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CLADDING BY WELDING WITH HARD ALLOYS

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ABSTRACT

The paper presents the results of a research on the role of cladding by welding support of continuous casting plant. Emphasizing that plating leads to outer layer the study presents a complex of properties favorable for the working conditions of abrasion and oxidation resistance at high temperatures.

KEYWORDS: cladding, refractory, abrasive wear, thermal stability

1. Introduction

Application in extreme conditions of machines: mechanical stress, thermal, chemical, etc. leds to the need to design new materials that meet these requirements. Coated materials are included in these types of materials group. Cladding, is understood in the metallurgical combination of two or more layers of metallic materials in certain thicknesses, in the form of products that resist to external demands and show no tendency to separate. Combining layers of materials coated components various processes depending on the nature of the materials are mode, thickness, destination products and demands imposed on them, the tools and technologies available. Each of the layers of components over a certain part of the requirements of the product like: strength, thermal, chemical, physical appearance etc. Coated materials find their application in all fields. In the construction machinery and equipment, saving expensive materials, poor and ensuring sustainability in mining depends on expanded the concept with constructive and judicious choice of materials. Coated metallic material are used, frequently, in the chemical industry, energetic industry etc.

These materials are, habitually, carbon steels or low alloyed steels coated with stainless, refractory and abrasion resistant materials. This paper’s aim is the increasing of the sustainability of rolls at the exit of the slabs continuous casting machine. Rolls are made out of steel for hot working tools type 40VMoCr52 with a good thermal stability and mechanical properties but a lower oxidation resistance at high temperatures. Making of rolls by refractory steel is very expensive. We adopted the version of cladding of rolls, by welding with a layer of refractory steel with high hardness at high temperature (over 50HRC and over 650^{0}C, for the working temperature).

2. Working method

It was adapted the welding flux layer method which ensures high productivity very good quality of the layer and reduces failure risk.

As coating material we used WELDCLAD 3 electrode which ensures the obtaining of the prescribed chemical composition, in accordance with working conditions. Thus it be will obtained a high-alloy chromium layer with martensite structure what has a good mechanical and thermal stability.

Chemical composition of the initial materials is presented in Table 1.

Tabelul 1

Material	**C**	**Si**	**Mn**	**S**	**P**	**Ni**	**Cr**	**Mo**
	[%]							
40VMoCr52	0,37-0,42	0.9-1,2	0,3-0,5	0,025	0,025	-	5-5,5	1.2-1,5
WELDCLAD 3	0,1	0,4	1,0	0,01	0,01	2,0	12,5	1,0

Welding procedure parameters were:
-Direct polarity of the welding current
-Electrode with a single thread without tilting,
-3-5 mm diameter of at electrode wire
-Welding current intensity I = 350-650A
-Welding current voltage U = 26-34V
-Preheating temperature T_p = min.320^{0}C

-Recomended temperature for welding between layers T_s = max 450^{0}C
-Flux protection Weldclad-Universal

2. Analysis of samples coated by welding flux

Analysis of chemical composition

Chemical composition of the materials was determined by spectral analysis.

Samples were cut by cutting abrasive disc with abundant cooling water to avoid chemical and structural changes. The clad layer was removed by grinding. The result analysis is presented in Table 2.

Table 2

Sample	C	Mn	Si	P	S	Cr	Ni	V	Mo	Ti	Nb
	[%]										
Base material	0,38	0,44	0,98	0,025	0,008	5,5	0,45	0,94	1,54	0,021	0,011
Transition zone	0,18	0,79	0,21	0,015	0,006	6,4	1,42	0,09	0,42	0,003	0,095
Clad layer	0,10	1,02	0,42	0,010	0,009	12,5	2,03	0,04	1,04	0,003	0,021

Compositions of the transition zone show a dilution of the concentration of alloying elements and an increasing in carbon concentration. To ensure the composition in the prescribed limits, the increasing of the concentration of elements in the added material or the welding of several successive layers are necessary. Considering the large diameter of the rolls, it was accepted the multi-layer coating method.

3. Analysis of the microstructure

Microstructural analysis has been achieved in optical microscopy. In Figure 1 the microstructures of base steel 1a, clad layer 1b, transition zone 1c, are shown.

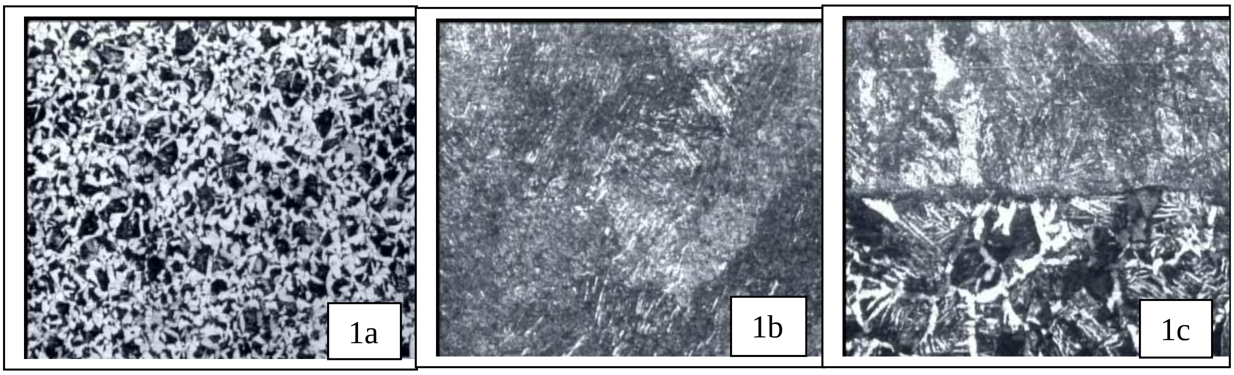

Fig.1. *Microstructures by welding clad material layer flow: 1a-base material x100, 1b-plated layer x200, 1c-transition zone x200*

The base material exhibits a structure ferrite-perlite, specific to a medium carbon steel containing about 0.4%. Clad layer presents a martensite structure, highly alloyed martensite with chromium and a small amount of delta ferrite. Transition zone is well defined as a result of distinct composition of both materials and automatic welding process. In this zone the temperature is very high.

The overheat of the material leads to the increasing of grains and acicular ferrite appearance. In the nearer zone of the transition surface, of the coated layer, a decrease of the alloying in elements content is performed and determines a particular aspect of the structure. The amount of ferrite is also higher near the transition area.

4. Analysis of hardness variation in plated material

Hardness test were carried out at ambient temperature by Vickers method with small task force (200gf, 1.962 N for 15 seconds) at the microdurimeter PMT3. After each trial were measured and calculated hardness diagonals fingerprints using the known relationship:

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$$HV_{02} = 1{,}8544 \frac{F}{d^2} daN / mm^2$$

F-pressing force F = 0.1962 daN;

d-arithmetic average of the diagonals footprint

Results of measurements are presented in Table 3 and Figure 2.

Table 3

Sample	Distance from the line of separation Material base-layer	The average diagonal footprint	HV_{02} hardness value
Sample plated layer by welding flux	-0,200	0,0460	175
	-0,009	0,0462	172
	-0.006	0,0450	183
	0	0,300	412
	0,015	0,0288	448
	0,045	0,0282	468
	0,075	0,0282	468
	0,105	0,0276	490
	0,135	0,0276	490
	0,165	0,0270	508
	0,250	0,0270	508

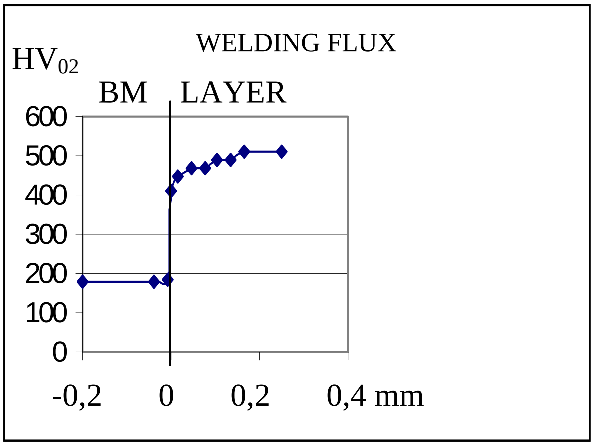

Fig.2. *Variation of hardness in the transition zone.*

5. Analysis of thermal stability of the clad layer by welding flux

It was carried out the ROCKWEL HRC hardness test on samples coated by welding, at ambient temperature and heated from to 100^{0}C until 600^{0}C. Test results are presented in Table 4 and Figure 3.

The analysis shows a good hardness stability at temperatures up to 550^{o}C, hardness values being within ranges of 40HRC. This fact stands for a good resistance to abrasive wear of the plated layer in welding flux.

Table 4

Temp.^{o}C	20	100	200	300	400	450	500	550	600
HRC	50	49,5	50	49,5	50	49	50	46	39

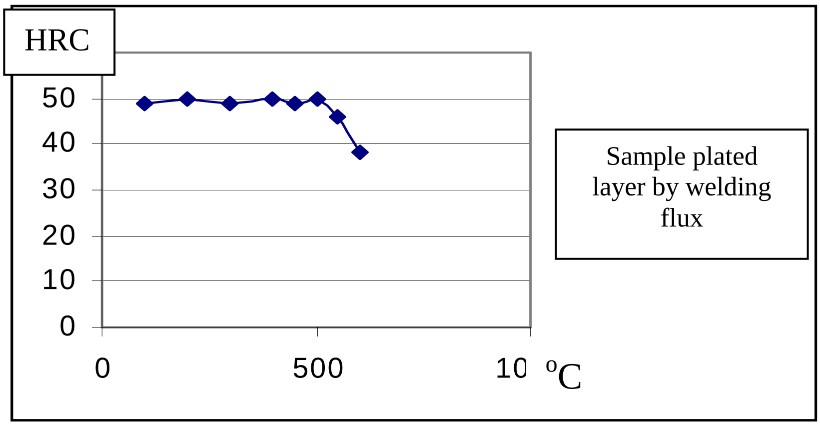

Fig.3 *Variation of hardness of clad layer with temperature.*

6. Determination of resistance to abrasive wear

To determine the abrasive wear resistance the friction torque by abrasive disc roller was used. System testing parameters were as follows:

-sample area 0.5 cm^2, the sample section, with 7x7mm,

- abrasive paper surface is 800 grit

-revolution of abrasive disc 25 rpm

-burden of proof on the press of 0.1 MPa or 1daN/cm^2 abrasive disk,

-sliding speed 10m/min,

-length of road covered 25 linear meters,

-samples during a 2 minute and 15 seconds' test,

-number of turns 56,

-abrasive disc diameter Dmin = 90mm, Dmax = 170mm,

-radial advance to a full rotation 0,7 mm / rev,

-radial speed 16mm/min.

Test results of the abrasive wear tests are presented in Table 5 and Figure 4.

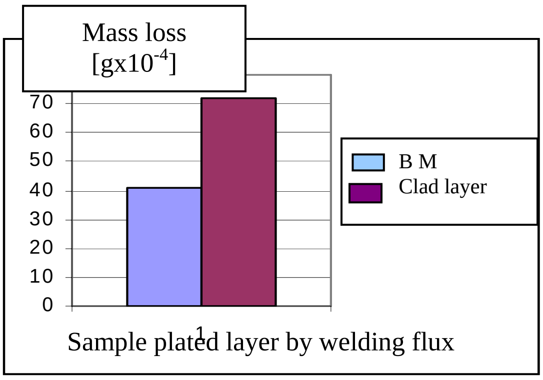

Fig. 4. *Determination of mass loss from abrasive wear by welding clad layer flow compared with base material.*

Table 5

Sample Type	Hardness		Mass loss from abrasive wear			
	Vickers	**Rockwel**	**Sample 1**	**Sample 2**	**Sample 3**	**Mear**
	[daN/mm^2]	[HRC]	[g]			
Plated layer by welding flux	508	49-50	0,0041	0,0039	0,0043	0,0041
Base material	183		0,0072	0,0069	0,0074	0,0072

4. Conclusions

The researches showed that the plating layer by flux welding allows the increasing of the rolls durability of the slabs continuous casting machine by:

-martensite structure of the layer, with a hardness of approximately 50HRC

-alloyed layer with over 12% Cr with the addition of Ni, Mo ensures, resistance to oxidation at high temperatures

- high thermal stability, mechanical properties, hardness ensure the safe operation and abrasive wear resistance

- preheat, before welding, ensures a good weldability, avoiding the appearance of cracks in the transition zone

-through training in welding flux of a transitional area with an average composition of the two constituent materials it is ensured the resistance to thermal cycles of heating and cooling, avoiding crossing the cracking between the material and the clad layer.

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