METHOD OF OBTAINING POWDERED COMPONENTS WITH TRANSITIONS IN HEIGHT AND IMPERMEABLE TO FREON

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To produce components of refrigerating installations, viz., cylinder heads of compressors which have a complex configuration, by methods of powder metallurgy is expedient on condition that the material is impermeable to freon and that sufficient uniformity of distribution of its density throughout the bulk is ensured. The known methods of hot pressing of porous compacts [1], their pressing under high pressures [2, 3], liquid-phase sintering [4-6] ensuring such conditions entail, nevertheless, either a more laborious process, or poorer durability of the tool, or else instability of the dimensions of the products.

It became necessary to work out a new method of producing these items, free of the above-mentioned shortcomings. For that purpose we investigated the shaping of a double-layer powder compact and subsequent sintering combined with impregnation. In shaping, the mold with floating die was filled with iron powder (PZhV 2.200.28) of the base, and then copper powder (PMS-1) of the infiltrating material (Mcu = 0–23.1% of the weight of the base) was strewn on. Pressing was effected with 540.5 MPa. Sintering was carried out in an atmosphere of dissociated ammonia at 1453 K for 7.2·10³ sec.

To optimize the technological parameters, we studied the regularities of compaction and the degree of uniformity of distribution of the material. For that we used model specimens "cylinder head of the compressor" (Fig. 1). The chambers of the cylinder head were shaped by a nondetachable punch by one-sided pressing. To ensure removal of the powder compact from the die, its protrusions were provided with technological slopes ≈ 17%. The use of the nondetachable punch enhances the reliability of the shaping tool, simplifies its design, and makes the die less laborious.

At the first stage we investigated the influence of the cold-consolidation pressure on the density, and also the uniformity of distribution of the material Pp [7] within the bulk of the compact made of iron powder, and the magnitude of its inequidensity Hp:

\[ P_{p1} = \rho_1 \rho_{mc}^{-1} \times 100 \%, \quad P_{p2} = \rho_2 \rho_{mc}^{-1} \times 100 \%, \quad H_p = P_{p2} - P_{p1}, \]

where \( \rho_1 \) and \( \rho_2 \) are the density of the protrusions and of the flange (of the upper and lower part of the head), respectively; \( \rho_{mc} \) is the mean density of the cylinder head.

An increase of the cold-consolidation pressure to 630.6 MPa does not ensure that high-quality products with density exceeding 7 g/cm³ and inequi-density of less than 3% will be attained (Fig. 2) but the degree of inequi-density decreases from 16.1 to 9.4%.

While the compact is being shaped, its upper part is predominantly compacted (Table 1). At the second stage we studied the influence of the amount of copper in the infiltrating layer of the compact on the regularities of compaction and distribution of the powder material during sintering that was combined with the impregnation of the cylinder heads. The effectiveness of infiltration was evaluated with the aid of the coefficient of increase of density of the forming material:

\[ K_p = (\theta_1 \theta_{mc}^{-1} - 1) \times 100 \%, \]

where \( \theta_1 \) and \( \theta \) are, respectively, the relative density of the infiltrated material and of the iron carcass.

During sintering of the bimetallic compact, in which the weight proportion of copper is 23.1%, uniform distribution of the material is ensured (Fig. 3, Table 2). After infiltration the cylinder heads had density 7.02 g/cm³ which satisfies the requirements of the Scientific and Production Association "Temp" in regard to impermeability to freon, which is attained...
TABLE 1. Influence of the Cold-Consolidation Pressure on the Uniformity of Distribution of the Powder Material in the Bulk of the Compact and Its Inequidensity (%)

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<tr>
<th>Index</th>
<th>$P_{c,p}$, MPa</th>
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<tbody>
<tr>
<td></td>
<td>180,2</td>
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<tr>
<td>$P_{p1}$</td>
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<tr>
<td>$P_{p2}$</td>
<td>110,5</td>
</tr>
<tr>
<td>$H_p$</td>
<td>16,1</td>
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Fig. 1. Powder compact of the cylinder head: 1) protrusions; 2) flange; 3) chambers.

Fig. 2. Influence of the consolidation pressure on the relative density of the iron carcass. Here and in Fig. 3: 1) protrusions; 2) flange; 3) component.

Fig. 3. Influence of the amount of copper in the bimetallic compact on the relative density of the infiltrated material.

when $\rho_{me} = 7 \, \text{g/cm}^3$. In the range from 0 to 9.56% the amount of copper changes only imperceptibly the density of the component (Fig. 3) and the effectiveness of infiltration (Table 2). Its further increase to 23.1% brings about a rapid increase of relative density of the material (from 0.806 to 0.878) and of the coefficient of increase of density (from 0.1 to 9.07).

A change of the amount of copper entails a nonmonotonic change of density of the protrusions and of the flange. With $M_{Cu} = 6.67-9.56\%$ the upper layer of the iron carcass shows decreasing density (Fig. 3, Table 2). The maximal density of the flange ($\theta = 0.88$) is attained when $M_{Cu} = 14.3$ (wt.)%. A further increase of the amount of copper hardly changes the relative density. During the sintering of the bimetallic compact enhanced effectiveness of infiltration of protrusions of the cylinder head is ensured. The values of $K_y$ of the protrusions increase substantially when $M_{Cu} > 9.56\%$ (Table 2).