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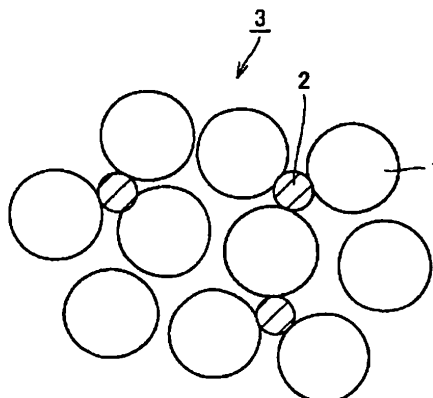
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(54) **METHOD FOR FORMING POWDER IN POWDER METALLURGY AND METHOD FOR PRODUCING SINTERED PARTS**

(57) A mixed powder (3) is obtained by adding at least one kind of solid ester wax (2) to an iron-based powder (1) for powder metallurgy use. The mixed powder (3) is molded. The melting point of the ester wax (2) is 100°C or lower, the quantity of the ester wax (2) added is in the range of 0.02 wt% or more to 0.6 wt% or less, and the

temperature of the mold when the molding is performed is set in a range of (the melting point of ester wax (2) + 10°C) or more to 200°C or less. The ester wax (2) thereby liquefies on the surface of the mold and bleeds out when the molding is performed. As a result, molded sintered parts with complex shapes, good surface characteristics, and high densities can be easily obtained.

FIG. 1B



Description

Technical Field

5 **[0001]** The present invention concerns a method for molding powder in powder metallurgy and a method for producing sintered parts. More specifically, it concerns an improved method for lubricating during molding in the field of powder metallurgy, by which it is made easy to obtain molded sintered parts which have complex shapes, good surface characteristics, and high densities.

10 Background Art

[0002] In the process of compacting a metal powder in a mold, a large molding pressure is required in order to obtain high-density molded articles due to the fact that friction is produced at the interface between the mold walls and the powder particles and between the particles themselves, and if the frictional force between the mold walls and the powder particle interfaces becomes large, problems arise, namely, the surface condition of the molded articles becomes bad, the abrasion of the mold is accelerated, and the lifetime of the mold is shortened.

[0003] Therefore, it is necessary to suppress friction between the mold and the powder particles. As methods for reducing the friction between the mold and the powder particles, there are the "mixed lubrication method" and the "compaction mold lubrication method." According to the Japan Industrial Standards related to powder metallurgy terminology (JIS Z2500-1960), lubricants which are applied to the compaction mold are called "compaction mold lubricants," and lubricants mixed with the raw material powder are called powder lubricants. However, the materials used for the lubricants themselves are not different; stearic acid and its metal soaps, waxes, etc., are generally used.

[0004] The mixed lubrication method is a method in which the lubricant is added to the raw materials beforehand; it is necessary to add 0.5 wt% or more of the lubricant in order to have sufficient lubricating property with the mold. This is because, since the lubricant is a solid, only the lubricant which is present in the interface between the powder and the mold contributes to the lubrication. If the powder lubricant is increased, the friction and the ejection force are reduced, but the density of the compacted powder article is reduced.

[0005] Moreover, since the compaction mold lubrication method is one in which powdered lubricant is electrostatically adhered to the inner walls of the mold and causes the friction between the powder and the mold to be reduced, the lubricating properties between the powder and the mold can be increased efficiently, and since an excess quantity of lubricant need not be added to the powder, a high-density compacted powder article can be formed. However, when molded articles with complex shapes or ones with great heights in the depth direction, in relationship to their diameters, are fabricated, it is difficult to make the powdered lubricant adhere uniformly to the inner mold walls, and burning or "gnawing" occurs at the places where the lubricant has not adhered. In addition, there is the problem that the lubricant is sucked in where it adheres in excess, causing instability of the density and worsening of the surface condition.

[0006] As a method for overcoming these problems, the method of using an amide lubricant, so that the lubricant is deformed when it is subjected to compaction and shear forces and the force which pulls the lubricant out is reduced by plastic deformation of the lubricant between the particles of the powder composition, is introduced in Japanese Patent Application Publication Nos. 2003-509582 (Patent Reference 1) and H10-501270 (Patent Reference 2).

Patent Reference 1: Japanese Patent Application Publication No. 2003-509582

Patent Reference 2: Japanese Patent Application Publication No. H10-501270

Disclosure of Invention

Problems to be Solved by the Invention

[0007] However, when amide lubricants are used, as in the publications mentioned above, since the bonding of the amide bond is strong, there are the problems, if the mold temperature is comparatively low, that the lubricant is not caused to bleed out sufficiently between the molded article and the mold and the surface properties of the molded article cannot be made good enough.

[0008] The present invention provides a method which is effective in reducing the ejecting force by plastic deformation of the resin or wax and reducing the dynamic friction, which is required to improve the surface properties.

[0009] Therefore, the purpose of the present invention is to provide a method for molding powder in powder metallurgy which facilitates the molding of sintered parts with complex shapes, good surface properties, and high densities and a method for producing sintered parts.

Means for Solving the Problem

[0010] One of the methods for molding powder in powder metallurgy of the present invention is characterized in that it includes a step in which a mixed powder is obtained by adding at least one kind of solid ester wax to an iron-based powder for powder metallurgy use and a step in which the mixed powder is molded, the melting point of the ester wax is 100°C or lower, the quantity of the ester wax added is in the range of 0.02 wt% or more to 0.6 wt% or less, and the temperature of the mold when the molding is performed is set in a range of (the melting point of the aforementioned ester wax + 10°C) or more to 200°C or less.

[0011] As to friction during the molding process in powder metallurgy, there is static frictional force in the initial stage of the ejecting of the compacted powder (the stage up to the point at which the powder begins to move) and dynamic frictional force, starting at the point at which the compacted powder begins to move. A solid lubricant is suitable for reducing the static friction, and a liquid lubricant is preferable for reducing the dynamic friction. In addition, reducing the dynamic friction is effective for the surface properties of the compacted powder.

[0012] Therefore, the inventors investigated methods for putting the liquid lubricant uniformly on the interface between the mold and the powder even when complex shapes are involved. They discovered a method for reducing dynamic friction by first adding the lubricant to the raw material, and then melting the lubricant at the time the press molding is performed by the mold temperature or by the frictional heat between the particles, and raising the molding pressure as the lubricant is pushed out to the boundaries with the mold and functions as a liquid lubricant. Specifically, they discovered a method in which an ester wax is liquefied on the surface of the mold at the time molding is performed and made to bleed out.

[0013] By means of this method, since the lubricant added is pushed out to the boundaries with the mold during the molding, the quantity of the lubricant remaining inside the molded article can be reduced and it is possible to obtain molded articles with good surface properties and high densities (essentially, relative densities of 95% or higher).

[0014] Moreover, since the lubricant bleeds out on the whole surface of the molded article, there are no unevennesses of the lubricant even with complex mold shapes, and molded objects with good surface properties and high densities can be obtained by reducing the frictional force. In particular, this method is effective in stainless-steel/alloy systems.

[0015] Ester wax is included in lubricants. While waxes include amide waxes (stearic acid amide, ethylene bisstearic acid amide) and hydrocarbon waxes (paraffin wax, polyethylene wax), etc., in the case of ester waxes, it is possible to synthesize ones with very narrow melting temperature regions by making them purer than other waxes. By using these ester waxes, it is possible to melt the waxes efficiently and cause them to bleed out in the interface with the mold in a short cycle time of compaction molding.

[0016] Examples of desirable ester waxes mentioned above are those mentioned in Japanese Patent Application Publication Nos. 2002-212142 and 2004-059744. Specifically, these are ones obtained by condensation reactions between (a) linear saturated monocarboxylic acids with carbon numbers of 14-30 and (b) linear saturated monohydric alcohols with carbon numbers of 14-30 or polyhydric alcohols with 2-6 hydroxyl groups and carbon numbers of 2-30. These ester waxes are waxes of the sharp-melt type, with narrow melting point ranges.

[0017] In ordinary ester waxes, branched fatty acids or polyhydric carboxylic acids are also used as ingredient (a) mentioned above, but since the viscosities of the esters become high, they do not spread out uniformly in the boundaries between the mold and the molded article at the time the latter is pushed out, even if they melt during the molding. Therefore, this causes a bad appearance, such as burning and stripes on the molded article.

[0018] Moreover, in waxes which use branched fatty acids or polyhydric carboxylic acids as ingredient (a) mentioned above, there is also the problem of residues being produced, because they become difficult to decompose at the time of the heat treatment, compared with waxes which use linear saturated monocarboxylic acids with carbon numbers of 14-30 as ingredient (a) mentioned above.

[0019] Therefore, by using waxes that contain linear saturated monocarboxylic acids with carbon numbers of 14-30 as ingredient (a) mentioned above, one can obtain a stable lubricating effect and obtain good products with no residues after the heat treatment.

[0020] Besides amide waxes, waxes with low melting points and viscosities include hydrocarbon waxes (paraffin wax, polyethylene wax). However, ester waxes can be synthesized with narrower melting temperature regions than these waxes. In this way, the waxes can be melted efficiently in short periods of time and the boundaries between the mold and the molded article can be effectively lubricated.

[0021] Furthermore, the melting points of the waxes are 100°C or lower. Since this is a system in which the wax added inside it melts when the temperature of the mold is raised, it is effective if the mold temperature is made 10°C or more higher than the melting point of the wax. If the mold temperature is raised, the deformation among the particles is accelerated; therefore, the density can be made high. However, since the flowability of the particles becomes inferior, there is a tendency for the density distribution to become inferior. Therefore, the optimum course is to make the melting point of the wax 100°C or lower and the mold temperature 200°C or lower.

[0022] In this case, moreover, the mold temperature is raised, but the temperature of the powder before it is introduced

into the mold must be around room temperature. That is, the method of the present invention is not a method in which the powder and the mold are both heated, as in warm molding.

[0023] The quantity of ester wax added is from 0.02 wt% or more to 0.6 wt% or less. If it is less than 0.02 wt%, the quantity of molten wax bleeding out on the mold interface will not be sufficient, and burning and "gnawing" will be produced. If it is greater than 0.6 wt%, the quantity of wax bleeding out will be great, so that good liquid lubricating property is obtained, but the quantity of wax remaining inside will increase and the desired high-density molded articles cannot be obtained. High density means a relative density of 95% or higher. Therefore, the quantity of ester wax added is from 0.02 wt% or more to 0.6 wt% or less, preferably 0.05 wt% or more to 0.3 wt% or less.

[0024] Moreover, another method for molding powder in powder metallurgy of the present invention is characterized in that it includes a step in which a mixed powder is obtained by adding at least one kind of solid ester wax to an iron-based powder for powder metallurgy use and a step in which the mixed powder is molded, the melting point of the ester wax is 60°C or lower, the quantity of the ester wax added is in the range of 0.02 wt% or more to 0.6 wt% or less, and cold molding is performed.

[0025] By making the melting point of the ester wax 60°C or lower, the necessity of raising the mold temperature can be eliminated, as shown in the powder molding method in powder metallurgy mentioned above. It was discovered that, when the iron-based powder is compaction-molded, the compacted-powder body is heated to approximately 60°C by the frictional force between the particles. Based on this, by making the melting point of the ester wax 60°C or lower, the melting of the wax is encouraged by using the frictional heat between the particles even if the mold temperature is not raised, and the ester wax is liquefied and caused to bleed out on the interface with the mold. In this way, the ester wax is liquefied and made to bleed out on the surface of the mold during molding and the dynamic frictional force between the molded articles and the mold can be reduced. The quantity of wax added is the same as in the aforementioned method for molding powder in powder metallurgy.

[0026] In both of the aforementioned methods for powder molding in powder metallurgy, preferably the acid values of the ester waxes are 1.0 (mgKOH/g) or less and the hydroxyl group values are 4.0 (mgKOH/g) or less.

[0027] Moreover, in the first method for powder molding in powder metallurgy mentioned above, the powder mixture preferably includes one or more solid lubricants selected from a group consisting of amide waxes, polyamide resins, and metal soaps, the melting points of the solid lubricants are preferably at or above the temperature of the mold during the molding, and the quantity of the solid lubricants added is preferably more than 0 and 0.4 wt% or less.

[0028] In this manner, the static friction force between the mold and powder can be reduced by including at least one kind of solid lubricant, such as an amide wax, polyamide resin, metal soap, etc., besides the ester wax and making the melting points of these waxes and resins at or above the set mold temperature. Therefore, it becomes possible to reduce the stress acting on the molded article when it is pushed out of the mold, and the surface properties of the molded article can be further improved and the lifetime of the mold further lengthened.

[0029] However, it is necessary to keep the quantity of the solid lubricant added at or below 0.4 wt%. If it is greater than 0.4 wt%, the density of the molded articles will be reduced. Preferably, the quantity of solid lubricant added is 0.2 wt% or less.

[0030] Moreover, in the second method for powder molding in powder metallurgy mentioned above, the powder mixture preferably includes one or more solid lubricants selected from a group consisting of amide waxes, polyamide resins, and metal soaps, the melting points of the solid lubricants are preferably 60°C or higher, and the quantity of the solid lubricants added is preferably more than 0 and 0.4 wt% or less.

[0031] If the melting point of the ester wax is made 60°C or lower, then, if a solid (powdered) lubricant such as a wax or resin, etc., with a melting point of 60°C or higher is added, the static frictional force can be reduced and the surface properties can be further improved and the suppression of mold abrasion achieved.

[0032] Moreover, the method for producing sintered parts of the present invention is characterized in that the molded articles molded by the aforementioned first and second powder molding methods in powder metallurgy are sintered at a temperature of 1000°C or higher.

[0033] Since the molded articles formed by the aforementioned first and second powder molding methods in powder metallurgy come to be in a state in which the wax is fixed to their surfaces, it is desirable to sinter them at a temperature of 1000°C or higher. By sintering at a temperature of 1000°C or higher, the wax is completely decomposed, it is not left on the surface as residue, and good surface properties can be obtained.

Effect of the Invention

[0034] As explained above, sintered parts with complex shapes, good surface properties, and high densities can be molded easily by using the method for molding powder in powder metallurgy and the method for producing sintered parts of the present invention.

Brief Description of the Drawings

[0035]

- 5 Fig. 1A: Simplified drawing showing the first step of the method for molding powder in powder metallurgy in a working embodiment of the present invention.
 Fig. 1B: Enlarged drawing of the essential parts of Fig. 1A.
 Fig. 2A: Simplified drawing showing the second step of the method for molding powder in powder metallurgy in a working embodiment of the present invention.
 10 Fig. 2B: Enlarged drawing of the essential parts of Fig. 2A.
 Fig. 3A: Simplified drawing showing the third step of the method for molding powder in powder metallurgy in a working embodiment of the present invention.
 Fig. 3B: Enlarged drawing of the essential parts of Fig. 3A.
 Fig. 4: Simplified drawing showing the fourth step of the method for molding powder in powder metallurgy in a working embodiment of the present invention.
 15 Fig. 5: Simplified drawing showing the state of performing the sintering of the molded article.

Explanation of the Elements

- 20 **[0036]** 1 Iron-based powder for powder metallurgy use; 2, 2a Ester waxes; 3a Molded article; 3 Mixed powder; 11 Die; 12 Lower punch; 13 Upper punch; 21 Furnace; 22 Heater.

Best Mode for Carrying Out the Invention

- 25 **[0037]** Below, working embodiments of the present invention will be explained, based on the drawings. Figs. 1A-4 are simplified drawings showing, in the order of the steps, the method for molding powder in powder metallurgy in a working embodiment of the present invention. Fig. 5 is a simplified drawing showing the state of performing the sintering of the molded article. Fig. 1B is an enlarged drawing of the essential parts of Fig. 1A, Fig. 2B is an enlarged drawing of the essential parts of Fig. 2A, and Fig. 3B is an enlarged drawing of Fig. 3A.
- 30 **[0038]** Referring to Fig. 1B, a mixed powder 3 is obtained by adding at least one kind of solid ester wax 2 to an iron-based powder for powder metallurgy use 1. At this time, the mixing ratio is adjusted so that the proportion of the ester wax 2 with respect to the mixed powder is in the range of 0.02 wt% or more to 0.6 wt% or less. Moreover, the melting point of the ester wax used is 100°C or lower. This ester wax preferably should have an acid value of 1.0 (mgKOH/g) or less and a hydroxyl group value of 4.0 (mgKOH/g) or less.
- 35 **[0039]** Moreover, one or more solid lubricants selected from a group consisting of amide waxes, polyamide resins, and metal soaps may be contained in the mixed powder 3. It is desirable to use a solid lubricant having a melting point at or above the temperature of the mold at the time of molding. The quantity of the solid lubricant added is preferably more than 0 and 0.4 wt% or less.
- [0040]** Furthermore, the mixing method is not particularly limited. Mixing is ordinarily performed by using a V-type mixer, but it is also possible to use various kinds of ball mills, and the powder surface may be coated.
- 40 **[0041]** Referring to Fig. 1A, a step of compaction-molding the mixed powder 3 which was obtained is performed. First, a current is passed through the band heater (not shown) of the molding device and the inner wall of the die 11 is heated to a temperature at or above the temperature at which the ester wax 2 exists as a liquid on the interface of the inner wall of the die 11 and the mixed powder 3. Specifically, the die 11 is heated to a temperature of (the melting point of the ester wax + 10°C) or more and 200°C or less. Moreover, the temperature of the mixed powder 3 is set at a temperature at or below the melting point of the ester wax 2.
- 45 **[0042]** Next, the position of a shoe (not shown) is set above the inner space of the die 11 and the mixed powder 3 obtained in the previous step is fed into the inner space from the shoe.
- [0043]** Referring to Fig. 2A, the position of the upper punch 13 is set above the inner space of the die 11. The upper punch 13 is moved downward and the mixed powder 3 is compaction-molded.
- 50 **[0044]** Referring to Fig. 2B, at the time of this compaction molding, the ester wax 2 is melted by the mold temperature or the heat of friction between the powder particles, becoming the molten body 2a and functioning as a liquid lubricant by bleeding out as a liquid on the interface between the inner wall of the die 11 and the mixed powder 3. It thereby reduces the dynamic friction force and suppresses burning between the inner wall of the die 11 and the mixed powder 3. Furthermore, when the solid lubricant is put in, the solid lubricant has the action of lowering the frictional resistance between the iron-based powder 1 and the wax 2. Therefore, a good lubricating property is imparted to the mixed powder 3, which has had its flowability reduced by the addition of the wax, and this contributes to increasing the density, strength, and magnetic properties of the molded article.
- 55

[0045] The molded article 3a is obtained by this compaction molding.

Referring to Fig. 3A and Fig. 3B, in the molded article 3a obtained by compaction molding, the ester wax 2a has bled out and solidified on the surface of the molded article 3a.

[0046] Referring to Fig. 4, the upper punch 13 and the lower punch 12 are moved upward (or the die 11 is moved downward) and the molded article 3a is removed from within the mold.

[0047] Referring to Fig. 5, sintering of the molded article 3a is performed at a temperature at or above the decomposition temperature of the ester wax 2a (1000°C or higher) by means of the heater 22 in the furnace 21 (in a nitrogen atmosphere, ambient atmosphere, etc.). In this way, the ingredients of the ester wax 2a which bled out onto the surface of the molded article 3a when the compaction molding was performed and which then solidified are thermally decomposed and a good surface state of the molded article 3 is obtained.

[0048] Finally, there are also cases in which a suitable processing, such as cutting, is performed on the heat-treated molded article.

Furthermore, if the melting point of the ester wax is 60°C or below, the molding may be performed by cold molding, wherein the ester wax 2 is made to liquefy and bleed out on the surface of the mold when the molding is performed. In this case, the melting point of the solid lubricant may be 60°C or above.

[0049] According to this working embodiment, the ester wax 2, as mentioned above, bleeds out as a liquid on the interface between the inner wall of the die 11 and the mixed powder 3, and it thereby becomes possible to obtain molded articles with no unevenness of the lubricant, even in molds with complex shapes, and with good surface properties and high densities, due to the reduction in the frictional force. Moreover, due to the fact that the ester wax 2 bleeds out as a liquid on the interface between the inner wall of the die 11 and the mixed powder 3, the quantity of the ester wax 2 remaining inside the molded article can be reduced, and molded articles with good surface properties and high densities (essentially, relative densities of 95% or higher) can be obtained.

[0050] Working examples of the present invention will be explained below.

Working Example 1

[0051] The kinds of waxes shown in Fig. 1 were prepared and 0.2 wt% of each one was added to iron powder ASC100.29 (Höganäs Co.). Mixing was performed for 1 hour with a V-type mixer and the raw material (mixed powder) was prepared.

Table 1

	1	2	3	4	5	6	7	8	9
Kind	Ester	Ester	Ester	Ester	Ester	Ester	Amide	Paraffin	Stearic acid
Melting point (°C)	41	50	65	95	110	125	78	65	60

[0052] Using the prepared powder, press-molding was performed with a 30 mm diameter cylindrical mold. The mold temperature was 120°C and the molding pressure was 800 MPa. The surface state of the molded article and the state of the bleeding of the wax were evaluated, and the results are shown in Table 2. In the tables of this Specification, extremely good results are shown by S, good results by Z, somewhat bad results by Y, and bad results by X.

[0053]

Table 2

Mold temperature		1	2	3	4	5	6	7	8	9
Room temperature	Surface state	S	S	S	Y	X	X	Y	Y	X
	Bleeding	S	S	Z	Y	X	X	X	Y	Y
85°C	Surface state	S	S	S	Y	X	X	Y	Y	X
	Bleeding	S	S	S	Y	X	X	Y	Y	Y
110°C	Surface state	S	S	S	S	X	X	Y	Z	Y
	Bleeding	S	S	S	S	X	X	Y	Y	Y
185°C	Surface state	S	S	S	S	Z	Y	Z	Z	Y
	Bleeding	S	S	S	S	Z	Z	Z	Y	Y

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(continued)

Mold temperature		1	2	3	4	5	6	7	8	9
210°C	Surface state	S	S	S	S	S	Z	Z	Z	Y
	Bleeding	S	S	S	S	S	Z	Z	Y	Y

[0054] When Sample 5 of Table 2 was press-molded in a 210°C mold, the state of the bleeding was good and the surface state was also good, but the flowability of the powder was found to become bad. From the results in Table 2, it can be seen that when ester waxes with melting points at or below 100°C are used, and the mold temperature is at or above (ester wax melting point + 10°C), the surface state of the molded article and the bleeding state of the wax are both good.

[0055] Raw materials with different addition quantities were prepared by using the waxes of Samples 2 and 4 of Table 1. Using these raw materials, press-molding was performed at a molding pressure of 800 MPa, and the surface states of the molded articles, the bleeding states of the waxes, and the densities were evaluated. The results are shown in Table 3.

[0056]

Table 3

Wax	Mold temperature (°C)		Quantity of wax added (wt%)								
			0.01	0.03	0.05	0.1	0.2	0.4	0.6	0.8	1.0
2	Room temperature	Surface state	Y	Z	S	S	S	S	S	S	S
		Bleeding	Y	Z	Z	S	S	S	S	S	S
		Density (g/cm ³)	7.51	7.55	7.55	7.51	7.50	7.42	7.40	7.27	7.18
4	150	Surface state	Y	Z	S	S	S	S	S	S	S
		Bleeding	Y	Z	S	S	S	S	S	S	S
		Density (g/cm ³)	7.62	7.62	7.60	7.58	7.54	7.48	7.42	7.36	7.27

[0057] From the results of Table 3, it can be seen that both the surface state of the molded articles and the state of bleeding of the wax are good when the quantity of ester wax added is 0.02 wt% or more. Moreover, it can be seen that the density of the molded article becomes as low as less than 7.40 g/cm³ when the quantity of ester wax added exceeds 0.6 wt%.

Working Example 2

[0058] The types of waxes shown in Tables 4 and 5 were prepared and 0.2 wt% of each one was added to iron powder ASC100.29 (Höganäs Co.). Mixing was performed for 1 hour with a V-type mixer and the raw material (mixed powder) was prepared.

[0059]

Table 4

	A	B	C	D
Melting point	85	85	85	85
Acid value (mgKOH/g)	0.6	0.6	1.4	1.4
Hydroxyl group value (mgKOH/g)	3.0	4.7	3.0	4.7

[0060]

Table 5

	E	F	G	H
Melting point	41	41	41	41

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(continued)

	E	F	G	H
Acid value (mgKOH/g)	0.6	0.6	1.4	1.4
Hydroxyl group value (mgKOH/g)	3.0	4.7	3.0	4.7

[0061] Using the prepared powder, press-molding was performed with a 30 mm diameter cylindrical mold. When the raw materials with Samples A, B, C, and D added were used, the mold temperature was 120°C; when the raw materials with Samples E, F, G, and H added were used, the mold temperature was set at room temperature. The press-molding was performed at a molding pressure of 800 MPa. The surface state of the molded article and the state of the bleeding of the wax were evaluated, and the results are shown in Table 6.

[0062]

Table 6

Mold temperature	120°C				Room temperature			
Wax	A	B	C	D	E	F	G	H
Surface state	S	S	S	Z	S	S	S	Z
Bleeding	S	Z	Z	Z	S	Z	Z	Z

[0063] The acid and hydroxyl group values of the esters are indices of the purity of the waxes; those with smaller acid and hydroxyl group values have narrower melting temperature regions, and therefore show good bleeding abilities. This result can also be seen from Table 6. That is, it can be seen from the results of Table 6 that in Samples A and E, for which the acid value of the ester wax is 1.0 (mgKOH/g) or less and the hydroxyl group value is 4.0 (mgKOH/g) or less, both the surface state of the molded article and the bleeding state of the wax are good.

Working Example 3

[0064] Ethylene bisstearic acid amide and zinc stearate were further added in the cases in which 0.2 wt% of the ester waxes of Samples 2 and 4 of Working Example 1 were added. The molding was evaluated under the same conditions as in Working Example 1 and the results are shown in Table 7.

[0065]

Table 7

Wax	Mold temperature (°C)		Ethylene bisstearic acid amide				Zinc stearate			
			0.03	0.2	0.35	0.5	0.03	0.2	0.35	0.5
2	Room temperature	Surface state	S	S	S	S	S	S	S	S
		Bleeding	S	S	S	S	S	S	S	S
		Density (g/cm ³)	7.50	7.46	7.42	7.32	7.52	7.48	7.44	7.35
4	150	Surface state	S	S	S	S	S	S	S	S
		Bleeding	S	S	S	S	S	S	S	S
		Density (g/cm ³)	7.53	7.48	7.44	7.36	7.56	7.50	7.46	7.40

[0066] Compared with Working Example 1, the surface states were better, and further improvement in the surface state is expected if other non-melting waxes are added. This is thought to be because the static frictional force can be reduced by adding solid lubricants. Since the density is caused to be reduced by adding other waxes, the quantity added is determined by considering the balance between the lubricating property and the density.

[0067] It should be kept in mind that all of the aspects of the working embodiments disclosed above are examples and are not limiting. The scope of the present invention is shown by the scope of the claims, not by the explanations given above; it is intended to include all variations falling within the meaning and scope equivalent to the scope of the claims.

Industrial Applicability

[0068] The present invention can be applied especially advantageously to molding sintered parts which have complex shapes and for which good surface properties and high densities are required.

Claims

1. A method for molding powder in powder metallurgy, **characterized in that** it includes a step in which a mixed powder (3) is obtained by adding at least one kind of solid ester wax (2) to an iron-based powder for powder metallurgy use (1) and
a step in which said mixed powder (3) is molded;
the melting point of said ester wax (2) is 100°C or lower, the quantity of said ester wax (2) added is in a range of 0.02 wt% or more to 0.6 wt% or less, and the temperature of the mold when the molding is performed is set in a range of (the melting point of said ester wax (2) + 10°C) or more to 200°C or less.
2. The method for molding powder in powder metallurgy in accordance with Claim 1, **characterized in that** the acid value of said ester wax (2) is 1.0 (mgKOH/g) or less and its hydroxyl group value is 4.0 (mgKOH/g) or less.
3. The method for molding powder in powder metallurgy in accordance with Claim 1, **characterized in that** said mixed powder (3) contains one or more solid lubricants selected from a group including amide waxes, polyamide resins, and metal soaps; the melting points of said solid lubricants are at or above the temperature of said mold when the molding is performed; and the quantity of said solid lubricants added is in a range of more than 0 to 0.4 wt% or less.
4. A method for producing sintered parts, **characterized in that** the molded article (3a) molded by the powder molding method described in Claim 1 is sintered at a temperature of 1000°C or higher.
5. A method for molding powder in powder metallurgy, **characterized in that** it includes a step in which a mixed powder (3) is obtained by adding at least one kind of solid ester wax (2) to an iron-based powder for powder metallurgy use (1) and
a step in which said mixed powder (3) is molded;
the melting point of said ester wax (2) is 60°C or lower, the quantity of said ester wax (2) added is in a range of 0.02 wt% or more to 0.6 wt% or less, and cold molding is performed.
6. The method for molding powder in powder metallurgy in accordance with Claim 5, **characterized in that** the acid value of said ester wax (2) is 1.0 (mgKOH/g) or less and its hydroxyl group value is 4.0 (mgKOH/g) or less.
7. The method for molding powder in powder metallurgy in accordance with Claim 5, **characterized in that** said mixed powder (3) contains one or more solid lubricants selected from a group including amide waxes, polyamide resins, and metal soaps; the melting points of said solid lubricants are 60°C or higher; and the quantity of said solid lubricants added is in a range of more than 0 to 0.4 wt% or less.
8. A method for producing sintered parts, **characterized in that** the molded article (3a) molded by the powder molding method described in Claim 5 is sintered at a temperature of 1000°C or higher.

FIG. 1A

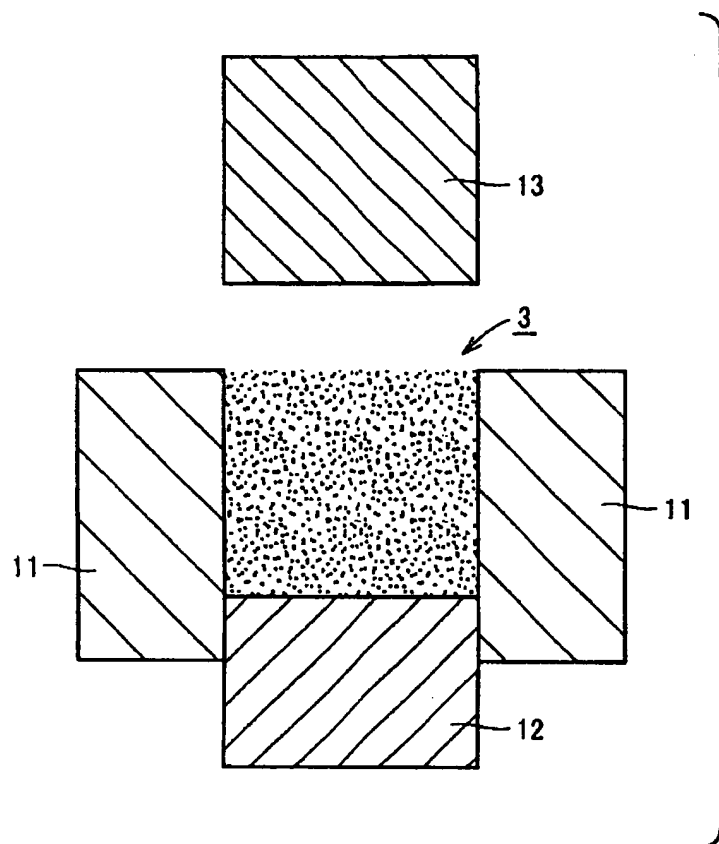


FIG. 1B

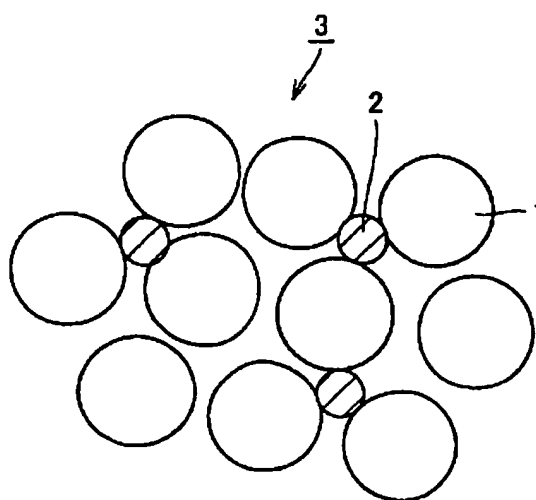


FIG. 2A

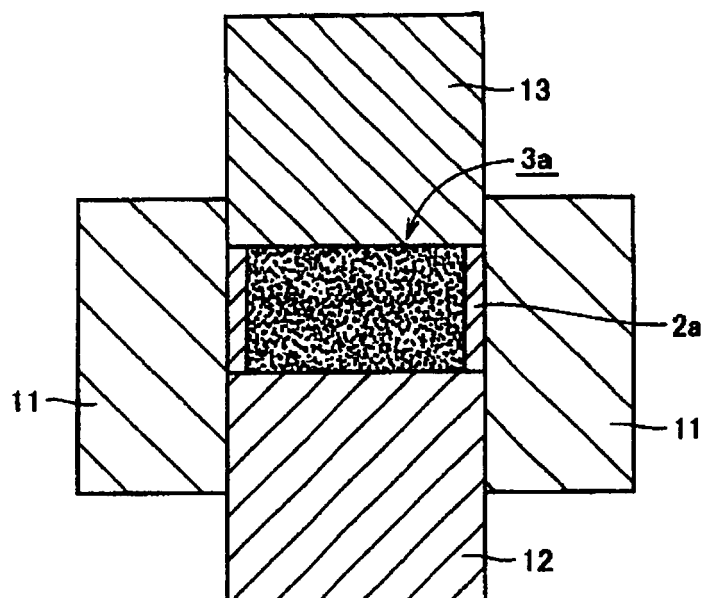


FIG. 2B

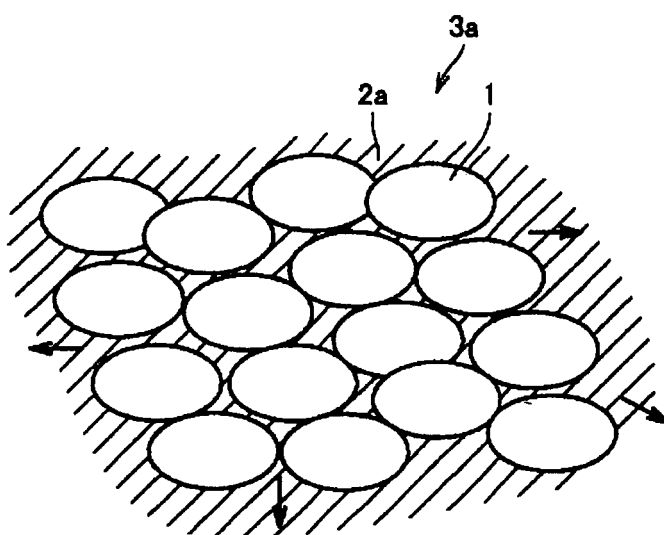


FIG. 3A

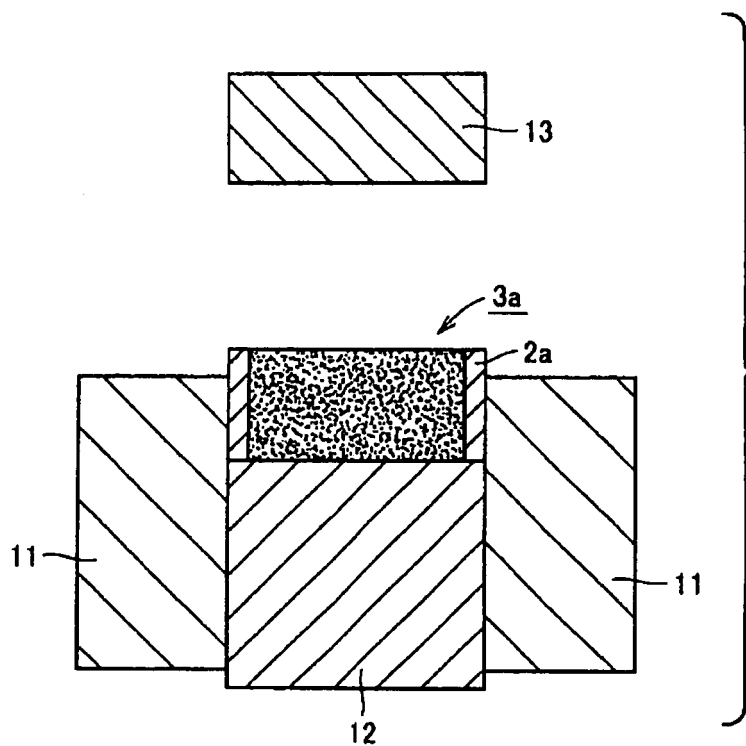


FIG. 3B

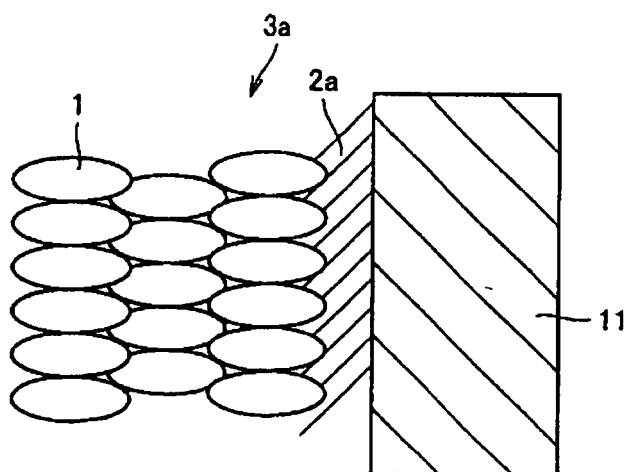


FIG. 4

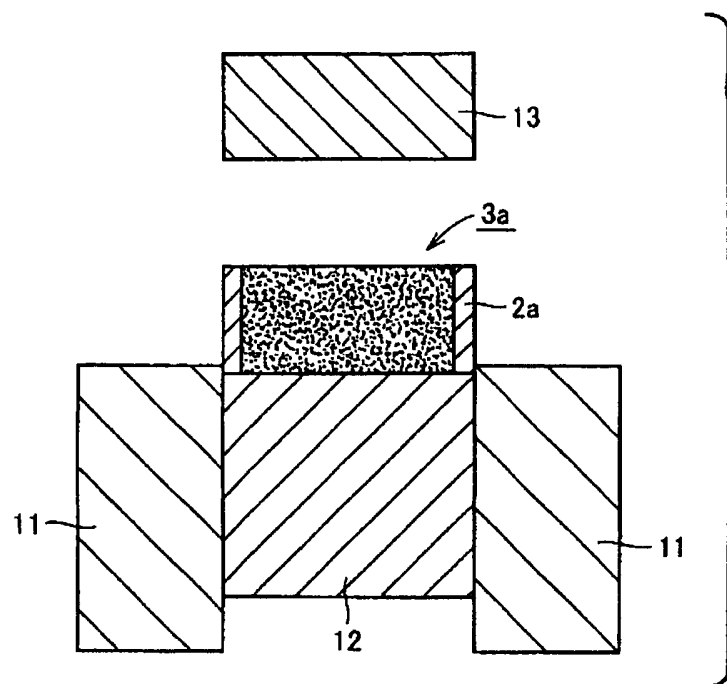
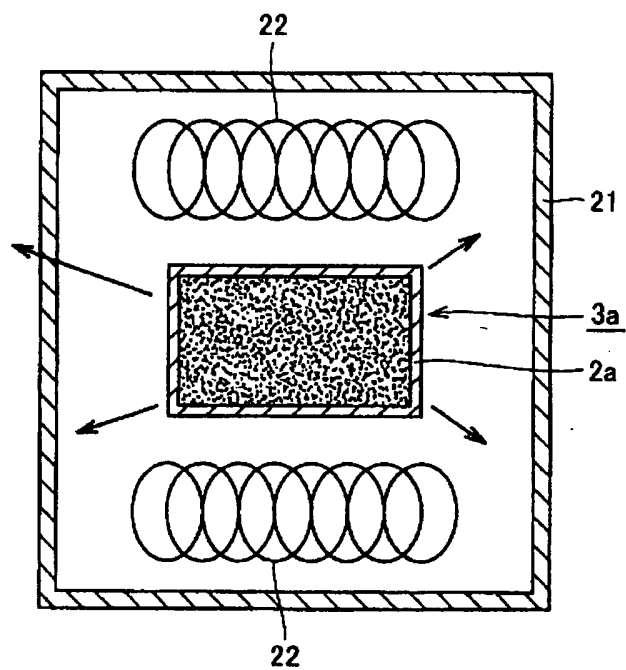


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/015874

A. CLASSIFICATION OF SUBJECT MATTER B22F3/02 (2006.01)		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) B22F3/02 (2006.01)		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2005 Kokai Jitsuyo Shinan Koho 1971-2005 Toroku Jitsuyo Shinan Koho 1994-2005		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2001-294902 A (Kawasaki Steel Corp.), 26 October, 2001 (26.10.01), Claims; Par. Nos. [0028], [0031] to [0045] & US 6355208 B1 & EP 1145788 A1 & WO 2001/032337 A1	1-8
A	JP 2004-59744 A (NOF Corp.), 26 February, 2004 (26.02.04), Par. No. [0028] (Family: none)	2, 6
A	JP 4-136104 A (Hitachi Powdered Metals Co., Ltd.), 11 May, 1992 (11.05.92), Page 3, upper left column (Family: none)	2, 6
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 25 November, 2005 (25.11.05)		Date of mailing of the international search report 06 December, 2005 (06.12.05)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/015874

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2001-234205 A (Kawasaki Steel Corp.), 28 August, 2001 (28.08.01), Par. Nos. [0027] to [0028]	1-8

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003509582 A [0006] [0006]
- JP H10501270 B [0006] [0006]
- JP 2002212142 A [0016]
- JP 2004059744 A [0016]