
PRODUCTION AND PROPERTIES OF BRASS–BASE P/M CONSTRUCTIONAL MATERIALS.

A REVIEW

I. D. Radomysel'skii, G. A. Baglyuk, and G. E. Mazharova

The methods of manufacture and properties of constructional parts from copper and copper alloy powders were reviewed in [1]. More recently, further works dealing with this subject have been published. Apart from this, in the earlier review P/M brasses received comparatively little attention. The present survey is therefore devoted specifically to the methods of manufacture of brass powders and P/M parts.

Brasses owe their extensive application to the fact that they combine good mechanical and processing properties. The structure, properties, and production of cast and wrought copper–zinc alloys have been investigated by numerous authors, and good reviews of the results obtained by them will be found in [2–4]. In contrast to cast materials, until recently P/M brasses did not receive a great deal of study mainly because orthodox cast and rolled brasses are very easy to machine, and little advantage would be gained from producing these materials by the powder metallurgy method [5]. However, some investigations carried out in the last decade have shown that labor consumption in the manufacture of brass P/M parts is only one half that in the manufacture of cast parts [6], and the high coefficient of utilization of materials characteristic of the powder metallurgy method — 0.90 or more against 0.2–0.5 in casting, combined with the same high level of physicomechanical properties, enables the former to compete successfully with other methods of manufacture of constructional parts. It must also be borne in mind that today, these are a number of plants in the Soviet Union that produce atomized brass powders on a large scale. Consequently, there is now much greater interest in published works dealing with the exploration of the possibilities of employing these materials for the production of parts for various types of service.

The first attempts to produce brass P/M parts were made in the United States and Britain as long ago as the early 1940s [1]. It was found that production of brass parts from a mixture of copper and zinc powders by conventional powder metallurgy techniques (pressing and sintering) presents considerable difficulties because zinc evaporates during sintering, and it is impossible to decrease the porosity of parts to less than 7–10%. This high residual porosity has such a deleterious effect on the physicomechanical properties of materials that they often become unsuitable for constructional applications. Apart from this, evaporation of zinc may lead to nonuniformity of chemical composition and hence of properties across specimens. Use of copper powders prealloyed with zinc markedly decrease the heterogeneity of P/M brass.

Production of Brass Powders. One of the simplest methods of producing brass powders is mechanical comminution of cast blanks [7]. As starting material, machining swarf can also be employed [8, 9]. Swarf is ground, degassed, and subjected to treatment designed to improve the compressibility of the resultant powder and prevent loss of zinc by evaporation. This may consist in heating swarf with a 0.1% Li2CO3 addition to 550–560°C in an inert gas atmosphere.
In [6, 10-14] accounts are given of investigations into the manufacture of brass powders by a diffusion method in which a copper powder is annealed together with a material constituting an assembly of point sources of zinc, such as a zinc powder, brass swarf, or a copper—zinc master alloy. In the diffusional impregnation of copper using the particles of a zinc powder as point sources the components are mixed together, the charge obtained is sintered in a hydrogen or inert gas atmosphere at 530-550°C, and the resultant cake is ground. Use of brass swarf for impregnating a copper powder with zinc enables the temperature of the process to be raised to 850-900°C [11]. In addition, use of swarf makes it possible to set an upper zinc content limit because under steady-state equilibrium conditions the composition of a powder being impregnated is determined by the composition of the starting brass. The process is performed in a closed container placed in a furnace without a protective atmosphere. A mixture of a copper powder and brass swarf is soaked for 1 h at 670-700°C. When a copper—zinc (35% Cu—65% Zn) master alloy is used as an impregnation source, brass powders containing up to 40% Zn can be obtained [14]. A master alloy produced by melting in an electric furnace [13] is comminuted in a ball mill to a particle size of 100-150 μm and mixed with a copper powder, the mixture being annealed and the resultant sponge ground. It is recommended that the diffusion annealing should be performed in a three-zone furnace at temperatures of 400 ± 20 in the first zone, 600 ± 20 in the second, and 500 ± 20°C in the third [6]. The highest degree of homogeneity is attained with a mixture subjected to 1- to 1.5-h diffusion annealing at a temperature of 650 ± 10°C [12, 14].

Comacts of various porosities from PM-2 copper powder can also be subjected to impregnation [11]. This is done by placing them in a container filled with a material consisting of 50% of LS-59 (59% Cu—Zn—Pb) brass swarf and 50% of Al₂O₃, which prevents the swarf from welding to the compact surfaces; treatment is carried out for 1 h at 850-900°C without a protective atmosphere. Thorough impregnation is observed with specimens whose starting density does not exceed 5.89 g/cm³. The resultant material has an α-brass structure. After impregnation specimens have a density of 6.95-7.7 g/cm³ and, at 21-30% Zn, a tensile strength of 100-188 MPa. Re-pressing increases the density of specimens to 8.3-8.4 g/cm³. A major disadvantage of a brass powder production technique in which a mixture of copper and copper—zinc master alloy powders undergoes homogenizing annealing is that it comprises a large number of slow and labor- and energy-consuming operations such as milling, mixing, annealing, and comminution of a sintered sponge.

In recent years industrial methods have been developed for the production of brass powders from melts by atomization with water under high pressure and compressed air on nitrogen [15, 16]. The principal advantage of this method is that it enables brass powders to be obtained with stable zinc concentrations in both fine and coarse fractions. However, specimens from an atomized brass powder are slightly inferior in compactibility, compressibility, electrical conductivity, and strength to those from a powder produced by a diffusion technique. This is mainly due to a difference in their specific surfaces [16]. It has also been found that the particles of an atomized brass powder are elongated and irregular-shaped because zinc markedly lowers the surface tension of liquid brass [5]. In [17] data are cited in the manufacture of semifinished products from LS63-3 (63% Cu—Zn—3% Pb) lead brass involving granulation. The casting of granules solidifying in water ensures high rates of cooling, as a result of which inclusions of an insoluble phase (lead) are evenly distributed in the resultant granules and semifinished products obtained from them. The granules (of size 3-5 mm) surpass cast brass in ductility.

Recently, the results have been published of an investigation into the electrolytic production of fine-grained deposits of multicomponent nonferrous alloys [18]. In particular, electrodeposition from an alkaline ferrocyanide electrolyte at a current density of 0.5-2.0 mA/cm² has been employed as a means of producing, with a brass current efficiency of about 98%, brass powders of composition 60% Cu—40% Zn [19]. The powders have been found to adhere strongly to a steel basis. However, electrodeposition as a method of producing brass powders, or in fact powders of any materials containing heavy nonferrous metals, has not found practical application. The reason for this is that a constant composition of a complex electrolyte and constant electrolysis parameters in such a case are difficult to maintain. Moreover, it is not possible to produce fine alloy particles of a strictly constant composition by this method [18].

Thus, from this short review and analysis we can conclude that atomization holds