IMPROVING THE UNIFORMITY OF PROPERTY DISTRIBUTION ALONG THE SURFACE OF FILTER MATERIALS OBTAINED USING POROGENS

ПОВЫШЕНИЕ РАВНОМЕРНОСТИ РАСПРЕДЕЛЕНИЯ СВОЙСТВ ПО ПОВЕРХНОСТИ ФИЛЬТРУЮЩИХ МАТЕРИАЛОВ, ПОЛУЧАЕМЫХ С ПРИМЕНЕНИЕМ ПОРООБРАЗОВАТЕЛЕЙ

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Abstract: A method of obtaining filter materials from metal powders intended to significantly improve the uniformity of properties along their working surface has been described. The method is easy to perform and is based on granulating the initial powders by the porogen through transferring it into an aqueous solution. It eliminates the segregation of porogen in the bulk of the charge during the implementation of technological operations and enables the automation of the pressing process.

KEYWORDS: FILTER MATERIALS, POROGEN, METAL POWDERS, CHARGE, GRANULATING, UNIFORM PROPERTIES

1. Introduction

Regulation of properties of filter materials (FM) in the traditional pressing of metal powders is limited to powder particle sizes and compaction pressure, and the products obtained by this method have relatively low porosity and permeability [1-3]. One of the main ways of creating FM with high porosity and permeability is the introduction of various porogens into the charge [4-8]. This method allows you to create a so-called bidisperse structure in the material [5, 6] consisting of two pore systems, which significantly differ in pore sizes. The first system is formed by large pores formed as a result of additive volatilization; the second system is formed by small natural pores between the particles of metal powder. Large pores, the dimensions of which are determined by the amount of filler and its particle sizes, are distributed in the matrix having small pores, the dimensions of which depend on the particle size of the metal powder and compaction pressure. Thus, such bidisperse structures may be divided into “closed” and “open” ones: the first are structures having large pores formed by porogen, which are isolated from each other by powder matrix and hardly affect the average and maximum pore sizes; the second are those having large pores which form their own pass-through communicating pore system and completely define the average and maximum pore sizes. Examples of both structures are shown in Figure 1.

Fig. 1 – Bidisperse structure of porous samples
a – “closed” bidisperse structure;
b – “open” bidisperse structure

Most often in practice, the introduction of porogen into the charge is carried out by conventional mixing [6, 9, and 10]. However, conventional mixing cannot ensure a uniform distribution of porogen by volume of the compact and, accordingly, a uniform distribution of properties over the surface of FM, especially in cases when, owing to its chemical nature, the mixture components’ densities in the charge (porogen and metal powder) vary by 5-6 times [11]. In addition, low charge fluidity does not allow using press machines for molding porous preforms. The work [12] is of particular interest; it describes the granulations of the charge with porogen by aqueous solutions of binder - 1% polyvinyl alcohol solution, which improved charge fluidity and allowed application of press- machines for its molding. However, this method does not solve the problem of obtaining FM with increased distribution uniformity of FM properties over the filtration surface during pressing of metal powders with porogen.

The objective of this work is improving the distribution uniformity of properties over the surface of filter materials obtained using porogens.

2. Results and discussion

The following assumption was accepted as a working hypothesis: the goal may be achieved by transferring the porogen into dissolved state, filling the metal powder into a prepared solution, drying with occasional stirring, grinding of the formed conglomerates and sifting through sieves or, in other words, by granulating the metal powder...
with porogen. Thus such granulation advantages as the possibility of using press machines and the provision of enhanced conditions for storage and transport of the charge will be realized. Furthermore, there is no need to provide certain charge humidity parameters for the process of pressing with this granulation method. It should be noted that the subject of this paper are “open” bidisperse structures.

Carbamide was used as porogen in this paper, distilled water as solvent, and electrolytic nickel powder PNE-1 as metal powder. The volume ratio of carbamide and PNE-1 was kept 0.4; 0.6; 0.8; 1.0; 1.2; 1.4. The granules were distinguished into 3 fractions: (minus 2.0 + 1.0), (minus 1.0 + 0.63) and (minus 0.63 + 0.2) mm; the appearance of the granules is shown in Figure 2; distribution pattern of carbamide and powder in the granules are shown in Figure 3.

Compaction pressure ranged from 50 to 150 MPa, sintering was performed at a temperature of 950 °C for 1 h in an atmosphere of dissociated ammonia with two holdings of 40 minutes at temperatures 150 and 400 °C.

As a result of studies, it was found that nickel powder granulation with porogen enables adjusting of fundamental FM properties within a wide range: porosity from 0.38 to 0.82, average pore size from 2 to 108 µm, permeability coefficient from $2 \times 10^{-13}$ to...
100×10⁻¹³ m². Figure 4 shows an example dependence of changes in porosity and permeability coefficient when using granules in the fraction (minus 0.63 + 0.2) mm on compaction pressure.

Experimental samples of porous materials were prepared by conventional mixing of nickel powder PNE–1 in delivered state and carbamide having a particle size (minus 0.2 + 0.16) mm under similar modes to compare the distribution uniformity of the local permeability over the filtration area. It has been shown that the proposed method allows a wide range of options to control the properties of permeable materials. High distribution uniformity of properties has been confirmed by measuring local permeability. High stability of granule composition by the amount of contained porogen has been shown.

### Table 1 – Porogen weight in a weighed charge portion of 50 g

<table>
<thead>
<tr>
<th>Sample No</th>
<th>Particle size of granules, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(minus 2.0+1.0)</td>
</tr>
<tr>
<td>1</td>
<td>6.46</td>
</tr>
<tr>
<td>2</td>
<td>6.46</td>
</tr>
<tr>
<td>3</td>
<td>6.7</td>
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<tr>
<td>4</td>
<td>6.53</td>
</tr>
<tr>
<td>5</td>
<td>6.49</td>
</tr>
</tbody>
</table>

Analysis of obtained data showed that granules of all factions are distinguished by high stability of porogen content separately and in total for all sizes of granules; variation coefficient in the first case does not exceed 1.4 %, and is 1.3 % in the second case. This is very important for the practical application of the proposed method, as it enables not dividing the granules into smaller fractions by using only sieves with mesh size 0.2 and 2.0 mm.

### 3. Conclusion

The results of investigating the granulation method of metal powder by porogen to create “open” bidisperse porous structures with enhanced distribution uniformity of properties over the filtration area have been shown. It has been shown that the proposed method allows a wide range of options to control the properties of permeable materials. High distribution uniformity of properties has been confirmed by measuring local permeability. High stability of granule composition by the amount of contained porogen has been shown.

### 4. Literature

