STRUCTURAL AND HYDRAULIC CHARACTERISTICS OF POROUS METAL GAUZE MATERIALS

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In recent years there has been a considerable increase in interest in porous metals produced from fibers, spirals, and gauzes of various types of weave [2-5]. What distinguishes such porous metals from porous metals from powders is that they are easy to process, enable the structural properties (porosity and mean and maximum pore sizes) of finished parts to be varied within wide limits, have increased strength, and are suitable for the production of porous parts characterized by a predetermined pattern of variation of structural properties in their volume. Porous metals from fibers and gauzes can successfully compete with other types of porous metals in virtually all of their present-day engineering applications.

In this article an examination is made of porous gauze metals (PGMs) produced at the N. E. Bauman Moscow Higher Technical College by rolling packs of the following one-sided serge-woven Kh18N10T (Ti-stabilized 18/10) steel filter gauzes: S-120 and S-200 (to GOST 3187-65 standard), S-450 (to TU MU MOS-71-97-63 technical specification), and S-685 (to ChMTU4-330-70 technical specification). PGMs from these gauzes were produced by a vacuum sheath rolling process similar to the rolling of clad metals. The process consists of the following operations: preparation and assembly of a gauze compact into an airtight pack, evacuation of the pack, and hot rolling [4]. Use of various starting gauzes in the manufacture of PGMs and production under various processing conditions enabled the structural and hydraulic characteristics of the resultant materials to be varied within wide limits. The above-mentioned process was employed for producing 200-mm-long, 100-mm-wide, and 0.6- to 2.0-mm-thick porous plates, from which 30-mm-diameter disks were cut out for tests. In experiments determinations were made of the effect of the degree of deformation in the rolling of gauze packs on the porosity ($\Pi$) of the resultant plates, of the variation of the mean ($d_p$) and maximum ($d_{p,\text{max}}$) pore sizes with PGM porosity, and of the hydraulic characteristics of the PGMs.

The degree of deformation of a gauze pack in rolling is determined by its coefficient of relative compression,

$$\varepsilon = 1 - \frac{h}{h_0},$$

where $h$ is the thickness of the PGM and $h_0$ is the thickness of the starting gauze pack. By changing the degree of deformation in the hot rolling of a gauze pack it is possible to vary within a wide range such characteristics of the resultant PGMs as porosity and mean pore size.

In Fig. 1 experimental data on the porosity of the PGMs as a function of the coefficient of relative gauze pack compression in rolling are shown. As can be seen, with increasing $\varepsilon$ the porosity of the PGMs invariably decreased. Analytically, this relationship is expressed by the formula

$$\Pi = \Pi_0 - a \cdot \varepsilon^c,$$

where $\Pi_0$ is the porosity of the starting gauze.

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Fig. 1. Variation of porosity of PGMs with coefficient of relative gauze pack compression. Approximating curves constructed with Eq. (2) for PGMs from gauzes: I) S-120; II) S-450; III) S-200 and S-685. Experimental data for PGMs from gauzes: 1) S-450; 2) S-120; 3) S-200; 4) S-685.

Fig. 2. Variation of $d_{p,m}/d_w$ with porosity for PGMs from gauzes: 1) S-450; 2) S-120; 3) S-200; 4) S-685 [curve I was constructed with Eq. (3)]; 5) S-450; 6) S-685 (data from [2]).

<p>| TABLE 1 |
|----------------------|-----------------|-----------------|---|---|</p>
<table>
<thead>
<tr>
<th>PGMs from gauzes</th>
<th>Gauze porosity</th>
<th>PGM porosity</th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-120</td>
<td>0.474</td>
<td>0.04-0.32</td>
<td>0.96</td>
<td>1.22</td>
</tr>
<tr>
<td>S-450</td>
<td>0.428</td>
<td>0.13-0.32</td>
<td>1.07</td>
<td>1.23</td>
</tr>
<tr>
<td>S-200</td>
<td>0.417</td>
<td>0.1-0.35</td>
<td>1.13</td>
<td>1.26</td>
</tr>
<tr>
<td>S-685</td>
<td>0.417</td>
<td>0.1-0.35</td>
<td>1.13</td>
<td>1.26</td>
</tr>
</tbody>
</table>

The values of the constants $a$ and $b$ for the PGMs investigated were determined (see Table 1). From the experimental data it follows that the values of $a$ and $b$ in Eq. (2) depend on the starting gauze parameters: They increase with decreasing gauze porosity.

The mean and maximum pore sizes of the PGMs were determined experimentally by the method consisting in expelling a liquid from pores. In Fig. 2 the results of our mean pore size determinations for all the PGMs investigated are shown. The experimental data are closely approximated by the formula

$$\frac{d_{p,m}}{d_w} = 8.75 \cdot \sqrt{FP},$$

where $d_w$ is the weft diameter of the starting gauze. Equation (3) is valid for the PGMs investigated in the porosity range indicated in Table 1.

In Fig. 2, for comparison, the experimental values of the $d_{p,m}/d_w$ ratio obtained in [5] for single S-450 and S-685 gauze layers prerolled between rolls are shown. The values of $d_{p,m}/d_w$ obtained in [5] are slightly smaller than those yielded by our experiments, probably as a result of the use of different methods of determining mean pore sizes. In [5] mean pore sizes were determined by solving simultaneously the Darcy and Hagen-Poiseuille equations, which, as has been noted in [1], invariably gives lower values compared with those obtained by the liquid expulsion method.

When a PGM is used as a filter element for removing contaminants from gases and liquids, it is, as a rule, necessary to determine its maximum pore size, with which it is possible to approximately assess its stopping power. In Fig. 3 experimental data illustrating the variation of the $d_{p,max}/d_{p,m}$ ratio with porosity for all the PGMs investigated is presented. To a first approximation these data, which show a scatter of up to 30%, are expressed by the formula

$$\frac{d_{p,max}}{d_{p,m}} = 0.77 \cdot \sqrt[0.37]{P},$$

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