The possibilities to increase the hardness of welded coating layers

A. OLÁH*, M. H. TIEREAN
Transilvania University of Brasov, Romania

The paper presents a research about the influence of nitrocarburizing on welded coating layers. The research was made with four types of electrodes for welding coating layers. Evaluation of results was made studying microhardness and microstructure. Results reveal a good effect of nitrocarburizing in case of coating with low carbon and chrome electrodes.

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1. Introduction

The welding coating process enables the recuperation by means of reworking of some parts or machine components that reached the wear limit. In this situation some examples are: dies, crankshafts, different machinery axles, camshaft which can be brought back at the nominal quota. Usually, the hardness obtained after coating depends only on the filler material characteristics. The goal of this research is to demonstrate the increasing of hardness if a thermochemical heat treatment will be applied on the welded layer.

2. Sample preparation and testing equipment

The metal coating condition was made with arc welding with Luftarc 150 Ductil equipment, using four types of electrodes. The welding current intensity was 700 A and the welding voltage was 40 V [1]. The base metal was S275JR SR EN 10025-2:2004, 20 mm thick. The coating layer was 5 mm thick. After the coating, the samples were tempered at 600ºC. The results were evaluated with PMT – 3 microhardness tester and BEL MTM-1A metallographic microscope.

3. Experimental research

Plasma nitrocarburizing was applied on four types of welding coating layers, presented in Table 1. The sample was subjected to plasma nitrocarburizing in three variants, in NITRION thermo chemical furnaces [2].

Table 1. Electrode used in research

Electrodes	C	Si	Mn	Cr	W	Nb	Ni	S
ElCrW8Co	0,3	0,8	0,8	2,0	7,0	1,2	-	-
El CrW2	0,4	1,3	-	1,2	2,3	-	-	-
E Cr25Ni20R	0,12	1	3	24	-	-	22	0,020
El 62 H	0,7	0,8	0,3	3,5	3			

- *Nitro 1* in ammonia + carbon oil
  Tension: 1000V,
  Temperature: Tref = 570 °C, Treg: 580-590 °C,
  Pressure: P_{NH3} = 1,5 Torr, $P_{NH3} + P_{CH3OH}$ = 1,5 Torr max,
  Time: 3 h;
- *Nitro 2* in ammonia + hexachloride CH_3-$(CH_2)_4$-CH_3
  Tension: 1000V,
  Temperature: Tref = 570 °C, Treg = 580-590 °C,
  Pressure: P_{NH3} = 1,5 Torr, $P_{NH3} + P_{C6H6}$ = 1,6 Torr max,
  Time: 3 h.
- *Nitro 3* in ammonia + benzeneC_6H_6
  Tension: 1000V,
  Temperature: Tref = 570 °C, Treg = 580-590 °C,
  Pressure: P_{NH3} = 1,5 Torr, P_{C6H6} = 1,6 Torr max,
  Time: 3 h.

In the case of ElCrW8Co electrode there are obtained the results presented in figures 1 and 2.

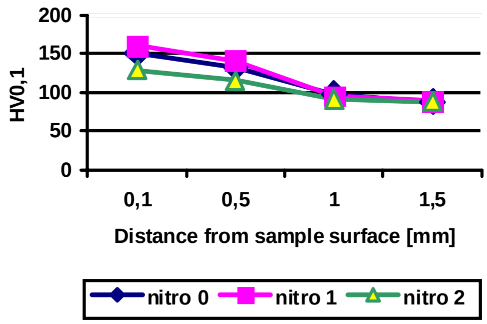

Fig. 1. Variation of microhardness of samples coated with El CrW8Co electrode

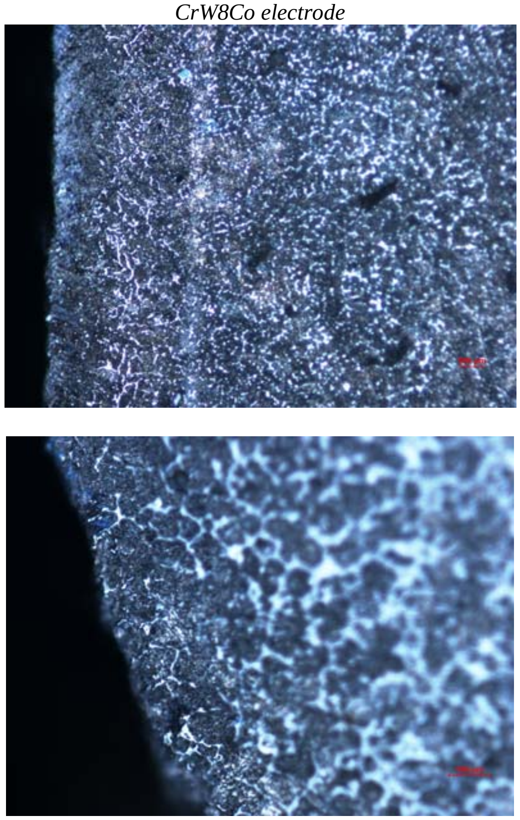

Fig. 2. Nitrocarburized layers, El CrW8Co electrode coating, X 200, Nital etch.

The formation of nitrocarburized layer can be observed, which explains the increase of microhardness. The formation of carbon chemical compound can also be observed, which has the effect of increasing the microstructures. Welding coating layer is characterized by martensite structures and the base steel has a ferrite structures.

In the case of El CrW2 electrode, the results obtained are presented in figures 3 and 4.

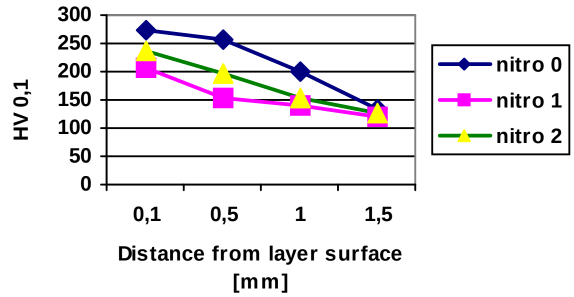

Fig. 3. Variation of microhardness of samples coated with El CrW2 electrode

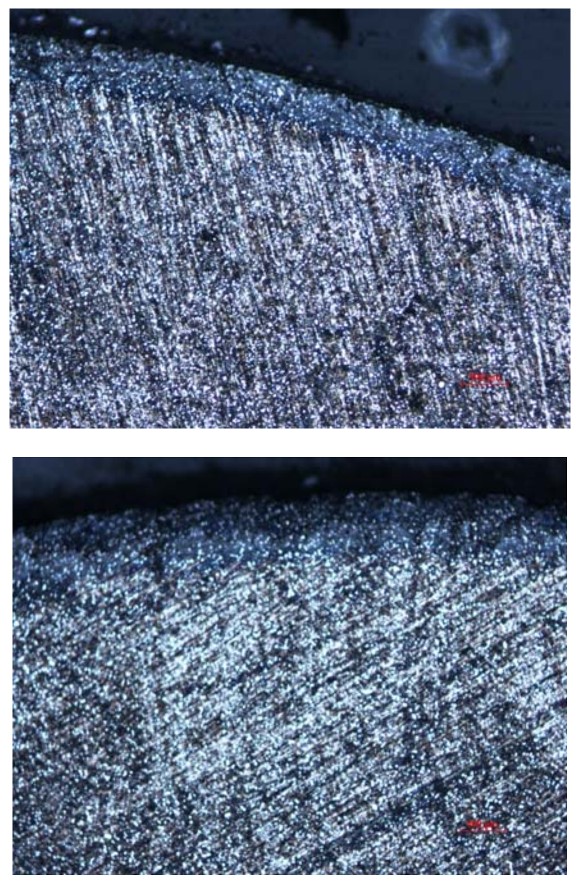

Fig. 4 - Nitrocarburized layers, El CrW2 electrode coating, X 200, Nital etch

The nitrocarburized layer is visible on the sample surface. The hardness increasing is stronger than in the first case due to increasing of carbon content of the electrode.

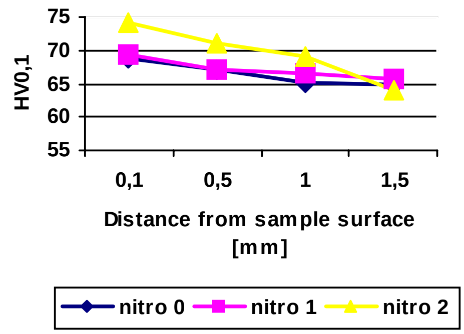

Fig. 5. Variation of microhardness of samples coated with El Cr25Ni20R electrode.

In the case of electrode E Cr25Ni20R electrode, the results obtained are presented in figure 5 and in the case of El 62 H we obtained microhardnesses presented in Fig. 6.

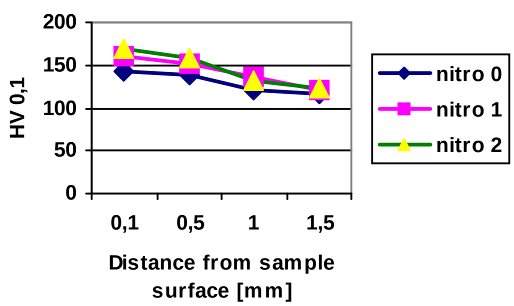

Fig.6. Variation of microhardness of samples coated with El 62 H electrode

4. Conclusion

In the case of coating with electrode ElCrW8Co, which has a medium carbon content of 0,45%, and alloys elements are relatively high, Cr = 2%, W = 7%, the effect of nitrocarburizing is very good for microstructures and micro hardness. So the microhardness in case of classical treatment (600ºC) after welding coating the microhardness is 87,6 $HV_{0,1}$, and in the case of application of nitrocarburizing after welding coating, the microhardness is 128 $HV_{0,1}$, 151 $HV_{0,1}$, 160 $HV_{0,1}$.

From the study of microstructures one can observe the formation of nitrocarburized layer, which explains the increase of microhardness. One can observe the formation of chemical compound of carbon, which has the effect of increase the microhardness. Welding coating layer is characterized by martensite structures and the base steel has a ferrite structures.

In the case of coating with El CrW2 electrode, which has 0,4% Carbon and the alloys elements are very low, maximum is Vanadium (3%), the influence of nitrocarburizing is very good, the microhardness increasing from 116 $HV_{0,1}$ in the case of classical heat treatment after welding coating, to 274 $HV_{0,1}$, 206 $HV_{0,1}$ and 236 $HV_{0,1}$, in the case of application the nitrocarburazing after welding coating.

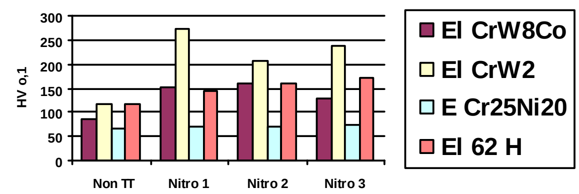

Fig. 7. Variation of microhardness of all coated samples

When coating is made with the electrode E Cr25Ni20R, the concentration of alloying elements is very high, Cr (24%) and Ni (22%). Because the concentration of C (0,12%) is very low, increasing of microhardness after nitrocarburizing is insignificant. That fact is explained by blocking of the chemical compound development by the Cr and Ni atoms, which means a low influence of the nitrocarburizing heat treatment [3]. In case of application of classical heat treatment, we obtained 65,4 $HV_{0,1}$, and in case of application of nitrocarburization we obtained only 68,6 $HV_{0,1}$, 69,4 $HV_{0,1}$, 74,2 $HV_{0,1}$.

In the case of El 62 H electrode although the concentration of carbon is big, 0,7%, the concentration of alloys elements is small, favoring the formation of nitrocarburized layers which explain the increase of microhardness. So in the case of application of classical heat treatment at 600ºC we obtained 116 $HV_{0,1}$ and in case of nitrocarburizing we obtained in welding coating layer 143 $HV_{0,1}$, 160 $HV_{0,1}$, 170 $HV_{0,1}$.

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*Corresponding author: oart@unitbv.ro