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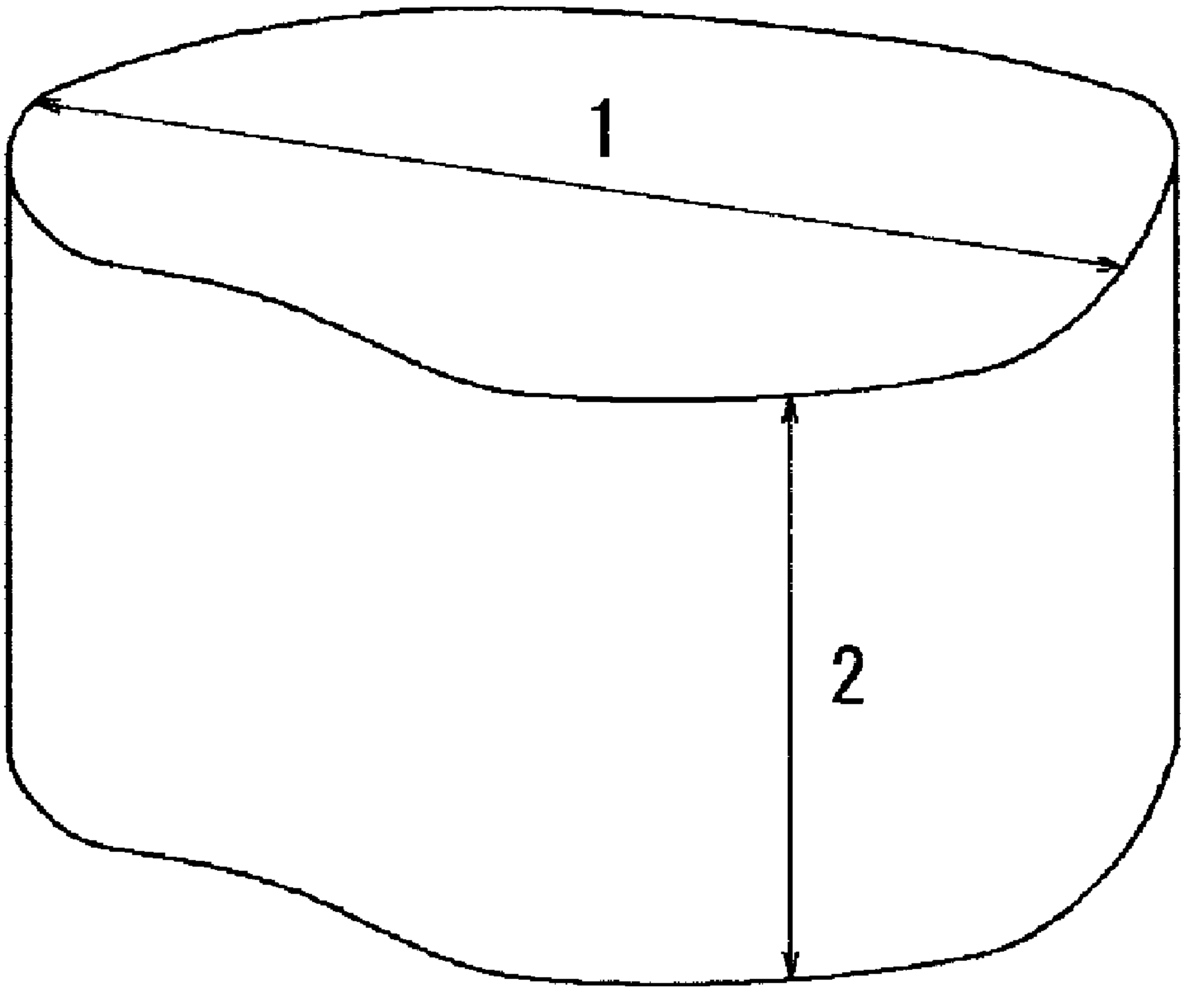
(54) **Titre : MELANGE PULVERULENT A BASE DE FER POUR METALLURGIE DES POUDRES**
(54) **Title: IRON-BASED MIXED POWDER FOR POWDER METALLURGY**



(57) **Abrégé/Abstract:**
In an iron-based powder, 0.01% to 5.0% by mass of oxide particles having an average size of 0.5 μm or more are contained, whereby the flowability of an iron-based mixed powder is increased and thereby the density of a green compact is increased, and ejection force is greatly reduced after compaction, thereby accomplishing an increase in product quality and a reduction in production cost.

ABSTRACT

In an iron-based powder, 0.01% to 5.0% by mass of oxide particles having an average size of 0.5 μm or more are contained, whereby the flowability of an iron-based mixed powder is increased and thereby the density of a green compact is increased, and ejection force is greatly reduced after compaction, thereby accomplishing an increase in product quality and a reduction in production cost.

DESCRIPTION

Title of Invention

IRON-BASED MIXED POWDER FOR POWDER METALLURGY

Technical Field

[0001]

The present invention relates to an iron-based mixed powder suitable for use in powder metallurgy. In particular, the present invention is intended to increase green density and is also intended to advantageously reduce the ejection force necessary to withdraw a green compact from a die after compaction.

Background Art

[0002]

In a powder metallurgy process, source powders are mixed together; the mixture is transferred, is filled into a die, and is then pressed into a formed body (hereinafter referred to as a green compact); and the green compact is withdrawn from the die and is then subjected to a post-treatment such as sintering as required.

In the powder metallurgy process, in order to achieve an increase in product quality and a reduction in production cost, it is necessary to ensure all of high powder flowability in a transferring step, high compressibility in a pressing step, and low ejection force in a step of withdrawing the green compact from the die.

[0003]

As for techniques for improving the flowability of iron-based mixed powders, Patent Literature 1 discloses that the flowability of an iron-based mixed powder can be improved by adding a fullerene, which serves as a carbon supply component, thereto.

Furthermore, Patent Literature 2 discloses a technique for improving the flowability of a powder composition for metallurgy by adding a particulate inorganic oxide with an average particle size of less than 500 nm thereto.

However, the use of these techniques is insufficient to achieve high compressibility and low ejection force while flowability is maintained.

[0004]

In order to increase the density of a green compact or in order to reduce the ejection force thereof, it is effective to use a lubricant that has ductility and that is soft at a temperature at which an iron-based mixed powder is pressed. This is because the lubricant seeps out of the iron-based mixed powder during pressing to adhere to a surface of a die and therefore reduces the friction between the die and the green compact.

However, the lubricant has ductility and therefore is likely to adhere to particles of an iron powder and powder for an alloy. Hence, there is a problem in that the flowability and filling ability of an iron-based mixed powder are impaired.

[0005]

The blending of the above carbon material, fine particles, and lubricant reduces the theoretical density (the density determined assuming that the voidage is zero) of the iron-based mixed powder to cause a reduction in green density; hence, it is not preferable to blend large amounts of these materials.

It has been extremely difficult to balance the flowability of a conventional iron-based mixed powder, high green density, and low ejection force.

[0006]

As for techniques relating to additives for iron-based mixed powders, Patent Literature 3 discloses a technique in which a powder of iron oxide (such as mill scale) is added to a powder of finish-reduced iron to control a dimensional change of a sintered body.

As for techniques relating to iron oxide powders, Patent Literature 4 discloses a method for synthesizing micaceous iron oxide (MIO) known as a pigment for rust-proof paints for steel materials. According to the method disclosed in Patent Literature 4, primary particles of α-iron oxide that have a size of 1 μm to 100 μm and an aspect ratio of 5 to 30 are obtained.

Related Art Document

Patent Literature

[0007]

PTL 1: Japanese Unexamined Patent Application Publication No. 2007-31744

PTL 2: PCT Japanese Translation Patent Publication No. 2002-515542

PTL 3: Japanese Unexamined Patent Application Publication No. 8-325667

PTL 4: Japanese Unexamined Patent Application Publication No. 3-131526

Summary of Invention

Problems to be Solved by the Invention

[0008]

The present invention has been developed in view of the aforementioned circumstances and has an object to suggest an iron-based mixed powder for powder metallurgy. The iron-based mixed powder can accomplish both an increase in product quality and a reduction in production cost in such a way that the density of a green compact is increased by increasing the flowability of the iron-based mixed powder and ejection force is greatly reduced after compaction.

Solution to Problem

[0009]

The inventors have investigated various additives for use in iron-based powders for the purpose of achieving the above object.

As a result, the inventors have found that the addition of an appropriate amount of oxide particles with an average size of 0.5 μm or more to an iron-based powder provides significantly improved flowability and also provides improved green density and ejection force.

The present invention is based on the above finding.

[0010]

The present invention is as summarized below.

1. An iron-based mixed powder for powder metallurgy, containing: an iron-based powder; 0.01% to 5.0% by mass of particles of an oxide selected from a group consisting of iron, aluminum, and silicon, and the oxide particles having an average size of 0.5 μm or more and a longitudinal size to thickness aspect ratio of less than 5; 0.1% to 10% by mass of a powder for an alloy, the alloy powder including graphite powder, or a metal selected from the group of Cu, Mo, and Ni; and 0.01% to 1.0% by mass of an organic binder.

[0011]

2. The iron-based mixed powder for powder metallurgy according to Item 1, further containing a free lubricant.

[0012]

3. The iron-based mixed powder for powder metallurgy according to Item 1 or Item 2 containing 0.05% to 1.0% by mass of said oxide particles.

Advantageous Effects of Invention

[0015]

According to the present invention, not only increased flowability but also high green density and low ejection force can be achieved by adding an appropriate amount of oxide particles having an average size of 0.5 μm or more to an iron-based powder. This results in an increase in production efficiency and a reduction in production cost.

Brief Description of Drawing

[0016]

[Fig. 1] Fig. 1 is a schematic view illustrating the aspect ratio of powder.

Description of Embodiments

[0017]

The present invention will now be described in detail.

In the present invention, oxide particles are used as a component for improving the flowability of an iron-based powder. The reason is as described below.

Common iron-based mixed powders contain about 1% by mass of organic lubricants for the purpose of increasing the flowability of powder or decreasing the ejection force of green compacts. The organic lubricants have a specific gravity of about 1.0 and are significantly lower in specific gravity than iron powders, which have a specific gravity of 7.8. In general, in the case of mixing powders that are significantly different in specific gravity from each other, segregation occurs during mixing to cause a reduction in flowability or differences in properties between lots.

Thus, in the case of mixing different types of powders, it is important that the difference in specific gravity therebetween is as small as possible.

[0018]

When the oxide particles used herein are made of, for example, iron oxide (hematite), the oxide particles have a specific gravity of 5.3 and are higher in specific gravity than the organic lubricants. Therefore, the oxide particles are less affected by the flow of air in a powder bed during fluidization as compared to the organic lubricants. In an iron-based mixed powder according to the present invention, presumably, an organic lubricant is entirely or partially replaced with the oxide particles and therefore the segregation of various additives is prevented. This probably results in the improvement of the flowability of the iron-based mixed powder.

In the present invention, when the oxide particles have a large size, the oxide particles do not cover the surface of the iron-based powder unlike a flowability-improving powder, disclosed in Patent Literature 2, containing primary particles with a size on the order of nanometers but are probably filled in voids in the iron-based powder in a preferred manner. Thus, in a forming step presumably, the effective contact area between a green compact and a die is increased and therefore the springback stress is distributed.

This probably results in a reduction in ejection force.

[0019]

In order to exhibit the above effect, the oxide particles need to have an average size of 0.5 μm or more. When the average size of the oxide particles is less than 0.5 μm, the effect of reducing ejection force cannot be sufficiently obtained. However, when the average size of the oxide particles is more than 100 μm, the oxide particles cannot be uniformly mixed with iron-based mixed powders (an average size of about 100 μm) usually used in powder metallurgy and therefore cannot exhibit the above effect. Thus, the average size of the oxide particles is preferably 100 μm or less. The average size of the oxide particles is more preferably 40 μm or less and further more preferably 20 μm or less. The average size of the oxide particles is preferably determined by a method described in Example 1.

The oxide particles may contain about 20% by mass or less (the percentage with respect to the oxide particles) of an impurity other than the oxide. Those having lower impurity content (for example, 10% by mass or less or 2% by mass or less) are preferably used if the commercial availability thereof is not difficult. The impurity is not particularly limited and any impurity (for example, a metal or another inorganic compound) contained in oxide particles produced by a known commercial process is not particularly problematic.

[0020]

In the present invention, particles containing an oxide containing at least one selected from the group consisting of iron, aluminum, and silicon are particularly advantageous and are appropriate to the oxide particles. Examples of the oxide include Fe_2O_3, Al_2O_3, and SiO_2 and are not particularly limited in component or crystal structure. The content of an oxide of at least one selected from the group consisting of iron, aluminum, and silicon in the oxide particles is preferably about 80% by mass or more (the percentage with respect to the oxide) and more preferably 98% or more in total.

[0021]

In order to carry out the present invention at low cost, a particulate oxide satisfying the above is preferably readily available at low cost. In view of availability, an oxide of iron or an iron-based oxide containing an oxide of iron as a major component is particularly preferred. Commercially available examples of the iron-based oxide include those containing about 70% to 95% by mass (the percentage with respect to the oxide) of an oxide of iron and about 5% to 30% by mass of an oxide of Al and/or an oxide of Si in total.

When the form of powder is viewed form the viewpoint of aspect ratio, particles with high aspect ratio can be artificially synthesized. For example, Patent Literature 4 discloses a method for synthesizing α-iron oxide with an aspect ratio of 5 to 30. However, this method requires heating and pressurizing for a long time in the course of synthesis, is irreversibly high in production cost, and also is not readily available. Thus, the aspect ratio is preferably less than 5.

In the present invention, the aspect ratio refers to the ratio of the longitudinal size 1 to the thickness 2 of powder as shown in Fig. 1. The aspect ratio of the oxide particles is preferably determined by a method described in Example 1.

[0022]

In the present invention, when the content of the oxide particles in the iron-based mixed powder is less than 0.01% by mass, the effect of adding the oxide particles is not obtained. However, when the content thereof is more than 5.0% by mass, an extreme increase in ejection force is caused, which is not preferred. Thus, the content of the oxide particles is 0.01% to 5.0% by mass.

The lower limit is preferably 0.05% by mass. The upper limit is preferably 1.0% by mass.

[0023]

In the present invention, the following powders are examples of the iron-based powder, which is a major component of the iron-based mixed powder: pure iron powders such as atomized iron powders and reduced iron powders, diffusion alloyed steel powders, prealloyed steel powders, and hybrid steel powders produced by diffusion alloy components in prealloyed steel powders. The iron-based powder preferably has an average particle size of 1 μm or more and more preferably about 10 μm to 200 μm. The term "major component" as used herein means that the content of the iron-based powder in the iron-based mixed powder is 50% by mass or more.

[0024]

Examples of powder for an alloy include graphite powders; powders of metals such as Cu, Mo, and Ni; and metal compound powders. Other known powders for alloys also can be used. The strength of a sintered body can be increased by mixing the iron-based powder with at least one of these powders for alloys.

The sum of the contents of these powders for alloys in the iron-based mixed powder is preferably about 0.1% to 10% by mass. This is because when the content of these powders for alloys is 0.1% by mass or more or more than 10% by mass, the strength of an obtained sintered body is advantageously increased or the dimensional accuracy of the sintered body is reduced, respectively.

[0025]

The powder for an alloy is preferably in such a state (hereinafter referred to as an iron powder with alloy component adhered thereon) that the powder for an alloy is attached to the iron-based powder with an organic binder therebetween. This prevents the segregation of the powder for an alloy and allows components in powder to be uniformly distributed therein.

[0026]

Herein, an aliphatic amide, a metallic soap, or the like is particularly advantageous and appropriate to the organic binder. Other known organic binders such as polyolefins, polyesters, (meth)acrylic polymers, and vinyl acetate polymers can be used. These organic binders may be used alone or in combination. In the case of using two or more the organic binders, at least a part of the organic binders may be used in the form of a composite melt. When the content of the organic binder is less than 0.01% by mass, the powder for an alloy cannot be uniformly or sufficiently attached to iron powders. However, when the content thereof is more than 1.0% by mass, the iron powders adhere to each other to aggregate and therefore flowability may possibly be reduced. Thus, the content of the organic binder preferably ranges from 0.01% to 1.0% by mass. The content (mass percent) of the organic binder refers to the percentage of the organic binder in the iron-based mixed powder for powder metallurgy.

[0027]

In order to improve the flowability and formability of the iron-based mixed powder for powder metallurgy, a free lubricant (powder) may be added thereto. The content of the free lubricant in the iron-based mixed powder for powder metallurgy is preferably 1.0% by mass or less. On the other hand, the content of the free lubricant is preferably 0.01% by mass or more (the percentage with respect to the iron-based mixed powder). The free lubricant is preferably a metallic soap (for example, zinc stearate, manganese stearate, lithium stearate, or the like), a bis amide (for example, ethylene bis-stearamide or the like), an aliphatic amide (for example, monostearamide, erucamide, or the like) including an monoamide, an aliphatic acid (for example, oleic acid, stearic acid, or the like), a thermoplastic resin (for example, an polyamide, polyethylene, polyacetal, or the like), which has the effect of reducing the ejection force of a green compact. A known free lubricant other than the above free lubricant can be used.

[0028]

In the present invention, the content of the organic lubricant is less than ever and the organic lubricant is replaced with the oxide particles, whereby flowability and green density can be improved while excellent ejection force is maintained. That is, the reduction in content of the organic lubricant usually degrades ejection force; however, in the present invention, this adverse effect can be avoided by the addition of the oxide. The use of the oxide instead of the organic lubricant improves green density. Furthermore, the presence of the oxide particles improves fluidity. In order to obtain the above advantages, the content of the organic lubricant in the iron-based mixed powder is preferably 0.8% by mass or less, more preferably 0.7% by mass or less, and further more preferably 0.6% by mass or less. The lower limit of the content of the organic lubricant is preferably 0.02% by mass, which is the sum of the lower limit of the content of the organic binder and that of the free lubricant.

The organic lubricant contains at least one of the organic binder, an organic free lubricant, and an organic non-free lubricant (an organic lubricant attached to an iron powder with a binder therebetween). The organic non-free lubricant is frequently substituted by that of the organic binder in view or the function thereof. Therefore, the sum of the content of the organic binder and that of the organic free lubricant corresponds to the content of the organic lubricant.

The content of iron in the iron-based mixed powder is preferably 50% by mass or more.

[0029]

A method for producing the iron-based mixed powder according to the present invention is described below.

The iron-based powder is mixed with the oxide particles according to the present invention and additives such as a binder and a lubricant and is further mixed with powder for an alloy as required. The additives, such as the binder and the lubricant, need not be necessarily added to the iron-based powder at once. After primary mixing is performed using a portion of additives, secondary mixing may be performed using the rest thereof.

[0030]

A mixing method is not particularly limited. Any conventionally known mixer can be used. The following mixer can be used: for example, an impeller-type mixer (for example, a Henschel mixer or the like) or a rotary mixer (for example, a V-type mixer, a double-cone mixer, or the like), which is conventional known. When heating is necessary, the following mixer is particularly advantageous and appropriate: a high-speed mixer, a disk pelletizer, a plough share mixer, a conical mixer, or the like, which is suitable for heating.

[0031]

In the present invention, an additive for property improvement may be used in addition to the above additives according to purpose. For example, the addition of a powder of MnS or the like for machinability improvement is exemplified for the purpose of improving the machinability of a sintered body.

[EXAMPLES]

[EXAMPLE 1]

[0032]

Prepared iron-based powders were two types: Pure Iron Powder A (an atomized iron powder with an average particle size of 80 μm) and iron powder with alloy component adhered thereon B prepared by attaching powders for alloys to this pure iron powder with organic binders therebetween. The powders, for alloys, used for B were 2.0% by mass of a Cu powder (an average particle size of 25 μm) and 0.8% by mass of a graphite powder (an average particle size of 5.0 μm). The organic binders used were 0.05% by mass of monostearamide and 0.05% by mass of ethylene bis-stearamide. The percentage of each of these additives is a proportion to iron-based mixed powder.

[0033]

Pure Iron Powder A and iron powder with alloy component adhered thereon B were mixed with oxide particles with an aspect ratio of less than 5 and free lubricants at various ratios, whereby iron-based mixed powders for powder metallurgy were obtained. The oxide particles used were JC (TM) (Fe_2O_3 produced by JFE Chemical Corporation), MIOX (TM) (an Fe_2O_3-SiO_2-Al_2O_3 mixture, containing 90% by mass of Fe_2O_3, 5% by mass of SiO_2, and 3% by mass of Al_2O_3, the remainder being impurities (each is an approximate value), produced by Karntner Montanindustrie Gesellschaft mbH), and A31 (TM) (Al_2O_3 produced by Nippon Light Metal Company, Ltd.). The free lubricants used were zinc stearate, ethylene bis-stearamide, and erucamide in addition to 0.1% by mass of lithium stearate. The iron powders and the oxide particles were measured for average particle size by a laser diffraction/scattering method (according to JIS R 1629) and the particle size at 50% in the particle size distribution (the cumulative volume fraction) was used. The oxide particles were observed with a scanning electron microscope. The average of the aspect ratios of randomly selected 50 particles was used as the aspect ratio.

The blending ratio of these mixed powders is shown in Table 1. The blending ratio is a proportion to each iron-based mixed powder for powder metallurgy. For Pure Iron Powder A, the content (mass percent) of an organic lubricant is equal to the content of a free lubricant shown in Table 2.

For iron powder with alloy component adhered thereon B, the content thereof is equal to the sum of the content (0.1% by mass) of an organic binder and the content of a free lubricant shown in Table 2.

[0034]

Each obtained iron-based mixed powder was filled into a die and was then pressed at room temperature with a pressure of 980 MPa, whereby a cylindrical green compact with a diameter of 11 mm and a height of 11 mm was obtained. In this operation, the flowability of the iron-based mixed powder, the ejection force needed to withdraw the green compact from the die, and the density of the green compact were measured. The measurement results are shown in Table 1. The flowability of the iron-based mixed powder was evaluated in accordance with JIS Z 2502.

Herein, the flowability is good when the fluidity is not more than 30 seconds per 50 grams, the compressibility is good when the green density is 7.35 Mg/m^3 or more, and the drawability is good when the ejection force is 25 MPa or less.

[0035]

[Table 1]

Table 1

No.	Type of iron-based powder	Oxide particles				Free lubricant		Properties			Remarks
		Type	Average particle size (μm)	Aspect ratio	Content (mass percent)	Type	Content (mass percent)	Fluidity (sec/50 g)	Green density (Mg/m^3)	Ejection force (MPa)	
1	B	Iron oxide	1.0	1	0.05	Zinc stearate	0.4	23.9	7.38	17	Example 1
2	A	Iron oxide	1.0	1	1.0	Zinc stearate	0.4	23.9	7.36	17	Example 2
3	B	$Fe_2O_3 \cdot SiO_2 \cdot Al_2O_3$ mixture	0.8	2	0.2	Ethylene bis-stearamide	0.1	21.0	7.42	18	Example 3
4	B	$Fe_2O_3 \cdot SiO_2 \cdot Al_2O_3$ mixture	4.0	2	0.2	Ethylene bis-stearamide	0.1	21.1	7.42	18	Example 4
5	B	$Fe_2O_3 \cdot SiO_2 \cdot Al_2O_3$ mixture	18	3	0.2	Erucamide	0.1	21.8	7.43	21	Example 5
6	B	$Fe_2O_3 \cdot SiO_2 \cdot Al_2O_3$ mixture	38	4	0.2	Ethylene bis-stearamide	0.1	21.3	7.42	22	Example 6
7	A	Aluminum oxide	5.0	1	0.1	Erucamide	0.4	23.1	7.38	19	Example 7
8	B	Aluminum oxide	<u>0.2</u>	1	0.2	Erucamide	0.4	Not flow	7.33	16	Comparative Example 1
9	A	Iron oxide	<u>0.08</u>	1	0.2	Erucamide	0.8	Not flow	7.29	45	Comparative Example 2
10	B	Iron oxide	<u>180</u>	2	0.2	Erucamide	0.8	Not flow	7.29	45	Comparative Example 3
11	B	$Fe_2O_3 \cdot SiO_2 \cdot Al_2O_3$ mixture	38	4	<u>0.005</u>	Erucamide	0.3	Not flow	7.31	25	Comparative Example 4
12	B	Iron oxide	20	1	<u>6.0</u>	Zinc stearate	0.2	30.7	7.31	35	Comparative Example 5

*A: Pure iron powder, B: iron powder with alloy component adhered thereon

[0036]

As is clear from Table 1, an iron-based mixed powder excellent in flowability, compressibility, and ejection force can be obtained by the addition of an appropriate amount of oxide particles according to the present invention.

In contrast, comparative examples are poor in at least one of flowability, green density, and ejection force.

[EXAMPLE 2]

[0037]

A prepared iron-based powder was the same as iron powder with alloy component adhered thereon B described in Example 1. The iron-based powder was mixed with oxide particles (an aspect ratio of less than 5) and free lubricants as shown in Table 2, whereby iron-based mixed powders for powder metallurgy were obtained. The oxide particles used were similar to the commercial products described in Example 1. The percentage of each additive shown in Table 2 is a proportion to corresponding iron-based mixed powder. The flowability of each iron-based mixed powder, the ejection force needed to withdraw a green compact (obtained from the iron-based mixed powder) from the die, and the density of the green compact were measured in the same manner as that described in Example 1. The measurement results are summarized in Table 2.

[0038]

[Table 2]

Table 2

No.	Content of binder mass percent	Free lubricant		Content of organic lubricant mass percent	Oxide powder				Properties			Remarks
		Type	Content mass percent		Type	Average particle size (μm)	Aspect ratio	Content mass percent	Fluidity sec/50 g	Green density Mg/m^3	Ejection force MPa	
13	0.1	Ethylene bis-stearamide	0.1	0.20	$Fe_2O_3 \cdot SiO_2 \cdot Al_2O_3$ mixture	4	2	0.05	24.6	7.41	20	Example
14	0.1	Ethylene bis-stearamide	0.3	0.40	$Fe_2O_3 \cdot SiO_2 \cdot Al_2O_3$ mixture	4	2	0.2	23.8	7.43	19	Example
15	0.1	Ethylene bis-stearamide	0.4	0.50	$Fe_2O_3 \cdot SiO_2 \cdot Al_2O_3$ mixture	4	2	0.2	24.2	7.42	19	Example
16	0.1	Ethylene bis-stearamide	0.7	0.80	$Fe_2O_3 \cdot SiO_2 \cdot Al_2O_3$ mixture	4	2	0.2	29.0	7.35	15	Example
17	0.1	Ethylene bis-stearamide	0.1	0.20	Not used	-	-	-	28.2	7.34	35	Comparative Example
18	0.1	Ethylene bis-stearamide	0.4	0.50	Not used	-	-	-	Not flow	7.33	22	Comparative Example
19	0.1	Ethylene bis-stearamide	0.5	0.60	Not used	-	-	-	Not flow	7.30	20	Comparative Example
20	0.1	Ethylene bis-stearamide	0.7	0.80	Not used	-	-	-	Not flow	7.27	18	Comparative Example
21	0.1	Ethylene bis-stearamide	0.2	0.30	Iron oxide	1	1	0.2	24.2	7.41	16	Example
22	0.1	Ethylene bis-stearamide	0.4	0.50	Aluminum oxide	5	1	0.2	24.6	7.42	15	Example

[0039]

Table 2 shows that iron-based mixed powders (Nos. 14 and 15) which contain iron oxide particles (particles of an Fe_2O_3-SiO_2-Al_2O_3 mixture) and which have a reduced organic lubricant content of 0.4% to 0.5% by mass have substantially equal ejection force and also have significantly improved green density and flowability as compared to, for example, an iron-based mixed powder (No. 20) containing 0.8% by mass of an organic lubricant. As is clear from No. 13, good flowability, green density, and ejection force can be obtained even though an organic lubricant is further reduced.

In the case of changing an organic binder, a free lubricant, powder for an alloy, and/or oxide particles (in particular, oxide particles containing iron, aluminum, and/or silicon) or in the case of adding powder for machinability improvement, substantially the same results as those described in Example 1 or 2 were obtained.

Industrial Applicability

[0040]

Not only flowability but also green density and ejection force can be improved by adding an appropriate amount of oxide particles according to the present invention to an iron-based powder. Therefore, production efficiency can be increased and production costs can be reduced.

Reference Signs List

[0041]

1 longitudinal size

2 thickness

CLAIMS

[Claim 1]

An iron-based mixed powder for powder metallurgy, containing:

an iron-based powder;

0.01% to 5.0% by mass of particles of an oxide selected from a group consisting of iron, aluminum, and silicon, and the oxide particles having an average size of 0.5 μm or more and a longitudinal size to thickness aspect ratio of less than 5;

0.1% to 10% by mass of a powder for an alloy, the alloy powder including graphite powder, or a metal selected from the group of Cu, Mo, and Ni; and

0.01% to 1.0% by mass of an organic binder.

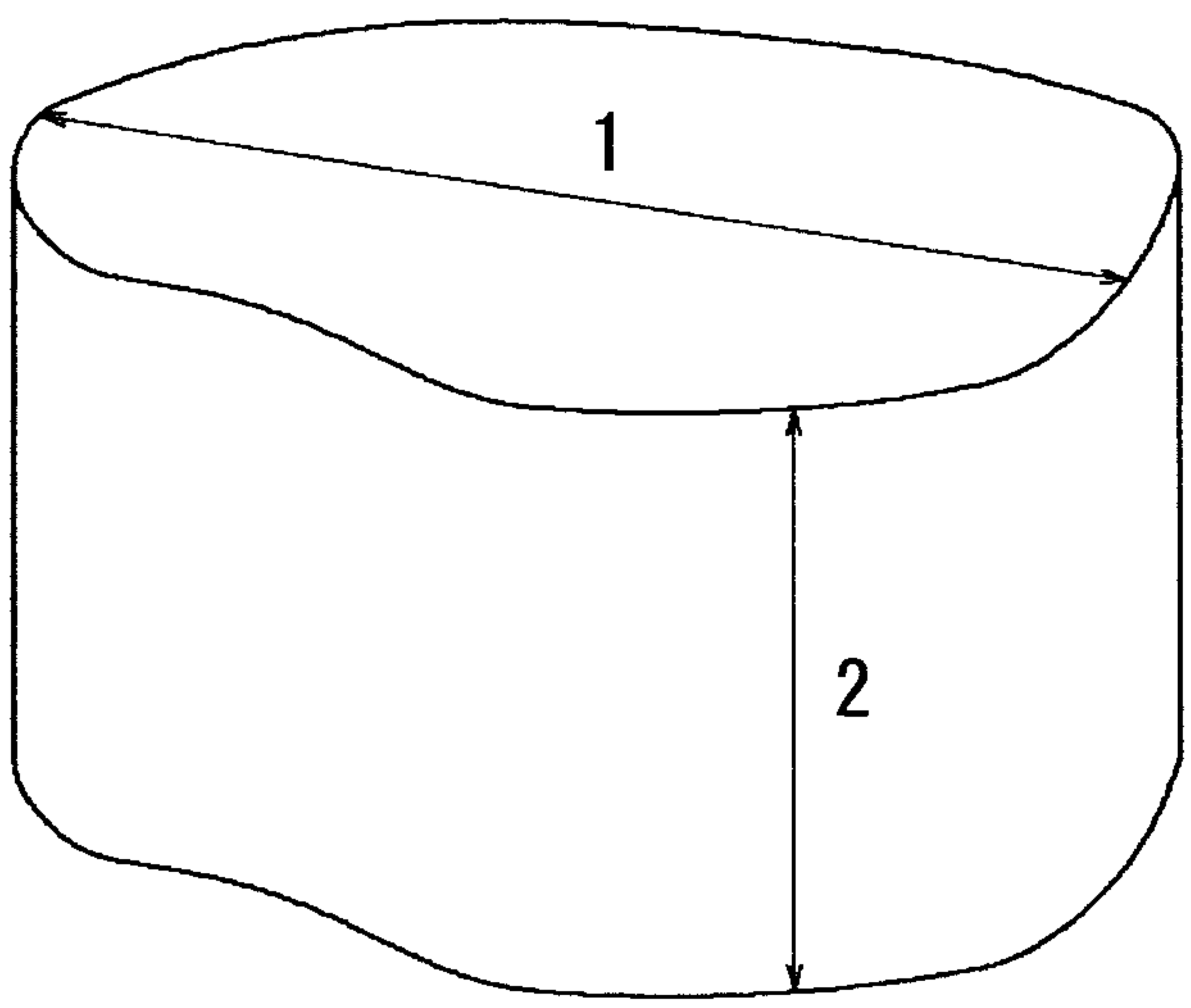
[Claim 2]

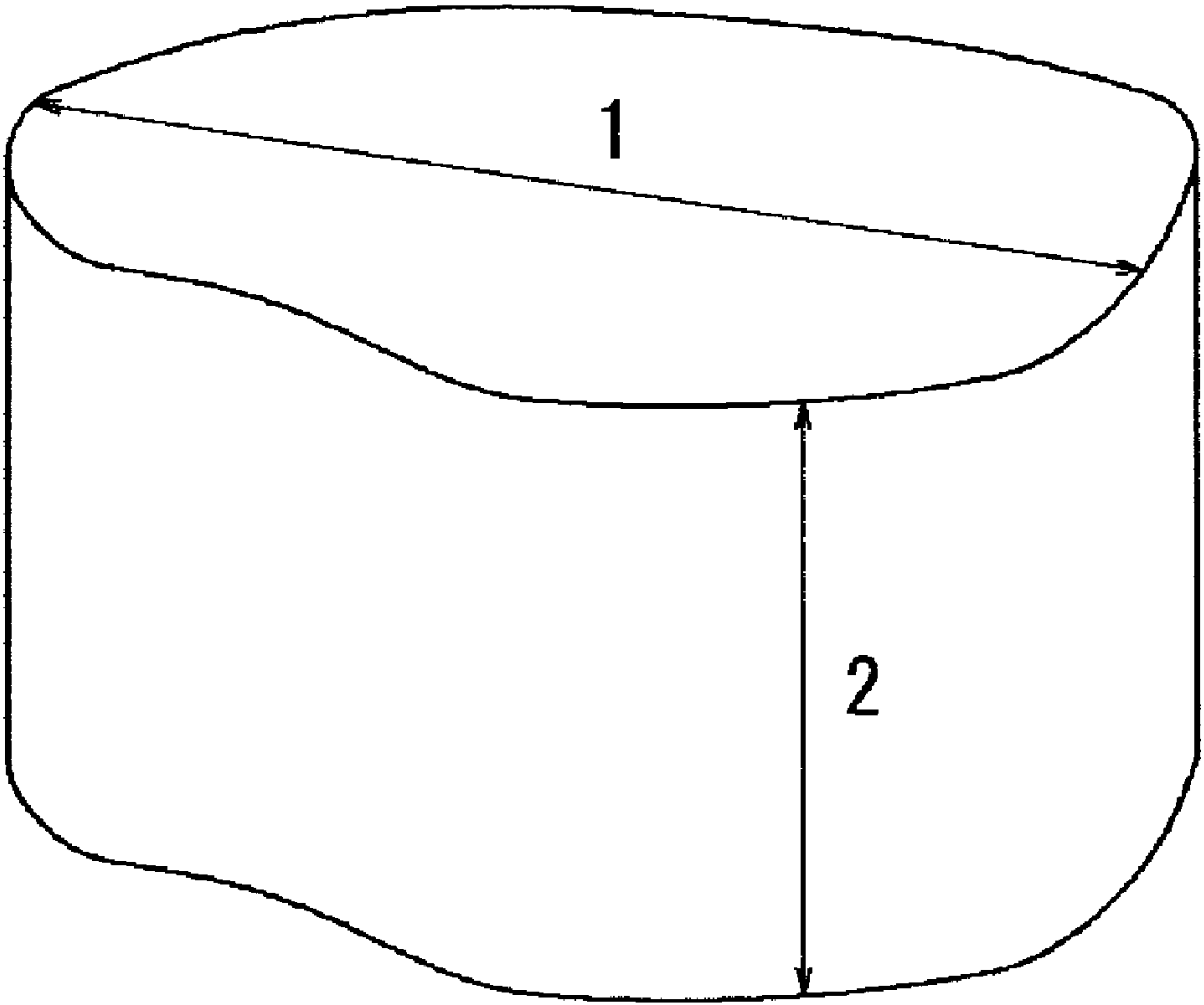
The iron-based mixed powder for powder metallurgy according to Claim 1, further containing a free lubricant.

[Claim 3]

The iron-based mixed powder for powder metallurgy according to Claim 1 or Claim 2 containing 0.05% to 1.0% by mass of said oxide particles.

[F I G. 1]

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