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CONTROL OF GRANULOMETRIC COMPOSITION OF POWDERS APPLIED IN MANUFACTURE OF WELDING CONSUMABLES

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The industrial experience on development of requirements to the analysis of granulometric composition of consumables, applied in the electrode coatings was described. The importance of selecting the method of analysis and the applied equipment was noted. The conclusion on importance of unification of analysis procedures at the manufacturers of consumables and suppliers of powders was made. 8 Ref., 3 Tables.

Keywords: *arc welding, coated electrodes, production of electrodes, dry charge, powders, granulometric composition, control*

The growing competition with the leading world producers of welding consumables specifies ever-increasing requirements to the stability of technological process of their manufacture, which, in its turn dictates the growth of requirements to the reliability of data on characteristics of the applied components. The requirements to high speed of data acquisition grow also. Of course, the above-said belongs to granulometric composition of components as well.

It is known that granulometric composition of dry charge components is the most important and often determining factor in manufacturability of electrodes during their manufacture and application. The rational requirements to it should take into account the ability of ore mineral components at their mixing with liquid glass to provide producing the covering masses with the necessary properties; chemical activity of a number of metals and ferroalloys in the liquid glass environment; the differences in coarseness of different metals and ferroalloys, intended for alloying of deposited metal and/or deoxidizing of molten metal [1]. At the same time the brand requirements to granulometric composition should be based on reliable real data and take into account the specific technological features of a particular enterprise.

At the department of the E.O. Paton Electric Welding Institute, created and headed by Prof. I.K. Pokhodnya over many years, many research and practical works were carried out devoted to technological problems of technology for production of welding consumables. Of course, the problems associated with granulometry of powders, in particular those considered in the work [2], were also studied. However, in these works the methods of analysis of coarseness of materials were not covered. Until recently, the manufacturers of welding consumables at the territory of the former Soviet Union carried out crushing, grinding and preparation of electrode coating components and flux-cored wires in the own crushing-grinding divisions.

The transition to producing the components in the form of finished powders requires not only a clear formulation of user's requirements to their granulation, but also unification or harmonization of procedures for determination of particle sizes with the supplier. The delicacy of the problem lies in the fact that granulometric composition is often «know-how» of welding consumables manufacturers. In the same cases when in the technical literature the data on coarseness of different materials are given, they are represented, as a rule, in general form. Thus, in the work [3] it is pointed out that the amount of material on the sieves 045, 0355 and the upper limit of granulation of minerals in the «basin» of sieve 005 (according to GOST 6613) is approximate. In the [4] it is indicated that the sieve analysis is carried out mainly during setting up the grinding modes, and the given data on granulometric composition are approximate. Sometimes the indications on requirements to coarseness prepared to application of components can be found in the branch documentation of a limited use.

The some enterprises, producing electrodes, gained a considerable experience and statistics, on the basis of which the requirements to granulometric composition of different materials used as electrode coating components were developed. The most famous of them are the data of the Moscow Pilot Welding Plant (MOSZ), which are the basis of norms of many domestic enterprises [1]. It was particularly emphasized, that at each enterprise, producing electrodes, the requirements to granulometric composition should be specified taking into account the specifics of production.

Let us precise that such specifics, except of taking into account the nomenclature of the produced electrodes, their type and size series, physical nature of the used components and their nomenclature, structural characteristics and capabilities of the main technological equipment, characteristics of a binder, etc., should consider the characteristics of testing equipment used to determine the granulometric composition. After all, in fact the accuracy of sieve analysis is determined by the quality of fractionation and precision of sieves and its reliability is determined also by the quality of sampling and its careful performance.

The data of MOSZ are true in carrying out the sieve analysis in the device of the model 029 (basic technical characteristics: number of sieves oscillations is 300 rpm, number of strikes of a striker is 180 strikes/min), where the material is sieved through the system of rotating and shaking sieves in a semi-automatic mode. The other widespread device is the model 01412 which is the electromagnetic vibrator with the frequency of sieves oscillation being 50 s^{-1} at the amplitude of 0.1–1.0 mm. In the vibrostand PE 6700 used by one of the suppliers of finished powders (Table 1, C), the number of oscillations amounts to 12–25 Hz at the amplitude of 0.25–4.00 mm. The principle of operation of the device is the rendering of reciprocal oscillations in vertical plane to the sieves fixed at the desktop.

No wonder that during the control of one and the same batches of powders of different materials using different equipment the results are also different (Table 1). At the same time the determinations were performed in the devices of 029 model at two different enterprises (Table 1, A and B), and the obtained results were similar. In this case the difference of data on the sieve 016 can be attributed to the accuracy of grids and that will be discussed below.

Table 1. Results of determination of granulometric composition of materials applying different equipment. Remnant on sieves (in % from the mass of initial sample)

Number	Description of material, model of device	Index of enterprise	Numbers of sieves according to GOST 6613–86						
			0315	02	016	01	0063	005	–005
1	Ferroboron PE6700	C	0	N/D	N/D	N/D	91.5	7.6	0.9
	029) 1	A	0.6	13.8	10.6	24.2	11.8	8.6	30.0
	(029) 2	B	0	22.44	0.57	28.27	15.93	7.36	24.58
	01412	A	0	22.16	8.53	23.40	15.52	7.70	22.68
2	Metallic manganese PE6700	C	0	N/D	N/D	N/D	84.5	11.7	3.8
	(029) 1	A	0	17.2	12.6	22.6	8.0	5.0	33.6
	(029) 2	B	0	17.09	0.95	29.31	16.76	9.09	27.22
	01412	A	0	14.53	8.78	26.18	14.30	12.1	24.16
3	Ferroniobium PE6700	C	0	N/D	N/D	N/D	78.2	9.9	11.89
	(029) 1	A	0	7.8	8.6	25.2	11.2	8.2	37.6
	(029) 2	B	0	9.38	0.68	28.92	20.22	12.10	28.69
	01412	A	0	8.78	6.11	25.78	19.31	13.64	25.59
4	Ferromanganese PE6700	C	0	N/D	N/D	N/D	85.37	10.62	4.01
	(029) 1	A	0.2	11.6	10.4	22.0	9.6	9.2	37.0
	(029) 2	B	0	20.48	1.53	26.35	14.80	10.54	24.58
	01412	A	0	18.33	0.37	64.62	10.54	5.54	0.15
5	Ferrosilicium PE6700	C	0	N/D	N/D	N/D	81.4	13.4	5.2
	(029) 1	A	0	20.2	12.2	23.4	8.2	5.0	30.2
	(029) 2	B	0	22.34	0.36	28.22	15.56	6.78	25.97
	01412	A	0	20.02	8.43	23.33	14.59	8.49	24.38
6	Ferrotitanium PE6700	C	0	N/D	N/D	N/D	75.38	14.97	9.65
	(029) 1	A	3.6	22.6	12.4	22.4	8.0	5.8	24.6
	(029) 2	B	2.69	21.63	7.45	20.74	16.63	8.20	22.46
	01412	A	1.42	20.06	8.09	23.72	16.42	10.88	19.45
7	Ferrochrome PE6700	C	0	N/D	N/D	N/D	81.85	13.49	4.66
	(029) 1	A	4.6	22.4	9.6	19.0	7.8	6.4	28.8
	(029) 2	B	2.75	21.40	6.07	17.22	14.15	8.13	29.1
	01412	A	1.12	21.98	6.59	19.73	12.92	10.75	25.82
8	Metallic chrome PE6700	C	0.06	N/D	N/D	N/D	90.3	3.3	6.34
	(029) 1	A	1.3	23.6	13.6	26.8	8.4	5.2	20.2
	(029) 2	B	3.08	26.99	7.43	27.87	14.26	5.13	13.45
	01412	A	2.52	27.90	10.40	27.70	12.79	5.40	11.56

Note. N/D — no data.

Table 2. Results of sieve analysis of powders of different materials

Number	Description of material, model of device	Index of enterprise	Numbers of sieves according to GOST 6613–86						
			0315	02	016	01	0063	005	–005
1	Ferroniobium	A	–	26.50	5.58	28.47	14.57	6.64	20.13
		B	–	24.20	12.5	24.0	12.2	3.9	21.9
2	Ferrochrome	A	0.06	1.52	12.68	46.81	20.90	6.63	11.27
		B	–	0.6	13.7	55.7	15.1	3.5	11.1
3	Nickel	A	0.08	0.55	0.95	90.75	4.55	1.24	1.82
		B	–	0.6	1.8	93.7	1.7	1.2	0

Table 1 presents the data on control of domestic materials, but the similar results were obtained also during control of powders of the Swedish Company MRT in the device of the model 029 at the enterprises A and B (Table 2).

It is noteworthy that in the branch technological documentation and in the majority of standards the types and models of devices for sieve analysis are not specified. The more precise control of technological processes in the electrode production also requires obtaining the data about granulometric composition of that part of powders, which have sizes smaller than 50 μm, which can not be determined using conventional vibrating methods. This is explained by the fact that for the particles of such sizes the forces of adhesion and cohesion are comparable with their mass, sharply increasing at the further reduction in sizes. This results in conglutination of particles, clogging of sieve meshes, hindered sieving and obtaining the erroneous data [5]. The possibilities of analysis of granulometric composition of powders using dry method are expanded by electrostatic sieving realized, for example, in domestic devices Elsa-M and Gran [6].

One of the most advanced equipment is of the Company «Fritch» (Germany), which reliably proved itself over many years of practice. For example, the vibrating screen Analysett 3 with a vertical movement of high-quality analytic sieves provides a measurement of particles in the range from 63 mm to 20 μm. The laser diffraction measuring devices of the series Analysett 22 using the physical principle of fluctuation of electromagnetic waves, provide the ability to measure particles from 0.1 μm, moreover, the model Analysett 22 NanoTek also simultaneously detects the shape of particles. The software Autosieve allows carrying out automatic processing of results, including graphical representation, calculation of statistical values, calculation of values, keeping data bank [7]. Unfortunately, until now the Russian enterprises do not have such equipment in their disposal.

The metal grids used for sieving materials are delivered according to the standards GOST 2715 «Metallic wire grids. Types, basic parameters and dimensions» and according to GOST 6613 «Wire cloth grids with square meshes». To control the granulometric composition in electrode production, the grids according to GOST 6613 are mainly used, manufactured of non-ferrous metals and alloys. The systematization of grids for welding production was carried out by the authors of work [8].

Briefly the grids are designated by the number corresponding to the inside size of a mesh side in mm. The abbreviated notation for the meshes being smaller than 1.0 mm is made without a comma separating the integer part from the fractional one and zeros after significant digits are omitted. For example, a grid with an inside size of 0.315 mm of a mesh is designated with the number 0315, and a grid with an inside size of a mesh of 0.100 mm with the number 01. Formerly in the USSR and even now in a number of countries the number of a grid denoted the number of meshes accounted per 1 linear inch (mesh). Depending on the number of a grid the standard provides a different type of interweaving of wires of base and filling: in linen one the interweaving is through one wire and in serge one the interweaving is through two wires:

Table 3. Results of sieve analysis of powders of the company MRT

Number of grid	Nominal sides of mesh, μm	Accuracy of manufacture					
		H		B		K	
		Maximum deviation from nominal value, μm	Share, %	Maximum deviation from nominal value, μm	Share, %	Maximum deviation from nominal value, μm (interval)	Share, %
005	50	34	≤ 8	25	≤ 5	13–23	≤ 5
01	100	60		40		19–34	
0315	315	151		79		40–67	
04	400	180		96		47–78	

Number of grid	Type and order of interweaving
004–0063	Serge 2/2
0071–014	Serge 2/2 or linen 1/1
016–2.5	Linen 1/1

The grids are distinguished by the manufacture accuracy: N — normal, H — high, R — reference, differing, first of all, by tolerances on maximum deviation of size of a mesh side from the nominal value. As an example, Table 3 shows the corresponding data for several grids applied in the electrode production.

Unfortunately, according to the survey of enterprises-manufacturers that we conducted, in the country only the grid of normal manufacturing accuracy is produced, namely which is mostly applied in the sieves used in installations, including those produced by the OJSC «Litmashpribor». The aforementioned should be taken into account when considering the results of the analysis. At the same time, as in industrial sieves the grids of normal accuracy are used, it becomes unnecessary to adjust granulometric composition according to the data of analysis for practical application.

A unified approach to standardization of requirements on granulometric composition is absent even in the state standards on the materials of electrode coatings. Also in the most of standard documentation on electrode coating materials delivered in a powder form, the procedures for determination of granulometric composition are insufficiently described. Even in a separate standard such as GOST 19724, for example, which covers the method for determination of granulometric composition of fluorspar, including flotation concentrate, it is only specified that the mechanical shaker and grids according to GOST 6613 are applied. The analysis of pulverized quartz according to GOST 8077 should be performed in a wet method using the similar grids; during analysis of mica according to GOST 14327 the use of the sieving mechanical analyzer at the frequency of not less than 280 oscillations per minute, etc. is prescribed (GOST 19572).

It follows from the above mentioned that it is necessary to unify the methods for determination of granulometric composition at the enterprises-manufacturers of welding consumables and manufacturers of powder materials, as well as to include the norms on granulometric composition to the contracts for delivery of powder materials with the agreement of acceptance test procedures. During cooperation with the major domestic supplier of powder ferroalloys OJSC «MELDIS-FERRO» the practical realization of such approach allowed eliminating the misunderstandings encountered before and provided a stable and coordinated work in the future.

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