

SINTERED ALLOY MATERIAL AND PROCESS FOR
THE PREPARATION OF THE SAME

Background of the Invention

Field of the Invention

The present invention relates to a sintered alloy material and a process for the preparation of the same. Particularly, it provides a sintered alloy material which is excellent in strength, corrosion resistance and fitness, i.e. adaptability, with a mating member such as a shaft and exhibits a low coefficient of friction, thus having performance suitable for use as a bearing material and a process for the preparation of the same.

As described above, the present invention is applicable to sintered alloy materials including oil-impregnated sintered bearings and the preparation thereof.

Description of the Prior Art

JIS B 1581-1976 prescribes for an oil-impregnated sintered bearing. Particularly, it prescribes in detail for various bearings including those of cylindrical, flanged cylindrical and spherical shapes which are applicable to domestic electrical appliances, sound facilities, business machines, agricultural machines, automobiles and other cargo-transporting or handling

machines. Further, it also contains description on bearing materials and representative examples thereof including pure iron, iron-copper, iron-carbon, iron-copper-carbon, iron-copper-lead, bronze, copper and lead-bronze alloys.

Further, Japanese Patent Laid-Open No. 51554/1981 discloses a bearing material obtained by sintering a green compact comprising powdered iron and powdered brass. Furthermore, it has been proposed in Japanese Patent Laid-Open NO. 200927/1985 by the inventors of the present invention to sinter a green compact comprising powdered iron, powdered brass and powdered nickel silver in a reducing atmosphere.

The above oil-impregnated sintered bearings comprising iron as a major component are poor in their fitness with a mating member and corrosion resistance. so that the application thereof is limited, though they are excellent in skeletal strength to be suitable for use under a high load.

On the contrary, the above oil-impregnated sintered bearings comprising copper or bronze as a major component are too poor in strength to be used under a high load, though they are excellent in the fitness and corrosion resistance.

Although the above oil-impregnated sintered

bearings comprising iron and copper (including iron-copper-lead alloys and iron-copper-carbon alloys) exhibit characteristics which are intermediate between those of the above two kinds of bearings, they are yet insufficient in strength and corrosion resistance.

The bearing of the Japanese Patent Laid-Open No. 51554/1981 prepared by using a green compact comprising iron and brass is poor in strength and fitness with a mating member, though it is excellent in corrosion resistance.

Further, the Japanese Patent Laid-Open No. 200927/1985 aims at attaining a sufficient improvement in the corrosion resistance and lowering in the coefficient of friction by the additional use of nickel silver, while securing the strength. However, the resulting bearing is not always satisfactory in these characteristics, particularly in the fitness with a mating member such as a shaft.

The present invention provides:

A sintered alloy material comprising 20 to 80% by weight of iron, 11 to 52% by weight of copper, 6 to 32% by weight of zinc, 0.1 to 0.8% by weight of tin, 0.1 to 4.0% by weight of manganese and 0 to 4.0% by weight of aluminum and having a porosity of 15 to

28% by volume;

a sintered alloy material comprising 20 to 80% by weight of iron, 11 to 51.7% by weight of copper, 6 to 32% by weight of zinc, 0.1 to 0.8% by weight of tin, 0.1 to 4.0% by weight of manganese, 0 to 4.0% by weight of aluminium and 0.5 to 5.0% by weight of one or more solid lubricants such as graphite, molybdenum disulfide or lead and having a porosity of 15 to 28% by volume; a process for the preparation of sintered alloy material which comprises adding 25 to 400 parts by weight of powdered manganese bronze comprising 30 to 40% by weight of zinc, 0.5 to 5% by weight of manganese, 0.3 to 1.0% by weight of tin, 0 to 5.0% by weight of aluminium and the balance of copper and unavoidable impurities to 100 parts by weight of powdered iron, compacting the obtained powder mixture, sintering the obtained green compact and sizing the sintered compact so as to give a porosity of 15 to 28% by volume, and

a process for the preparation of a sintered alloy material which comprises adding 17.7 to 387.8 parts by weight of powdered manganese bronze comprising 30 to 40% by weight of zinc, 0.5 to 5.0% by weight of manganese, 0.3 to 1.0% by weight of tin, 0 to 5.0%

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by weight of aluminum and the balance of copper and unavoidable impurities and 0.5 to 5.3 parts by weight of one or more solid lubricants such as graphite, molybdenum disulfide or lead to 100 parts by weight of powdered iron, compacting the obtained powder mixture, sintering the obtained green compact and sizing the sintered compact so as to give a porosity of 15 to 28% by volume.

Detailed Description of Preferred Embodiments

The sintered alloy material according to the present invention comprises 20 to 80% by weight of iron, 11 to 52% by weight of copper, 6 to 32% by weight of zinc, 0.1 to 0.8% by weight of tin, 2 to 4.0% by weight of aluminum and 0.1 to 4.0% by weight of manganese. Owing to this restriction on the composition, the material is improved in corrosion resistance and strength, while keeping the fitness with a mating member at a high level. That is, high-strength manganese bronze is formed among iron powder particles by the addition of manganese, aluminum and tin in proper amounts to thereby improve the corrosion resistance without lowering the fitness with a mating member.

If the iron content is less than 20% by weight, the skeletal strength due to iron particles will not be

obtained sufficiently and the use of large amounts of other components will be necessary resulting in an enhanced cost. On the contrary, if the iron content exceeds 80% by weight, the coefficient of friction will be enhanced, while the corrosion resistance will be remarkably lowered.

The sintered material according to the present invention contains at least 11.0% by weight of copper to thereby secure excellent fitness. Further, the copper content is also limited to 52% by weight or below to lower the cost.

The sintered material according to the present invention contains at least 6% by weight of zinc, which is coupled with copper, manganese, aluminum and tin to secure high corrosion resistance. The zinc content is also limited to 32.0% by weight or below to secure suitable fitness. Further, the material of the present invention contains at least 0.1% by weight of manganese to thereby enhance the strength and corrosion resistance efficiently. The manganese content is also limited to 4.0% by weight or below, so that excellent fitness is secured, while the increase in the coefficient of friction is depressed.

The powder mixture comprising the above components is compacted, sintered and sized so as to give a

porosity of at least 15% by volume. The sized compact thus obtained can be impregnated with a suitable amount of oil to exhibit improved lubricating properties. The porosity is also limited to 28% by volume or below to secure high strength.

The material of the present invention may contain at least 0.5% by weight of one or more solid lubricants such as graphite, molybdenum disulfide or lead for the purpose of enhancing the lubricating properties and reducing the coefficient of friction. The content thereof is also limited to 5.0% by weight or below to thereby secure high strength.

According to the present invention, copper, zinc, manganese, aluminum and tin are simultaneously added as manganese bronze powder comprising 30 to 40% by weight of zinc, 0.5 to 5.0% by weight of manganese, 0.3 to 1.0% by weight of tin, 0 to 5.0% by weight of aluminum and the balance of copper and unavoidable impurities. This method of adding manganese bronze powder overcomes a trouble of separately preparing these components and successively adding them and prevents the segregation of each component to permit the homogeneous mixing of the components and the easy formation of a sinter of a homogeneous structure. Accordingly, the sinter thus obtained exhibits

characteristics by virtue of the high-strength copper alloy formed among iron particles.

According to the present invention, iron powder and high-strength copper alloy powder (i.e., manganese bronze) can be suitably sintered at 800 to 950°C.

The sintering of a green compact is preferably carried out in a state wherein the green compact is placed in a heat-resistant container kept apart from its bottom and the container is closed, so that the loss of zinc by evaporation is prevented and a homogeneous sintered structure can be formed.

According to the present invention, the sinter is sized so as to give a porosity of at least 15% by volume. Thus, an article containing pores suitable for oil impregnation dispersed therein can be obtained to permit the formation of a bearing having preferred lubricating properties. The porosity is also limited to 23% by volume or below, so that a suitable radial crushing strength coefficient is secured and the scattering or run-off of impregnating oil is prevented.

Particular embodiments according to the present invention will now be described in more detail. The present invention relates to a sintered alloy substantially comprising iron, copper, zinc and manganese. Although these components may be

separately prepared, as described above, they may be prepared as an alloy. For example, a combination of a manganese-aluminum alloy powder with brass powder and iron powder and a combination of 95 to 98 Mn alloy powder with brass powder and iron powder can be used. Particularly, it is preferred to use pure iron powder and manganese bronze powder as raw materials.

According to the present invention, the iron content is generally 20 to 80% by weight, preferably 30 to 60% by weight, still preferably 40 to 55% by weight.

The copper content is generally 11 to 52% by weight, preferably 25 to 50% by weight, still preferably 35 to 45% by weight.

The zinc content is generally 6 to 32% by weight, preferably 8 to 25% by weight, still preferably 10 to 25% by weight.

The manganese content is generally 0.1 to 4.0% by weight, preferably 0.5 to 2.0% by weight.

According to the present invention, the manganese bronze described in Table 2 of JIS H 2205 containing at most 5% by weight of aluminum may be used so as to give an article containing at most 4.0% by weight thereof. The strength and other characteristics of the sintered material according to the present

invention are not particularly affected by the presence of such an amount of aluminum, so that the material may contain substantially no aluminum.

The compaction is generally carried out under a load of about 2 to 3 ton/cm² and the porosity of the obtained green compact is 22 to 35% by volume. If the porosity of the green compact is less than 22% by volume, it will be difficult to size the green compact so as to give an article having a porosity suitable for oil impregnation. On the contrary, a green compact having a porosity exceeding 35% by volume tends to break or chip off during sintering.

The sintering is carried out at 800 to 950°C in a reducing atmosphere. As described above, from the standpoint of preventing the evaporation of zinc, it is preferred to carry out the sintering in a closed heat-resistant container. Of course, the sintering may be carried out in a state buried in carbon powder. Further, the evaporation of zinc during sintering can be prevented by the presence of tin in the above manganese bronze powder.

It is of a usual practice to add a solid lubricant such as graphite or molybdenum disulfide as a powder. However, a solid lubricant such as graphite has a smaller specific gravity than that

of any of iron powder and manganese bronze powder, so that it is difficult to homogeneously disperse such a solid lubricant in the other powdery materials merely by mixing and the graphite powder comes to the surface or is localized in the transportation, feeding into a press hopper or compaction to cause segregation. Therefore, it is advantageous that a solid lubricant (such as graphite) of relatively coarse powder is selected and is further subjected to classification to remove finer powders prior to its use, which has been experimentally confirmed. That is, it is preferred that the solid lubricant to be used in the present invention have a particle size of 10 to 150 μm , particularly 20 to 100 μm , though a commercially available one generally has a particle size of 1 to 30 μm or 1 to 50 μm . That is, according to the present invention, a solid lubricant obtained by ridding a coarse solid lubricant of finer particles having a size smaller than 10 μm or 20 μm is preferably used so that the homogeneous dispersion thereof is facilitated and the segregation thereof is prevented during transportation and other handling. The above finer particles having a size smaller than 10 μm or 20 μm can be effectively separated off by wet classification, without generating dust.

If necessary, the sintered alloy material according to the present invention may suitably contain other metal or alloy. For example, even when the material further contains Pb, Ni or Si in a small amount, the characteristics of the present invention are not affected adversely. Such alloys include Sn-containing brass, Al-containing brass, Pb-containing brass, Ni-containing brass, Fe-containing brass and Si-containing brass.

The green compact containing manganese bronze causes deformation, distortion and dimensional change by sintering, so that the sintered compact must be sized to obtain an article having predetermined dimensions.

Preparative Examples according to the present invention will now be described.

Preparative Example 1

Iron powder having a particle size of 100 mesh or smaller was blended with manganese bronze powder comprising 64.5% by weight of copper, 30% by weight of zinc, 5.0% by weight of manganese and 0.5% by weight of tin and having a particle size of 100 mesh or smaller in a weight ratio given in Table 1.

Table 1 (parts by weight)

	Iron powder	Manganese bronze powder
①	100 parts	400 parts
②	100 parts	100 parts
③	100 parts	25 parts
④	100 parts	150 parts

The raw materials ① to ④ shown in Table 1 were each compacted into an annular bearing and put on a gauzy material placed on the bottom of a heat-resistant box of iron, i.e., in a state apart from the bottom, and the box closed. The tubes were sintered in a reducing atmosphere of ammonia gas at 890°C for 45 minutes. The sinters thus obtained were sized to obtain articles each having a porosity of 20% by volume. The articles were vacuum-impregnated with turbine oil to obtain oil-impregnated bearings.

Separately, comparative bearings (A) and (B) having the same porosity as the one described above were prepared by using iron alone or a mixture comprising 50% of iron powder and 50% of brass powder, respectively. The bearings ① to ④ and the comparative bearings (A) and (B) were examined for radial crushing strength constant, coefficient of friction and temperature

rise caused by continuous rotation with a PV value of $1000 \text{ kgf/cm}^2 \cdot \text{m/min}$ for 40 minutes. The results are shown in Table 2.

Table 2

		Radial crushing strength constant (kg/cm^2)	Coefficient of friction	Temperature rise caused by continuous rotation ($^{\circ}\text{C}$)
Bearing of the present invention	①	27	0.074	20.7
"	②	30	0.076	20.8
"	③	34	0.086	27.9
"	④	30	0.072	22.6
Comparative bearing	Ⓐ	36	0.10	31.0
"	Ⓑ	21	0.08	21.6

The bearings ① to ④ according to the present invention and the comparative bearings Ⓐ and Ⓑ were also examined for the corrosion resistance at a humidity of 80% and 60°C to determine the time which has elapsed until the generation of rust is observed. The results are shown in Table 3.

Table 3

	Time which has elapsed until rust is observed (days)
Bearing of the present invention ①	120 or above
" ②	78 or above
" ③	50 or above
" ④	70 or above
Comparative bearing (A)	6
" (B)	60 or above

It can be understood from the above results that the bearings according to the present invention are all excellent in strength and bearing properties and are remarkably improved in corrosion resistance for their content of copper alloy.

Preparative Example 2

The same procedure as the one described in Preparative Example 1 was repeated by using the same raw materials as those shown in the column ② of Table 1 except that graphite powder was further added in an amount of 2% by weight (outer percentage).

The bearing thus obtained exhibited a coefficient of friction of 0.057, which reveals that the bearing

is extremely excellent in lubricating properties. Further, it exhibited a radial crushing strength constant of 38 kg/mm^2 , which reveals that it is also excellent in strength.

Preparative Example 3

100 parts by weight of the same iron powder as that used in Preparative Example 1 was blended with 150 parts by weight of manganese bronze comprising 63.5% by weight of copper, 29.5% by weight of zinc, 4.8% by weight of manganese, 0.5% by weight of tin and 1.7% by weight of aluminum and having a particle size of 100 mesh or smaller. The obtained mixture was compacted, sintered and sized in a similar manner to that described in Preparative Example 1 to obtain an article having a porosity of 20%. This article was vacuum-impregnated with turbine oil to obtain an oil-impregnated bearing. This bearing exhibited a radial crushing strength constant of 29.8 kg/mm^2 , a coefficient of friction of 0.073 and temperature rise caused by continuous rotation of 22.2°C , which reveals that it is excellent as an oil-impregnated bearing.

As described above, the present invention provides a sintered alloy material which is excellent in strength, corrosion resistance and fitness with

a mating member such as a shaft at a low cost and a relatively simple process for the preparation of the same. Thus, the present invention is industrially valuable.

CLAIMS

1. A sintered alloy material comprising from 20 to 80% by weight of iron, from 11 to 52% by weight of copper, from 6 to 32% by weight of zinc, from 0.1 to 0.8% by weight of tin, from 0.1 to 4.0% by weight of manganese and from 0 to 4.0% by weight of aluminium and having a porosity of from 15 to 28% by volume.

2. A sintered alloy material comprising from 20 to 80% by weight of iron, from 11 to 51.7% by weight of copper, from 6 to 32% by weight of zinc, from 0.1 to 0.8% by weight of tin, from 0.1 to 4.0% by weight of manganese, from 0 to 4.0% by weight of aluminium and from 0.5 to 5.0% by weight of one or more solid lubricants and having a porosity of from 15 to 28% by volume.

3. A sintered alloy material as claimed in claim 2, wherein the solid lubricants are selected from the group consisting of graphite, molybdenum disulphide and lead.

4. A process for the preparation of the sintered alloy material of claim 1, which comprises adding 25 to 400 parts by weight of manganese bronze powder comprising from 30 to 40% by weight of zinc, from 0.5 to 5% by weight of manganese, from 0.3 to 1.0% by weight of tin, from 0 to 5.0% by weight of aluminium and the balance of copper and unavoidable impurities to 100 parts by weight of iron powder, compacting the obtained mixture, sintering the obtained green compact and sizing the sintered compact so as to give a porosity of from 15 to 28% by volume.

5. A process for the preparation of a sintered alloy material as claimed in claim 4, wherein the green compact is sintered in a reducing atmosphere at 800 to 950°C in a closed heat-resistant container.



6. A process for the preparation of the sintered alloy material of claim 2 or claim 3, which comprises adding 17.7 to 387.8 parts by weight of manganese bronze powder comprising from 30 to 40% by weight of zinc, from 0.5 to 5% by weight of manganese, from 0.3 to 1.0% by weight of tin, from 0 to 5.0% by weight of aluminium and the balance of copper and unavoidable impurities and from 0.5 to 5.3 parts by weight of one or more solid lubricants to 100 parts by weight of iron powder, compacting the obtained mixture, sintering the obtained green compact and sizing the sintered compact so as to give a porosity of from 15 to 28% by volume.

7. A process for the preparation of a sintered alloy material as claimed in claim 6, wherein the green compact is sintered in a reducing atmosphere at 800 to 950°C in a closed heat-resistant contained kept apart from its bottom.

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