

LASER CLADDING OF Ni-Cr-B-Fe-Al ALLOY ON A STEEL SUPPORT

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ABSTRACT

Multilayer coating by injection of powder with 8.9% Cr, 4.5% Fe, 5.1% B, 2.4% Al, 0.6% Cu; all reminded of Ni, as chemical composition, in melted bath by CO₂ continuous wave laser connected to x-y-z coordinate table was tested in order to rise the wear and corrosion resistance of 0.45% C superficial steel layers. Layers made by different laser running were characterized by macro and microstructure analysis, as well as phase quality analysis by X ray diffractometry, micro hardness analysis and hardness finding on coated layer surface in order to establish the optimal deposit running.

KEYWORDS: laser, cladding, nickel, microstructure, microhardness, diffractometry

2. Experimental conditions

1. Introduction

550°C temperature hot rolled tape is lined up on winding reel by some manipulators having the wearing plates in touch with moving tape edge.

Quick abrasion and oxidation wearing of these plates result. In order to enlarge their useful life, it is requested the coating of a superficial layer of material with higher wear and oxidation resistance.

Gas-thermal coatings (oxy-gas flame, spreading in plasma) by powder based on nickel from systems Ni-Cr-B-Si, Ni-Cr-Al, Ni-Mo-Si and others, for parts working under large thermal and mechanical loads in aggressive environments are known [1] ÷ [3]. Researches made on thermal spread coatings from Ni-Cr-B-Si alloys, lately melted by laser, pointed out rising of hardness and fatigue resistance, decreasing of friction coefficient, lapping period and seizing trend compared to coatings made by flame melting [2], [4].

Researches more recent shows the laser cladding structure and properties of some nickel alloys from predeposited or injected powder [4] ÷ [15].

Hereby paper work gives the results of multilayer coating by injection in laser melted bath by nickel alloy powder from Ni-Cr-B-Fe-Al system.

For coating „Alliages Speciaux 7569 Alliages Frites, Franța” powder with 8.9% Cr; 4.5% Fe; 5.1% B; 2.4% Al; 0.6% Al; All reminded Ni was used. By sieving the granulometric fractions, inside 80÷90 µm interval, were separated in order to be used as addition material. Powder had spherical shape that provided a fluid floating of addition material through the injection system. Powder dried at 110°C temperature for 15 minute before feeding the addition material into injection system tank. Coatings were performed on 25 x 25 x 15 mm³ samples made of 0.45% C carbon steel in improved condition.

Laboratory trials were performed in a CO₂ continuous wave laser installation as GT type of 1400 W (made in Romania), with coordinate working table and computer program for running, provided by powder injection system onto laser melted surface.

For laboratory tests it was used a 1150 W power laser beam by 1,8 mm in diameter on machined surface, which deposited the parallel partly superimposed strips by 1.5 mm transverse motion pass. Final layer thickness resulted by superimposing of 4÷5 layers. In order to establish the optimal coating laser run there were changed the addition material flow, sweeping speed of charging surface and initial sample temperature. In table no. 1 are given the layers running condition and thickness for several experimental running.

Table 1 Experimental conditions and layer thickness

Sample code	Addition material flow [mg/s]	No. of superimposed passes [initial sample temperature]	Sweeping speed [mm/s]	Layer thickness [mm]
1	55,5	5 [T _p =20°C]	9	1,50
2	105	4 [T _p =20°C]	7,5	2,07
3	105	4 [T _p =20°C]	11	0,59
4	63,9	4 [T _p =60°C]	11	0,42
5	63,9	4 [T _p =60°C]	7,5	0,35

Deposited layers were tested by: macroscopic analysis on both coated layer surface and cross section in laser processing direction, after its metallographic preparation; microstructure analysis and HV_{0,98} (0.98N load) micro hardness profile drafting in cross section of laser strips; phase quality analysis by X ray to coated layer surface made by DRON 3 diffract meter using: copper anticathode; monochromatic diffracted beam; U=34kV; I=30mA; F₁=2mm; F₂=0,5mm; ω=1°/min; s_{trip}=720mm/h, for diffraction angle variation between 2θ = 20°...75° limits.

3. Results and discussion

Macroscopic analysis pointed out the coated surface quality, tightness, coated layer thickness

and its adherence on support. Thick layers may be observed with good adherence on support, tight and with a plain surface of deposited layer (figure 1), as lately mechanical work to be minimally. Regarding to running influence on surface quality, tightness and thickness of coated layer, good results were obtained in a very large running range. It was found the lack of any support influence upon chemical composition throughout deposited layer depth after five passes. Figure no.2 shows the coated layer microstructure aspect for the sample 2, when multiply by x500. Good coated layer adherence to the support may be seen. In fusion line there are no tightness defects or non-metallic inclusions.

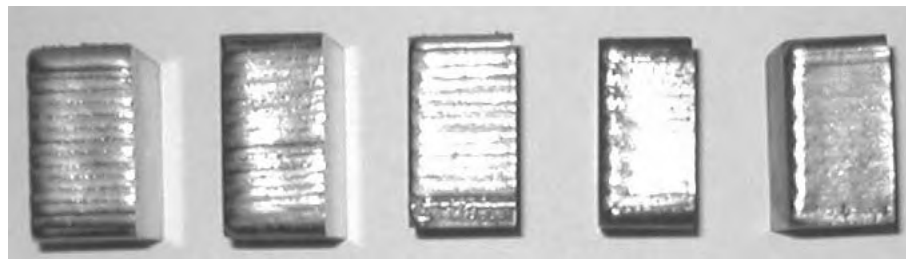


Figure 1. Samples coated by thick layers of nickel alloy

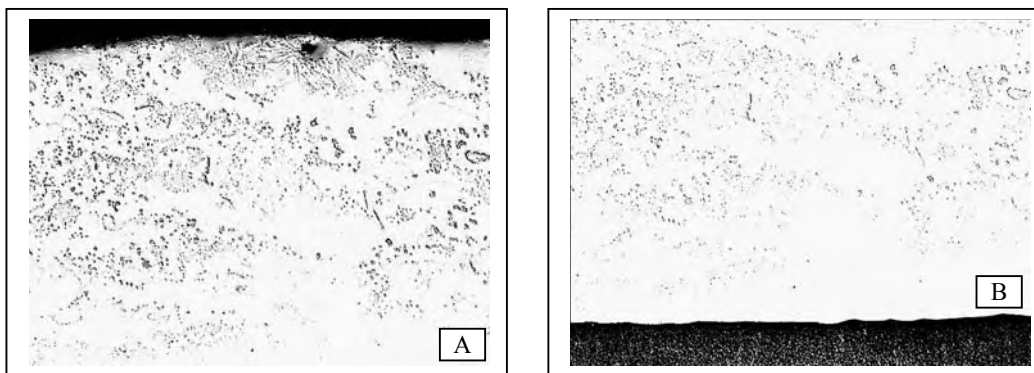


Figure 2. Nickel alloy microstructure deposited onto sample 2. A-layer surface; B-base deposited layer and support (x500). Nital attack 2%.

According to phase quality analysis (figure 3), deposit microstructure includes solid solution based on nickel and eutectic colonies of boride like NiB, Ni₂B, CrB, Cr₃B₄ and FeB, main hardening

phase being CrB. In the layer bottom a nickel-iron narrow dilution area may be seen, without eutectic carbides that make transition to support material.

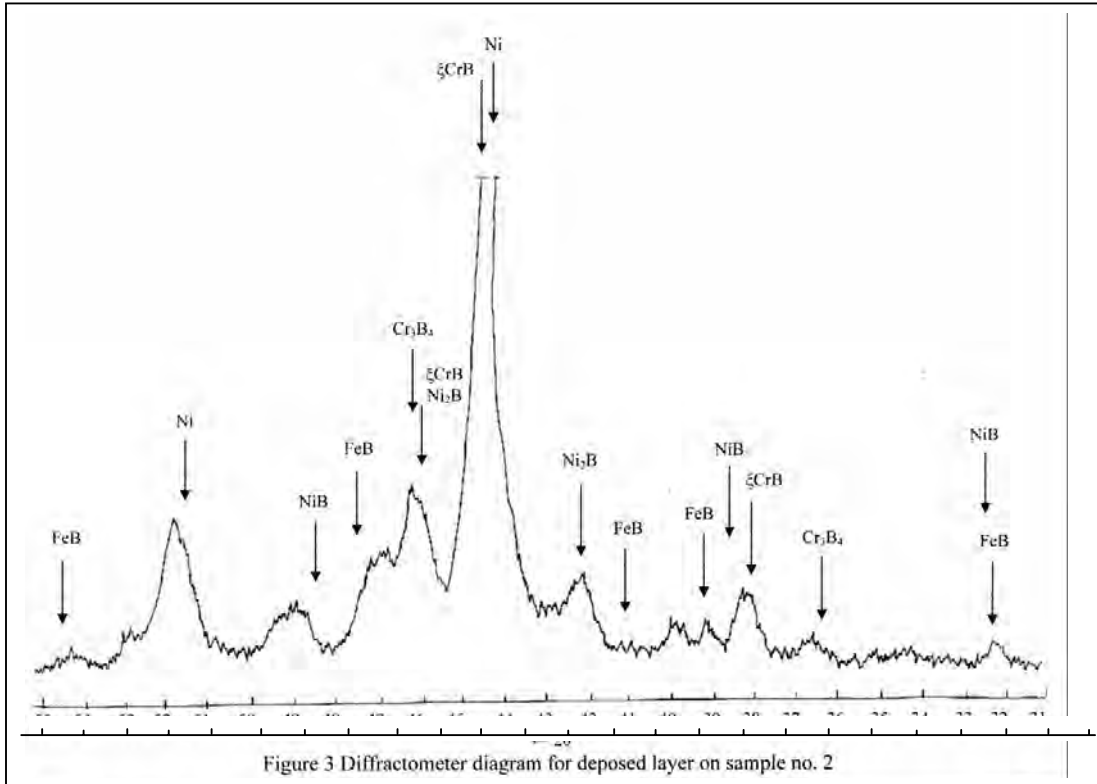


Figure 3 Diffractometer diagram for deposited layer on sample no. 2

Figure 4 shows HV_{0,98} micro-hardness variation through laser deposited layer depth in samples with code 1, 2 and 3, without support preheating. Maximum layer hardness and thickness were found at sample no.2, where the minimum sweeping speed was and maximum addition material injection volume was. Sample preheating to 60°C (samples no. 4 and 5) decreases the coated layer hardness and thickness, more emphasized in slow sweeping speeds because of superficial temperature rising and vaporization processes intensifying. As laser beam mainly gives the energy required to melt the addition material, the sweeping speed has to be correlated to addition material flow. The larger addition material flow determine the smaller the sweeping speed that provides maximum deposited layer thickness.

Optimal running (of sample no.2), was used in order to get the wearing plates of winding system manipulators of hot rolled stripes. Figure 5 gives a wearing plate on which nickel alloy in active area was deposited.

4. Conclusions

When multi layers coating by continuous wave laser beam, thick layers nickel alloy may be achieved to be wear and corrosion resistant, from Ni-Cr-B-Fe-Al system, dense, with good adherence to under-layer by dilution decreased layer. Laser coating by powder injected in melt bath is a complex process of mass and heat transfer, which is efficiently in condition of a powder injection system in continuous flux with steady flow. In condition of coating by powerful laser beam with given dimensions, hardness and thickness of deposited layer depend on addition material flow, surface sweeping speed, initial sample temperature, number of superimposed layers and laser strips superimposed degree. Dilution degree is influenced by powder flow and power factor used.

Optimal nickel alloy coating running (sample no.2) achieved a 2 mm in depth dense layer with HV_{0,98} micro hardness varying between 9543MPa and 12 640MPa.

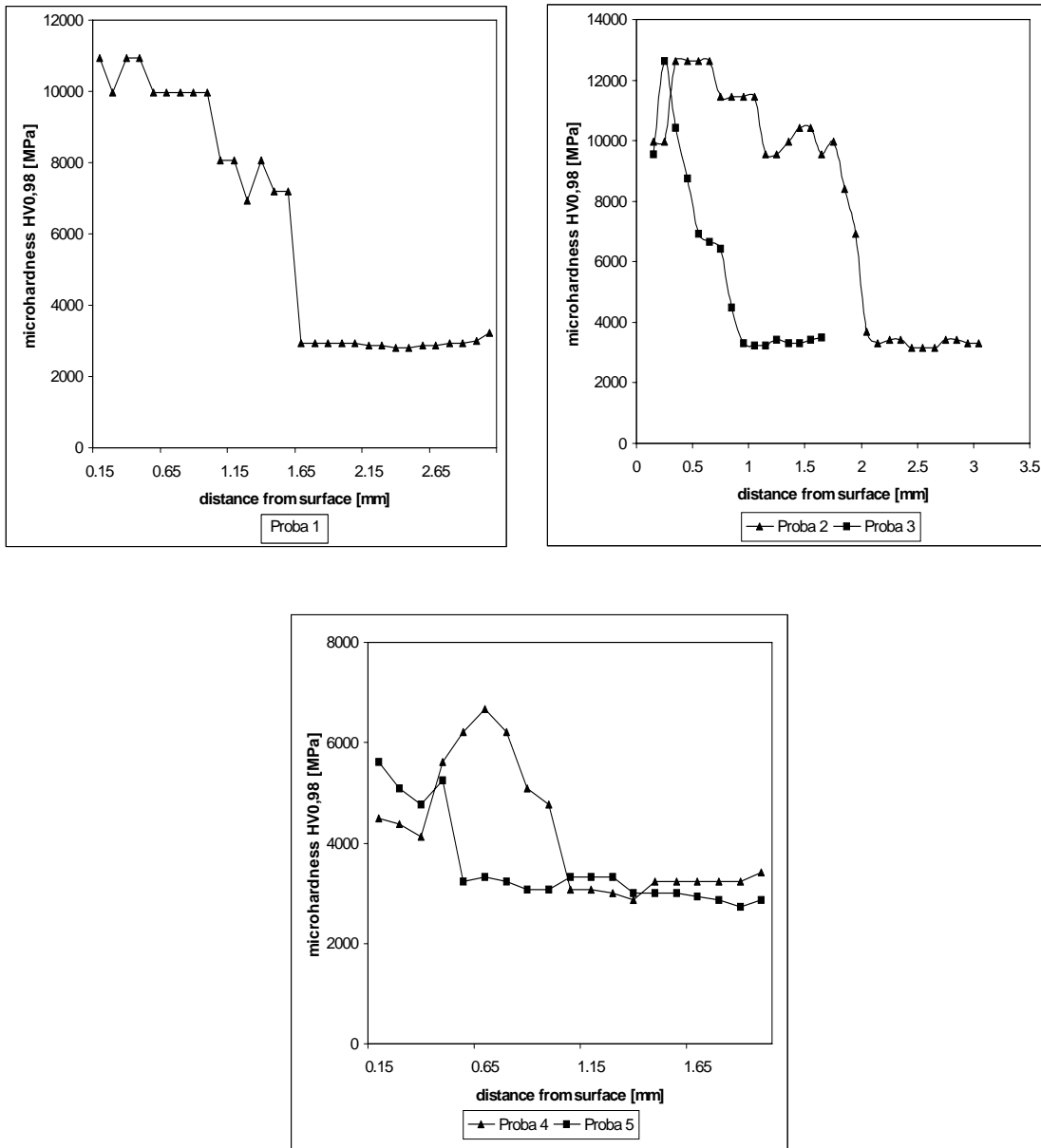


Figure 4. Vickers micro-hardness variation in relation with distance since deposited layer surface, samples no. 1, 2, 3, 4, 5.

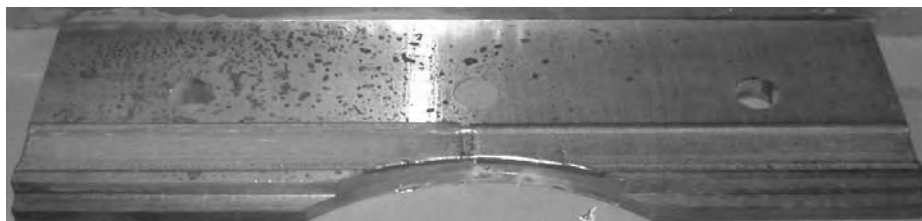


Figure 5. Wearing plate of winding system manipulators of hot rolled stripes

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