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Production of Electrodes for Manual Arc Welding Using Nanodisperse Materials

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Abstract: One of the most significant characteristics of a weld is its strength. Mechanical properties of weld metal may be improved in various ways. This article describes a technological scheme for electrodes production. Here the method of nanopowder introduction to a welding pool (during the production) via liquid glass, using mechanical-activation installation of cavitation type, is described. Obtained mechanical properties and chemical composition of a weld metal formed by welding electrodes using nanodisperse materials are presented.

Key words: Liquid glass · Nanopowder · Welding electrodes · Manual arc welding · Cavitation

INTRODUCTION

Coated welding electrodes are designed for manual arc welding of metal constructions of different steels, metals and alloys, for surfacing of layers with special properties on the surface of parts and assemblies, as well as for arc cutting and gouging of metals [1, 8].

Coated electrodes have a number of important functions:

- Supply of electric current to an arc gap;
- Ignition of an arc and its transfer in the space;
- Regulation of current mode during the welding process;
- Melting of base and filler metals;
- Welding pool formation;
- Formation of welds of required geometry and quality.

The quality of welding materials and electrodes is determined by the following factors (Fig. 1):

- Raw materials;
- Technology of welding electrodes preparation;
- Availability of necessary technological equipment providing welding materials technology;
- Availability of research base and corresponding scientific and technical personnel;
- Availability of welding equipment adapted for these electrodes and welding materials.

Therefore, the production of modern high-quality electrodes requires improvement of technologies for electrodes production, used materials and corporate culture. The production of welding electrodes is an appropriate treatment of each material, comprising the coating, prescribed dosage, production of homogeneous

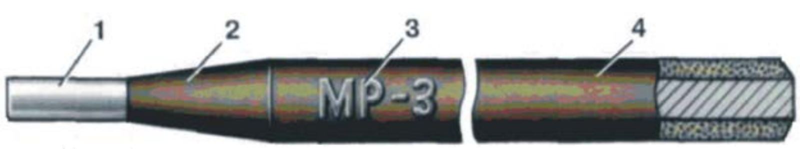

Fig. 1: The structure of MP-3 welding electrode
1 – pin; 2 – transition area; 3 – electrode mark; 4 – coating.

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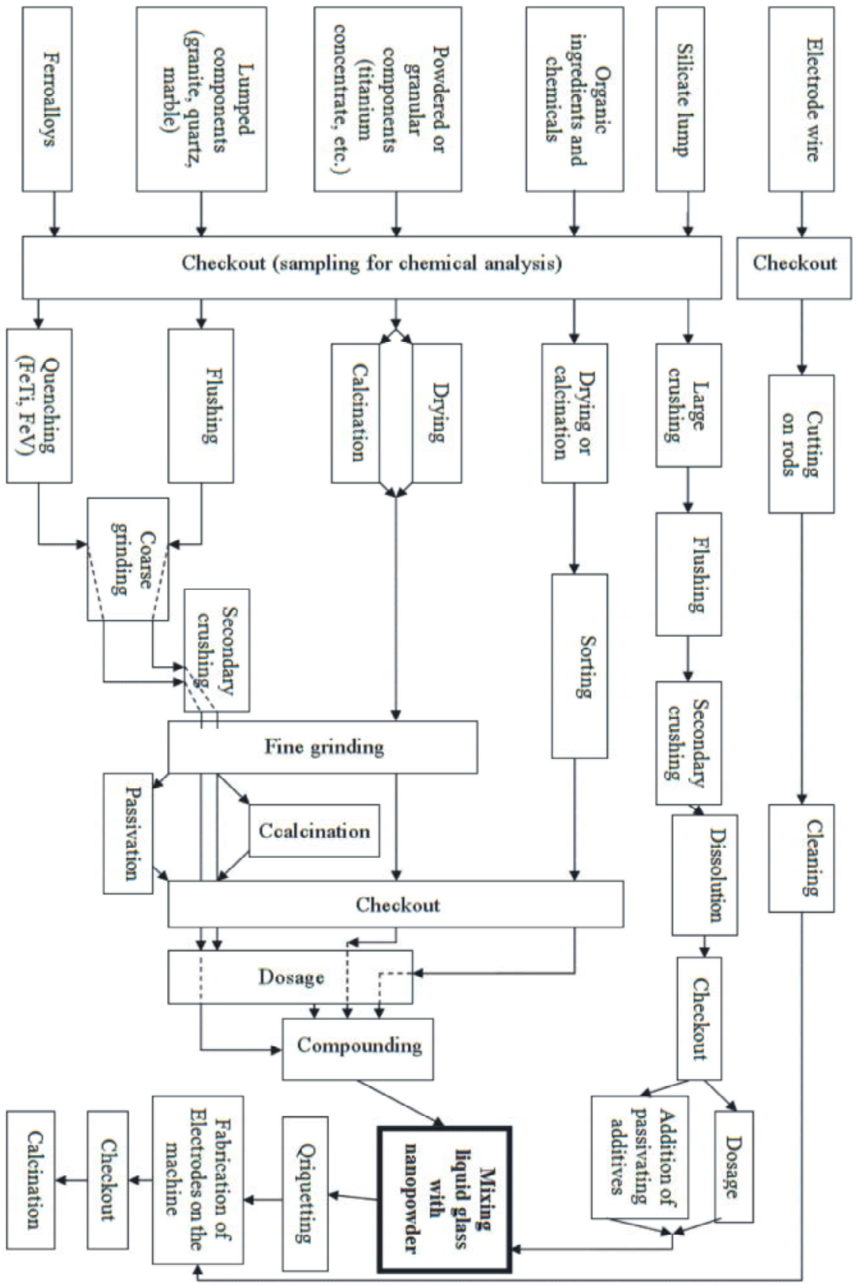

Fig. 2: Welding Electrodes Production Process Diagram

dry and wet mixtures, applying a certain layer of this mixture on the rods, drying and calcination of finished electrodes [2].

All coating materials undergo the following processing: crushing, grinding, sift, dosage, dry blending, mixing dry blend with liquid glass, cutting wire on rods, rods coating, wilting, drying and calcination of the electrodes, sorting, weighing and packing of the electrodes (Figure 2).

Electrodes are very sensitive to any smallest violations of the process. All operations for coating materials processing should be followed carefully, parameters of liquid glass are to be strictly maintained and batches are to be thoroughly mixed up. The volume of batches should be as small as possible, because such mixtures cannot be stored for a long time.

Ferroalloy and minerals supplied in large pieces are crushed to pieces of 15 – 20 mm.

The main goal pursued by ferroalloys grinding is to obtain the necessary fraction with a minimum content of dust. In addition, it is always necessary to remember that ferromanganese is explosive during grinding.

Ferroalloys grinding can be performed in the following ways:

- On continuous mills, in inert gas with sifting;
- By wet milling;
- On batch mills with introduction of an inert material and subsequent sifting on mechanical sifters.

Ferroalloy grinding on continuous mills in inert gas while sifting – the process is quite efficient and the obtained fraction is homogeneous with a low content of dust.

Grinding of ores and minerals is performed on continuous mills with separation and pneumotransportation, as well as on mills with simultaneous sifting and on batch mills.

Drum mixers in the form of a truncated cone, roll mixers, or compressed air can be used for batch mixing. The most effective mixer is a drum mixer in the form of a truncated cone with blades on an inner surface.

Suspended materials enter the mixer, where they are to be mixed for 10-12 minutes till fully homogeneous state.

Cutting wire on rods is to be performed by straightening and cutting mills of various types. These mills differ mainly by the construction of a cutting device: flying knives (knives are fixed on rotating rollers) and a guillotine knife. Rods cutting angle is more exact on mills with guillotine knife, but these machines are less efficient and of a more complex design.

Wet Mixtures Production Technology: A dry kneaded batch or a certain dose of a dry batch is transferred to a tempering mill, where, using an automatic dispenser and any another device, a predetermined amount of liquid glass of required characteristics is supplied to [6, 7]. Mixing time is 10-16 minutes. The mixture should be homogeneous, without any dry lumps [3].

Electrodes Calcination: The heat treatment of electrodes is carried out in order to provide sufficient mechanical strength of the coating, while keeping its moisture content within limits supporting a normal course of welding processes and allowing to provide a required chemical composition and properties of welding metal and welded joints [4].

The full heat treatment cycle includes pre-drying, drying, calcination and cooling [10]. Right after electrodes crimping the coating humidity is usually 9-13%. Allowable moisture content after calcination is dependent on the type of the coating. It is considered that electrodes with basic coating must have a moisture content of not more than 0.2% of the coating weight. Moisture content is to be measured at a temperature of 400±10°C with a coating sample of a constant weight.

There are many ways of introduction of nanodisperse materials into a welding pool, but the most effective one is the introduction of nanopowder in liquid glass using mechanical-activation installation of cavitation type [9], for the mixing of liquid glass and nanostructured materials.

The essence of this method consists of the following: into liquid glass (with a modulus of 3.130, viscosity of 0.604 Pa*sec and density of 1.433 g/cm^3) nanopowder of a complex composition (Al_2O_3, Si, Ni, Ti, W) in an amount of 1.0% of the liquid glass weight is to be added. The introduction of the nanopowder into the liquid glass is to be performed by mechanical-activation installation of cavitation type during 2 – 3 minutes at a temperature of 30-40°C [5].

Having analyzed Table 1 we can see that the introduction of the nanopowder into the liquid glass reduced viscosity of the glass 2 times.

In order to determine whether the use of nanopowders during the production of welding electrodes is possible or not, MP3 electrodes (Ø 4.0 mm) were produced. Despite the low viscosity of liquid glass, its cohesive properties allowed to produce coating mass of the required properties. It is necessary to pay attention to the fact that the flow of liquid glass was lower if compared with the same parameter for the standard technology (22 kg of glass per 100 kg of dry batch against 24.5 kg of glass per 100 kg of batch during the series production, i.e. the flow of liquid glass decreased by 10%).

Table 1: Indicators of Quality for Potassium-Sodium Liquid Glass

No.	Indicator	Serial	Experimental
1	Module	3.130	3.200
2	Viscosity, Pa*sec	0.604	0.292
3	Density, g/cm^3	1.433	1.430

Table 2: Mechanical Properties of Weld Metal

MP3 Electrodes (Ø4.0 mm)	σ_B, N/mm^2	δ_5,%	KCU, at 20°C, J/cm^2
Serial	460	25	159
Experimental	492	28	192
Requirements GOST 9467-75	450	20	80

Table 3: Chemical Composition of Welding Metal

MP3 Electrodes (Ø4.0 mm)	Mass Fraction of Elements,%				
	C	Si	Mn	S	P
Serial	0.07	0.03	0.47	0.025	0.046
Experimental	0.07	0.05	0.61	0.025	0.044
Requirements GOST 9467-75	-	-	-	0.040	0.045

Mechanical properties of weld metals and chemical composition of the welding metal are shown in Tables 2 and 3.

As it can be seen from Tables 2 and 3, mechanical properties of weld metal and chemical composition of welding metal correspond to GOST 9467-75.

CONCLUSION

It was established that the structure of weld metal performed with experimental electrodes is more homogeneous and disperse in comparison with a non-homogeneous structure performed with serial electrodes [5].

This method of introduction of nanostructured materials into welding pool is more efficient and rational due to the absence of any loss of nanopowder during its introduction into the welding pool; and mechanical properties of weld metal and the microstructure of welded joints are improved significantly.

REFERENCES

1. Yukhin, N.A., 2003. Selection of Welding Electrodes. Moscow: Souelo, pp: 68.
2. Kou, S., 2002. Welding Metallurgy, Edition 2. Wiley-Interscience, pp: 480.
3. Makarov, S.V., 2012. Heat Treatment of Welding Electrodes. In the Proceedings of the XII International Scientific and Practical Teleconference "Technical Sciences – from Theory to Practice", Novosibirsk: Siberian Association of Consultants, pp: 44-50.
4. Makarov, S.V. and S.B. Sapozhkov, 2012. Production of Electrodeswith Nanosized Powder of Complex Structure (Zr, Si, Ni, Ti, Cr). In the Proceedings of VIII International Scientific and Practical Conference «2012 Development of the Contemporary Science», Prague: Education and Science Publishing House, pp: 88-91.
5. Makarov, S.V. and S.B. Sapozhkov, 2013. Use of Complex Nanopowder (Al_2O_3, Si, Ni, Ti, W) in Production of Electrodes for Manual Arc Welding. World Applied Sciences Journal, #22(Special Issue on Techniques and Technologies): 87-90.
6. Brykov, A.S., 2009. Silica Solutions and their Application: Study Guide. St. Petersburg State Institute of Technology (Technical University), pp: 54.
7. Korneyev, V.I. and V.V. Danilov, 1996. Liquid and Water Glass. St. Petersburg: Stroyizdat, pp: 216.
8. Jeffus, L., 2011. Welding: Principles and Applications, Edition 7. Delmar Cengage Learning, pp: 976.
9. Brennen, C.E., 1995. Cavitation and Bubble Dynamics. Oxford University Press, pp: 282.
10. Kuznetsov, M.A. and E.A. Zernin, 2012. Nanotechnologies and Nanomaterials in Welding Production (Review). Welding International Journal, 26(4): 311-313.