

DESCRIPTION

IRON/COPPER COMPOSITE POWDER FOR POWDER METALLURGY AND PROCESS FOR PRODUCING THE SAME

5

TECHNICAL FIELD

The present invention relates to iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component to be used as powder-metallurgical raw powder in producing oil-impregnated sintered bearings and the like, as well as to the process for producing such iron/copper composite powder for powder metallurgy.

BACKGROUND ART

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Conventionally, copper-coated iron powder is being used as the powder-metallurgical raw powder for oil-impregnated sintered bearings and the like for use in IT-related devices and in-car electric devices. Iron plays the primary role regarding the strength of the bearing, and copper plays the role in corrosion resistance and abrasion resistance. Recently, there are demands of increasing the ratio of copper in the copper-coated iron composite powder in order to increase the abrasion resistance and corrosion resistance.

In the foregoing case, if the copper ratio is simply increased, the amount of iron will decrease by just that much, and the strength will decrease as a matter of course. The strength of the powder-metallurgical raw material is generally evaluated by the degree of the radial crushing strength, and it is necessary to improve this radial crushing strength.

As other problems, it is also necessary to achieve high apparent density and possess fluidity in order to improve the compactibility or sinterability of the powder-metallurgical raw material.

As conventional technology, Patent Document 1 discloses a method of pre-machining the powder obtained by coating iron powder with copper, and thereafter performing sintering thereto. Moreover, Patent Document 2 discloses

technology of increasing the copper ratio by additionally mixing copper powder to the copper-coated iron powder in which the surface of iron is coated with copper, and exposing the iron surface during the sizing process in order to improve the mechanical strength and durability.

5 Nevertheless, the former employs a special sintering method of performing machining prior to sintering, and is not a common method. The latter has the same object in increasing the amount of copper, and, although the strength of the surface portion where iron is exposed (primarily considered to be abrasion resistance) may increase, improvement in the strength of the sintered compact itself cannot be sought.

10 In light of the above, although attempts are being made to increase the copper ratio with the copper-coated iron powder as the base component, the current situation is that fundamental problems such as the decrease in the radial crushing strength, and decrease in the fluidity and apparent density of the sintered raw powder have not been resolved, and satisfactory results have not yet been achieved.

15 [Patent Document 1] Japanese Patent Laid-Open Publication No. 2002-348601

[Patent Document 2] Japanese Patent Laid-Open Publication No. 2001-279349

DISCLOSURE OF THE INVENTION

20 Thus, in producing powder-metallurgical raw powder having copper-coated iron as its primary component to be used in oil-impregnated sintered bearings and the like, an object of the present invention is to provide powder-metallurgical composite powder having copper-coated iron powder as its primary component and the
25 production method thereof capable of improving in the fluidity and apparent density of the sintered raw powder, and in sintering characteristics such as radial crushing strength, and also reducing the cost.

In order to overcome the foregoing problems, the present inventors discovered that it is possible to improve the fluidity and apparent density of the
30 sintered raw powder of copper, and improve the radial crushing strength and other sintering characteristics in the production of powder-metallurgical composite powder having copper-coated iron as its primary component.

Based on the foregoing discovery, the present invention provides:

1) Iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component, wherein the copper content in the copper-coated iron powder is 45 to 70wt%, the apparent density is 2.2g/cm³ or more, and the flow rate is 25s/50g or less;

2) Iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component, wherein the copper content in a mixed powder of copper-coated iron powder and electrolytic copper powder is 45 to 70wt%, the apparent density is 2.2g/cm³ or more, and the flow rate is 25s/50g or less;

3) The iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component according to 1) or 2) above, wherein the specific surface area of the composite powder after sintering and pulverization measured by the BET method is 0.2m²/g or less;

4) The iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component according to any one of 1) to 3) above, wherein the copper-coated iron powder or the mixed powder of copper-coated iron powder and electrolytic copper powder is further mixed with tin powder, graphite powder and a mold lubricant;

5) The iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component according to 4) above, wherein tin powder is 3.0 to 5.0wt%, and graphite powder and a mold lubricant are 1.0wt% or less; and

6) The iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component according to any one of 1) to 5) above, wherein the iron/copper composite powder for powder metallurgy is for use in producing oil-impregnated sintered bearings.

The present invention additionally provides:

7) A process for producing iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component, wherein after iron powder is plated with copper to prepare copper-coated iron powder and copper-coated iron powder having a copper content of 45 to 70wt% is produced, the copper-coated iron powder is sintered in a reduction atmosphere at 600 to 850°C for 20 to 60 minutes, and the obtained sintered compact is pulverized and sieved to -80 mesh;

8) A process for producing iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component, wherein after iron powder is plated with copper to prepare copper-coated iron powder and a mixed powder having a copper content of 45 to 70wt% is produced by mixing electrolytic copper powder to the copper-coated iron powder, the mixed powder is sintered in a reduction atmosphere at 600 to 850°C for 20 to 60 minutes, and the obtained sintered compact is pulverized and sieved to -80 mesh;

9) The process for producing iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component according to 7) or 8) above, wherein the specific surface area of the composite powder after sintering and pulverization measured by the BET method is 0.2m²/g or less; and

10) The process for producing iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component according to any one of 7) to 9) above, wherein the mixed powder of copper-coated iron powder and electrolytic copper powder is further mixed with tin powder, graphite powder and a mold lubricant.

By using copper-coated powder or a mixed powder of copper-coated powder and electrolytic copper powder, wherein the copper content is 45 to 70wt%, the apparent density is 2.2g/cm³ or more, and the flow rate is 25s/50g or less; the powder-metallurgical composite powder of the present invention can yield superior effects of improving in compactibility of the powder such as the green density and fluidity, and in sintering characteristics such as radial crushing strength, and also reducing the cost.

BEST MODE FOR CARRYING OUT THE INVENTION

The powder-metallurgical composite powder of the present invention uses copper-coated powder or a mixed powder of copper-coated powder and electrolytic copper powder, wherein the copper content is 45 to 70wt%, the apparent density is 2.2g/cm³ or more, and the flow rate is 25s/50g or less. The use of copper-coated powder or a mixed powder of copper-coated powder and electrolytic copper powder, of which the copper content is 45 to 70wt%, yields superior effects of increasing the apparent density or the flow rate, and improving the radial crushing strength.

If the copper content is 45wt% or less, the amount of iron will increase so that the copper layer on the surface will become thin. If this is used in bearings, the copper layer will easily be ground down and iron will be exposed upon rotating the shaft, and it causes such deterioration in sliding characteristics as the occurrence of
5 seizing.

Meanwhile, if the copper content is 70wt% or more, although it is possible to produce the powder, the amount of iron will be small, and the cost reduction effect as the original purpose will deteriorate.

10 In addition, as the copper powder to be mixed with the copper-coated iron powder, electrolytic copper powder having a grain size of -100 mesh and an apparent density of 2.0 to 2.2g/cm³ is used.

Oil-impregnated sintered bearings have a porous body with pores remaining in the sintered compact among the components manufactured with the powder metallurgy process, and differ from machine parts that are manufactured so as to
15 reduce pores in the sintered compact close to zero as much as possible.

Thus, the characteristics demanded in the raw powder to be used in producing oil-impregnated sintered bearings are that it can be molded as a porous body, (1) the green compact has a green strength of a level that the compact will not be damaged until proceeding to the sintering process, and (2) the powder possesses
20 fluidity so that the powder can be easily filled into the die. The foregoing characteristics are contradictory in certain aspects, and, although it would be advantageous that the powder shape is as random as electrolytic copper powder in order to improve the green strength, this kind of shape will deteriorate the apparent density and fluidity. Contrarily, with a round shape as with atomized copper powder,
25 although this will achieve high apparent density and favorable fluidity, the green strength will deteriorate. In light of the above, it is effective to set the apparent density to 2.2g/cm³ or more.

For the production of the copper-coated iron powder, used is a plating solution fundamentally having a copper concentration of 40±10g/L, a sulfuric acid
30 concentration of 5 to 10g/L, and a chlorine concentration of 5 to 10mg/L. A required amount of reduced iron powder is added to this plating solution, and the iron powder is plated with copper by substitution reaction of iron with copper.

Copper-coated iron powder with the intended copper content can be

produced by adding iron powder in an amount commensurate with the copper amount in the plating solution. After the plating process, water washing, rust prevention treatment and drying are performed, and coarse grains are eliminated with an 80 mesh sieve.

5 Sintering treatment is performed to produce a sintered compact by placing the copper-coated iron powder alone or the powder obtained by mixing copper-coated iron powder and electrolytic copper powder and adjusting the copper amount to be a prescribed amount, into a sintering furnace, flowing hydrogen gas as the reduction atmosphere, and heating and maintaining the powder at a prescribed sintering
10 temperature. Subsequently, the sintered compact removed from the sintering furnace is pulverized with a hammer mill-type pulverizer or the like, and the pulverized powder is sieved at 80 mesh in order to eliminate coarse grains.

The present invention is characterized in that the powder is produced by sintering and pulverizing copper-coated iron powder alone or the mixed powder of
15 copper-coated iron powder and electrolytic copper powder. As a result of performing sintering and pulverization, the specific surface area can be made to be $0.2\text{m}^2/\text{g}$ or less. If the specific surface area is $0.2\text{m}^2/\text{g}$ or more, although the radial crushing strength of the sintered compact will increase, the fluidity will deteriorate because the shape is random or minute protrusions are formed on the powder surface.

20 With respect to the sintering conditions, sintering of the powder will not proceed at 600°C or less, and it will not be possible to obtain the intended apparent density. Meanwhile, if the temperature is 850°C or higher, although the sintering will progress, the sintered compact will become too hard and be difficult to pulverize. In addition, since the copper coating of the iron powder surface will peel off considerably
25 during the pulverization, it is not desirable.

With respect to the retention time, the longer it is the more the sintering proceeds, and the sintered compact will become hard. If the retention time is short, sintering will be insufficient and the apparent density will deteriorate. In case the sintering temperature is high, even if the retention time is short, approximately the
30 same apparent density can be obtained in comparison to the case of sintering for a long time at a low temperature. However, if the sintering temperature is high, this is not preferable in view of the energy cost and cooling time.

-80 mesh refers to the powder that passed through a sieve of 80 mesh

(180 μ m), and in which coarse grains of 80 mesh or more are eliminated. Pursuant to the miniaturization of bearings to be produced with composite powder as the raw material, the sieve for eliminating coarse grains can also be made finer to 100 mesh (150 μ m), 150 mesh (106 μ m), 200 mesh (75 μ m), and so on.

5 The powder may be obtained by further mixing the copper-coated iron powder or the mixed powder of copper-coated iron powder and electrolytic copper powder with tin powder, graphite powder and one or more among solid lubricants such as zinc stearate. The addition of tin will enable to utilization of the bronze powder characteristics, and the use of graphite powder or a solid lubricant such as zinc
10 stearate is effective in improving the lubricity of the sintered compact.

Desirably, when adding tin powder, 3.0 to 5.0wt% of tin powder is added in order to achieve the standard copper-tin proportion of 9:1 in the mixed powder; when adding graphite powder, 1wt% or less of graphite powder is added; and when adding a solid lubricant such as zinc stearate, 1wt% or less of the solid lubricant is added.
15 When adding a solid lubricant, there is no particular lower limit, and the lubricating function can be retained in accordance with the additive amount, thereby using it so effectively as powder for use in producing oil-impregnated sintered bearings.

[Examples]

The present invention is now explained in detail with reference to the
20 Examples. These Examples are merely illustrative, and the present invention shall in no way be limited thereby. In other words, various modifications and other embodiments based on the technical spirit claimed in the claims shall be included in the present invention as a matter of course.

(Example 1)

25 A copper sulfate plating solution having a sulfuric acid concentration of 7g/L, a chlorine concentration of 7mg/L and a copper concentration of 40g/L was used, and iron powder of -100 mesh was added to produce copper-coated iron powder. The copper coated amount was 50wt% Cu. The copper-coated iron powder was subsequently sintered in a reduction atmosphere at 650°C for 30 minutes, and then
30 pulverized.

The apparent density, flow rate, and specific surface area of the obtained composite powder were checked. The results are shown in Table 1. As shown in Table 1, the apparent density of the iron-copper composite powder of Example 1 was

2.23g/cm³, the flow rate was 22.8s/50g, and the specific surface area was 0.12m²/g. Favorable iron/copper composite powder was obtained.

In addition, 4wt% of tin powder, 0.5wt% of graphite powder and 0.5wt% (excluded from the total) of zinc stearate as a mold lubricant were added to the foregoing iron/copper composite powder, and this mixed powder was used to form 20 bearing-shaped compacts (test pieces) having an inner diameter of 10mm × outer diameter of 18mm × height of 7mm via pressure forming so that the density became 6.5g/cm³. These compacts were sintered in a reduction atmosphere at 780°C for 30 minutes. Variation (standard deviation) in the sintered density and variation (standard deviation) in the radial crushing strength were confirmed by examining the obtained sintered compact test pieces. The results are shown in Table 2. As shown in Table 2, variation in the sintered density was small and variation in the radial crushing strength was also small. Favorable results were yielded in all cases.

Incidentally, when copper-coated iron powder not added with tin powder and graphite was sintered under the same conditions as those described above, the bronze alloy layer was not formed since tin powder was not added, and the radial crushing strength tended to decrease slightly, but the variation was roughly the same.

[Table 1]

	Apparent Density (g/cm ³)	Flow Rate (s/50g)	Specific Surface Area (m ² /g)
Example 1	2.23	22.3	0.12
Example 2	2.22	23.2	0.11
Example 3	2.27	23.0	0.09
Example 4	2.27	24.6	0.15
Example 5	2.28	23.7	0.14
Example 6	2.48	22.1	0.13
Comparative Example 1	1.83	31.6	0.56
Comparative Example 2	1.92	28.5	0.18
Comparative Example 3	2.38	34.7	0.67

[Table 2]

	Standard Deviation of Sintered Density	Average Value of Radial Crushing Strength	Standard Deviation of Radial Crushing Strength
Example 1	0.008	25.2	0.29
Example 2	0.007	25.9	0.25
Example 3	0.005	26.4	0.22
Example 4	0.005	27.3	0.19
Example 5	0.005	28.2	0.12
Example 6	0.005	30.7	0.10
Comparative Example 1	0.012	25.9	0.45
Comparative Example 2	0.015	25.3	0.50
Comparative Example 3	0.018	23.9	0.70

(Example 2)

A copper sulfate plating solution having a sulfuric acid concentration of 7g/L, a chlorine concentration of 7mg/L and a copper concentration of 40g/L was used, and iron powder of -100 mesh was added to produce copper-coated iron powder. The copper coated amount was 50wt% Cu. The copper-coated iron powder was subsequently sintered in a reduction atmosphere at 700°C for 30 minutes, and then pulverized. The apparent density (g/cm^3), flow rate (s/50g), and specific surface area (m^2/g) of the obtained iron/copper composite powder were checked. The results are shown in Table 1.

As shown in Table 1, the apparent density of the iron/copper composite powder of Example 2 was $2.22\text{g}/\text{cm}^3$, the flow rate was 23.2s/50g, and the specific surface area was $0.11\text{m}^2/\text{g}$. Favorable iron/copper composite powder was obtained.

In addition, 4wt% of tin powder, 0.5wt% of graphite powder and 0.5wt% (excluded from the total) of zinc stearate as a mold lubricant were added to the foregoing iron/copper composite powder, and this mixed powder was used to form bearing-shaped compacts (test pieces) having an inner diameter of 10mm $\times$ outer diameter of 18mm $\times$ height of 7mm via pressure forming so that the density became $6.5\text{g}/\text{cm}^3$. These compacts were sintered in a reduction atmosphere at 780°C for 30 minutes. Variation (standard deviation) in the sintered density and variation (standard deviation) in the radial crushing strength were confirmed by examining the obtained sintered compact test pieces. The results are shown in Table 2. As

shown in Table 2, variation in the sintered density was small and variation in the radial crushing strength was also small. Favorable results were yielded in all cases.

Incidentally, when copper-coated iron powder not added with tin powder and graphite was sintered under the same conditions as those described above, the bronze alloy layer was not formed since tin powder was not added, and the radial crushing strength tended to decrease slightly, but the variation was roughly the same. (Example 3)

A copper sulfate plating solution having a sulfuric acid concentration of 7g/L, a chlorine concentration of 7mg/L and a copper concentration of 40g/L was used, and iron powder of -100 mesh was added to produce copper-coated iron powder. The copper coated amount was 50wt% Cu. The copper-coated iron powder was subsequently sintered in a reduction atmosphere at 750°C for 30 minutes, and then pulverized. The apparent density (g/cm^3), flow rate (s/50g), and specific surface area (m^2/g) of the obtained iron/copper composite powder were checked. The results are shown in Table 1.

As shown in Table 1, the apparent density of the iron/copper composite powder of Example 3 was $2.27\text{g}/\text{cm}^3$, the flow rate was 23.0s/50g, and the specific surface area was $0.09\text{m}^2/\text{g}$. Favorable iron/copper composite powder was obtained.

In addition, 4wt% of tin powder, 0.5wt% of graphite powder and 0.5wt% (excluded from the total) of zinc stearate as a mold lubricant were added to the foregoing iron/copper composite powder, and this mixed powder was used to form bearing-shaped compacts (test pieces) having an inner diameter of 10mm $\times$ outer diameter of 18mm $\times$ height of 7mm via pressure forming so that the density became $6.5\text{g}/\text{cm}^3$. These compacts were sintered in a reduction atmosphere at 780°C for 30 minutes. Variation (standard deviation) in the sintered density and variation (standard deviation) in the radial crushing strength were confirmed by examining the obtained sintered compact test pieces. The results are shown in Table 2. As shown in Table 2, variation in the sintered density was small and variation in the radial crushing strength was also small. Favorable results were yielded in all cases.

Incidentally, when copper-coated iron powder not added with tin powder and graphite was sintered under the same conditions as those described above, the bronze alloy layer was not formed since tin powder was not added, and the radial crushing strength tended to decrease slightly, but the variation was roughly the same.

(Example 4)

A copper sulfate plating solution having a sulfuric acid concentration of 7g/L, a chlorine concentration of 7mg/L and a copper concentration of 40g/L was used, and iron powder of -100 mesh was added to produce copper-coated iron powder. The copper coated amount was 30wt% Cu. The copper-coated iron powder and electrolytic copper powder were mixed to produce iron/copper composite powder of 60wt% Cu. The iron/copper composite powder was subsequently sintered in a reduction atmosphere at 650°C for 30 minutes, and then pulverized. The apparent density (g/cm^3), flow rate (s/50g), and specific surface area (m^2/g) of the obtained iron/copper composite powder were checked. The results are shown in Table 1.

As shown in Table 1, the apparent density of the iron/copper composite powder of Example 4 was 2.27g/cm^3 , the flow rate was 24.6s/50g, and the specific surface area was $0.15\text{m}^2/\text{g}$. Favorable iron/copper composite powder was obtained.

In addition, 4wt% of tin powder, 0.5wt% of graphite powder and 0.5wt% (excluded from the total) of zinc stearate as a mold lubricant were added to the foregoing iron/copper composite powder, and this mixed powder was used to form bearing-shaped compacts (test pieces) having an inner diameter of 10mm $\times$ outer diameter of 18mm $\times$ height of 7mm via pressure forming so that the density became 6.5g/cm^3 . These compacts were sintered in a reduction atmosphere at 780°C for 30 minutes. Variation (standard deviation) in the sintered density and variation (standard deviation) in the radial crushing strength were confirmed by examining the obtained sintered compact test pieces. The results are shown in Table 2. As shown in Table 2, variation in the sintered density was small and variation in the radial crushing strength was also small. Favorable results were yielded in all cases.

Incidentally, when copper-coated iron powder not added with tin powder and graphite was sintered under the same conditions as those described above, the bronze alloy layer was not formed since tin powder was not added, and the radial crushing strength tended to decrease slightly, but the variation was roughly the same.

(Example 5)

A copper sulfate plating solution having a sulfuric acid concentration of 7g/L, a chlorine concentration of 7mg/L and a copper concentration of 40g/L was used, and iron powder of -100 mesh was added to produce copper-coated iron powder. The copper coated amount was 30wt% Cu. The copper-coated iron powder and

electrolytic copper powder were mixed to produce iron/copper composite powder of 60wt% Cu. The iron/copper composite powder was subsequently sintered in a reduction atmosphere at 750°C for 30 minutes, and then pulverized. The apparent density (g/cm^3), flow rate (s/50g), and specific surface area (m^2/g) of the obtained iron/copper composite powder were checked. The results are shown in Table 1.

As shown in Table 1, the apparent density of the iron/copper composite powder of Example 5 was 2.28g/cm^3 , the flow rate was 23.7s/50g, and the specific surface area was $0.14\text{m}^2/\text{g}$. Favorable iron/copper composite powder was obtained.

In addition, 4wt% of tin powder, 0.5wt% of graphite powder and 0.5wt% (excluded from the total) of zinc stearate as a mold lubricant were added to the foregoing iron/copper composite powder, and this mixed powder was used to form 20 bearing-shaped compacts (test pieces) having an inner diameter of 10mm $\times$ outer diameter of 18mm $\times$ height of 7mm via pressure forming so that the density became 6.5g/cm^3 . These compacts were sintered in a reduction atmosphere at 780°C for 30 minutes. Variation (standard deviation) in the sintered density and variation (standard deviation) in the radial crushing strength were confirmed by examining the obtained sintered compact test pieces. The results are shown in Table 2. As shown in Table 2, variation in the sintered density was small and variation in the radial crushing strength was also small. Favorable results were yielded in all cases.

Incidentally, when copper-coated iron powder not added with tin powder and graphite was sintered under the same conditions as those described above, the bronze alloy layer was not formed since tin powder was not added, and the radial crushing strength tended to decrease slightly, but the variation was roughly the same. (Example 6)

A copper sulfate plating solution having a sulfuric acid concentration of 7g/L, a chlorine concentration of 7mg/L and a copper concentration of 40g/L was used, and iron powder of -100 mesh was added to produce copper-coated iron powder. The copper coated amount was 30wt% Cu. The copper-coated iron powder and electrolytic copper powder were mixed to produce iron/copper composite powder of 60wt% Cu. The iron/copper composite powder was subsequently sintered in a reduction atmosphere at 800°C for 30 minutes, and then pulverized. The apparent density (g/cm^3), flow rate (s/50g), and specific surface area (m^2/g) of the obtained iron/copper composite powder were checked. The results are shown in Table 1.

As shown in Table 1, the apparent density of the iron/copper composite powder of Example 6 was 2.48g/cm^3 , the flow rate was $22.1\text{s}/50\text{g}$, and the specific surface area was $0.13\text{m}^2/\text{g}$. Favorable iron/copper composite powder was obtained.

In addition, 4wt% of tin powder, 0.5wt% of graphite powder and 0.5wt% (excluded from the total) of zinc stearate as a mold lubricant were added to the foregoing iron/copper composite powder, and this mixed powder was used to form 20 bearing-shaped compacts (test pieces) having an inner diameter of 10mm $\times$ outer diameter of 18mm $\times$ height of 7mm via pressure forming so that the density became 6.5g/cm^3 . These compacts were sintered in a reduction atmosphere at 780°C for 30 minutes. Variation (standard deviation) in the sintered density and variation (standard deviation) in the radial crushing strength were confirmed by examining the obtained sintered compact test pieces. The results are shown in Table 2. As shown in Table 2, variation in the sintered density was small and variation in the radial crushing strength was also small. Favorable results were yielded in all cases.

Incidentally, when copper-coated iron powder not added with tin powder and graphite was sintered under the same conditions as those described above, the bronze alloy layer was not formed since tin powder was not added, and the radial crushing strength tended to decrease slightly, but the variation was roughly the same. (Comparative Example 1)

A copper sulfate plating solution having a sulfuric acid concentration of 7g/L, a chlorine concentration of 7mg/L and a copper concentration of 40g/L was used, and iron powder of -100 mesh was added to produce copper-coated iron powder. The copper coated amount was 50wt% Cu. The apparent density (g/cm^3), flow rate ($\text{s}/50\text{g}$), and specific surface area (m^2/g) of the obtained iron/copper composite powder were checked. The results are shown in Table 1.

As shown in Table 1, the apparent density of the iron/copper composite powder of Comparative Example 1 was 1.83g/cm^3 , the flow rate was $31.6\text{s}/50\text{g}$, and the specific surface area was $0.56\text{m}^2/\text{g}$. Iron/copper composite powder with inferior characteristics was obtained.

In addition, 4wt% of tin powder, 0.5wt% of graphite powder and 0.5wt% (excluded from the total) of zinc stearate as a mold lubricant were added to the foregoing iron/copper composite powder, and this mixed powder was used to form 20 bearing-shaped compacts (test pieces) having an inner diameter of 10mm $\times$ outer

diameter of 18mm × height of 7mm via pressure forming so that the density became 6.5g/cm³. These compacts were sintered in a reduction atmosphere at 780°C for 30 minutes. Variation (standard deviation) in the sintered density and variation (standard deviation) in the radial crushing strength were confirmed by examining the obtained sintered compact test pieces. The results are shown in Table 2.

As shown in Table 2, variation in the sintered density was significant and variation in the radial crushing strength was also significant. Inferior characteristics were obtained in all cases.

Incidentally, when copper-coated iron powder not added with tin powder and graphite was sintered under the same conditions as those described above, the bronze alloy layer was not formed since tin powder was not added, and the radial crushing strength tended to decrease slightly, but the variation was roughly the same. (Comparative Example 2)

A copper sulfate plating solution having a sulfuric acid concentration of 7g/L, a chlorine concentration of 7mg/L and a copper concentration of 40g/L was used, and iron powder of -100 mesh was added to produce copper-coated iron powder. The copper coated amount was 30wt% Cu. The copper-coated iron powder was subsequently sintered in a reduction atmosphere at 650°C for 30 minutes, and then pulverized. The apparent density (g/cm³), flow rate (s/50g), and specific surface area (m²/g) of the obtained iron/copper composite powder were checked. The results are shown in Table 1.

As shown in Table 1, the apparent density of the iron/copper composite powder of Comparative Example 2 was 1.92g/cm³, the flow rate was 28.5s/50g, and the specific surface area was 0.18m²/g. Iron/copper composite powder with inferior characteristics was obtained.

In addition, 4wt% of tin powder, 0.5wt% of graphite powder and 0.5wt% (excluded from the total) of zinc stearate as a mold lubricant were added to the foregoing iron/copper composite powder, and this mixed powder was used to form bearing-shaped compacts (test pieces) having an inner diameter of 10mm × outer diameter of 18mm × height of 7mm via pressure forming so that the density became 6.5g/cm³. These compacts were sintered in a reduction atmosphere at 780°C for 30 minutes. Variation (standard deviation) in the sintered density and variation (standard deviation) in the radial crushing strength were confirmed by examining the

obtained sintered compact test pieces. The results are shown in Table 2.

As shown in Table 2, variation in the sintered density was significant and variation in the radial crushing strength was also significant. Inferior characteristics were obtained in all cases.

Incidentally, when copper-coated iron powder not added with tin powder and graphite was sintered under the same conditions as those described above, the bronze alloy layer was not formed since tin powder was not added, and the radial crushing strength tended to decrease slightly, but the variation was roughly the same. (Comparative Example 3)

A copper sulfate plating solution having a sulfuric acid concentration of 7g/L, a chlorine concentration of 7mg/L and a copper concentration of 40g/L was used, and iron powder of -100 mesh was added to produce copper-coated iron powder. The copper coated amount was 40wt% Cu. The copper-coated iron powder and atomized copper powder were mixed to produce iron/copper composite powder of 60wt% Cu. The apparent density (g/cm^3), flow rate (s/50g), and specific surface area (m^2/g) of the obtained iron/copper composite powder were checked. The results are shown in Table 1.

As shown in Table 1, the apparent density of the iron/copper composite powder of Comparative Example 3 was $2.38\text{g}/\text{cm}^3$, the flow rate was 34.7s/50g, and the specific surface area was $0.67\text{m}^2/\text{g}$. Iron/copper composite powder with inferior characteristics was obtained.

In addition, 4wt% of tin powder, 0.5wt% of graphite powder and 0.5wt% (excluded from the total) of zinc stearate as a mold lubricant were added to the foregoing iron/copper composite powder, and this mixed powder was used to form 20 bearing-shaped compacts (test pieces) having an inner diameter of 10mm $\times$ outer diameter of 18mm $\times$ height of 7mm via pressure forming so that the density became $6.5\text{g}/\text{cm}^3$. These compacts were sintered in a reduction atmosphere at 780°C for 30 minutes. Variation (standard deviation) in the sintered density and variation (standard deviation) in the radial crushing strength were confirmed by examining the obtained sintered compact test pieces. The results are shown in Table 2.

As shown in Table 2, variation in the sintered density was significant and variation in the radial crushing strength was also significant. Inferior characteristics were obtained in all cases.

Incidentally, when copper-coated iron powder not added with tin powder and graphite was sintered under the same conditions as those described above, the bronze alloy layer was not formed since tin powder was not added, and the radial crushing strength tended to decrease slightly, but the variation was roughly the same.

5 As described above, with the Comparative Examples, the apparent density showing the powder characteristics was lowest at 1.83g/cm^3 , and the flow rate was highest at 34.7s/50g. These showed inferior compactibility. In addition, variation in the sintered density was significant and variation in the radial crushing strength was also significant. Inferior characteristics were obtained in all cases. Inferior
10 characteristics were similarly obtained when tin powder and graphite were not added.

Meanwhile, the Examples showed improvement in that the apparent density showing the powder characteristics was 2.2g/cm^3 or more and the flow rate was 25s/50g or less. In addition, variation in the sintered density was small and variation in the radial crushing strength was also small. Favorable results were yielded in all
15 cases. Favorable characteristics were similarly obtained when tin powder and graphite were not added.

INDUSTRIAL APPLICABILITY

20 As described above, by using copper-coated powder or a mixed powder of copper-coated powder and electrolytic copper powder, wherein the copper content is 45 to 70wt%, the apparent density is 2.2g/cm^3 or more, and the flow rate is 25s/50g or less; the powder-metallurgical composite powder of the present invention can yield superior effects of improving in compactibility of the powder such as the green density
25 and fluidity, and in sintering characteristics such as radial crushing strength, and also reducing the cost. Accordingly, the present invention is useful in producing oil-impregnated sintered bearings of copper-coated iron powder series or the like.

CLAIMS

1. Iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component, wherein the copper content in the copper-coated iron powder is 45 to 70wt%, the apparent density is 2.2g/cm³ or more, and the flow rate is 25s/50g or less.
2. Iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component, wherein the copper content in a mixed powder of copper-coated iron powder and electrolytic copper powder is 45 to 70wt%, the apparent density is 2.2g/cm³ or more, and the flow rate is 25s/50g or less.
3. The iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component according to claim 1 or claim 2, wherein the specific surface area of the composite powder after sintering and pulverization measured by the BET method is 0.2m²/g or less.
4. The iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component according to any one of claims 1 to 3, wherein the copper-coated iron powder or the mixed powder of copper-coated iron powder and electrolytic copper powder is further mixed with tin powder, graphite powder and a mold lubricant.
5. The iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component according to claim 4, wherein tin powder is 3.0 to 5.0wt%, and graphite powder and a mold lubricant are 1.0wt% or less.
6. The iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component according to any one of claims 1 to 5, wherein the iron/copper composite powder for powder metallurgy is for use in producing oil-impregnated sintered bearings.
7. A process for producing iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component, wherein after iron powder is plated with copper to prepare copper-coated iron powder and copper-coated iron powder having a copper content of 45 to 70wt% is produced, the copper-coated iron powder is sintered in a reduction atmosphere at 600 to 850°C for 20 to 60 minutes, and the obtained sintered compact is pulverized and sieved to -80

mesh.

8. A process for producing iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component, wherein after iron powder is plated with copper to prepare copper-coated iron powder and a mixed powder having a copper content of 45 to 70wt% is produced by mixing electrolytic copper powder to the copper-coated iron powder, the mixed powder is sintered in a reduction atmosphere at 600 to 850°C for 20 to 60 minutes, and the obtained sintered compact is pulverized and sieved to -80 mesh.

9. The process for producing iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component according to claim 7 or claim 8, wherein the specific surface area of the composite powder after sintering and pulverization measured by the BET method is 0.2m²/g or less.

10. The process for producing iron/copper composite powder for powder metallurgy having copper-coated iron powder as its primary component according to any one of claims 7 to 9, wherein the mixed powder of copper-coated iron powder and electrolytic copper powder is further mixed with tin powder, graphite powder and a mold lubricant.