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## POWDER METALLURGY

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This invention relates to powder metallurgy, and more particularly to the production of metal objects in which a plurality of metals are constituents. More specifically, the invention contemplates improvements in the production of metal objects from metal powders, the metallic constituents of which have different melting points and do not alloy readily with each other in all proportions.

The invention is particularly applicable to the production of lead-copper bearings. Bearings containing these two metals or alloys thereof have an extensive application, because of their ability to withstand high temperatures without melting and abrading. However, because these two metals are relatively insoluble in each other and have widely different melting points and specific gravities the manufacture of lead-copper bearings by the heretofore customary methods has proved difficult. When molten lead and molten copper are combined they tend to segregate into immiscible layers, so that operations involving a mixture of the fused metals present unending difficulties. Furthermore, prior attempts to produce lead-copper bearings from powdered metals have been relatively unsuccessful. Thus, efforts involving the compression and heat treatment of mechanical mixtures of lead and copper powders have resulted in inferior products, because in order to insure a bond between copper particles and a low degree of porosity, the mass usually becomes heated above the melting point of lead, whereupon the lead tends to segregate and sweat out. When lead-coated copper powders were employed, a similar sweating and segregation occurred.

As a result of my investigations, I have developed a process for the production of lead-copper bearings and the like, in which I may employ metallic constituents with different melting points and which do not alloy readily with each other. My invention also contemplates the production of novel metallic objects of greatly improved character.

In accordance with my invention, I employ plated metal powders in which the core is composed of metal having a lower melting point than the metal of the surrounding plating. The plated metal powders are subjected to heat and pressure and thus compacted into coherent mass. Depending upon the pressure employed, the mass may be solid or it may possess any desired degree of porosity. The mass is preferably heated to a temperature intermediate the melting points of the core and the plating of the powder particles.

My invention will be more thoroughly understood in the light of the following specific example, wherein copper-coated lead powders are employed. The application of my invention, however, is not limited to the use of these two metals. On the contrary, my invention is applicable whenever it is desired to combine in a metallic object two or more metals or alloys having different melting points and which do not alloy readily with each other, without danger of sweating or segregation of the more easily fusible constituent.

A suitable copper-coated lead powder for the practice of my invention may be prepared as follows:

Approximately a liter of water is brought to boiling and made slightly acid with acetic acid. 200 grams of copper acetate containing 1 molecule of water of crystallization are dissolved in the boiling water. When solution is complete, at a temperature of about 85° C., 250 grams of 100 mesh lead powder is added and the solution is rapidly stirred. In order to insure the production of a uniform coating of copper on the powder, it is preferably added as a suspension in water. Stirring is continued until all of the copper in solution has been displaced by the lead, as will be indicated by the disappearance of blue color.

The coated powder is permitted to settle out. The supernatant solution is decanted off and the powder is washed at least four times, each time with about 500 ccs. of water. It is then filtered in a Buchner funnel to which suction is applied, and is again washed in place in the funnel at least four times, each time with about 500 ccs. of water. Finally, the material in place on the Buchner funnel is washed with about 100 ccs. of commercial anhydrous ethyl alcohol and allowed to dry partially under the suction applied to the filter. The drying may be accelerated by washing the plated powder on the filter with about 50 ccs. of ether. After the partial drying, the copper-coated powder is removed from the filter, spread out so that it will dry further and then passed through a 100 mesh screen so that clusters of particles are broken up.

The thickness of the copper coating and hence the ratio of copper to lead in the powder may be varied by changing the ratio of the copper content of the solution to the amount of lead employed. In the foregoing example, the copper content of the plated powder was approximately 63%. The plated powders may be produced by other methods. For example, lead powders may be coated with copper, deposited by electrolysis.

Care should be taken in the production and

treatment of copper-coated lead powders to prevent oxidation.

Copper-coated lead powder prepared in the aforementioned ways or by another suitable method is placed in a mold of suitable shape and compressed under a pressure which may vary from 5 to 50 tons per square inch depending upon the degree of porosity desired in the final material. In this way a coherent mass is produced.

The coherent mass is sintered in an inert or reducing atmosphere, at an elevated temperature, so as to produce a bond between adjacent particles. An atmosphere of hydrogen or nitrogen is satisfactory. The maximum temperature to which the material may be subjected without encountering sweating of the lead will depend upon the proportions of copper and lead present. I have found, for instance, that objects produced from copper-coated lead powders containing about 20% lead can be heat treated at about 900° C. without encountering a segregation of lead. Copper-plated lead powder containing 45% lead and 55% copper can be heated to 750° C. without the occurrence of lead segregation. Generally speaking, the sintering temperature lies between the melting point of lead (327° C.) and that of copper (1083° C.). The higher the percentage of copper present, the higher will be the maximum temperature to which the copper-coated lead powders or objects made therefrom may be subjected.

Following the sintering operation, the density of the material may be increased by cold rolling. For example, the thickness of a metal object produced from copper-coated lead powder and containing 41% lead can be decreased by 50% by cold rolling without producing undue strain upon the object, or the development of cracks. The cold rolling of the material is particularly desirable when bearings or other objects of great hardness are desired.

That copper-lead bearings and similar objects prepared in accordance with my invention do not sweat or segregate at elevated temperatures, I attribute to the fact that the metal of lower melting point is encased by a film of less fusible metal. Whatever be the explanation, the fact remains that little or no sweating or segregation occurs even when objects prepared in accordance with my invention are subjected to relatively high pressures at temperatures in excess of the melting point of the lowest melting ingredients, such as lead.

In the practice of my invention, the proportion of lead and the like to copper and the like present in a bearing is independent of the solubility and crystallization characteristics of molten mixtures of these metals, so that any desired proportion of copper to lead may be produced in bearings or other objects.

Insert bearings may be formed conveniently by welding sheets of copper-lead metal or the like onto sheets of steel, or other metal backings. Such welding is best effected by a diffusion process wherein the copper-lead sheet and the backing sheet are placed in juxtaposition, compressed together and heated for a considerable time at a relatively elevated temperature. The speed and quality of welding increases as the temperature or pressure or both increases. At temperatures below the melting point of lead (327° C.) diffusion welding is practically impossible. For this reason, even if it were possible to produce commercially satisfactory copper-lead bearing metal

from mixtures of copper and lead powders or from lead-coated copper powders, diffusion welding under the necessary conditions of temperature would cause a sweating out of lead. However, when bearing metal produced from copper-coated lead powder in accordance with my invention is employed, diffusion welding furnishes a convenient means of fastening the bearing metal to the backing. Temperatures considerably in excess of the melting point of lead may be employed without causing lead segregation.

The backing sheet for the manufacture of insert bearings may be of any convenient metal. Copper, bronze and steel sheets have been proved satisfactory. Both the backing sheet and the copper-lead sheet should be carefully cleaned. Several modifications of diffusion welding for bonding the lead-copper metal to the backing sheet have proved satisfactory. Thus, for example, carefully cleaned copper or bronze backing sheets may be placed in juxtaposition with copper-lead sheets produced in accordance with my invention, and held in contact with each other under moderate compression. The juxtaposed sheets may then be heated in an atmosphere of hydrogen to temperatures lying between the melting points of lead and copper (327° C. to 1083° C.). At these high temperatures the high diffusion rate between the backing sheet and the sheet produced from copper-coated lead powders permits the establishment of an intimate bond even though no additional bonding agent is used.

In accordance with another modification of my invention, the copper-lead sheet is rolled under slight pressure on a copper or bronze backing sheet which has been previously roughened by electro-plating, sand-blasting or by fusing a thin layer of copper powder of a mesh coarser than 100 onto the sheet. Following rolling, the juxtaposed sheets are subjected to a temperature intermediate the melting points of copper and lead for a period which may vary from 20 minutes to several hours, or until a satisfactory diffusion weld has been obtained.

When steel backing sheets are employed, an intermediate layer of tin facilitates welding. The steel backing sheet is first cleaned and then given a thin coating of tin by dipping in molten tin. The tinned backing sheet is then disposed adjacent a sheet of copper-lead bearing metal produced in accordance with my invention, and heated to a temperature in excess of 450° C. in a reducing atmosphere. At this temperature tin is melted and a good diffusion weld is obtained.

It is also possible to sweat the bearing metal onto the backing by heating the tinned steel backing sheet to 450° C. in a reducing atmosphere of, for example, hydrogen gas, and thereafter pressing the copper-lead bearing metal sheet onto the backing. If desired, bronze or copper backing sheets may also be tinned prior to welding on the bearing metal.

I have found that the production of a diffusion weld between the bearing metal and the backing strip, whether it be of tinned steel, bronze, copper, or other metal of relatively high melting point, may be facilitated in the following manner:

In the production of the sheet of bearing metal a thin layer of copper powder is disposed adjacent the copper-coated lead powder in the mold, and the two layers are then compressed and sintered together. In the subsequent welding of the bearing metal sheet to the backing, the surface formed by the copper powder is placed adjacent the backing metal. Apparently, the pure

copper layer diffuses more easily with the backing than the copper-lead layer. In any event, a stronger weld is produced in this fashion.

Throughout the specification and the appended claims, I used the term "lead" to include lead alloys, tin alloys and similar materials, which have a lower melting point than copper and are not soluble in copper in all proportions. I use the term "copper" to include those metals and alloys which have a higher melting point than "lead" and similar materials and do not alloy therewith to a great degree.

I claim:

1. A process for the manufacture of metallic objects from two or more metals that do not alloy readily with each other in all proportions and have different melting points which comprises compressing and heating a mass of plated metal powders having cores of the metal having the lower melting point and coatings of the metal having the higher melting point to form a coherent mass.

2. A process for producing a metal object from two or more metals that do not alloy readily with each other in all proportions and have substantially different melting points which comprises compressing a mass of metal powders the particles of which have cores of the metal having the lower melting point and coatings of the metal having the higher melting point to form a coherent mass and then sintering the coherent mass.

3. A method of producing metallic objects from two or more metals which do not alloy readily with each other in all proportions and that have different melting points which comprises compressing and heating a mass of plated powders having cores of the metal of the lower melting point and coatings of the metal having the higher melting point to form a coherent mass, the temperature of the heat treatment being intermediate the melting points of the metals forming the core and the coating of the plated powders.

4. In the manufacture of metallic objects from a plurality of metals at least two of which do not alloy with each other in all proportions and have substantially different melting points the improvement which comprises compressing a mass of metal powders the particles of which are coated with a metal having a higher melting point than the metal of the core of the particles to form a coherent mass, and then sintering the coherent mass at a temperature intermediate the melting points of the metals constituting the core and the coating of the particles.

5. In the manufacture of laminated metal objects in which at least one of the lamina contains metals which do not alloy readily with each other in all proportions and have different melting points, the improvement which comprises forming said lamina by compressing plated metal powders having cores of the metal having the

lower melting point and coatings of the metal having the higher melting point, the metal of the cores and the coatings being such that they do not alloy readily with each other, disposing the lamina thus formed adjacent a second lamina, and subjecting the laminae thus disposed to pressure and to a temperature intermediate the melting points of the metals forming said cores and said coatings until the adjacent laminae are welded together.

6. Process according to claim 5 wherein the lamina formed from the plated metal powders is coated on at least one side with metal powders corresponding to the metal of the plating on the powders, said coated side being disposed adjacent the second lamina during the subsequent pressure and heat treatment to facilitate the welding of the two laminae together.

7. In the manufacture of laminated metal objects having at least one lamina in which metals that do not alloy with each other in all proportions and have substantially different fusion points are combined, the improvement which comprises compressing a mass of plated metal powder having cores of the more fusible metal and coatings of the less fusible metal to form a coherent layer, and sintering the compressed layer in juxtaposition with a metal backing at a temperature above the melting point of the metal comprising the cores of the particles until a firm bond is formed.

8. In the manufacture of metal objects containing copper and lead, the improvement which comprises compressing and sintering lead powders coated with copper to form a coherent mass.

9. In the manufacture of metal objects containing copper and lead, the improvement which comprises compressing to form a coherent mass lead powders that have been coated with copper and then sintering the coherent mass at a temperature above the melting point of lead and below the melting point of copper.

10. In the manufacture of laminated metal objects containing copper and lead the improvement which comprises compressing lead powders that have been coated with copper to form a coherent mass and then compressing and sintering the coherent mass in juxtaposition with a layer of metal until a firm bond has formed between the coherent mass and the layer of metal.

11. A metal object comprising compressed and sintered metal powders having cores of relatively low melting point metal and coatings of relatively high melting point metal, the low melting point metal and the high melting point metal being such that they do not alloy with each other in all proportions.

12. A metal object comprising a coherent mass of compressed and sintered copper-coated lead powders.

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