensure strength of the crystal structure of cobalt, as well as to improve resistance to corrosion and oxidation. The addition of tungsten and molybdenum, due to their large atomic size, gives additional strength to the crystal structure of cobalt.

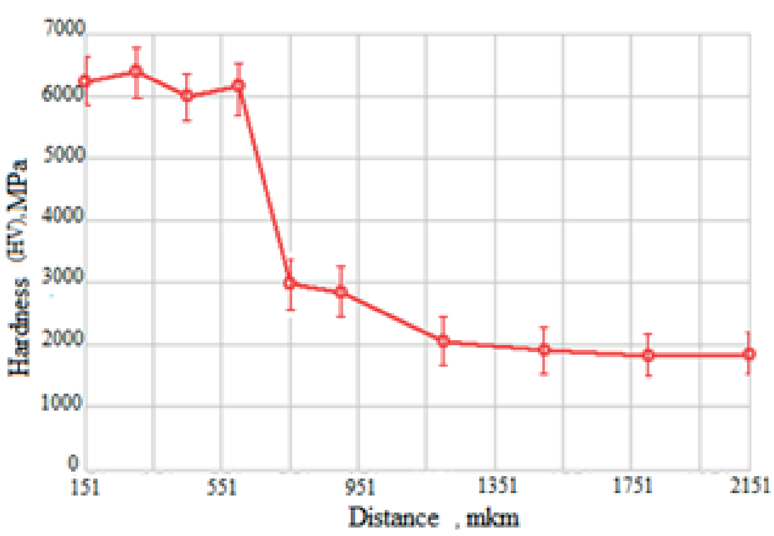


Figure 14: Microhardness surfacing **№3**.

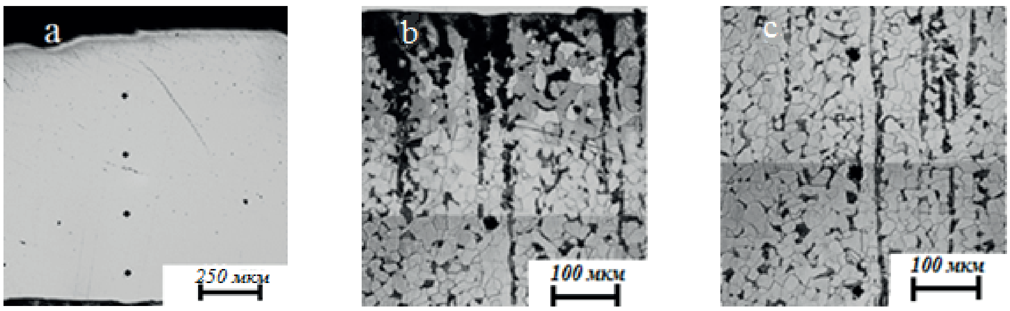


Figure 15: Microstructure surfacing **№3** based on **Co**. a – Top and middle part surfacing, b – Thermal effect area, c – Sample

3.3. Interim findings of the Co-based surfacing

1. The maximum thickness of the surfacing of ~670–890 mkm.
2. Thermal influence zone of up to 107 mkm.
3. The structure of the surfacing - cellular-dendritic, visible grain refinement of ferrite and pearlite. There is the beginning of martensitic transformation.
4. The structure of the substrate - polyhedral grains of ferrite and pearlite. Phase composition - ferrite with a small layer of perlite and martensite.
5. The boundary of the substrate and facing a clear, no peeling, cracking and porosity.

6. Microhardness changes sharply at the boundary of cladding and the substrate 6000 MPa (surfacing) to 2800 MPa (substrate material).

7. Adhesion to substrate deposition satisfactory.

4. Conclusion

1. It was found that nickel-based hardfacing powder has a dendritic microstructure, the microhardness increased value (7000 MPa), characterized by the absence of thermal influence zone.

2. The optimal mode of application of built-up layers of powder based on nickel on the installation "Huffman HC-205", which causes a defect-free substrate adhesion and surfacing, as well as the absence of pores and cracks.

3. It was found that powder deposition based on iron and cobalt formed on installation "Huffman HC-205", have cell-dendritic microstructure and heat affected zone depth, microhardness value based surfacing Fe does not exceed 3200 MPa, 6200 based on Co MPa.

Acknowledgement

Authors would like to acknowledge the financial support of the National Research Nuclear University MEPhI Academic Excellence Project (Contract No. 02.a03.21.0005).

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