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COATING OF THE LASTING MOULDS WITH HARD ALLOYS

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ABSTRACT

This paper presents the researches on the welded coating of lasting moulds used for casting at high melting temperatures. It shows that the coating through the flux welding with the addition of metal powders and graphite leads to a complex properties with a favorable resistance of abrasion and high temperature oxidation resistance compared to other methods analysed.

KEYWORDS: coating, refractoriness, abrasive wear, thermal stability.

1. Introduction

To obtain the lasting moulds with high durability it is recommended to use materials that ensure the following characteristics: wear resistance, high hardness, low adhesions, refractoriness, high temperature stability, thermal shock resistance, etc..

The main materials which are recommended for lasting moulds are: steels for hot working tools with V, W, Mo, Cr; special cast iron alloyed with Cu, Cr, etc.

2. Working method

For experimental researches we use the samples of hot working tools coated by welding with cladding welding flux and cladding welding flux and added powders.

2.1. Variant A: Cladding welding flux

The added material was WELDCLAD 3 tubular wire electrode which allows with necessary elements, to obtain the chemical composition prescribed in accordance with the working conditions. It results a plated layer with martensitic structure, high-alloy plated with chromium, which has a good thermal stability at the oxidation process. This material is structurally in harmony with the basic material, tools steel type 40VMoCr52.

Welding procedure parameters were:

- welding power source DC-direct polarity,
- universal Weldclad basic flow,
- tubular electrode diameter d_e= 3.2 mm and oscillation amplitude of 55mm,
- current intensity I= 750-1000A for swing electrode d_e= 3.2 mm,
- current voltage U= 26-34V to ensure rapid initiation and arc stability,
- preheating temperature Tp= min.320^{o}C and between layers Ts= max.450^{o}C,
- speed advancing the wire electrode Ve=190-220 m/min. ,
- 55mm oscillating amplitude of a layer welded wide 60mm,
- welding speed Vs= 100-175mm/min.

2.2. Variant B: Cladding welding flux with added powders

The novelty consists in introducing and mixing a graphite quantity inside the ferroalloys powder. This quantity of graphite interacts, during the welding with the molten alloy bath, leading to the formation of martensite with a separation layer of complex carbides. To achieve this performance, it was studied the welding regime, to determine the favorable parameters. For these, it was established the set input wire electrode and the ferrous-alloys and graphite powder quantity.

Materials used for the research were:

-basic flow Fb20 STAS 10125-75.

-wire electrode S10Mn1 STAS 10123-75.

-ferro-alloys powder made by crushing and grinding and sieving using sieves with mesh size of 0.63 mm.

The grain size influences: the bath homogeneity, the dimensional uniformity trend, favouring the segregation trends.

The chemical composition of the clad layer used for establishing the ferro-alloys powder composition (see Table 1). The high percentage of graphite leds to obtaining complex carbides. The presence of vanadium in the composition prevents the growth trend of primary carbide crystals which adversely affect the abrasive wear resistance.

Table 1

Powders	FeCr	FeMn	FeSi	FeV	Ni	Graphite	Comments
%	70	6	9	1	4	10	Be welded with S10Mn1

The electric intensity is the most important factor of the welding process which depends on material quality and other technological factors. The experiences show the necessity of using a higher intensity, as in normal welding, considering the need to achieve a high temperature of molten metal bath to melt powders of ferro-alloys and melt mixing. Welding was done with wire S10Mn1, 2mm in diameter, the welding current intensity was I= 480A. Bath size and weld penetration size are suitable for inclusion and melting all the powder. It was studied the velocity regime (Ve) for the trolley wire electrode and the velocity regime for the welding machine (Vs) studding the parameters behaviour in the following domains: Vs = 21.5 ... 63.5 m / h and Ve = 103 ... 307 m / h. It was found that keeping the ratio Ve/Vs = 5, the overheating basic material and the heat influence area are lower.

It was also found that participation in a ratio of between 1 and 1.5 the amount of ferro-alloys and wire led to superior results. Under these conditions the diffusion of the elements was more pronounced achieving uniform deposition tipped. The optimum working arrangements set is given in Table 2.

Table 2

Elements	Ve	Vs	Input eletrod wire	Input ferro-alloys and graphite powder	Input basic flow
U.M.	[m/h]		[g/100mm]		
	204	40.5	12.5	20.1	35

3. The analysis of welding coated samples

The analysis of samples coated by welding procedures consists in: the welding wire flux allied Weldclad 3 (Variant A), the flux welding wire S10Mn1 by adding alloying ferro-alloys and graphite deposit (Version B), and the arc welding discovered Sormait electrode currently used (Version C)

3.1 Chemical analysis of base material and coated material

The chemical composition of the materials was determined by spectral analysis of both materials, the coated layer and the transition zone plated samples. The results of the determinations are presented in Table 3.

The steel base material corresponds to hot working tools with 0.38% carbon, 5.5% chromium, about 1.5% molybdenum, up to 1% and 0.5% Vanadium, Nickel.

Deposited material: for the Variant A, the composition is appropriate for a martensitic steel with 0.1% carbon, 12.5% chromium, 2% nickel, 1% molybdenum, while, for the Version B, the composition consists in the contribution of electrode wire and S10Mn1 graphite and ferroalloys powder (Table 1 and Table 2.).

Table 3

Sample	C	Mn	Si	Cu	Cr	Ni	V	Mo	Nb
	%								
Basic material	0.38	0.44	0.98	0.2	5.5	0.45	0.94	1.54	0.011
Layer Variant A	0.10	1.02	0.42	0.02	12.5	2.03	0.04	1.04	0.021
TA Variant A	0.18	0.79	0.21	0.03	6.4	1.42	0.09	0.42	0.095
Layer Variant B	2.61	1.11	1.80	0.05	20.58	1.37	0.15	0.12	0.012
TA Variant B	0.72	0.81	1.2	0.04	12.8	0.92	0.09	0.04	0.01
Layer Variant C	2.55	0.98	0.82	0.04	20.12	1.57	0.04	0.12	0.010

In the transition layer material (TA) because of the melted base material dilution, the chemical composition differs widely, being characterised, in the following context: for the Variant A and Variant B, decrease of the chromium and nickel concentrations and the increase of carbon concentration. To obtain the desired composition layers, relatively homogenous welding requires several overlapping layers.

For comparison it is also presented the composition layer deposited by arc welding SORMAIT discovered electrode (Variant C).

3.2. Hardness tests

The Hardness tests were done by Vickers HV_{02} with small tasks. The results of hardness measurements and changes in the transition of basic material - coated layer, deposited by welding (Variant A, B and Variant C) are shown in Figure 1.

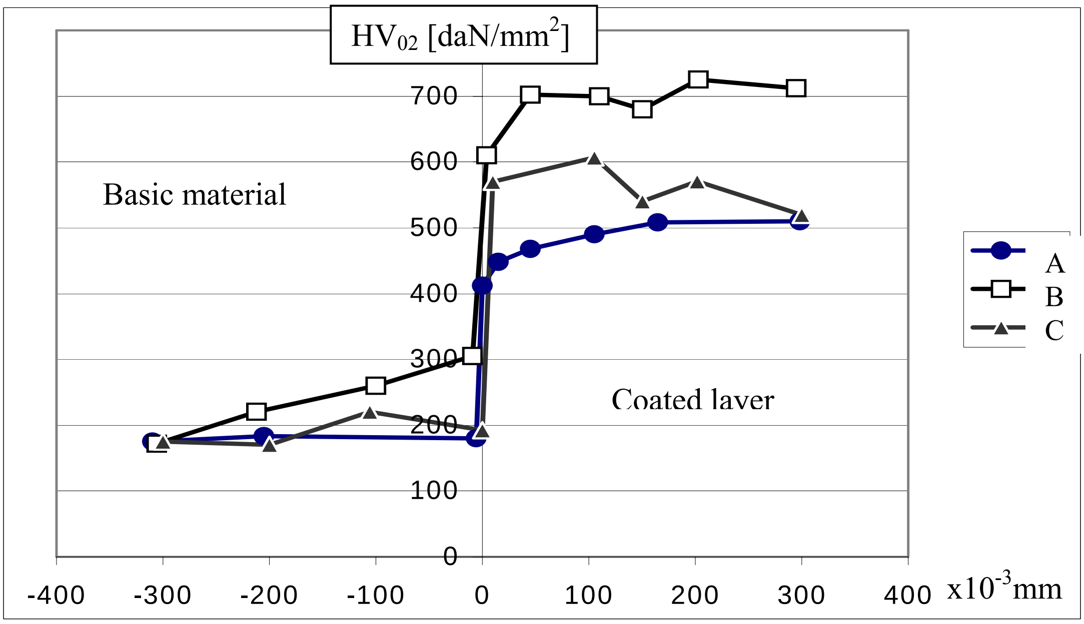

Fig. 1. *The hardness variation in the transition-area of basic material BM - LAYER deposited by flux shielded arc welding (Variant A, B and Variant C).*

In the case of the Variant A, the base material hardness is relatively constant 175daN/mm^2. Inside the fusion zone, the hardness variation is abrupt from 175 to over 400daN/mm^2.

The increase of the hardness on the depth of the plated layer increases relatively slowly but continuously, confirming the existence of the layer with diluted concentrations of the carbon and alloying elements. The next hardness layer remains relatively constant at about 510daN/mm^2

In the case of welded clad with flux and additions of ferro-alloys and metal powders, Variant B, there is an increase of hardness in the material near the fusion zone caused by carbon diffusion and the rapid cooling. Fusion zone hardness increases rapidly at over 300daN/mm^2, still almost 600daN/mm^2 and attains the value over 700daN/mm^2 slightly oscillating because of carbides separations.

The increase is relatively steep and continuous compared to arc welding SORMAIT-discovered electrode Variant C, due to a more homogeneous layer; it will be highlighted and structure analysis, too.

3.3. Structure analysis

The structure analysis was done by optical microscopy. The base material used in the research, 40VMoCr52 steel grade, has a ferrite and pearlite structure with uniform polyhedral grains in a proportion of 50-50%. In the case of the Variant A the coating layer has a homogeneous martensitic structure with fine separation of ferrite delta. The transition zone with a width of few millimetre tenths has a characteristic structure with spinal ferrite results of overheating, followed by relatively fast cooling and the deposited material of martensitic heterogeneous structure and rough separation of delta ferrite. [11]

This structure leads to lower values and a slower increase in hardness.

If the welding flux has ferro-alloys in the addition (Variant B), the plated layer has a dendritic structure of martensite and carbides formed homogeneous needle-targeted form of heat propagation direction Figure 2. The transition zone in welding submerged powder flow presents a heterogeneous structure due to the formation of a diffusion layer of carbon and other elements into the basic material.

Note that the added powder was a large amount of graphite to form very complex carbides. The basic material is strongly carburized up to 0.7-0.8% C. Its structure is composed of one hundred to one hundred percent approximately, allied pearlite. Hardness in this area grows fast from 180daN/mm^2 to about 300daN/mm^2, Figure.3.

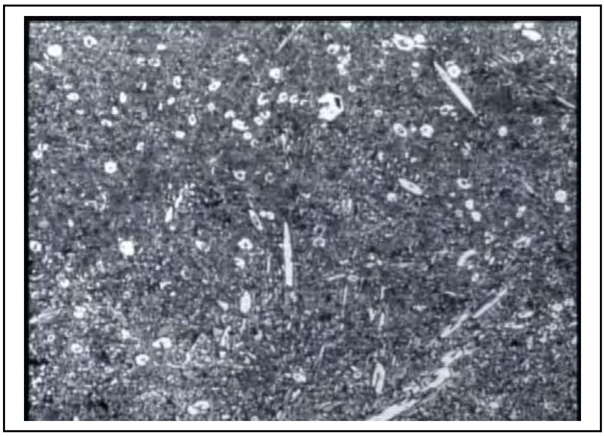

Fig. 2 *Variant B layer structure made up of highly alloyed martensite and carbides dispersed fine needle, x200.*

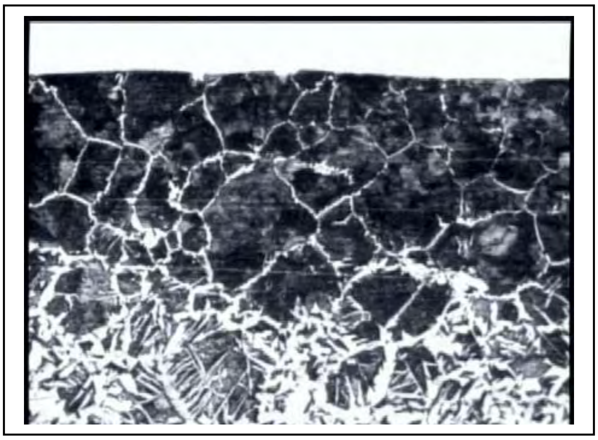

Fig. 3 *Variant B, the transition area from basic material, x200.*

Near the joint area, the layer deposited has a martensitic structure with finely dispersed carbide separation.

In the case of the plating arc welding with SORMAIT electrode, the layer structure consists of martensite with separation of coarse carbides (see Figure 4). Near the transition zone, the structure looks more uniform. As with Variant B, the transition is highlighted in two sub co-driven diffusion of carbon and chromium. SORMAIT notes that electrodes have a concentration of over 2.5%C.

Fig. 4. *Variant C, layer structure, martensite and coarse acicular carbide x200.*

3.4. Determination of resistance to abrasive wears

The research physical model was a mechanical system composed of an abrasive disc in the revolution motion and plane sample.

The grinding wheel was covered with a determined grain abrasive paper.

Test system parameters were:

- sample area 0.5 cm^2
- surface is abrasive paper with metallographic grit 800,
- grinding wheel speed of 25 rpm, grinding wheel diameter Dmin = 90mm, Dmax = 170mm,
- length of road travelled - 25 meters,
- number of turns - 56,
- the advance to a full rotation radius of 0.7mm/rev;
- burden of proof on press grinding wheel of 0.1 MPa.

The results of abrasive wear test are shown in Table 4 and Figure 5. How results from the abrasive mass loss at the samples covered with hard alloys, indifferent of the coating applied method, have an abrasive resistance much great of the base material.

The presence of dispersed carbides in martensite mass for allied Variant B and Variant C increased the resistance to abrasive wear, which is consistent with the values of hardness and degree of homogeneity of the structures.

Table 4

Samples type	Hardness		Mass loss abrasive wear			
	Vickers HV_{10}	**Rockwel**	**Sample1**	**Sample2**	**Sample3**	**Average**
	[daN/mm^2]	[HRC]	[g]			
Cladding under flow Variant A	510	49	0.0041	0.0039	0.0043	0.0041
Basis material	180		0.0072	0.0069	0.0074	0.0072
Cladding under flow Variant B	720	60	0.0037	0.0035	0.0033	0.0035
Cladding by welding Sormait Variant C	540	51	0.0039	0.0036	0.0037	0.0037

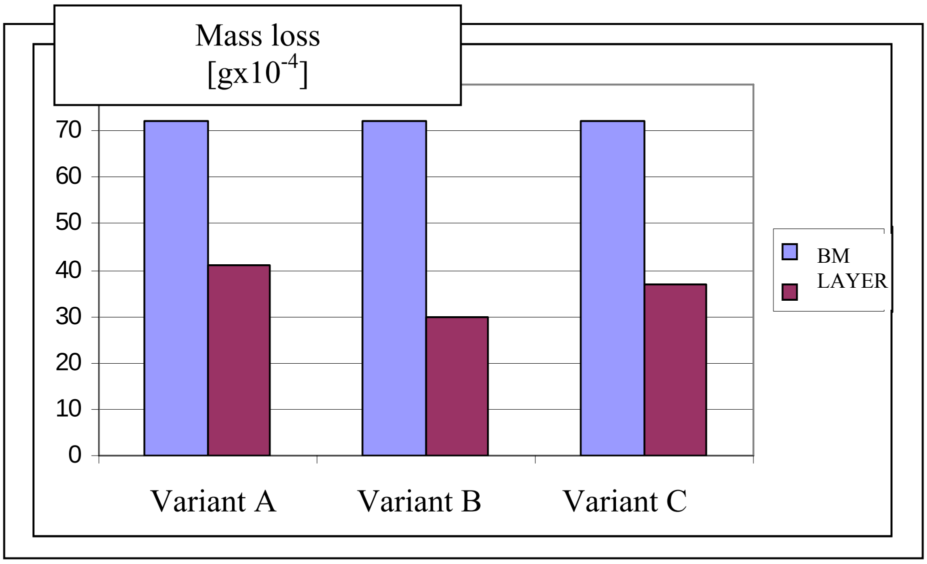

Fig. 5. *The variation of the mass loss, during abrasive process, in the case of the welding clad layer for three variants examined.*

4. Conclusions

These researches showed that the coating by arc welding is a method that allows the increasing of durability of the support material.

In the case of WELDCLAD 3 welding electrode in flow, because of the martensitic structure, the layer has a hardness increased up to approximately 50HRC. Alloying layer with over 12% with addition of Ni Cr Mo ensures the increase in refractoriness, the increase of the resistance to oxidation at high temperatures, high thermal stability, mechanical properties, hardness and the tenacity, ensuring reliability and resistance during the abrasive wear.

The welding flux with the addition of metal powders and graphite leads to formation of fine carbides dispersed in a mass of martensite, the structure having higher hardness, of 60HRC and consequently a higher wear resistance. For all the technological options discussed, preheating the work piece before welding ensures good weldability, avoiding cracks in the transition, the formation of welding flow transition areas with average compositions which provide resistance to thermal cycles of repeated heating and cooling.

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