

SPRAYED BRONZE AND ALUMINUM POWDERS FOR RESTORING WORN-OUT SURFACES USING GAS-FLAME SPRAYING

РАСПЫЛЕННЫЕ ПОРОШКИ БРОНЗЫ И АЛЮМИНИЯ ДЛЯ ВОССТАНОВЛЕНИЯ ИЗНОШЕННЫХ ПОВЕРХНОСТЕЙ ГАЗОПЛАМЕННЫМ НАПЫЛЕНИЕМ

Prof., Dr. Eng., Cor. Member of NAS of Belarus Ilyushchanka A.^{1,2},
PhD of Eng., Doc. Kusun R.A.³, Head of the Lab. Charniak I.N.², Res. Kusun A.R.²,
PhD of Eng., Manoilo Y.D.⁴, Lead. Res., Dr. Semenov V.I.⁵

State Research and Production Powder Metallurgy Association¹ – Minsk, Republic of Belarus
State Scientific Institution "O.V. Roman Powder Metallurgy Institute"² – Minsk, Republic of Belarus
Belarusian State Agriculture Technical University³ – Minsk, Republic of Belarus
Separate Self-Supporting Enterprise "Institute of Welding and Protective Coating"⁴ – Minsk, Republic of Belarus
⁵Ufa State Aviation Technical University, Ufa, Russia
E-mail: alexil@mail.belpak.by, 19081877@mail.ru, irinacharniak@tut.by, semenov-vi@rambler.ru

Abstract: The information is given about small-sized equipment for producing sprayed powders of alloys based on copper and aluminum, intended for strengthening new and restoring worn-out surfaces by applying a gas-flame coating, as well as for the protection of parts against corrosion, process modes and powder properties. The high quality of the coatings obtained with the use of manufactured powders has been confirmed.

KEYWORDS: EQUIPMENT FOR POWDER PRODUCTION, SPRAYED BRONZE AND ALUMINUM POWDERS, PROPERTIES, GAS-FLAME SPRAYING

1. Introduction

The simplicity and cost-efficiency of the application of coatings by gas-flame spraying for strengthening new and restoring worn-out surfaces, as well as for the protection of parts of various functional purposes against corrosion, make this method attractive [1, 2]. Available equipment for gas-flame spraying of powders, consisting of a sprayer and a gas control panel, as well as powder materials for applying coatings are required to implement this method [3].

2. Results and discussion

To solve this problem, the small-sized equipment was developed to study the processes of powder production based on copper and aluminum (Fig. 1).

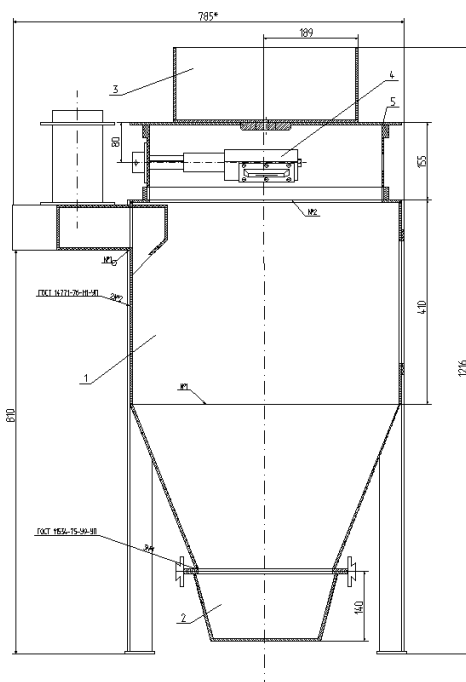


Fig. 1. Equipment for production of metal powders by spraying a metal melt by air:
1 – body; 2 – bottom plate; 3 – metal reservoir;
4 – nozzle; 5 – cover

As a rule, powders of various fractions are obtained by air spraying. By varying the air pressure during spraying and the angle of inclination of the nozzles, it is possible to regulate the output of a given powder fraction to a certain extent. Studies have shown that the output of powder is 95%. Depending on the modes of spraying, the output of the sprayed powder of large fractions is 5-35% when using slot nozzles and fractions with a particle size less than 0.16 mm – up to 5-10%. Figure 2 shows the particle size distribution diagrams of tin-phosphorous bronze powders produced by means of this equipment.

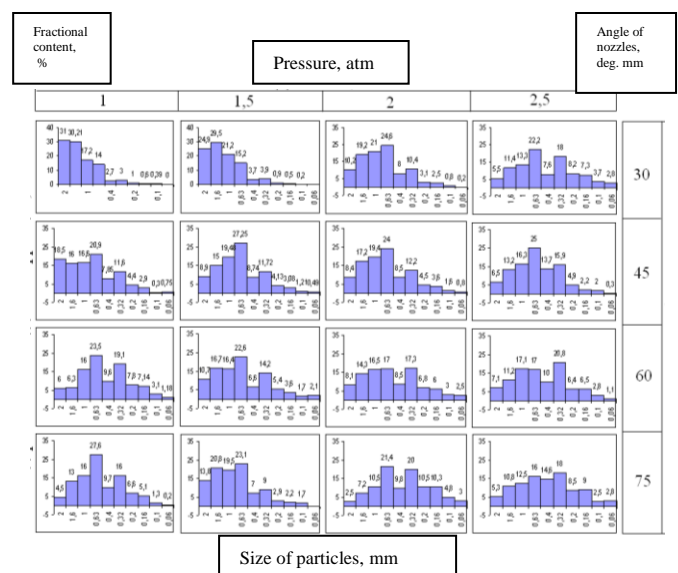


Fig. 2. Particle size distribution diagrams of the powder

When using these powders for the production of porous products, such a distribution is acceptable and almost all of the powder without remelting can be used at manufacturing site. However, for applying gas-thermal and gas-dynamic coatings onto worn-out surfaces or to protect them against corrosion, powders with particle sizes less than 100 μm are required. This leads to the remelting of powder with large particles and, accordingly, to significant

additional energy costs. In this regard, a specialized spray unit was developed with a set of removable nozzles. It is known that the main factors determining the powder dispersion are the viscosity, the surface tension of the melt and the gas flow energy [4, 5]. The viscosity of the melt is regulated by the chemical composition of the alloy and the temperature of the melt, and the surface tension of the melt is regulated by the diameter of the flowing jet of the melt. To obtain powders with particles less than 100 μm , it was decided to increase the relative gas flow rate. To solve this problem, a nozzle design was developed for spraying a metal melt by air based on a de Laval nozzle. A set of removable nozzles makes it possible to change the angle of gas attack in a wide range and change the area of their cross section.

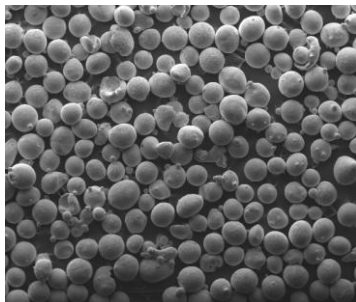
The output of applicable powder with fractions less than 100 μm was more than 80% when using a specialized spraying unit to produce sprayed spherical powders of tin-phosphorus bronze. Figure 5 shows the particles of the produced powder of the specified particle size distribution. The same results were obtained in the study of the process of producing aluminum powders with the only difference that spraying was carried out using argon, and not air, and the output of powders with the fraction minus 125 μm did not exceed 60%. The properties of tin-phosphorus bronze powders are given in Table 1; the bulk density of aluminum powders is in Table 2; the appearance of the powders is shown in Figure 3.

Table 1. Properties of tin-phosphorous bronze powders

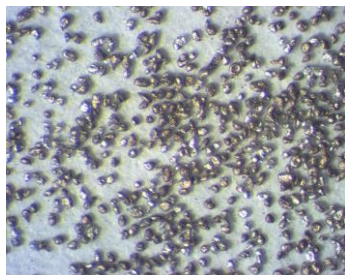
Fraction, mm	Bulk density, γ , g/cm ³	Flow rate τ , sec	Tap density, g/cm ³	Spherical shape factor
(-1,0+0,63)	4,05	3	4,42	0,95
(-0,63+0,4)	4,96	3	5,3	0,95
(-0,4+0,2)	5,0	3	5,37	0,95
(-0,2+0,16)	5,22	3	5,7	0,95
(-0,16+0,1)	5,22	3	5,7	0,95
(-0,1+0,063)	5,32	3	5,8	0,95

Table 2. Values of bulk density for aluminum powders

Powder fraction, mm	(- 1,0 + 0,63)	(- 0,63 + 0,4)	(- 0,4 + 0,315)	(- 0,315 + 0,2)	(- 0,2 + 0,1)
Tap density, g/cm ³	1,07	1,08	1,09	1,13	1,15



a)



b)

Fig. 3. Powders of tin-phosphorous bronze (a) and aluminum (b) with a particle size of less than 125 μm

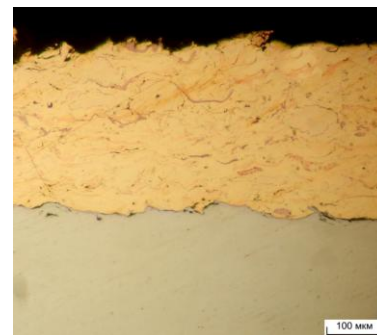
It should be noted that this equipment can produce powders of alloys based on copper and aluminum of other compositions used, for example, for restoring and strengthening the surfaces of crankshaft necks, "fits" for rolling bearings, internal surfaces of slider bearings (provided that the coating length does not exceed the diameter of the hole), surfaces of transmission shafts, camshaft necks, wheel hubs, etc. [6].

The produced tin-phosphorus bronze and aluminum powders with a particle size of less than 100 μm were sprayed onto steel substrates by high-speed gas-flame spraying on TENA-Ppm equipment (Figure 4) using MAF (methyl-acetylene-allene fraction) as combustible synthetic gas.

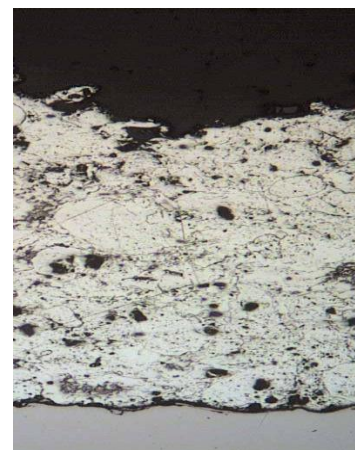


Fig. 4. Chamber of semi-automatic spraying TENA-KPAN-1300 with the equipment of gas-flame spraying TENA-Ppm

Coating microstructures are shown in Figure 5.



a)



b)

Fig. 5. Microstructures of the sprayed coatings of tin-phosphorous bronze powders $\times 100$ (a) and aluminum (b) applied on steel plates

Analysis of the microstructures of the obtained coatings makes it possible to conclude that the quality of the sprayed coatings is high: the total porosity in the sprayed layer is much lower than the allowable 2%.

3. Conclusion

Information about the equipment design for producing sprayed powders based on copper and aluminum, intended for applying coatings by gas-flame spraying when strengthening new and restoring worn-out surfaces, as well as for the protection of parts for various functional purposes against corrosion, including crankshafts, transmission shafts, wheel hubs, camshafts, etc. is presented.

It is shown that the equipment provides powders with a high level of properties and powder output of fine fractions. The possibility of using the obtained powders for applying high-quality sprayed coatings has been experimentally confirmed.

4. References

- [1] Ilyushchanka, A.Ph. Heavy Engineering, (2000), No. 2. P. 12-17 (A.Ph. Ilyushchanka, E.D. Manoylo, T.N. Tolstyak) (in Russian).
- [2] Vityaz, P.A. Theory and practice of coating application, Minsk: Belaruskaya navuka, (1998). P. 158 (P.A. Vityaz et al.) (in Russian).
- [3] Kaptsevich, V.M. Filtering materials: promising areas of application in the agro-industrial complex and modern production technologies, Minsk: BSATU, (2006). P.189 (V.M. Kaptsevich, L.S. Boginsky, R.A. Kusun, O.P. Reut) (in Russian).
- [4] Silaev, A.Ph. Dispersion of liquid metals and alloys, Moscow: Metallurgy, (1983). P. 144 (A.Ph.Silaev, B.D. Fishman) (in Russian).
- [5] Gopienko, V.G. Production and application of aluminum powders and fine powders, Moscow: Metallurgy, (1980). P. 68 (V.G. Gopienko, B.R. Osipov, B.P. Nazarov, V.M. Ryumin, I.V. Volkov, N.I. Yasakov) (in Russian).
- [6] Ilyushchanka, A.Ph. Advanced materials in agricultural engineering: monograph, Minsk: BSATU, (2009), P. 256 (A.Ph. Ilyushchanka, V.M. Kaptsevich, R.A. Kusun, A.M. Yarkovich, A.R. Kusun) (in Russian).