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RESEARCH ON OBTAINING TUBULAR RODS TYPE Fe-25% Cr-4% W-Ti-La USED FOR CLADDING

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Abstract: *The paper presents research carried out for new materials for flame cladding or WIG welding. These materials contain layers with low dilution and high resistance to abrasion and corrosion combined with intense thermomechanical shock. In the first part of the research the tests for the composite core recipe are presented. This core is formed from powders of ferroalloys and protective elements against heating when they pass through the electric arc. The results obtained in this stage are: hollow rods prescription product and the specific characteristics of their manufacturing process in terms of using.*

Key words: *hollow rods, welding load, coated electrodes.*

1. Develop Product Recipe

Studies [1-3], [5], [6] on materials of Fe-Cr system have shown that if these markers in certain compositional limits can provide mono throughout their existence in the field of solid state, which we recommend insurance terms of hardness at least 50 HRC, for use in the manufacture of such tools highly stressed bimetallic corrosion and abrasion combined with thermo-mechanical fatigue.

Research Catalog prescriptions of coated electrodes to charge manufacturers emphasized the need to obtain weld Metal Deposited (MD) indicative of the chemical composition in Table 1.

Chemical composition of MD is the starting point in developing the product recipe hollow rods with a diameter of 3 mm, commonly used technical-economic reasons for charging the WIG welding processes or oxy-acetylene flame that will produce layers with small thickness and low dilution.

A chemical composition Table 1

MD definite chemical composition in mass [%]										
C	Mn	Si	P	S	Cr	Ni	W	Mo	Ti	other
max. 5.0	max. 14.0	max. 3	max. 0.03	max. 0.03	max. 35.0	max. 5.0	max. 10.0	max. 8.0	max. 2.0	otherwise

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The experience gained so far in manufacturing toroidal sheath tubular rods and composite core, consisting of ferroalloys and metals in powder state, highlights the possibility of manufacturing their stakes in proportions roughly equal or slightly higher in favor of the core, so the filling coefficient 0.55...0.65%.

In this situation it is appropriate to choose as a material for cladding a small plate of thickness and width of 10 mm and a profile by closing overlapping (Figure 1).

In order to optimize the product recipe VTCr25W4TiLa diameter 3 mm hollow rods, dosing and mixing were done in a series of cores, Table 2.

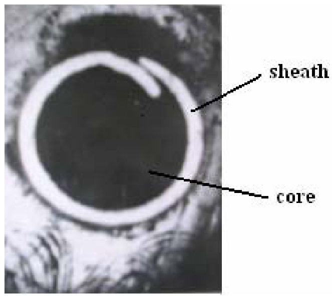

Fig. 1. *Profile of closing*

Core series Table 2

Material	Ferrochromium 6	Ferrosilicon 75	Ferromangan 45	Ferrotitanium 60	Colloidal graphite	Lantanium
Participation % mass	60±1	6±1	8±1	4±1	20±1	2±1

At this stage we aimed to conduct the manufacturing technology and it was found a reduced compactness of the composite core, which required further experiments to optimize the composite core recipe grading criterion maximum predetermined.

Recipe optimized grain size is shown in Table 3.

Recipe optimized in terms of size was used to achieve a new set of experimental rods that varied within the coefficients above to supervise the filling and it was seen the way of closing profile. It was established that the optimal filling factor of 0.55.

Recipe granulometric Table 3

Granulometric fraction	0.3-0.15	0.15-0.05	>0.05
Participation in mass%	20	30	50

Chemical composition Table 4

Material	Material chemical composition determined on the MD, in mass [%]										
	C	Mn	Si	P	S	Cr	Ni	W	Mo	Ti	Other
Rolled deep drawing 10 x 0.5 mm	0.03	0.53	0.21	0.001	0.015	–	–	–	–	–	Fe
Ferrochromium 6	5.4	0.3	0.2	0.03	0.04	62.1	–	–	–	–	Fe
Ferrosilicon 75	0.2	0.1	75.2	0.04	0.02	–	–	–	–	–	Fe
Ferromangan 45	0.1	482	0.3	0.01	0.04	–	–	–	–	–	Fe
Ferrotitanium 60	0.01	–	–	–	–	–	–	–	–	60.3	Fe
Colloidal Graphite	99.5	–	–	–	–	–	–	–	–	–	Ash

2. The Experiment

To achieve these hollow rods, we used the materials from Table 4.

These materials were assayed according to the recipe of Table 5 and further homogenized for 15 min in stomacher ball - Figure 2.

Were used for homogenization parameters recommended in the literature [5], namely, mill load was determined on the basis of regulation 1/1. Participation of grinding bodies in volume load was 50%. For filling the tube/hollow rods with powdered core we used different variants of dispensers. The most common dispensers are disc type or tape type.

Filling is done in the following order: first, coarser tungsten carbide and then finer mixture, which fills the gaps between the carbide grains. In this way we ensure a more homogenuous core than other dosage systems with a single mixed of significantly different grains.

Recipe Table 5

Material	Ferrochromium 6	Ferrosilicon 75	Ferromangan 45	Ferrotitanium 60	Colloidal graphite	Lantanium
Participation % mass	58.5	5.5	10	4	20	2

Fig. 2. *Ball homogenizer*

These types of mixtures with two classes of core grains are useful especially for processing the tubular rods based on tungsten carbide, when for alloying the matrix, it is necessary to introduce finer metal powders (<0.1 mm) in the core along with coarser tungsten carbide (2-3 mm).

The filling flow of the powdered mixture depends on the electrode diameter (rod) and can be adjusted by changing (varying) the tape speed of the dispenser and the thickness of the powdered mixture layer on the tape.

For a specific forming speed of the tube, we can determine the dispenser tape speeds for different diameters and thickness of mixture layer on the tape. For this, we consider the cross section of the gutter having a „U" form filled with powdered mixture, according to Figure 3 and the cross section of the powdered mixture layer on the tape according to Figure 4.

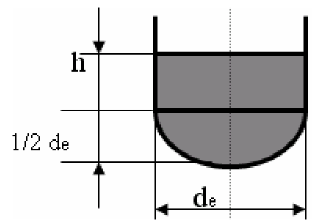

Fig. 3. *Section of the „U" gutter filled with powdered mixture* [4]

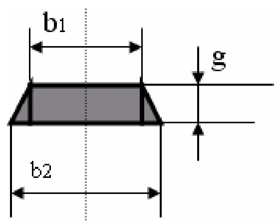

Fig. 4. *Section of the powdered mixture layer on the tape* [4]

Flow q in [m^3/s] necessary for the fill of the gutter is calculated for the section from Figure 3 according to the relation [4]:

$$q = \left(\frac{1}{2}\cdot\frac{\pi\cdot d_e^2}{4} + h\cdot d_e\right)\cdot v_t\,, \tag{1}$$

where: d_e - is the diameter of the gutter (electrode/tubular rod) [m]; h - filling height of the gutter on the portion with parallel wings [m]; v_t - forming speed of the tube (rod) [m/s].

The same flow q must be carried on the dispenser tape and can be calculated for the section from Figure 4 (that can be considered an isosceles trapezoid) with the relation [4]:

$$q = \frac{b_1 + b_2}{2}\cdot g\cdot v_b\,, \tag{2}$$

where: b_1, b_2 - bases of the isosceles trapezoid [m]; g - thickness of the powdered mixture layer on the tape [m]; v_b - tape dispenser speed [m/s].

From the relations (1) and (2), which are equivalent, we get the dispenser tape speed according to the electrode diameter, which is:

$$v_b = \frac{\left(\frac{1}{2}\cdot\frac{\pi\cdot d_e^2}{4} + h\cdot d_e\right)\cdot v_t}{\frac{b_1 + b_2}{2}\cdot g}\,. \tag{3}$$

For the manufacturing equipment of hollow rods, the tube formation speed is v_t = 0.06 m/s and the filling height of the gutter $h = 1/3\ d_e$.

For the tape dispenser, the average width of the powdered mixture layer on the tape is $(b_1 + b_2)/2$ = 50 mm.

Replacing this data into the equation (3), we obtain [4]:

$$v_b(d_e) = k\cdot\frac{d_e^2}{g}\,, \tag{4}$$

where, for a constant value of $k = 1.74\cdot 10^{-3}$ [$m^{-1}\cdot s^{-1}$]; v_b in [cm/s] is obtained if d_e and g are given in [mm].

Equation (4) represents a family of paraboles with the parameter g having a constant value and has the graph in Figure 5.

Hollow rods were adjusted on manufacturing machines stands so that the final diameter of the rods was 3 mm and in

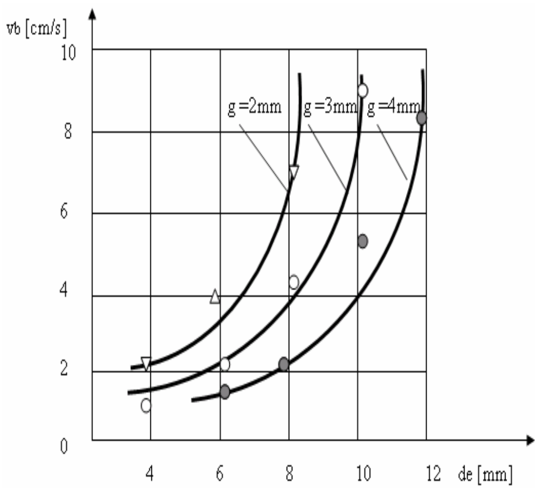

Fig. 5. *Tape filling speed depending on the diameter of the electrode* [4]

these conditions was done a lot of 10 kg hollow rods mark VTCr25W4TiLa.

3. Testing Hollow Rods

The rods thus obtained were tested to assess behaviors in WIG welding process for determining the physicochemical characteristics of the MD.

Deposits were made with the technological parameters in Table 6, the weld metal chemical composition was determined with the spectrometer in Figure 6 and the results are shown in Table 7.

Hardness and structural characteristics were determined according to current standards on the specimens taken from weld metal in welded condition. The results are shown in Table 8 and Figure 7.

Analysis of the results emphasize the specific characteristics framing grade material from the group Fe-Cr steel with high resistance to abrasion combined with corrosion and thermo-mechanical fatigue.

Fig. 6. *Spectrometer*

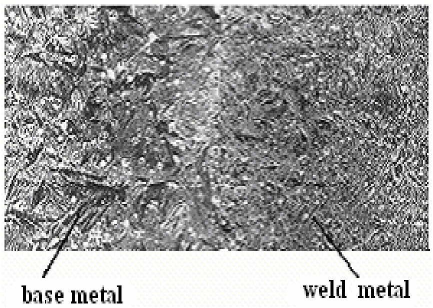

Fig. 7. *Metallographic structure of weld metal (200X, Nital attack 2%)*

Load welding technological parameters Table 6

Brand electrode	**W electrode diameter, [mm]**	**Diameter rod, [mm]**	**Welding Current [A]**	**Current nature**	**Temperature, [^{0}C]**		**Argon debit, [L/min]**
					the preheating	**lines**	
VTCr25W4TiLa	2	3	145 ± 10	cc +	400	max 400	15 ± 2

Chemical composition determined MD Table 7

Material	**MD definite chemical composition in mass [%]**										
	C	**Mn**	**Si**	**P**	**S**	**Cr**	**Ni**	**W**	**Mo**	**Ti**	**Other**
VTCr25W4TiLa	2.8	1.2	1.1	0.02	0.03	25.3	0.3	4.1	0.2	0.15	Fe

Structural and Hardness results Table 8

Mark test	**Structure ascertained**	**MD Hardness [HRC]**
MD	Complex carbide austenite Cr, W and Ti	55, 58, 56, 58, 56

4. Conclusions

The tubular rods with composit core have been tested to assessing the reaction to WIG welding and determining the physico-chemical characteristics of weld metal (MD).

In this sense has followed:

- technological parameters with which make the deposit;
- chemical composition of tubular rods and the metal deposited with their help;
- hardness characteristics of the material deposited;
- metallographic analysis of the weld metal.

The hardness characteristics and the structural matrix, has determined according to current standards, on samples taken from weld metal in welded state.

Research has results in developing and implementing the new marks of VTCr25W4TiLa hollow rods and an alloy with austenitic structure, complex carbides rich in Cr, W and Ti, combined with increased resistance to abrasion and corrosion fatigue Thermo using the WIG welding process.

Acknowledgements

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