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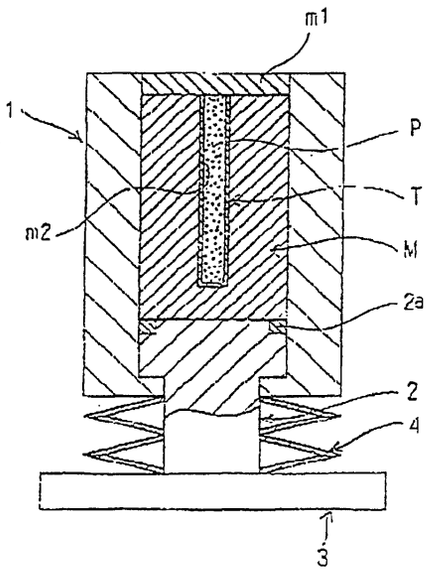
(54) Method of producing powder compacts and foil or film-like mold members for use in the method

(57) A powder compact is produced by disposing a foil or film-like mold member (T) packed with a powder (P) in a cavity of a rubber mold (M) which is loaded in a die. The rubber mold (M), the foil or film-like type mold member (T) and the powder (P) packed in the foil or film-like mold member are compressed by a punch to obtain a powder compact. The powder compact with the foil or film-like mold member being attached thereto is removed, by pressure, from the rubber mold (M). Since the powder to be compressed into a compact is not packed directly in the cavity of the rubber mold, but is packed in the mold member, no part of the rubber mold is caught in the space formed by the powder that is in contact with the rubber mold. Accordingly, cracks and chips in the powder compact can be prevented even when the rubber mold is restored to its initial shape and many shape and size variations of the powder compact can be realized.

FIG. 2



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Description

BACKGROUND OF THE INVENTION

Field of the Invention:

[0001] The present invention relates to a method of producing powder compacts in which a powder packed in an intended space is compressed into a powder compact, and a foil or film-like mold member for use in the method. The resultant powder compact may be used as it is or as a sintered compact after sintering.

Description of Related Art:

[0002] A conventional method of producing powder compacts is now described referring to Fig. 4.

[0003] A cylindrical die is denoted by the numeral 1. A lower punch 2 is provided at its upper end portion with an annular recess into which a ring-shaped backup ring 2a, made of a hard synthetic resin or the like, is fitted and is inserted into the die 1. An internally extending edge part 1a, formed at the lower end portion of the die 1, is engaged with a tiered part between the upper larger diameter portion 2b and a lower smaller diameter portion 2c of the lower punch 2 to prevent the die 1 from moving upward with respect to the lower punch 2. A support table on which the lower punch 2 is mounted is denoted by numeral 3. An appropriate number of disc springs 4 is provided at the smaller diameter portion 2c of the lower punch 2 between the bottom face of the die 1 and the upper surface of the support table 3. An upper punch 5 is provided such that the bottom face 5a thereof is placed on the upper surface 1b of the die 1. A backup ring 5c made of hard synthetic resin is fitted into an annular groove 5b formed in the bottom face 5a of the upper punch 5. The backup ring 5c is arranged so that it covers the boundary area between the die 1 and a rubber cover m1 for covering a rubber mold M described later. Rubber mold M can be loaded into a space formed by the die 1 and the lower punch 2 inserted therein. For example, the rubber mold M has an elongated cylindrical cavity m2 to accommodate a powder P to be packed therein to produce an elongated bar-like powder compact.

[0004] In the process of producing powder compacts, the powder P is packed into the cavity m2 of the rubber mold M. The rubber cover m1 is then attached. The upper punch 5 is lowered and placed on the upper surface 1b of the die 1. The upper pun ch 5 is then further lowered so that the die 1 descends together with the upper punch 5, resisting the disc springs 4 provided between the die 1 and the support table 3. While the upper punch 5 and the die 1 descend as discussed above, the lower punch 2, being held by the support table 3, does not move. Accordingly, the space 6 formed by the die 1 and the lower punch 2 is reduced in depth so that the powder particles P packed in the cavity m3 of the rubber mold M are compressed in a pseudo-isostatic manner through the rubber mold M, thereby forming an elongated cylindrical powder compact. Subsequently, the upper punch 5 is lifted and the cover m1 is detached. The resultant powder compact is then taken out of the rubber mold M. Meanwhile, the compact shaped in the above manner can be sintered in an appropriate manner to obtain a sintered compact.

[0005] In the above-described conventional method of producing powder compacts, as Fig. 5 (a) illustrates for example, the rubber mold M has not yet been caught in the spaces s formed between the powder particles P, which are in contact with the rubber mold M before the pressing process is carried out by the upper punch 5 and the lower punch 2. However, as Fig. 5 (b) illustrates for example, in the final pressing step by the upper punch 5 and lower punch 2, the rubber mold M is caught in the spaces s formed between the powder particles P that is in contact with the rubber mold M. In this condition, when the upper punch 5 is lifted and the pressure on the rubber mold M is released, the rubber mold M moves in the direction away from the powder compact which has been compressed while contained in the cavity m2 of the rubber mold M. Since stress is generated when the rubber mold M, which has been caught in the spaces s formed between the powder particles P in contact with the rubber mold M, is separated from the powder compact, the powder compact is cracked or chipped.

[0006] In the process of compressing the powder into a powder compact mentioned above, the rubber mold M enters and leaves the spaces s formed by the powder particles P in contact with the rubber mold M. When the rubber mold M repeatedly enters and leaves the space s, the areas of the rubber mold M which are in contact with the powder particles P are damaged. This shortens the life of the rubber mold M.

SUMMARY OF THE INVENTION

[0007] The primary, but not sole, object of the present invention is to solve the problems mentioned above which the conventional method of producing powder compacts has suffered.

[0008] In order to achieve the above stated object, the present invention provides a method of producing powder compacts comprising disposing a foil or film-like-like mold member packed with a powder in a cavity of a rubber mold which is loaded in a die; compressing the rubber mold, the foil or film-like type mold member and the powder packed in the foil or film-like mold member with a punch to obtain a powder compact; and subsequently using pressure to remove the powder compact with the foil or film-like mold member still being attached thereto from the rubber mold.

[0009] The present invention also provides a method of producing powder compacts comprising disposing a foil or film-like mold member packed with a powder in a

cavity of a rubber mold which is loaded in a die; compressing the rubber mold, the foil or film-like type mold member and the powder packed in the foil or film-like mold member with a punch to obtain a powder compact; subsequently removing the powder compact with the foil or film-like mold member being attached thereto by pressure from the rubber mold; and thereafter removing the foil or film-like mold member that is attached to the powder compact.

[0010] The invention further provides a foil or film-like mold member for use in the aforementioned method of producing powder compacts, the foil or film-like mold member being provided inside a space portion into which powder can be packed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Figs. 1(a) and 1(b) are a perspective views of an example mold member used in the method of producing powder compacts according to the invention.

[0012] Fig. 2 shows an elevational cross section of an apparatus for producing powder compacts for use in the method of producing powder compacts according to this invention.

[0013] Fig. 3 shows an elevational cross section of the apparatus shown in Fig. 2.

[0014] Fig. 4 shows an elevational cross section of an apparatus used in a conventional method of producing powder compacts.

[0015] Figs. 5(a) and 5(b) illustrate contact states between the rubber mold and powder in the conventional apparatus for producing powder compacts shown in Fig. 4.

DETAILED DESCRIPTION OF THE INVENTION

[0016] Preferred embodiments of this invention are hereinafter described. However, this invention is not limited to these specific embodiments but may be modified in other ways without departing from the scope of the invention. In the drawings, like components are denoted by like numerals throughout and will not be further explained.

[0017] An example of a produced elongated columnar powder compact which is difficult to produce by the above-mentioned conventional powder compacting method is explained below.

[0018] In Figs. 1(a) and (b), foil or film-like mold members T1 and T2 are shown. These mold members are made of a soft, low melting point metal and are capable of holding a packed powder. These mold members are configured to be inserted into the cavity m2 of the rubber mold M. Specifically, Fig. 1(a) shows a foil or film-like mold member T1 made of a soft, low melting point metal and formed integrally with a bottom. Fig. 1(b) shows a foil or film-like mold member T2 having an integrally formed, jointless pipe t1 made of a soft, low melting point metal, and a bottom plug t2, which is made of a material such as rubber or synthetic resin or the like, is fitted into the lower opening of the bottomless pipe t1.

[0019] The foil or film-like mold member T1 or T2 (hereinafter simply referred to as T) is inserted into the cavity m2 of the rubber mold M in the manner shown in Fig. 2 either before or after the mold member T is filled with powder P. In the case of the foil or film-like mold member T not being filled with powder P before being inserted into the cavity m2 of the rubber mold M, the mold member T is packed with the powder P after being inserted into the cavity m2 of the rubber mold M. Then, the rubber cover m1 is mounted on the rubber mold M.

[0020] Subsequently, in the same manner as described above, the upper punch 5 is lowered so as to pseudo-isostatically compress the foil or film-like mold member T which has been packed with the powder P and inserted into the cavity m2 formed within the rubber mold M, thereby forming the powder P packed in the foil or film-like mold member T into a powder compact. The upper punch 5 is then lifted and the cover m1 is detached. The powder compact having the foil or film-like mold member T attached by pressure is taken out of the cavity m2 of the rubber mold M.

[0021] The powder compact obtained through the above-mentioned process and contained in the foil or film-like mold member T may be used as it is. Otherwise, the powder compact contained in the foil or film-like mold member T may be heated at an appropriate temperature above the melting point of the foil or film-like mold member T to melt and remove the foil or film-like mold member T. The powder compact may be sintered to be used as a sintered compact. It is possible to heat the powder compact contained in the foil or film-like mold member T at a temperature below the melting point of the foil or film-like mold member T to obtain a presintered compact with the foil or film-like mold member T tightly attached thereto. Then, the foil or film-like mold member T can be mechanically removed from the presintered compact so that the presintered compact is fully sintered thereafter and used as a sintered compact formed in a desired shape.

[0022] According to this embodiment, the powder P to be compressed into a compact is not packed directly in the cavity m2 of the rubber mold M. Rather, the powder P is packed in the foil or film-like mold member T. Accordingly, the problem where a part of the rubber mold M is caught in the space s formed by the powder P that is in contact with the rubber mold M does not arise during the compression by the upper punch 5. It is therefore possible to prevent the powder compact from cracking or chipping even when the rubber mold M is restored to its initial shape when the pressure is released by lifting the upper punch 5.

[0023] In addition, unlike the conventional case, since the powder P is not directly in contact with the rubber mold M, damage to the rubber mold M due to contact with the powder P does not occur. The life of the rubber mold M is therefore extended.

[0024] The shape of the foil or film-like mold member T is designed such that a compact with a desired shape can be obtained after compaction. A wide variety of materials may be employed for the foil or film-like mold member T including metals such as tin, aluminum, copper, iron, nickel and stainless steel, paper and synthetic resin. The most appropriate material will be determined according to the properties, treatment temperature, or proposed use of the desired compact. The thickness of the foil or film-like mold member T, when it is metal, is in the range of about 0.01 to 1.50 mm, and preferably, it is about 0.03 mm to 1.00 mm. The thickness of the foil or film-like mold member T, when it is paper or synthetic resin, is in the range of about 0.05 to 3.0 mm, and preferably it is about 0.1 to 2.0 mm.

[0025] To make the foil or film-like mold member T most easily, a flat foil or film is wound around a master mold with the desired shape and bonded at the ends. To fabricate a metal foil mold member T, any kind of plastic working process may be employed such as pressing, forging, drawing, and extrusion. The most appropriate process is determined according to the shape and material of the metal foil mold member T. When it is made of synthetic resin, injection molding or casting may be used. The foil or film-like mold member T is formed so as to closely fit into the cavity m2 of the rubber mol d M, and may or may not have a bottom.

[0026] The above-described embodiment is arranged such that the upper punch 5 is lowered to be mounted on the upper surface of the die 1, and further lowered so as to compress the rubber mold M, foil or film-like mold member T and powder P packed in the foil or film-like mold member T. However, the arrangement may be such that with the upper punch 5 being fixed, the support table 3 provided with the lower punch 2 and die 1 is moved up and down, thereby compressing the powder into a powder compact.

[0027] The example above shows an apparatus for compacting powder, which comprises the die 1, the lower punch 2 inserted into the die 1, the upper punch 5 to be mounted on the upper surface of the die 1, and the disc springs 4 provided at the smaller diameter portion 2c of the lower punch 2 between the bottom face of the die 1 and the upper surface of the support table 3. However, it is also possible to employ an apparatus for compacting powder which comprises a die having an opening in its upper part and a bottom, and an upper punch to be inserted into the die, in which the lower punch 2 and disc springs 4 in the above apparatus are omitted.

[0028] Being structured as described above, the present invention provides the following effects.

[0029] Since the powder to be compressed into a compact is not packed directly in the cavity of the rubber mold, but is packed in the mold member, the problem where a part of the rubber mold is caught in the space formed by the powder that is in contact with the rubber mold will not arise. Accordingly, cracking or shipping of the powder compact can be prevented even when the rubber mold is restored to its initial shape. Thus, the ranges of shape and size variations possible for the powder compact can be largely expanded. In addition, since this invention allows coarse powders with large grain sizes to be compressed into various powder compacts, product cost can be reduced and the variety of products can be increased.

[0030] Unlike the conventional method, the powder does not directly come into contact with the rubber mold in this invention. Therefore, damage to the rubber mold due to the direct contact with the powder P does not occur, thereby extending the life of the rubber mold.

[0031] In addition, since the powder compact is protected by the mold member, it does not suffer damage when it is ejected from the rubber mold or loaded into a sintering furnace. Handling the powder compact is therefore made easier.

Claims

1. A method of producing a powder compact, comprising: disposing a foil or film-like mold member packed with a powder in a cavity of a rubber mold which is loaded in a die; compressing the rubber mold, the foil or film-like mold member and the powder packed in the foil or film-like mold member with a punch to obtain a powder compact; and removing the powder compact with the foil or film-like mold member from the rubber mold.

2. A method according to claim 1, further comprising: removing the foil or film-like mold member from the powder compact.

3. A method of producing a powder compact, comprising: packing a foil or film-like mold member with a powder; disposing the foil or film-like mold member packed with powder in a cavity of a rubber mold which is loaded in a die; compressing the rubber mold, the foil or film-like mold member and the powder packed in the foil or film-like mold member with a punch to obtain a powder compact; and removing the powder compact with the foil or film-like mold member from the rubber mold.

4. The method of any of claims 1 to 3, wherein the foil or film-like mold member is made of a low melting point metal.

5. The method of any of claims 1 to 3, wherein the foil or film-like mold member is made of a material selected from the group consisting of tin, aluminium, copper, iron, nickel, stainless steel, paper and synthetic resin.

6. The method of claim 5, wherein the foil or film-like mold member is made of a material selected from

the group consisting of tin, aluminium, copper, iron, nickel and stainless steel and has a thickness in a range of about 0.01 to 1.50 mm.

7. The method of claim 6, wherein the foil or film-like mold member has a thickness in the range of about 0.03 mm to 1.00 mm.

8. The method of any of claims 1 to 3, wherein the foil or film-like mold member is made of paper or synthetic resin and has a thickness in a range of about 0.05 to 3.0 mm.

9. The method of claim 8, wherein the foil or film-like mold member has a thickness in the range of about 0.1 to 2.0 mm.

10. The method of claim 1 or 3, further comprising applying heat to the powder compact with the foil or film-like mold member after it is removed from the rubber mold to melt or to remove the foil or film-like mold member.

11. The method of claim 1 or 3, further comprising applying heat to the powder compact with the foil or film-like mold member after it is removed from the rubber mold at a temperature below the melting point of the foil or film-like mold member to produce a presintered compact.

12. The method of claim 2, further comprising applying heat to the powder compact after it is removed from the rubber mold at a temperature to produce a presintered compact.

13. An apparatus for producing powder compacts, comprising: a foil or film-like mold member having an inside portion which is packed with a powder; a rubber mold having a cavity, the foil or film-like mold member being disposed in the cavity; and a die for receiving the rubber mold, wherein the rubber mold, the foil or film-like mold member and the powder packed in the foil or film-like mold member are compressed by a punch to obtain a powder compact, and the powder compact with the foil or film-like mold member is removed from the rubber mold.

14. The apparatus of claim 13, wherein the foil or film-like mold member is removed from the powder compact after the powder compact is removed from the rubber mold.

15. The apparatus of claim 13, wherein the foil or film-like mold member is made of a low melting point metal.

16. The apparatus of claim 13, wherein the foil or film-like mold member is made of a material selected from the group consisting of tin, aluminium, copper, iron, nickel, stainless steel, paper and synthetic resin.

17. The apparatus of claim 16, wherein the foil or film-like mold member is made of a material selected from the group consisting of tin, aluminium, copper, iron, nickel and stainless steel and has a thickness in the range of about 0.01 to 1.50 mm.

18. The apparatus of claim 17, wherein the foil or film-like mold member has a thickness in the range of about 0.03 mm to 1.00 mm.

19. The apparatus of claim 13, wherein the foil or film-like mold member is made of paper or synthetic resin and has a thickness in a range of about 0.05 to 3.0 mm.

20. The apparatus of claim 19, wherein the foil or film-like mold member has a thickness in the range of about 0.1 to 2.0 mm.

21. The apparatus of claim 13, further comprising a heater for applying heat to the powder compact with the foil or film-like mold member after it is removed from the rubber mold to melt or remove the foil or film-like mold member.

22. The apparatus of claim 13, further comprising a heater for applying heat to the powder compact with the foil or film-like mold member after it is removed from the rubber mold at a temperature below the melting point of the foil or film-like mold member to produce a presintered compact.

FIG. 1

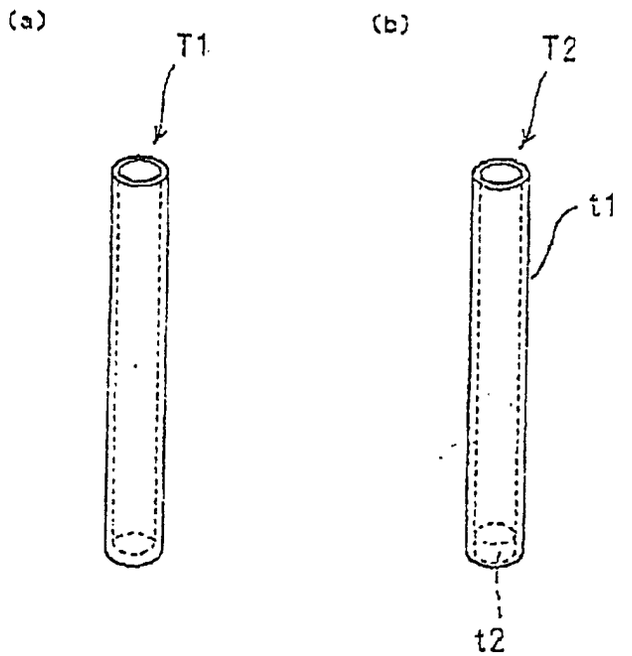

FIG. 2

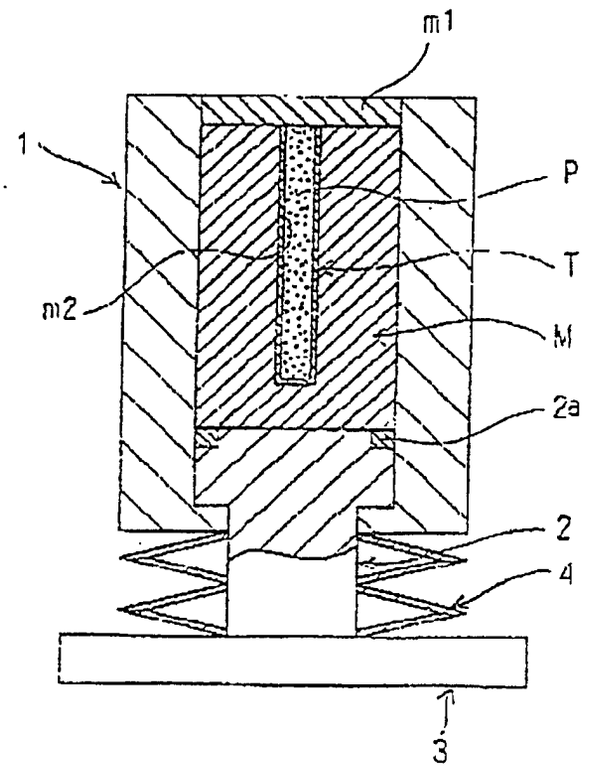

FIG. 3

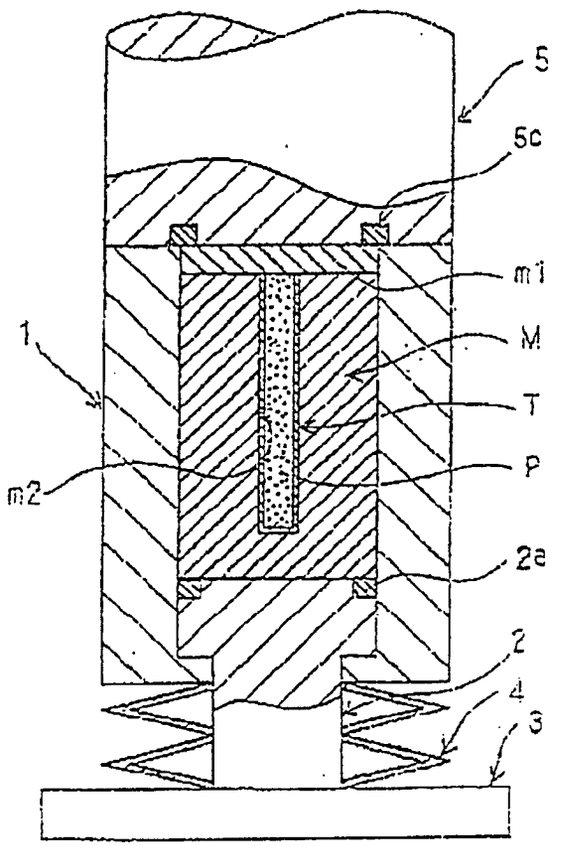

FIG. 4

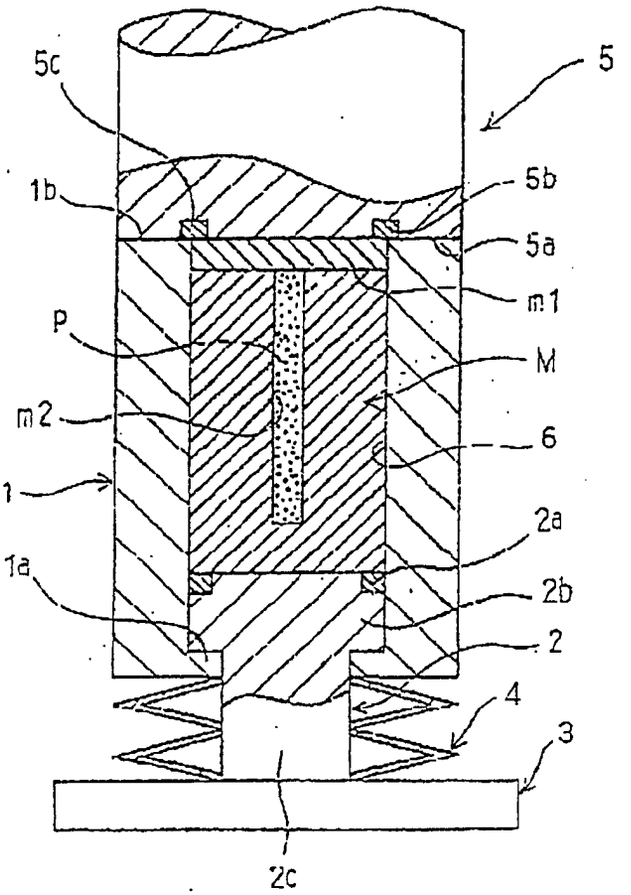

FIG. 5