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[54] **IRON POWDER INFILTRANT**

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[58] **Field of Search**..........75/0.5 R, 0.5 B, 153, 159, 75/161; 29/182.1, 182.5

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[57] **ABSTRACT**

Infiltrant and process for using same for impregnating iron and iron base alloy powder compacts, said infiltrant being an atomized cupreous alloy powder composition containing at least 85 percent by weight of copper and having iron, manganese, aluminum and nickel as essential alloying components thereof. Carbon and lubricant may be incorporated therein as optional ingredients.

10 Claims, No Drawings

IRON POWDER INFILTRANT

This invention relates to infiltrants for impregnating metal powder compacts and relates more particularly to new and novel atomized cupreous alloy powder infiltrants which may be advantageously used for impregnating iron and iron base alloy powder compacts.

BACKGROUND OF THE INVENTION

Infiltrating iron and iron base alloy powder compacts with other metals and alloys having a melting point lower than that of iron is a well established practice in powder metallurgy, the purpose thereof being to increase the density and strength of the porous iron skeleton. Infiltration is effected either by dipping or fully immersing the porous iron compact in the molten infiltrant or by the more commonly used procedure of either bringing the unsintered or previously sintered porous iron powder compact into contact with the solid infiltrant as by placing the infiltrant in powder, powder compact, or other suitable form on the surface of the porous iron compact and heating the assembly to a temperature between the melting point of the infiltrant and iron powder compact. In all these procedures, the voids of the porous iron powder compact become substantially filled with the infiltrant metal by the action of the capillary forces thereby enhancing the density and strength of the resulting iron powder skeleton.

In the so-called "two step process" the iron powder compact is first sintered in the absence of infiltrant and then a sufficient amount of the infiltrant is suitable form is placed thereon. The composite is then heated to a temperature sufficient to melt the infiltrant and impregnate the sintered iron powder compact. The more commonly used so-called "one step process," also sometimes referred to as "sintration," involves essentially the same procedure except that the iron powder compact is not previously sintered in the absence of the infiltrant. In this process, the green compact with infiltrant on its surface is heated to a temperature sufficient to effect sintering of the iron and also cause the infiltrant to melt and impregnate the iron compact in a single operation.

It is essential that the infiltrant used in either of the aforementioned one or two step processes possess a melting point below the melting point of iron and that it impart to the sintered iron powder compact the prerequisite increase in density and strength sought to be achieved by infiltration. Commercial use considerations make it highly desirable that the infiltrant also (a) not be unduly costly, (b) not occasion heavy erosion, i.e., pitting of the porous iron skeleton surface, (c) not leave excessive infiltrant residue, (d) not result in a strongly adhering residue requiring costly removal treatment, (e) not be overly temperature sensitive so as to become too fluid within the range of furnacing temperature ordinarily used thereby causing infiltrant run-off, (f) not result in undue loss of infiltrant due to vaporation of one or more of its constituents at furnacing temperatures, and (g) not cause the iron powder skeleton to become adhered to its supporting surface in the course of infiltration. Moreover, the infiltrant in compacted form should possess adequate green strength and otherwise lend itself to effective use at the commonly used furnacing temperatures for infiltrating iron powder compacts, said temperature usually ranging between 2,010° to 2,050° F. or thereabouts.

It is a principal object of the present invention to provide new and novel infiltrant compositions which meet the aforementioned requirements for a satisfactory infiltrant for iron and iron base alloy powder compacts. It is another object of this invention to provide an improved process for impregnating iron and iron base alloy powder compacts whereby practically no erosion of the infiltrated skeleton takes place and the resulting infiltrant residue does not adhere to the skeleton surface. Further objects and advantages of the present invention will become apparent from the detailed description hereinafter presented.

THE PRIOR ART

Known infiltrants for iron and iron base alloy powder compacts include copper powder and a variety of cupreous alloy powder compositions and powder blends including brass, bronze, copper-iron, copper-iron-manganese, copper-iron-manganese-aluminum, copper-cobalt and copper-cobalt-zinc, among others. While some of the known cupreous alloy powder infiltrant compositions as, for example, those containing cobalt possess the attribute of leaving no residue, such infiltrant powder compositions are relatively costly and result in the production of a somewhat rough skeleton surface. Such infiltrant powders also possess relatively low green strength and further tend toward excessive fluidity especially at the higher furnacing temperatures. Excessive fluidity of the infiltrant composition during furnacing not only causes infiltrant losses and sticking of the iron powder compact to its support but also usually necessitates more frequent furnace cleaning occasioned by deposition of volatile components on the furnace walls.

Of the known infiltrants of the type that ordinarily leave a residue, cupreous powder infiltrant compositions containing iron and manganese have been rather widely used in commercial practice in recent years. The heretofore used infiltrants of this type, however, have the drawback of causing substantial erosion, i.e., pitting of the surface of the iron or iron base alloy powder skeleton. Further, all such residue leaving infiltrant powder compositions have the detrimental characteristic of leaving a rather strongly adhering residue on the surface of the impregnated skeleton necessitating brushing, grinding or other treatment for its removal. There is a definite need in the industry for improved infiltrant powder compositions which can be made available at relatively low cost and which overcome or minimize the problems attributable to skeleton erosion and adhering of the infiltrant residue to the skeleton surface.

SUMMARY OF THE INVENTION

The present invention provides atomized powder infiltrant compositions containing at least 85 percent and preferably a minimum of 90 percent by weight of copper, said copper containing iron, manganese, aluminum and nickel, in the amounts hereinafter specified, as essential alloying components. Carbon, preferably as graphite, and lubricant of the type hereinafter specified may be additionally included as optional ingredients, it being preferable to include the same in intimate admixture with the atomized cupreous alloy powder infiltrant. The use of the atomized cupreous alloy powder infiltrant compositions of this invention enables improvements in the process for impregnating iron powder and iron base alloy powder compacts whereby erosion of the infiltrated skeleton is minimized and the infiltrant residue is non-adhering.

TECHNICAL DISCLOSURE OF THE INVENTION

Infiltrant alloy powder compositions within the scope of the present invention contain, on a weight basis, 2 to 7 percent iron, 1 to 7 percent manganese, 0.1 to 0.6 percent aluminum, 0.3 to 4 percent nickel and the balance copper and incidental impurities. Preferred infiltrant alloy powder compositions in accordance with the present invention, however, contain from 4 to 6 percent iron, 1.2 to 3 percent manganese, 0.2 to 0.4 percent aluminum, 0.4 to 2 percent nickel, balance copper. A representative infiltrant alloy powder composition contains approximately 5 percent iron, 1.5 percent manganese, 0.3 percent aluminum, 0.6 percent nickel, balance copper. Carbon and lubricant, when included, may be added in amounts ranging from about 0.2 to about 1.5 percent and from about 0.5 to about 1.5 percent by weight, respectively, with the use of about 0.5 percent graphite and about 1 percent lubricant being generally preferred.

For avoiding erosion of the skeleton and adherence of the infiltrant residue to the skeleton, it has been found important, particularly when infiltrating under furnacing conditions having a dew point exceeding 25° F., that the content of manganese and nickel in the cupreous alloy infiltrant powder be controlled such that a ratio of from 1:1 to 4:1 manganese to nickel is maintained, it being preferred, however, to maintain said ratio between 2:1 and 3:1 and optimally at about 2.5:1 manganese to nickel.

The atomized cupreous alloy powder infiltrants of this invention may be made using conventional atomization techniques and equipment for the making of metal and/or alloy powders. Water atomization employing an inert or reducing protective atmosphere has been found to produce satisfactory results. The particle size range of the atomized infiltrant alloy powder of from less than 60 mesh to minus 325 mesh (U.S. Standard Mesh) with about 40 percent being below 325 mesh has been found satisfactory by way of providing desirable flow characteristics to the powder whereby its being processed into green compacts is facilitated.

In making the atomized cupreous alloy powder infiltrant, the desired content of the various alloying ingredients may be added, with stirring, to the molten copper using elemental iron, manganese, aluminum and nickel in powder or any other suitable form. If desired, one or more master alloys such as copper-iron, manganese-nickel, ferro-manganese and the like may also be used in appropriate quantities. The resulting atomized cupreous alloy powder obtained by water atomization, suitably in a nitrogen atmosphere, is then dewatered and dried at about 1,000° F., in a reducing atmosphere. Carbon and lubricant, if included, may be incorporated by blending or otherwise admixing the same in desired amounts with the dried atomized cupreous alloy powder.

As previously indicated, it is not essential that graphite or other carbonaceous material be included in admixture with the infiltrant powder since there are some applications of the infiltrant powder composition of the present invention wherein carbon may be omitted. Similarly, the incorporation of lubricant directly in admixture with the atomized cupreous alloy powder is not essential but its inclusion is preferable not only for reducing friction of die walls during subsequent compaction of the infiltrant powder but also for enhancing the green strength of the infiltrant compacts. Various lubricants of the type commonly used for die lubricating purposes may be used as, for example, zinc stearate, lithium stearate, stearic acid, among others, may be used, it being preferred, however, to use a finely divided powder type lubricant such as ethylenediamine-bis-stearamide (sold by the manufacturer, Nopco Chemical Company under the trademark NOPCOWAX 22 DS).

The atomized cupreous alloy powder compositions so prepared have a melting point generally between 1,980° to 2,000° F. or thereabouts and may be used in powder form for some infiltrating applications. For making green compacts in which form infiltrants are more commonly used, the atomized and dried cupreous alloy powder is compacted into round, rectangular or other shape of desired size using conventional powder metallurgy compaction equipment and techniques. The resulting green compact is then ready for use in impregnating porous iron powder compacts using either the aforementioned sintration or two step processes, the infiltration being effected by furnacing at temperatures generally between 2,010° and 2,050° F. or thereabouts using a reducing atmosphere consisting, for example, of hydrogen, carbon monoxide, dissociated ammonia, endothermic gas, exothermic gas or the like, including mixtures thereof. Infiltration tests using the infiltrant compositions of the present invention gave no visible signs of skeleton erosion and, in each instance, the infiltrant residue left on the skeleton was non-adhering and readily removable, i.e., simply fell off.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention comprises an atomized cupreous alloy powder infiltrant composition containing 5 percent iron, 1.5 percent manganese, 0.3 percent aluminum, 0.6 percent nickel and the balance copper with its incidental impurities, said atomized cupreous alloy powder being made by water atomization at 2,700°–2,800° F. using an inert atmosphere of nitrogen followed by dewatering and drying at about 1,000° F. in a hydrogen or other reducing atmosphere. The resulting atomized powder of particle size ranging from less than 60 to below 325 mesh with about 65 percent thereof being −200 mesh and about 40 percent being below 325 mesh had an apparent density of 3.4 grams per cubic centimeter. Graphite and ethylenediamine-bis-stearamide lubricant were incorporated by blending 0.5 and 1 percent by weight, respectively, with the atomized and dried cupreous alloy powder. Compacts made using a compaction pressure of 30 t.s.i. possessed green density values in excess of 7 grams per cubic centimeter and green strength values of at least 1,000 p.s.i.

Infiltration tests with iron powder compacts containing 1 percent by weight of carbon and compacted to a density of 6.1 grams per cubic centimeter into the form of standard transverse rupture bars weighing 15.7 grams were conducted utilizing 20 and 25 percent by weight of similarly shaped compacted infiltrant. One step infiltration was used with furnace temperatures being varied from 2010° to 2050° F. and infiltration time from 5 to 20 minutes. Different furnace atmospheres including hydrogen, endothermic gas, exothermic gas and dissociated ammonia were separately used in the infiltration tests with the dew point being maintained at 25°–30° F. in accordance with usual infiltration practice. Infiltration results using higher dew points up to 60° F. also proved entirely satisfactory.

In each of the tests, the infiltrant effectively penetrated the iron powder compact without causing any visible erosion of the skeleton. The infiltrant residue amounting to 10 to 15 percent of the amount of infiltrant used fell off easily with no brushing or other type of cleaning being required. Typically, the density of the skeletons was increased to about 7.3 to 7.4 grams per cubic centimeter after impregnation, the transverse rupture strength thereof was approximately 160,000 p.s.i. and a hardness of about 90 (Rockwell B) was obtained.

Examples of other infiltrant compositions within the scope of this invention are listed in Table I wherein the amounts of the various alloying ingredients contained in the cupreous alloy infiltrant are shown, the balance being copper. Infiltrant compacts made in accordance with the same procedure as used in respect of the previously described preferred embodiment and similarly containing 0.5 and 1 percent by weight of graphite and lubricant possessed green strength values therein shown. Standard transverse rupture bars (M.P.I.F.) made as previously described and impregnated using 25 percent by weight of similarly shaped compacted infiltrant using one step infiltration, a furnacing temperature between 2,010° and 2,020° F., endothermic gas furnace atmosphere with the dew point maintained between 25° and 30° F., and furnacing time of 20 minutes and tested in accordance with standard M.P.I.F. procedures yielded the transverse rupture strength values shown in the table.

TABLE I

Infiltrant composition (wt. percent)				Infiltrant green strength (p.s.i.)	Transverse rupture strength (p.s.i.) of infiltrated skeleton
Fe	Mn	Ni	Al		
5	2.5	1	0.3	1730	162,300
5	4	1	0.3	1950	160,100
5	5	2	0.3	2250	158,100
6	4	3.3	0.15	1410	155,200

While I have described particular embodiments, various modifications may obviously be made by those skilled in the art without departing from the scope of the invention as defined by the claims.

I claim:

1. An infiltrant for iron and iron-base alloy powder compacts capable, when melted in contact therewith at furnacing temperatures generally between 2,010° and 2,050° F., of infiltrating the compact without eroding the surface of said compact and leaving a non-adherent residue thereon, said infiltrant consisting essentially of an atomized cupreous alloy powder containing, on a weight basis, from 2 to 7 percent iron, 1 to 7 percent manganese, 0.1 to 0.6 percent aluminum, 0.3 to 4 percent nickel, balance copper and incidental impurities, the copper content being at least 85 percent.

2. The infiltrant composition as defined in claim **1** wherein carbon and lubricant are included as additional ingredients thereof.

3. The infiltrant composition as defined in claim **2** wherein the carbon is in the form of graphite, and the content of graphite and lubricant is from 0.2 to 1.5 percent and from 0.5 to 1.5 percent by weight, respectively.

4. The infiltrant composition as defined in claim **1** wherein the ratio of manganese to nickel is maintained between 1:1 and 4:1.

5. An infiltrant for impregnating iron and iron base alloy powder compacts, said infiltrant comprising an atomized cupreous alloy powder having a minimal copper content of 90 percent by weight, and containing on a weight basis from 4 to 6 percent iron, 1.2 to 3 percent manganese, 0.2 to 0.4 percent aluminum and 0.4 to 2 percent nickel as essential alloying components thereof, the manganese and nickel being within the ratio from 2:1 to 3:1 manganese to nickel.

6. The infiltrant defined in claim **5** wherein carbon and lubricant are included as additional ingredients in intimate admixture therewith.

7. The infiltrant as defined in claim **6** wherein carbon is in the form of graphite and the lubricant is ethylenediamine-bis-stearamide the amounts thereof being about 0.5 and about 1 percent by weight, respectively.

8. An infiltrant for iron and iron base alloy powder compacts comprising an atomized cupreous alloy powder, said alloy powder, on a weight basis, consisting essentially of about 5 percent iron, about 1.5 percent manganese, about 0.3 percent aluminum, about 0.6 percent nickel and the balance copper and incidental impurities.

9. The infiltrant as defined in claim **8** wherein about 0.5 percent by weight of graphite and about 1 percent by weight of lubricant are contained therein as additional ingredients.

10. The infiltrant as defined in claim **9** wherein the cupreous alloy powder in admixture with graphite and lubricant is in the form of green compacts.

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