BIMETALLIC SINTERED IRON-BRASS
CONSTRUCTIONAL PARTS

I. V. Vlasyuk, V. N. Klimenko,
I. D. Radomyssel'skii, and L. M. Apininskaya

Brass is widely used for the manufacture of various constructional parts, including those which must meet the requirements of high corrosion resistance. For such service, the corrosion resistance of the surface layers of parts must be increased.

To make such parts in dense (cast) metals and alloys, it is necessary to use large amounts of scarce and expensive nonferrous metals. In view of this consideration, the present investigation was undertaken with the aim of developing a technique for the production of bimetallic sintered iron-brass constructional parts, which would lead to substantial savings in nonferrous metals and simplify machining. Parts of this type cannot be produced by the orthodox powder-metallurgy technique — compaction of iron and brass powders and subsequent sintering—because brass powder is not produced in our country; however, even if brass powder were available, this technique would present serious difficulties owing to the large difference in the sintering temperatures of brass and iron. The sintering temperature of brass is too low to ensure the required strength of the iron core of parts, while raising the temperature to 1000-1200°C leads to infiltration of brass into iron parts.

Another approach could be tried, consisting in pressing brass on to finished iron parts. Such a technique, however, would be technologically complicated and would be unlikely to achieve a strong bond between the brass and the iron core.

Bearing in mind the above considerations and taking into account the requirements to be met by the brass layer (small thickness, high density, strong adhesion to the iron core), the authors proposed the following scheme for the production of iron-brass parts: pressing of parts from iron powder or a mixture of iron powder and graphite, sintering of the resulting compacts, application of an electrolytic copper coating up to 200μ thick, and thermodiffusion impregnation of the copper coating with zinc.

The processes of pressing, sintering, and electroplating have already been investigated in sufficient detail. The aim of the present work was to investigate the process of diffusion impregnation of copper coatings with zinc and to study the properties of brass coatings produced in this manner. For the investigation, iron-powder specimens with a porosity of 15% were compacted. The specimens were intended for subsequent tensile, bending, and impact-strength tests. They were sintered at 1200°C for 2 h in hydrogen. After sintering, they were copper plated to a thickness of up to 150μ.

Fig. 1. Dependence of thickness of brass coating on temperature of diffusion impregnation with zinc. Impregnation duration 3 h.

Fig. 2. Dependence of thickness of brass coating on duration of diffusion impregnation with zinc at temperature of 900°C.
Fig. 3. Microstructures of brass layers obtained by diffusion impregnation with zinc. Impregnation temperature: a) 800°C; b) 850°C; c) 900°C. Impregnation time 3 h. × 500.

TABLE 1

<table>
<thead>
<tr>
<th>Type of specimen</th>
<th>Tensile strength, kg/mm²</th>
<th>Bending strength, kg/mm²</th>
<th>Impact strength, kg-m/cm²</th>
<th>Elongation, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron without brass coating ........</td>
<td>not less than 16</td>
<td>-</td>
<td>1</td>
<td>8-10</td>
</tr>
<tr>
<td>Sintered and brass coated for 3 h at 900°C ...</td>
<td>17-17.5</td>
<td>54-58</td>
<td>2.5</td>
<td>10-12</td>
</tr>
<tr>
<td>Brass coated without presintering ...</td>
<td>15-16</td>
<td>33-34</td>
<td>0.15</td>
<td>-</td>
</tr>
</tbody>
</table>

The diffusion impregnation of the specimens with zinc was performed in a ShPI shaft furnace, in a hydrogen atmosphere. The parts were suspended in a cylindrical container above a layer of brass shavings 10-15 mm thick, the shavings being used, in accordance with earlier recommendations [1], as a source of zinc. At a temperature of 450°C, zinc began to vaporize from the shavings and settled down on the copper surface of the parts. As a result of zinc diffusion, the copper layer became transformed into a brass layer.

Experiments conducted on specimens of 15% porosity, obtained by single pressing and sintering, demonstrated that copper-plated specimens should be subjected to annealing before the diffusion impregnation of their copper coating with zinc. Attempts to produce a brass coating on unannealed specimens yield unsatisfactory results: the coating tends to peel off, while the iron-powder core acquires a dark color, oxidizes, and suffers a loss of strength. Preannealing copper-plated specimens ensures that the electrolyte is eliminated from the porous iron core. When such an annealing treatment is not carried out, the copper coating becomes impervious as a result of zinc diffusion and prevents the escape of decomposition products of the electrolyte (CuSO₄·2H₂O). This is responsible for the peeling off of the coating from the iron core.

As a remedy, it was proposed to perform diffusion-reduction annealing, during which the electrolyte would be eliminated from the pores without disturbing the continuity of the coating. The annealing operation was to be conducted at 900°C for 3 h. These heat-treatment parameters ensure that the copper oxides remaining in the pores are fully reduced and improve the adhesion of the copper layer to the iron core as a result of diffusion processes. After such reduction annealing, the parts were subjected to diffusion impregnation with zinc.

A study was made of the influence of impregnation temperature and duration on the thickness of the resulting brass layer. The results of these investigations are presented in Figs. 1 and 2. As can be seen from the graph, the mean thickness of the brass layer increases with rise in the temperature of diffusion impregnation of the copper coating with zinc (Fig. 1) and with increase in the duration of this process (Fig. 2).

Brass layers obtained under various process conditions were also subjected to metallographic examination. Specimens treated for 3 h at 750°C had a brass coating with a thickness of only 80 μ. With rise in the temperature of diffusion impregnation with zinc, the thickness of brass coatings increased, attaining 180 μ at 900°C. This thickness exceeded the initial thickness of the electrodeposited copper layer by 20-30 μ.