Technical Sciences
Academy of Romania
www.jesi.astr.ro

Journal of Engineering Sciences and Innovation
Volume 2, Issue 3 / 2017, pp. 118-123
http://doi.org/10.56958/jesi.2017.2.3.118

D. Chemical Engineering, Materials Science and Engineering, Natural Resources

Electrods type Fe-25%Cr-4%W-V-Ti-La for hard surfacing

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Abstract. Performing the active surfaces subjected to abrasive wear by hard surfacing is difficult to made because the missing of adequate materials. This fact imposed the elaboration and implementation into industrial production of a new generation of materials with adequate properties. In order to assure the wear protection of the surfaces in contact with materials to be processed, these surfaces must be characterized by high hardness and toughness.
Elaboration of the product recipe for the electrodes type Fe-25%Cr-4%W-V-Ti-La was made by comparison between the data mentioned in the speciality literature and the experimental results obtained by SIMPLEX method for wear resistance.
Improving the depositions toughness was obtained by microalloying with lanthanides, but structures finishing was made by addition of V and Ti.
In the slagging process, the electrodes basicity was min. 3.2 B_B units, and metallic powders were been elected in such a way as the electrodes to be in the grade of max. 5cm^3/100g deposited metal.
The deposited metal using the electrodes fabricated in the above mentioned conditions has a fine grained martensitic structure, having a high content of complex carbides of Cr, V and Ti, and the hardness of min. 60 HRC.

Keywords: hard surfacing, abrasive wear, hard electrodes, metallic powders.

1. Introduction

The main object of this research is to obtain the electrodes with adequate technical and technological properties in order to assure the deposited layers made by welding. These layers must have a high wear resistance together with a good behavior to fatigue and corrosion in humid air.
The electrodes rods are obtained from dead-drawn wire from coils, with a precision of +0/-0.08 mm, by straightening and cutting. In the case of undistorted alloys, the electrodes rods are performed by continuous casting or using the specific technologies of powders metallurgy.

The electrode coating contains the grains of max. 0.3 mm, obtained by mechanical grinding of the raw materials specified in the product recipe. The participation of the alloying elements into deposited metal is influenced by the coating coefficient, and by the affinity of alloying elements to oxygen. The effects of the alloying element on the characteristics of deposited metal are similar to those discovered by the researches made in the field of materials engineering.

The coated electrodes fabrication is a complex process, usually made in four steps:

- ✓ Acquisition, verification and preliminary preparation of the raw materials specified in the product recipe;
- ✓ Performing the rod and the coating, according to the technical specifications and the fabrication procedure;
- ✓ Performing the green carbons by extrusion and verifying the coating coefficient and coaxiality of the rod with the coating;
- ✓ Drying, calcination and characterization of the product in accordance with the fabrication procedure and assurance of the coated electrodes quality.

The applied solutions, in this case, in order to satisfy the above mentioned requirements are:

- Performing the electrodes with high deposition rate, in order to assure the high wear resistance together with a good behavior to fatigue; these electrodes can deposit by welding such layers having the tough structural constituents, similar to those obtained by nanostructuring, namely high resistance to erosion and mechanical shocks;
- Using an adequate alloying system to obtain the deposited layers having minimum 12% free chromium, in order to assure the protection against oxidation of the alloy. Also, this alloying system must contains Cr, W, V and Ti, which determine the germination and precipitation of complex carbides, having a high hardness and toughness;
- Performing the coating with endotherm character and high basicity, who contains, in the field conditions, the substances which produce gases and slags having the presetting viscosity;
- Limiting the hydrogen content in the deposited metal to max. 5ml/100g, by using the metallic powders with low hydrogen content and minerals substances having a minimum content of crystallization water;
- Micro-alloying of deposited metals with lanthanides and limiting the content of S and P, in order to obtain the ductile layers;
- Introducing the substances with high electrical conductivity and low surface pressure in the liquid phase in the electrode coating, in order to obtain the deposited layers by welding having the ratio thickness/width of approx.1/4, and low tendency to dilution with base metal;
- Protection against oxidation of the alloying elements during the drops passing through the electric arc using the slaughtering elements with affinity to oxygen.

2. Experimental program

The elaboration of the concept of electrodes for welding surfacing having the pre-established properties and their obtaining procedure is a sequentially process, using the obtained results in the next researches.
Product recipe of the electrodes to be assimilated (Table 1) was elaborated by experimental researches, based on the information from speciality literature [1,2], and the law of matter conservation [3], using SIMPLEX method [4], IT assisted.

Table 1. **Product recipe**

Materials	Percentage [% massic]	Constituents [% massic]
Rods, type Fe-17%Cr	60%	Wire, Φ4x350mm
Deoxidant flux, basic calcium fluoride	39% powdery material, grade nanopowders 0.3mm	20,5% marble 19,5% fluorite 6% rutile 1% aluminum oxide 18% bonding agent +1% plasticizer 3% cellulose
Alloying, deoxidation and refining system from coating	30% nanopowders	16% ferrochromium 60 6% wolfram carbide 2% deflocculated graphite 1% ferrotitanium 60 0,5% ferro-vanadium 45 0,5% lanthanides 4% ferromanganese 45 2% ferosilicon 40
Coating coefficient 1.7		

The electrodes type Fe-25%Cr-4%W-V-Ti-La, testing lot, were performed by extrusion, on the production line, presented in figure 1, and having the technological parameters mentioned in table 2.

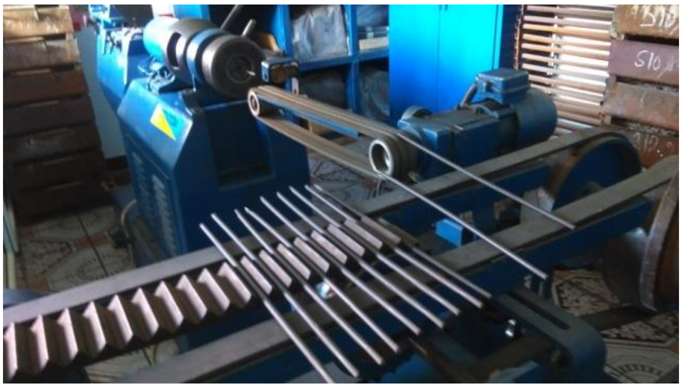

Fig. 1. Production line.

Table 2. **Technological parameters of fabrication for Fe-25%Cr-4%W-V-Ti-La electrodes**

Process parameters	Experimental values
Briquetting pressure	25±0.1 MPa
Extrusion pressure	25±10 MPa
Weight rate of rods	approx. 7 kg/h
Weight rate of coating composition	approx. 4 kg/h
Speed of band conveyer for coating rods	approx. 11 kg/h

The deposited layers performed with these electrodes were tested in order to evaluate the wear resistance using the method based on erosion with basaltic sand (Figure 2).
The experiment principle is presented in figure 3.

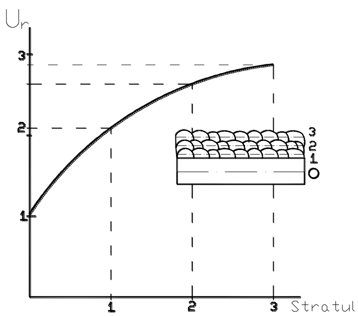

Fig. 2. Variation curve of relative wear resistance of the deposited layers.

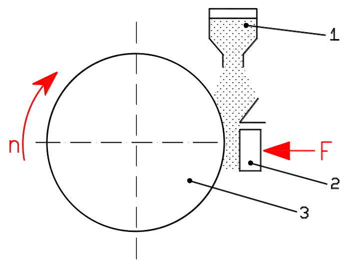

Fig. 3. Principle of wear resistance determination.
N - rotative speed of rubber drum; F-power press of specimen 2 on the rubber drum;
1-sand tank;
2-test specimen; 3-rubber rotating drum.

3. Results and discussions

The chemical composition of the deposited metal, determined by spectral method, is presented in table 3. These values assure a certain alloying level, which allow obtaining the tough structures with fine granulation.

Table 3. **Chemical composition of the deposited metal**

Sample	Elements content								
	[%]								
	C	Si	Mn	Cr	W	V	Ti	S	P
MD - deposited metal	1.98	0.73	1.42	24.7	3.95	0.31	0.12	0.024	0.018

The coating basicity was calculated using Boniszewski formula, only for the basic coating.

$$B_B = \frac{CaO + MgO + BaO + Na_2O + K_2O + \frac{1}{2}(MnO + Feo)}{SiO_2 + \frac{1}{2}(Al_2O_3 + TiO_2 + ZrO)} \quad (1)$$

Based on this formula, the coating character can be classified in:

- coating with acid character, B_B less than 1;
- coating with neutral character, B_B between 1.5 and 2.5;
- coating with semi-basic character, B_B between 1 and 1.5;
- coating with strong basic character, B_B more than 2.5.

The slagging system has a strong basic character, having a basicity ratio of 3.4.
The tendency to brittleness of the performed deposited layers using the recommended parameters was evaluated by diffusible hydrogen content determination in accordance with SR EN ISO 3690:2002 specifications. The structural analysis and the hardness measurements confirm the obtained structures.

The diffusible hydrogen extraction was made in vacuum, and the obtained results are presented in table 4.

Table 4 **Diffusible hydrogen content**

Electrode type	**Diffusible hydrogen content**				
	[cm^3/100 g deposited metal]				
	Specimen 1	Specimen 2	Specimen 3	Specimen 4	Mean value
Fe-25%Cr-4%W-V-Ti-La Φ4 mm	5.22	4.65	4.88	4.91	4.91

The sample cut from deposited metal used to determine the chemical composition was processed and etched with aqua regia, in order to be metallographic analyzed (Figure 4).

The working method is in accordance to SR 5000-97 and STAS 5500-74 standards.

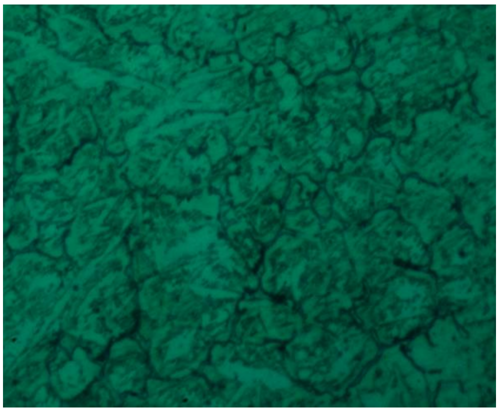

Fig. 4. Metallographic structure of deposited metal. [Etched Aqua Regia, 500x].

In figure 4 can be observed a fine martensitic structure, rich in complex carbides uniform distributed, having the grain boundaries well outlined. This fact can be explained by the presence of micro-alloying substances, including the lanthanides.
The structural examinations were been completed by hardness testing, made on the deposited metal sample. The testing method was in accordance with SR EN ISO 6507-1:2006, namely HV10. This test was performed using ZWICK 3212 microdurometer. The hardness test results are presented in the table 5.

Table 5. **Deposited metal hardness**

Sample	**HV10 hardness**	**ΔHV10 (%)**
Deposited metal	627; 606; 665	5.71

The structural hardening coefficient, ΔHV10≤50% shows a minimum tendency to depositions brittleness. The hardness values mentioned in table 5 confirm the analyzed structures.

4. Conclusions

4.1. The performed researches led to fabrication of electrodes type Fe-25%Cr-4%W-V-Ti-La, which can deposit by welding some alloys characterized by fine-grained structure and non-metallic compounds at the grain boundaries.
4.2. The participation into the high homogeneity depositions of complex carbides of Cr, W and Ti and the fine martensitic structure assure a good wear resistance at high pressure together with a good behavior to fatigue.
4.3. The industrial applications of the new generation of electrodes confirm the goal and the method to perform these electrodes by good behavior in exploitation of the new systems of protection and/or self protection to wear.

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