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Technology of Obtaining Powder Permeable Materials (PPM) with Invised Operational Properties

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ABSTRACT: In this work, the first investigated the production of powder permeable materials from a spherical shape of bronze powder brand BrTPh-10-1 by the methods of multiple deposition of particles into a porous workpiece from a gas-dust flow under the influence of vibration. It is shown that the operational properties of PPM obtained by the methods of multiple deposition of particles into a porous workpiece from a gas-dust flow under the influence of vibration, the hydraulic and mechanical properties of PPM are doubled in comparison with traditional methods.

KEY WORDS: powder metallurgy, powder permeable materials (PPM), porosity, permeability coefficient, operational properties, hydrodynamic and strength properties, nomogram, method of multiple deposition into a porous workpiece from a finely dispersed powder when applied by vibration.

I. INTRODUCTION

The constant complication of the designs of various machines and mechanisms, the improvement of their quality, the stricter requirements for their service life and reliability - all this requires the creation of porous permeable materials (PPM) with increased operational properties, the search for new methods of their manufacture. However, as shown by the analysis of literature data on the study of the processes of obtaining PPMs, their properties are closely related to the structure of the material and within the framework of traditional technology it is impossible to improve one group of properties (service life, dirt holding capacity, permeability coefficient) while maintaining the specified values of another group (fineness of cleaning, geometric dimensions, mechanical strength). At the same time, the required combination of properties can be achieved by purposefully regulating the pore structure. At the same time, as the most effective, but previously unexplored method of manufacturing products with high mechanical strength and permeability at a given pore size, the method of multiple deposition of particles into a porous workpiece, finely dispersed metal powder of various particle size and chemical composition from a gas-dust flow using vibration and their baking to the walls of the pore channels.

II. METHODS

We have carried out theoretical and experimental studies of the process of multiple deposition of metal particles of various granulometric and chemical compositions from gas and dust flow under the influence of vibration in the pore channels of the PPM and the development on this basis of a new technological process for regulating the steam

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distribution of the PPM, which ensures the production of products with higher operational properties, namely with high mechanical strength and permeability for a given pore size.

III. DISCUSSION

The paper presents the results of experimental studies on the creation of a new technological process for obtaining PPM by the method of multiple deposition of particles into a porous workpiece from a gas-dust flow under the influence of vibration. In this regard, the properties of initial powders and sintered blanks have been investigated; sintering modes of deposited powders of various granulometric composition, ensuring the production of PPM in one sintering cycle, determined and substantiated the optimal modes of multiple deposition, ensuring the production of PPMs with increased permeability and mechanical strength at a given pore size; develop a new technological process.

IV. MATERIALS

PPMs were made from powders with spherical particles of BrTPh-10-1 (Bronze-89 %, Tin-10 %, Phosphorus-1 %) bronze and HpT-9 (high-purity titanium) titanium.

Due to the fact that deposition into a porous workpiece is carried out from powders of various granulometric composition, and the sintering temperature of the powder depends on the size of its particles, in order to obtain high quality products, it was necessary to solve the problem of sintering powders of different fractions in one cycle. The idea of solving this problem was to compensate for the increase in the sintering temperature with an increase in the average particle size of the powders by additional alloying with such a component that would lower this temperature. For bronze grade BrTPh -10-1, phosphorus was chosen as the alloying component with which the sintering temperature was controlled. The relationship between the relative value of interparticle contact and the phosphorus content, average particle size, and sintering temperature was established by means of regression analysis. The dependence of the phosphorus content on the average particle size was established, which ensures the production of PPM from powders of various sizes with a relative value of interparticle contact equal to 0.2 (the optimal ratio for PPMs used as filters).

The description of the regularities of the change in the pore distribution of the PPM in the process of multiple deposition of particles and the construction of a mathematical model that adequately describes the dependence of the investigated quantities on the main factors of the process was carried out by the method of mathematical planning of the experiment. The main characteristics of the PPM were selected as optimization parameters, namely:

P - porosity, D_p^{avr} - average pore diameter, D_p^{max} - maximum pore diameter, Kμ - permeability coefficient, efficiency parameter $-E_1$, and ultimate strength in bending ben σ_{bend} , and as optimization factors - the ratio of the average size of deposited particles and the initial workpiece, a gas-dust flow velocity, frequency and acceleration of vibration.

The solution to the problem of finding the local maximum of the parameter Kμ under various constraints imposed on the minimum level of strength σ_{bend} at a fixed value of D_p^{avr} = 20 microns, based on the obtained regression models, is shown in the graph (Fig. 3).

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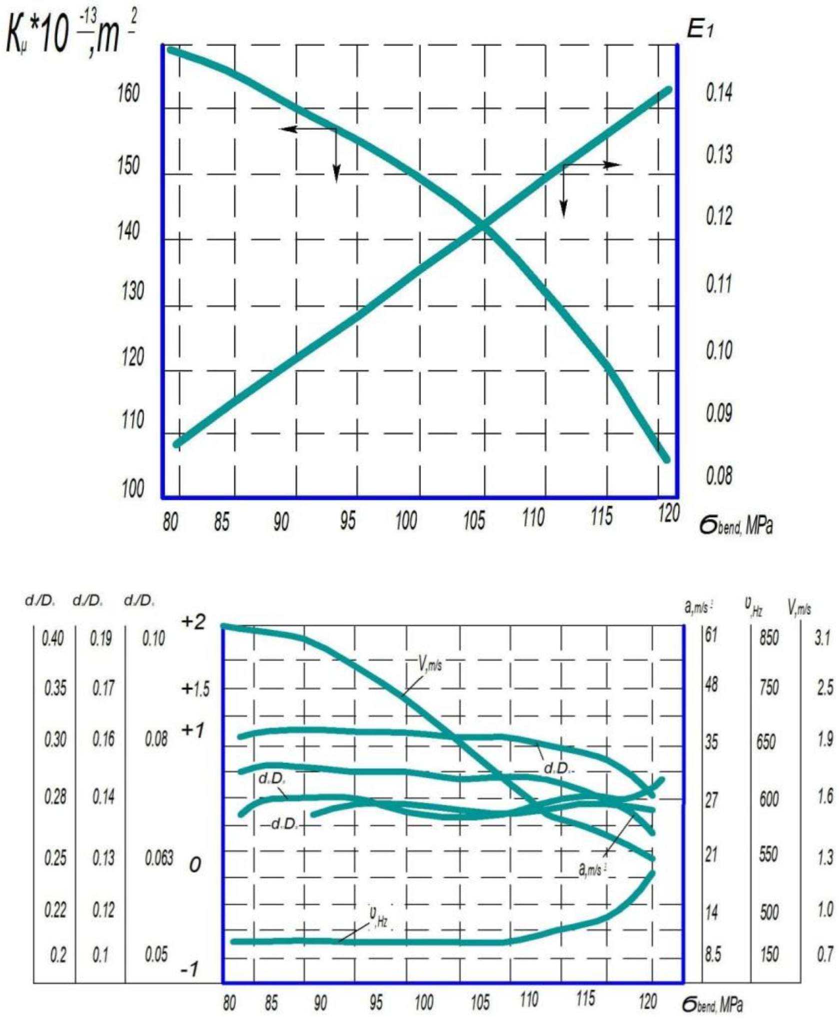

Figure. 3. Nomogram of finding the local maximum of the permeability coefficient Kμ at the given values of the average pore size (D_p^{avr} = 20 microns) and the fixed values of the ultimate strength σ_{bend} in bending bend for the PPM of bronze obtained by the multiple deposition method

Results. As a result, it was found that the maximum value of the permeability coefficient Kμ = Kμ = $170*10^{-13}$ m^2 with three-fold deposition (pore size D_p^{avr} = 20 microns) is achieved at a gas-dust flow velocity of 3.1 m/s, vibration frequency 630 Hz, vibration acceleration of 30 m/s^2, the ratio of the average sizes of the deposited particles and the initial workpiece 0.27, 0.16, 0.07 at the first, second and third stages of deposition, respectively.

The maximum value of the ultimate strength in bending σ_{bend} = 120 MPa is achieved at a gas-dust flow velocity of 1.3 m/s, a vibration frequency of 500 Hz, a vibration acceleration of 28 m/s^2 and a ratio of the average sizes of deposited particles and the initial workpiece 0.29, 0.14, 0.0625 at the first, the second and third stages of deposition, respectively.

The results of a comparison of the operational properties of PPMs obtained by the method of multiple deposition of particles into a porous workpiece from a a gas-dust flow under the influence of vibration and traditional methods (sintering with free filling, deformation of sintered workpieces, vibration molding, sintering of loose powder of 2 fractions are shown in the table.

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Table 1
The main properties of PPM obtained by known technologies and the method of multiple deposition

Methods of obtaining **PPM**	Powder material and particle size, mm	Porosity,%	Average pore size, μm	Permeability coefficient Kμ *10^{-13} м^2	Limit strength when bending, MPa	Efficiency parameter
Sintering of free-poured bronze powder	BrTPh -10-1 0,063…0,1	36	20	32	35…50	0,039
Deformation of sintered billets. Positive decision No. 4722293	BrTPh -10-1 0,125…0,315	36	20	70	40…55	0,045
Vibration molding	BrTPh -10-1 0,063…0,1 0,1…0,125 0,125…0,315	37	20	120	45…65	0,115
Sintering of free-poured powder of 2 fractions	BrTPh -10-1 0,4…0,5 0,063…0,08	38	20	130	40…60	0,118
Multiple deposition of particles into a porous workpiece from a gas-dust stream under the influence of vibration	BrTPh -10-1 0,8…1,0 0,2…0,25 0,1…0,125 0,05…0,063	38	20	170	100…120	0,140
	HpT-9 0,8…1,0 0,2…0,25 0,1…0,125 0,05…0,063	38	20	180	210…230	0,142

The data presented in the table indicate the increased operational properties of PPMs obtained by the method of multiple deposition of particles into a porous workpiece from a gas-dust flow under the influence of vibration.

Based on the research results, a new manufacturing process has been developed. PPM (TP № 01165.01510), allowing to obtain products with increased values of permeability and mechanical strength at a given pore size. The technological process includes the following main operations: powder sieving into fractions; sintering of a porous workpiece; multiple deposition of particles into a porous workpiece from a gas-dust stream under the influence of vibration; sintering the product; control of the performance properties of the finished product. The developed technological process was introduced at the pilot production of the Belarusian Republican RPA (research and production association) of powder metallurgy.

V. CONCLUSION

Optimal modes of multiple deposition of particles into a porous workpiece from a gas-dust flow under the influence of vibration have been theoretically and experimentally established. It is shown that the maximum value of the permeability coefficient $K\mu = 170 \cdot 10^{-13}$ m^2 with three-fold deposition (pore size D_p^{avr} = 20 microns) is achieved at a gas-dust flow velocity of 3.1 m/s, vibration frequency 630 Hz, vibration acceleration 30 m/s^2, the ratio of the average sizes of the deposited particles and the initial workpiece 0.27, 0.16, 0.07 at the first, second and third stages of deposition, respectively.

The maximum value of the ultimate strength in bending σ_{bend} = 120 MPa with triple deposition is achieved at a gas-dust flow velocity of 1.3 m/s, a vibration frequency of 500 Hz, a vibration acceleration of 28 m/s^2 and a ratio of the average sizes of deposited particles and the initial workpiece 0.29, 0.14, 0.0625 at the first, second and third stages of deposition, respectively.

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