Tubular electrode for hardfacing using GTAW technology

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Keywords

GTAW process, tubular electrode, welding, harsh layers

1. Introduction

The manufacture of tubular electrodes for welding is justified by the advantages that are obtained by making filler materials with special characteristics and adapted to the technical and qualitative requirements of the beneficiaries [1]. The design of the shapes, dimensions and chemical compositions of the composite cores is based on the performances obtained in the case of flux-cored wires used for mechanized or semi-mechanized welding, namely [2]:

- A high deposition rate (up to 20 g/Ah);
- Posibility to easy working in "all-position";
- A high potential for achieving a wide chemical compositions spectrum of depositions by electric arc welding processes;
- Resistance to moisture and hydrogen pick up;
- Less distortion and no burn-through;
- Low heat input and low base metal dillution;
- No special conditions to storage.

As disadvantages, there is the possibility of creating an incomplete fusion between the base metals and some slag inclusion or cracks in the welds may also result.

Depending on the purpose for which they were designed, tubular cored electrodes may contain different core recipes, according to EN 758: 1997 [3]: R type are characterized by a spray metal transfer, low spatter loss, and a rutile-based slag that fully covers the weld bead;

P type are similar to the R type, but the rutile-based slag is designed for fast-freezing characteristics that enable welding in all positions; B type are characterized by a globular metal transfer, slightly convex bead shape, and a slag that can or can not cover the weld bead surface; M type are characterized by a very fine droplet spray metal transfer and minimal slag cover; V type are used without a gas shield and exhibit a slightly globular to spray metal transfer. The rutile or basic/fluoride slag system of these tubular cored electrodes includes a range from slow to fast freezing slag, being designed for automatic welding at high speeds; W type are used without a gas shield and exhibit a globular to quasi-spray metal transfer. This basic/fluoride slag system is designed to make very high deposition rates possible; Y type are used without a gas shield and exhibit a quasi-spray transfer. These basic/fluoride slag tubular cored electrodes are designed for single and multiple pass, in all welding positions. Of all the types of tubular electrodes, the B-type ones are preferred when it is desired to obtain welds with superior impact properties and crack resistance.

When designing composite cores, the requirements to which the welded structure will be exposed must be taken into account first [4]. In the welding process, the melting and solidification occur very quickly, so that the thermo-physical conditions for the formation of metallographic phases and constituents are much more unfavorable compared to obtaining metallic alloys in metallurgical equipments [5, 6]. Therefore, the alloying, tuning and deoxidation systems that are part of the core of the tubular electrodes must be well dosed and calculated to ensure optimal conditions for the formation of quality welds [7, 8].

The vast majority of applications involving abrasive wear processes require the use of materials that combine characteristics of mechanical strength, hardness and toughness[9-14]. These materials are difficult to process, the simplest method being the loading with composite layers by welding on non-alloy steel support [15, 16].

Most of the time, filler materials with composite cores are used, which allow the deposition of different metallic matrices that including complex carbides [10, 11]. In the current practice of obtaining tubular electrodes two processes are used to manufacture them. In the case of a composite core with a low degree of segregation, the filling by vibration of the tubular profile is used. The composite core is a mixture of powders, that containig both mineral, ceramic and metallic particles. After filling, the tubular product is laminated succesively, to obtaining the final dimension of the product. The process has the advantage of low core losses and of relatively small variations of the tubular wall. It is used, in particular, for the manufacture of tubular wires filled with rutile core, to obtaining a nice appearance of welds surfaces. The manufacture of special tubular electrodes with composite core consist of introducing by pushing on the steel strips of a definite quantity of powder mixture (complex systems of alloying, finishing, deoxidation with a high tendency towards segregation) followed by profiling and closing the edges [16].

The paper presents the performances of welded deposits made with a experimental tubular electrode, which contains in the composite core both the classic systems of deoxidation, alloying and slagging as well as complex carbides W- and Cr-rich. The carbides role was to ensure the rough and hard surface of the weld deposit, to provide the increase of the friction coefficient and the improvement in wear resistance of the surface that operates under severe abrasion conditions.

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2. Experimental details

The experimental tubular electrode presented in the paper was designed and made to obtain the rough layers of the intelligent system that ensuring the rotation of the milling cutters around the own axis during asphalt cutting. Often, in the process of excavating the asphalt layers, as a result of wear and penetration of the residues in the milling fixture, locking of knives and loss of processing capacity occurs (Figure 1).

Figure 1. Effects of wear and blocking of knives after asphalt processing

To ensure the functional role of the knives, a mixture of complex carbides W- and Ti-rich has been introduced into the core of tubular electrode, allowing to obtain composite layers with high resistance to abrasive wear and contact pressure. The hard layer thus designed, was deposited by GMAW welding on the contact area of the knife with the asphalt, with the purpose of creating a frictional force superior to that of locking when this rotating about the itself axis.

3. Filler material obtaining

The experimental program for obtaining tubular electrodes was carried out in three research directions: Elaboration of the composite core recipe; Preparation for manufacturing of the technological line for obtaining tubular electrodes by profiling and filling the metal strips; Testing the characteristics of the tubular electrodes and performing the deposition of rough layers on the sample plates. The tubular electrode was made from a tubular shell inside which were introduced mixed powders comprising alloying, deoxidizing, tuning compounds and carbides, for assuring the specific characteristics of the high roughness layers. For this purpose, based on the previous knowledge, a filling coefficient of 0.5 was established and a matrix / reinforcing compounds ratio of approximately 1. The concept of the tubular electrode designing is shown in Figure. 2.

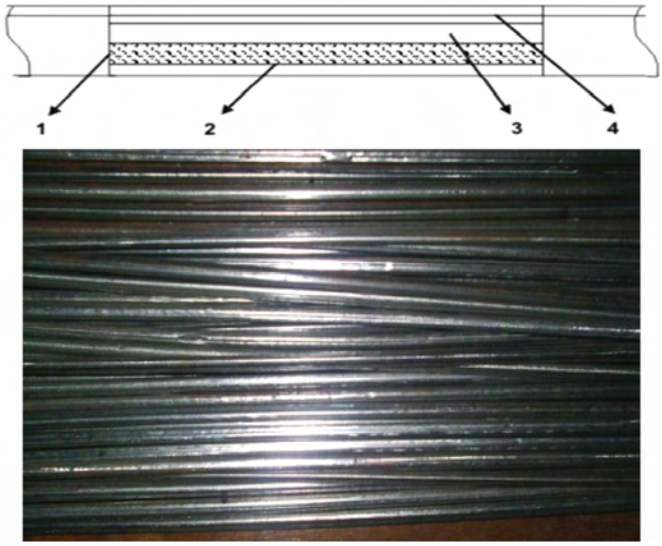


Figure 2. Tubular electrode with composite core:
1 - reinforcing system with a 60% participation rate from total of composite core; 2 - tubular shell made of soft steel; 3- alloying system with participation rate of 30%; 4 - closing and overlapping zone

To achieve the filling coefficient of 0.5 a soft steel strip with dimensions of 10x0.4 mm was chosen and a closure profile with an overlap of approx. 1 mm. The raw materials used to make the composite core alloying system were chosen according to the law of mass conservation in static regime. The component of the alloying system was as follows: 17...21% ferrochrome 60, 4...6% ferromangan 45, 4...6% ferrosilicon 45 and 8...14% iron powder. To ensure the optimum ratio between reinforcers and the deposition matrix, the composite core alloying system was completed with approximatively 10% iron powder having the granulation of max. 0.3 mm, to ensuring a good compactness of the core and to give the possibility of deformation the product with a reduction coefficient of up to 17%.

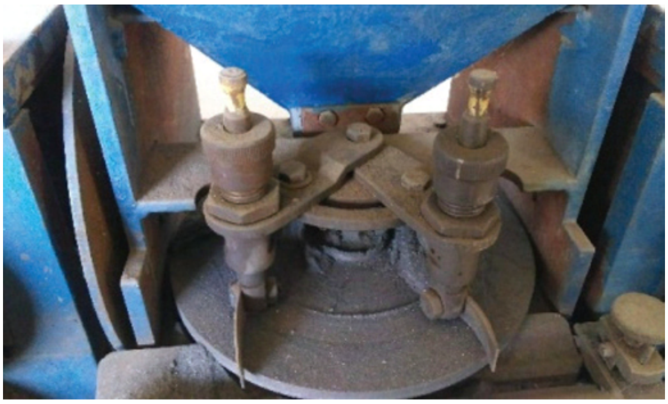


Figure 3. Circular dispenser

For this purpose, some adjustments were made to the technological line for the manufacture of tubular wires, to ensure the filling of the tube with two different layers, one of carbides for reinforcement and one for the realization of the alloying system. Therefore, the circular dispenser with continuous feed (Figure 3) was replaced with a new type of tape dispenser and 2 feed bunkers (Figure 4).

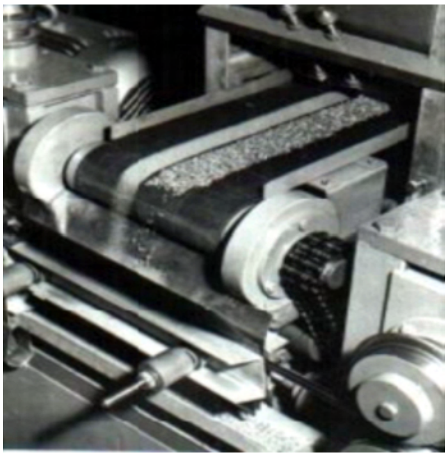


Figure 4. Tape dispenser

The advantages of the tape dispenser consist in the fact that it allows the multilayer deposition of the powder materials in the filling profile and substantially improves the homogeneity of the composite core along the length of the tubular electrodes. To validate the composite core recipe, weld layers were made using the new tubular electrodes, aiming at increasing the hardness by at least 400HV and obtaining a roughness as high as possible. The tubular electrodes thus obtained were used for the welding load of 220 knives for asphalt refrubishment, which were subsequently put into operation and followed to determine the losses by wear due to self-locking. The results performed on three groups of knives showed a reduction of the wearing removals of about 40%, ie reduction of losses due to knives locking when rotating at about 9-10% for the new reinforcing system.

4. Results and disscutions

In order to evaluate the characteristics of the welded deposits made with the new types of tubular electrodes, the samples were sectioned with abrasive disc under coolant then were polished using metalographic paper and alpha alumina suspension. Measurements of the chemical composition were performed by spectrometrical method (using Spark Optical Emission Spectrometer SPECTROMAXx M), the average values being presented in table 1.

Table 1. Chemical composition of weld deposit using tubular electrode with composite core

Measurement zone	Chemical composition, wt.%							
	C	Si	Mn	Cr	W	Mo	Ti	Ball.
Substrate	0.35	0.72	1.15	4.2	traces	traces	traces	Fe
Welded deposition	1.8	0.8	0.5	8.2	5	traces	traces	Fe

The microstructure was examined by electronical microscopy, the images being shown in Figure 5. The images of the microstructures indicate the presence in the weld deposit of large, undissolved carbides (W- and Ti- rich), surrounded by the metal matrix containing chemical elements from the melting of the steel rod and the composite core.

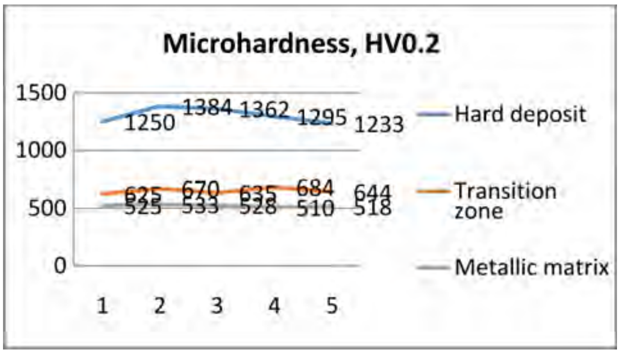
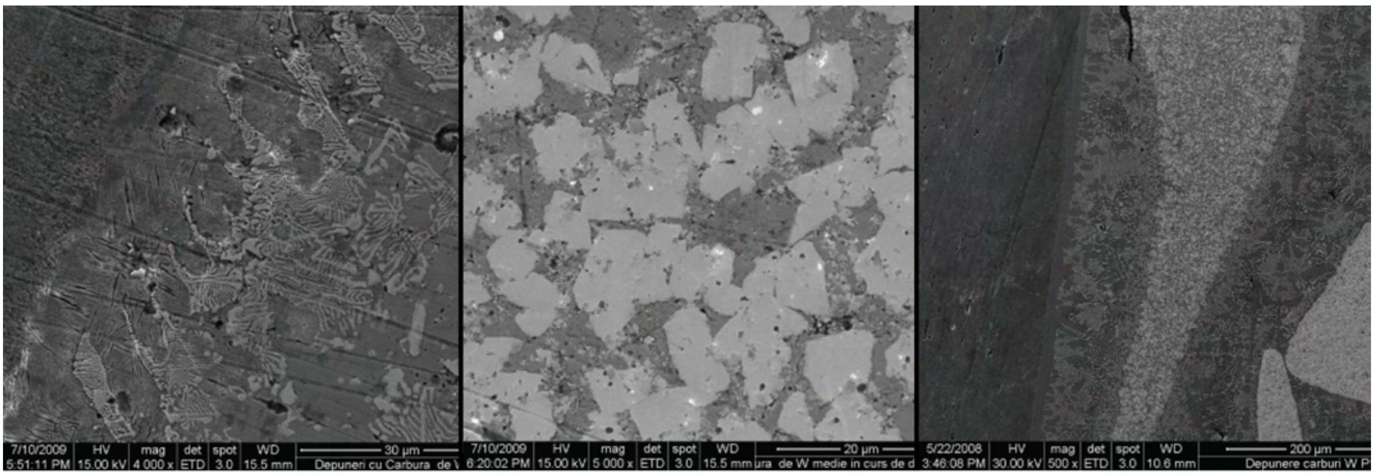


Figure 6. Microhardness values measured in different zone of the welded deposition

The results obtained can be influenced to a small extent by the diffusion of carbon from the reinforcers into the matrix, which required taking measures to cover the reinforcers with layers that would limit the diffusion. Hardness tests were performed on the cross-sectional surfaces of the sample processed metallographically, in the base material, on the transition area and on the welded deposition (Figure 6).

5. Conclusions

The researches have led to the obtaining of a new tubular electrode for GTAW welding, which realizes rough functional layers with wear resistance to abrasion under high pressure. The reinforcing elements inserted in the tubular electrode



a)Transition zone b)Weld deposit c)Un-melted WC carbides

Figure 5. Microstructure of weld deposit obtained using tubular electrode with composite core

were W and Cr carbides. The welded depositions were made on milling knives for asphalt processing, which were tested in real working conditions.

The welded deposits allowed the creation of rough surfaces that ensure the rotation around the own axes of the knives for the asphalt processing, thus avoiding the appearance of the phenomena of advanced wear.

The composite core was made in such a way as to ensure good welding conditions and to deposit layers with roughness and wear resistance under high pressure. The hardness characteristics determined in the specific areas of the welded deposition with the tubular electrode by the GTAW process confirm the obtaining of the hardness values imposed to ensure the proper functioning of the asphalt milling knives.

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