The present invention discloses a reciprocating compressor and a manufacturing method thereof. The reciprocating compressor includes a frame installed in a casing, an outer stator having a winding coil and being fixed to the frame, an inner stator disposed in the outer stator with a predetermined gap, and sintered by a powder metallurgy process using metal powder, a rotor having a permanent magnet between the outer stator and the inner stator, a cylinder disposed inside the inner stator of the reciprocating motor for forming a compression chamber, and sintered by a powder metallurgy process using metal powder, a piston slidably inserted into the inner circumference of the cylinder, for sucking and compressing gas by linear reciprocation, and a plurality of resonance springs for elastically supporting the connection part of the piston and the rotor, and inducing resonance of the piston. Accordingly, the cylinder is not deformed by the inner stator, and thus abrasion of the piston and the cylinder by deformation of the cylinder is prevented in advance. Moreover, the reciprocating compressor is easily manufactured by considerably simplifying the manufacturing process.
FIG. 3
CONVENTIONAL ART
FIG. 8

1. Form cylinder with primary metal powder
2. Manufacture cylinder by sintering primary metal powder
3. Insert secondary metal powder onto outer circumference of cylinder
4. Manufacture inner stator by sintering secondary metal powder

FIG. 9

1. Form cylinder and inner stator with primary and secondary metal powder
2. Manufacture inner stator by sintering secondary metal powder
3. Manufacture cylinder by sintering primary metal powder
FIG. 10

1. Form cylinder and inner stator with primary and secondary metal powder
2. Sinter primary and secondary metal powder at inner stator sintering temperature
3. Additionally sinter primary metal powder at cylinder sintering temperature

FIG. 11

1. Manufacture cylinder by sintering primary metal powder
2. Manufacture inner stator by sintering secondary metal powder
3. Insert and bond inner stator onto cylinder
RECIPIROCATING COMPRESSOR AND MANUFACTURING METHOD THEREOF

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a reciprocating compressor, and more particularly to, a reciprocating compressor which can be easily manufactured by a simplified manufacturing process, and which can prevent abrasion of a piston and a cylinder by deformation of the cylinder, and a manufacturing method thereof.

[0003] 2. Description of the Background Art

[0004] In general, a compressor, that is a major component for refrigeration and air conditioning of an air conditioner, a refrigerator, etc., has been widely used in various industrial fields. The compressors are classified into rotary compressors, scroll compressors and reciprocating compressors according to a compression mechanism for compressing refrigerants.

[0005] In the reciprocating compressor, a piston linearly reciprocates in a cylinder to suck, compress and discharge gas. Normally, when only the linear motion is necessary, the reciprocating compressor performing the linear motion without a special device is preferably used.

[0006] One example of the conventional reciprocating compressor will now be explained.

[0007] FIG. 1 is a cross-sectional diagram illustrating one example of the conventional reciprocating compressor, and FIGS. 2 and 3 are perspective diagrams illustrating examples of an inner stator of the conventional reciprocating compressor.

[0008] Referring to FIG. 1, the conventional reciprocating compressor includes a casing 10 in which a gas suction pipe SP and a gas discharge pipe DP are installed, a frame unit 20 elastically supported in the casing 10, a reciprocating motor 30 supported by the frame unit 20 and fixed in the casing 10, a compression unit 40 for performing linear reciprocation and sucking and compressing refrigerant gas, by connecting a piston 42 to a rotor 33 of the reciprocating motor 30, and a resonance spring unit 50 for inducing resonance by elastically supporting the reciprocating motor 30.

[0009] The frame unit 20 has a front frame 21 for supporting one side of an outer stator 31 and an inner stator 32 of the reciprocating motor 30, and also supporting a cylinder 41 and the piston 42 of the compression unit 40, a middle frame 22 coupled to the front frame 21 with the reciprocating motor 30 therebetween, for supporting the outer stator 31 of the reciprocating motor 30, and a rear frame 23 coupled to the middle frame 22, for supporting the resonance spring unit 50.

[0010] The reciprocating motor 30 includes the outer stator 31 having a coil and being fixed between the front frame 21 and the middle frame 22, the inner stator 32 positioned inside the outer stator 31 and fixed to the cylinder 41 of the compression unit 40 discussed later, and the rotor 33 positioned between the outer stator 31 and the inner stator 32, for performing linear reciprocation in the flux direction.

[0011] The outer stator 31 is manufactured by forming core blocks by stacking a plurality of stator cores sheet by sheet in the radial direction, and disposing the core blocks at both sides of a winding coil 31a to face each other.

[0012] As shown in FIG. 2, the inner stator 32 is manufactured by forming thin stator cores 32a in a rectangular plate shape, and stacking the stator cores 32a in the radial direction. As depicted in FIG. 3, to maximize a lamination factor, thin stator cores 32b and 32c can be formed in a ‘‘T’’ shape, disposed symmetrically to each other, and stacked in the radial direction.

[0013] The rotor 33 includes a magnet frame 33a formed in a cylindrical shape and fastened to the rear end of the piston 42, and a magnet 33b fixed to the outer circumference of the magnet frame 33a, and positioned between the outer stator 31 and the inner stator 32.

[0014] The compression unit 40 has the cylinder 41 inserted into the front frame 21, the piston 42 coupled to the rotor 33 of the reciprocating motor 30, for performing linear reciprocation in the cylinder 41, sucking refrigerant gas through a gas passage P and compressing the refrigerant gas, a suction valve 43 mounted on the front end of the piston 42, for opening/closing the gas passage P, a discharge valve 44 detachably installed on the front end of the cylinder 41, for restricting discharge of the compressed gas, a valve spring 45 for elastically supporting the discharge valve 44, and a discharge cover 46 housing the discharge valve 44 and the valve spring 45, and being fixed to the front frame 21 with the cylinder 41.

[0015] The resonance spring unit 50 includes a spring support member 51 coupled to the connection part of the rotor 33 and the piston 42, a plurality of front side resonance springs 52 for supporting the front side from the spring support member 51, and a plurality of rear side resonance springs 53 for supporting the rear side from the spring support member 51.

[0016] Here, reference numeral 32d denotes a fixing ring, and P denotes a compression chamber.

[0017] The operation of the conventional reciprocating compressor will now be described.

[0018] When power is applied to the outer stator 31 of the reciprocating motor 30, flux is formed between the outer stator 31 and the inner stator 32, and thus the rotor 33 and the piston 42 are moved in the flux direction. Therefore, the piston 42 linearly reciprocates in the cylinder 41 by the spring unit 50, and generates a pressure difference in the compression chamber P of the cylinder 41, thereby sucking refrigerant gas to the compression chamber P, compressing the refrigerant gas to a predetermined pressure, and discharging the compressed gas. The above procedure is repeated.

[0019] In the conventional reciprocating compressor, in order to reduce core loss resulting from alternating current magnetic flux and increase a magnetic path area of the magnetic flux, the inner stator 32 is formed by stacking the thin stator cores 32a sheet by sheet in the radial direction, or stacking two stator cores 32b and 32c in pairs in the radial direction. However, it is difficult to stack the thin stator cores 32a, 32b and 32c in the radial direction, which results in the high production cost.

[0020] Furthermore, since the stator cores 32a, 32b and 32c are formed sheet by sheet, the size control is difficult.
Accordingly, when the outer circumferences of the stator cores 32a, 32b, and 32c are irregular, a gap between the inner stator 32 and the outer stator 31 is widened, and when the inner circumferences of the stator cores 32a, 32b, and 32c are irregular, the cylinder 41 for indenting the inner stator 32 is deformed.

SUMMARY OF THE INVENTION

[0021] Therefore, an object of the present invention is to provide a reciprocating compressor which can be easily manufactured by simplifying a manufacturing process of a stator, and which can prevent abrasion of a piston and a cylinder by preventing deformation of the cylinder by an inner stator, and a manufacturing method thereof.

[0022] To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described herein, there is provided a reciprocating compressor, including: a frame installed in a casing; an outer stator having a winding coil and being fixed to the frame; an inner stator disposed in the outer stator with a predetermined gap, and sintered by a powder metallurgy process using metal powder; a rotor having a permanent magnet between the outer stator and the inner stator; a cylinder disposed inside the inner stator of the reciprocating motor for forming a compression chamber, and sintered by a powder metallurgy process using metal powder; a piston slidably inserted into the inner circumference of the cylinder, for sucking and compressing gas by linear reciprocation; and a plurality of resonance springs for elastically supporting the connection part of the piston and the rotor, and inducing resonance of the piston.

[0023] According to yet another aspect of the present invention, a manufacturing method of a reciprocating compressor includes: a first step for putting primary metal powder composing a cylinder into a die, and forming the cylinder in a predetermined shape; a second step for manufacturing the cylinder by heating and primarily sintering the primary metal powder in the die at an appropriate temperature; a third step for putting secondary metal powder composing an inner stator onto the outer circumference of the cylinder of the die, and forming the inner stator in a predetermined shape; and a fourth step for manufacturing the inner stator by heating and secondarily sintering the secondary metal powder in the die at an appropriate temperature.

[0024] According to yet another aspect of the present invention, a manufacturing method of a reciprocating compressor includes: a first step for manufacturing a temporary product by putting primary metal powder composing a cylinder and secondary metal powder composing an inner stator into a die, and forming the cylinder and the inner stator at the same time; and a second step for heating and sintering the temporary product at an appropriate temperature, and locally heating and sintering the primary metal powder composing the cylinder at an appropriate temperature at the same time.

[0025] According to yet another aspect of the present invention, a manufacturing method of a reciprocating compressor includes: a first step for manufacturing a cylinder by heating and sintering primary metal powder in a die at an appropriate temperature, and manufacturing an inner stator by heating and sintering secondary metal powder in another die at an appropriate temperature; and a second step for inserting and bonding the inner stator onto the outer circumference of the cylinder.

[0026] The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

[0028] In the drawings:

[0029] FIG. 1 is a cross-sectional diagram illustrating one example of a conventional reciprocating compressor;

[0030] FIG. 2 is a perspective diagram illustrating one example of an inner stator of the conventional reciprocating compressor;

[0031] FIG. 3 is a perspective diagram illustrating another example of an inner stator of the conventional reciprocating compressor;

[0032] FIG. 4 is a perspective diagram illustrating disassembly of an inner stator and a cylinder of a reciprocating compressor in accordance with a first embodiment of the present invention;

[0033] FIG. 5 is a cross-sectional diagram illustrating the inner stator and the cylinder of the reciprocating compressor in accordance with the first embodiment of the present invention;

[0034] FIG. 6 is a cross-sectional diagram illustrating an inner stator and a cylinder of a reciprocating compressor in accordance with a second embodiment of the present invention;

[0035] FIG. 7 is a cross-sectional diagram illustrating an inner stator and a cylinder of a reciprocating compressor in accordance with a third embodiment of the present invention;

[0036] FIG. 8 is a block diagram illustrating the manufacturing method of the inner stator and the cylinder of the reciprocating compressor in accordance with the first embodiment of the present invention;

[0037] FIG. 9 is a block diagram illustrating the manufacturing method of the inner stator and the cylinder of the reciprocating compressor in accordance with the second embodiment of the present invention;

[0038] FIG. 10 is a block diagram illustrating the manufacturing method of the inner stator and the cylinder of the reciprocating compressor in accordance with the third embodiment of the present invention; and

[0039] FIG. 11 is a block diagram illustrating the manufacturing method of the inner stator and the cylinder of the reciprocating compressor in accordance with the fourth embodiment of the present invention.
DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0040] Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

[0041] A stator structure of a reciprocating motor in accordance with the present invention will now be explained in detail with reference to the accompanying drawings. A casing, a frame unit and a resonance spring unit identical to the conventional ones will not be described.

[0042] FIG. 4 is a perspective diagram illustrating disassembly of an inner stator and a cylinder of a reciprocating compressor in accordance with a first embodiment of the present invention, FIG. 5 is a cross-sectional diagram illustrating the inner stator and the cylinder of the reciprocating compressor in accordance with the first embodiment of the present invention, and FIG. 6 is a cross-sectional diagram illustrating an inner stator and a cylinder of a reciprocating compressor in accordance with a second embodiment of the present invention.

[0043] Referring to FIG. 4, an inner stator 110 of a reciprocating motor is formed in an integral cylindrical shape by a powder metallurgy process using a soft magnetic composite that is a kind of metal powder and is coated with an insulation coating material to improve electric magnetic properties for application to an electromagnetic system such as a motor. Here, the powder metallurgy process produces a material having a special property or a product having a special shape by using a phenomenon that metal powder or composite powder is hardened at a high temperature.

[0044] The inner stator 110 is incorporated with a cylinder 120. The outside portion composing the inner stator 110 is sintered to have magnetism, but the inside portion composing the cylinder 120 is sintered to have abrasion resistance. The cylinder 120 can be made of magnetic metal powder or mixture of general metal powder and magnetic metal powder. The rate of the magnetic metal powder to the general metal powder (hereinafter, referred to as ‘powder rate’) in the portion composing the inner stator 110 is set higher than the powder rate of the cylinder 120 to improve magnetic density of the inner stator 110.

[0045] The cylinder 120 is manufactured by a powder metallurgy process using the same material as that of the inner stator 110, namely, metal powder such as a soft magnetic composite. In addition, as shown in FIG. 6, only the cylinder 120 can be manufactured by the powder metallurgy process using general metal powder. In this case, since the general metal powder is cheaper than the magnetic metal powder, the prime cost of production can be cut down without seriously reducing efficiency of the motor.

[0046] When the cylinder 120 is manufactured by mixing general metal powder and magnetic metal powder, the powder rate of the cylinder 120 is set lower than the powder rate of the inner stator 110 to reduce expenses and improve intensity.

[0047] Preferably, an abrasion resistance coating layer is formed on the inner circumference of the cylinder 120 to reduce abrasion in sliding motion with a piston, and the thickness thereof is sufficiently large to reinforce the intensity.

[0048] On the other hand, the inner stator 110 and the cylinder 120 can be individually manufactured by sintering magnetic metal powder or another metal powder, and bonded to each other by diffusion bonding. FIG. 7 is a cross-sectional diagram illustrating an inner stator and a cylinder of a reciprocating compressor in accordance with a third embodiment of the present invention. As depicted in FIG. 7, the inner stator 110 and the cylinder 120 are individually manufactured, and the inner stator 110 is inserted onto the outer circumference of the cylinder 120.

[0049] The manufacturing method of the present invention will now be explained.

[0050] Generally, when magnetic metal powder is heated at a high temperature, the bonding strength of particles is improved to increase abrasion resistance. However, when the magnetic metal powder is heated at a high temperature over 500°C, the sintering process, the magnetic metal powder may be demagnetized. It is thus very important to perform the sintering process without demagnetizing the inner stator 110 and reducing abrasion resistance of the cylinder 120. Preferably, the sintering temperature of the inner stator 110 ranges from 530 to 590°C, and the sintering temperature of the cylinder 120 ranges from 900 to 1100°C.

[0051] For this, as shown in FIG. 8, the cylinder 120 is temporarily formed by putting primary metal powder into a die.

[0052] The cylinder 120 is manufactured by primarily sintering the primary metal powder in the die at a high temperature of about 1000°C.

[0053] The inner stator 110 is temporarily manufactured by putting secondary metal powder onto the outer circumference of the cylinder 120 in the die in which the cylinder 120 has been manufactured. The inner stator 110 is manufactured by secondarily sintering the secondary metal powder at a temperature of about 400°C. Thus, the inner stator 110 and the cylinder 120 are incorporated.

[0054] FIG. 9 is a block diagram illustrating the manufacturing method of the reciprocating compressor in accordance with the second embodiment of the present invention.

[0055] As illustrated in FIG. 9, the inner stator 110 and the cylinder 120 are temporarily formed in a single form by supplying primary metal powder and secondary metal powder to a predetermined shape of die. The outside portion of the temporary product composing the inner stator 110 is heated and primarily sintered at a temperature of about 400°C, and the inside portion of the temporary product composing the cylinder 120 is locally heated and secondarily sintered at a temperature of about 1000°C. As a result, the inner stator 110 and the cylinder 120 are manufactured in a single form.

[0056] FIG. 10 is a block diagram illustrating the manufacturing method of the reciprocating compressor in accordance with the third embodiment of the present invention.

[0057] Referring to FIG. 10, the inner stator 110 and the cylinder 120 are temporarily formed in a single form by supplying primary metal powder and secondary metal powder to a predetermined shape of die. The temporary product is collectively sintered at a temperature of maintaining magnetism of the inner stator 110, namely, at a temperature of about 400°C, and the portion composing the cylinder
120 is locally heated and sintered at a temperature of about 1000°C to improve abrasion resistance. Accordingly, the inner stator 110 and the cylinder 120 are manufactured in a single form.

[0058] FIG. 11 is a block diagram illustrating the manufacturing method of the reciprocating compressor in accordance with the fourth embodiment of the present invention.

[0059] As shown in FIG. 11, the inner stator 110 and the cylinder 120 are individually manufactured by supplying primary metal powder and secondary metal powder to different dies, and heating and sintering the primary metal powder and the secondary metal powder at a necessary temperature for the inner stator 110 (about 400°C) and a necessary temperature for the cylinder 120 (about 1000°C), respectively. Thereafter, the inner stator 110 is bonded onto the outer circumference of the cylinder 120 by diffusion bonding.

[0060] As another example, although not illustrated, the inner stator 110 and the cylinder 120 are formed in a predetermined shape of die by using magnetic metal powder, and heated and sintered at a necessary temperature for the inner stator 110 (about 400°C). An abrasion resistance coating surface can be formed on the inner circumference of the cylinder 120.

[0061] The effects of the present invention will now be described.

[0062] As compared with the conventional inner stator formed by stacking a few hundreds of thin steel cores sheet by sheet in the radial direction, the inner stator of the present invention can be easily manufactured by considerably simplifying the manufacturing process.

[0063] Since the inner stator and the cylinder are manufactured by sintering the same metal powder, the cylinder is not deformed by the inner stator. Therefore, abrasion of the piston and the cylinder by deformation of the cylinder is prevented in advance, which results in high reliability of the compressor.

[0064] As the present invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, it should also be understood that the above-described embodiments are not limited by any of the details of the foregoing description, unless otherwise specified, but rather should be construed broadly within its spirit and scope as defined in the appended claims, and therefore all changes and modifications that fall within the metes and bounds of the claims, or equivalence of such metes and bounds are therefore intended to be embraced by the appended claims.

What is claimed is:
1. A reciprocating compressor, comprising:
   a frame installed in a casing;
   an outer stator having a winding coil and being fixed to the frame;
   an inner stator disposed in the outer stator with a predetermined gap, and sintered by a powder metallurgy process using metal powder;
   a rotor having a permanent magnet between the outer stator and the inner stator;
   a cylinder disposed inside the inner stator of the reciprocating motor for forming a compression chamber, and sintered by a powder metallurgy process using metal powder;
   a piston slidably inserted into the inner circumference of the cylinder, for sucking and compressing gas by linear reciprocation;
   and
   a plurality of resonance springs for elastically supporting the connection part of the piston and the rotor, and inducing resonance of the piston.
2. The reciprocating compressor of claim 1, wherein the metal powder composing the inner stator and the cylinder is a soft magnetic composite coated with an insulation coating material.
3. The reciprocating compressor of claim 1, wherein the metal powder composing the inner stator and the cylinder is formed by mixing general metal powder and magnetic metal powder.
4. The reciprocating compressor of claim 3, wherein the rate of the magnetic metal powder to the general metal powder is higher in the inner stator than the cylinder.
5. The reciprocating compressor of claim 1, wherein the metal powder composing the inner stator and the cylinder is magnetic metal powder.
6. The reciprocating compressor of claim 1, wherein the inner stator is manufactured by sintering magnetic metal powder, the cylinder is manufactured by sintering general metal powder, and the inner stator and the cylinder are bonded to each other.
7. The reciprocating compressor of claim 1, wherein an abrasion resistance coating surface is formed on the inner circumference of the cylinder.
8. A manufacturing method of a reciprocating compressor, comprising:
   a first step for putting primary metal powder composing a cylinder into a die, and forming the cylinder in a predetermined shape;
   a second step for manufacturing the cylinder by heating and primarily sintering the primary metal powder in the die at an appropriate temperature;
   a third step for putting secondary metal powder composing an inner stator onto the outer circumference of the cylinder of the die, and forming the inner stator in a predetermined shape; and
   a fourth step for manufacturing the inner stator by heating and secondarily sintering the secondary metal powder in the die at an appropriate temperature.
9. The manufacturing method of claim 8, wherein the sintering temperature of the cylinder in the second step ranges from 900 to 1100°C, and the sintering temperature of the inner stator in the fourth step ranges from 300 to 500°C.
10. The manufacturing method of claim 8, further comprising a step for forming an abrasion resistance coating surface on the outer circumference of the cylinder.
11. The manufacturing method of claim 8, wherein the primary metal powder and the secondary metal powder are formed by mixing general metal powder and magnetic metal powder at a predetermined rate, and the rate of the magnetic metal powder to the general metal powder is lower in the primary metal powder than the secondary metal powder.
12. The manufacturing method of claim 8, wherein the primary metal powder is general metal powder, and the secondary metal powder is magnetic metal powder.

13. A manufacturing method of a reciprocating compressor, comprising:

a first step for manufacturing a temporary product by putting primary metal powder composing a cylinder and secondary metal powder composing an inner stator into a die, and forming the cylinder and the inner stator at the same time; and

a second step for heating and sintering the temporary product at an appropriate temperature, and locally heating and sintering the primary metal powder composing the cylinder at an appropriate temperature at the same time.

14. The manufacturing method of claim 13, wherein the temperature of heating and sintering the temporary product in the second step ranges from 300 to 500°C, and the temperature of locally heating the primary metal powder ranges from 900 to 1100°C.

15. The manufacturing method of claim 13, further comprising a step for forming an abrasion resistance coating surface on the inner circumference of the cylinder.

16. The manufacturing method of claim 13, wherein the primary metal powder and the secondary metal powder are formed by mixing general metal powder and magnetic metal powder at a predetermined rate, and the rate of the magnetic metal powder to the general metal powder is lower in the primary metal powder than the secondary metal powder.

17. The manufacturing method of claim 13, wherein the primary metal powder is general metal powder, and the secondary metal powder is magnetic metal powder.

18. A manufacturing method of a reciprocating compressor, comprising:

a first step for manufacturing a cylinder by heating and sintering primary metal powder in a die at an appropriate temperature, and manufacturing an inner stator by heating and sintering secondary metal powder in another die at an appropriate temperature; and

a second step for inserting and bonding the inner stator onto the outer circumference of the cylinder.

19. The manufacturing method of claim 18, wherein the sintering temperature of the cylinder in the first step ranges from 900 to 1100°C, and the sintering temperature of the inner stator ranges from 300 to 500°C.

20. The manufacturing method of claim 18, further comprising a step for forming an abrasion resistance coating surface on the inner circumference of the cylinder.

21. The manufacturing method of claim 18, wherein the primary metal powder and the secondary metal powder are formed by mixing general metal powder and magnetic metal powder at a predetermined rate, and the rate of the magnetic metal powder to the general metal powder is lower in the primary metal powder than the secondary metal powder.

22. The manufacturing method of claim 18, wherein the primary metal powder is general metal powder, and the secondary metal powder is magnetic metal powder.

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