PRODUCTION OF THE METALLIC PARTS WITH THE ALLOYED LAYER CONTAINING DISPERSED COMPOUND PARTICLES, AND THE WEAR-PROOF PARTS

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ABSTRACT
A powder of an alloy containing a compound is enclosed in a cylindrical container, hot isostatic press and/or hot extrusion are applied in that state, and compound is isolated by these workings in order to metallically bond the powders with each other. When the metallic part is inserted into the container or the metallic part has a cylindrical shape, the container is formed of a material which can be the metallic part. Then, machining is applied in order to produce a metallic part having on a surface thereof an alloyed layer containing the dispersed compound particles.

The metallic parts having on a surface thereof an alloyed layer containing dispersed compound particles can be produced without using a joining method such as welding.
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FIELD OF THE INVENTION

[0001] The present invention relates to a method for producing a metallic part having on a surface thereof an alloyed layer containing dispersed compound particles, and a wear-proof part.

BACKGROUND OF THE INVENTION

[0002] Metallic parts having on a surface thereof an alloyed layer containing dispersed compound particles are used in wear-proof parts such as valves (see, e.g., claims of JP-A-11-63251 and JP-A-2001-288521).

[0003] JP-A-11-63251 discloses that a wearing surface of a valve is formed of a nickel-base alloy of a Ni-Cr-B-Si system in which chromium boride particles are dispersed. Further, JP-A-2001-288521 discloses that a wearing surface of a valve is formed of a cobalt-base, nickel-base or iron-base alloy in which granular or lumpy eutectic carbides are dispersed.

[0004] Both prior arts relate to increase a wear resistance and an antiseize property by dispersing hard compound particles into an alloy. The alloy in which the hard compound particles are dispersed generally has the poor ductility and is hard to be processed. Thus, an alloyed layer containing dispersed compound particles is formed on only a wearing surface, while a main body of a valve is formed of another metal having the excellent processability. As a method for forming the alloyed layer containing dispersed compound particles, welding is the most common method, but performing welding results in forming a solidification structure containing coarse and large compounds due to melting, and an initial fine particle state cannot be maintained.

SUMMARY OF THE INVENTION

[0005] It is an object of the present invention to form an alloyed layer containing dispersed compound particles on a surface of a metallic part without adopting joining means such as welding.

[0006] According to the present invention, a metallic part having on a surface thereof an alloyed layer containing dispersed compound particles is manufactured by at least one hot plastic working which is selected from hot isostatic press and hot extrusion.

[0007] When applying the hot plastic working, an alloy powder containing compounds is prepared and it is enclosed in a container. When enclosing, it is desirable to evacuate a gas, mainly air, remained in the container, thereby preventing the powder from being oxidized. In a state that the powder is enclosed in the container, one or both of the hot isostatic press and the hot extrusion are applied. With these plastic workings, the compounds are segmented and converted into a granular or lumpy state. Furthermore, the powders are metallically bonded with each other. If the container is formed of a metal, the metallic container and the powder are also metallically bonded to each other. There also occurs a phenomenon that the powder partially makes inroads into an inner surface of the metallic container. After the hot plastic workings, machining, e.g., cutting work by wire cutting is performed. If the container is a cylindrical metallic container, it is possible to produce a cylindrical metallic part having on an inner surface thereof an alloyed layer containing dispersed compound particles.

[0008] Moreover, when enclosing the powder in the container, inserting the metallic part at the same time can manufacture a metallic part having on a surface of the metallic part an alloyed layer containing dispersed compound particles. In case of forming an alloyed layer containing dispersed compound particles, on an inner surface of a tubular metallic part, the tubular metallic part can also function as the container.

[0009] The present invention is preferable as a method for forming an alloyed layer containing dispersed compound particles, on a wearing surface of a valve, a shaft of a valve, a ball sleeve, a bush or the like.

[0010] Other objects, features and advantages of the invention will become apparent from the following description of the embodiments of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0011] As an example of a preferable alloy containing dispersed compound particles when embodying the production method according to the present invention, a nickel-base, cobalt-base or iron-base alloy containing at least one selected from a silicide, a boride and a carbide, can be used.

[0012] As the nickel-base alloy, it is desirable to use a material which consists of not more than 8 weight % Si, 0 to 4 weight % B, 7 to 30 weight % Cr, not more than 1.2 weight % C, 0 to 5 weight % W, not more than 42 weight % Fe which does not exceed an amount of Ni, with a balance of Ni.

[0013] Additionally, it is desirable to use an atomized powder manufactured by atomization from a molten metal of an alloy. Since the atomized powder becomes excellently rounded particles, it is suitable to be packed in a container. As an atomization method, either a method for a liquid atomizing or a method for a gas atomizing can be applied, but a method for an inert gas atomizing is desirable. In case of a water atomized powder, a surface of the powder is apt to be oxidized, and it is hard to obtain particles with a rounded shape since this oxidation is involved. In case of an inert gas atomized powder, no oxidation occurs, and particles with a rounded shape can be readily obtained.

[0014] On enclosing the powder in a container, a compound in the powder does not have to be formed into a granular state. In case of the atomized powder, although a compound is dendritically precipitated in a process that the molten metal is powdered and then solidified, such a powder can be used. For example, an atomized powder of a nickel-base alloy with the above composition range can be used, while a silicide and, in some cases, a boride are dendritically precipitated. The dendritically precipitated compound is segmented to a granular or lumpy form in a process of hot isostatic press or hot extrusion.

[0015] According to the method of the present invention, an alloyed layer containing dispersed compound particles
can be formed on a surface of a metallic part. Further, since the alloyed layer is not molten in a process in which it is formed on the surface of the metallic part, compound particles having a fine granular form or lumpy form can be dispersed.

[0016] The hot isostatic press or the hot extrusion can be performed by a generally known method. For example, as the hot isostatic press, a known method by which an inert gas such as argon gas is used as a pressure medium and a container in which the powder is enclosed is subjected to pressurizing processing at a predetermined temperature under a predetermined pressure, can be applied. Furthermore, as the hot extrusion, a method by which a raw material is extruded by using a die has been known. The container in which the powder is enclosed can be extruded by applying this method.

[0017] According to the present invention, an alloyed layer containing dispersed compound particles is formed by the hot plastic working which is at least one selected from the hot isostatic press and the hot extrusion, and a wear-proof part integrated with a main body of the wear-proof part is provided at the time of that plastic working.

[0018] The wear-proof part according to the present invention can be used for various kinds of valves. Moreover, it can be used for a shaft of a swing check valve or a butterfly valve, a ball sleeve, a bush or others.

[0019] When the present invention is used in a wear-proof part, it is desirable to form on a surface of a part consisting of a carbon steel, a low-alloy steel or a stainless steel a layer of a nickel-base alloy, a cobalt-base alloy or an iron-base alloy in which at least one kind of silicide particles, boride particles and carbide particles is dispersed. The nickel-base alloy, the cobalt-base alloy or the iron-base alloy containing dispersed granular or lumpy compound particles has the excellent wear resistance and anti-seize property, and it is suitable for a wear-proof part. Additionally, when the present invention is used in a wear-proof part, a surface of the alloyed layer containing dispersed compound particles may be coated with a ceramic film, thereby increasing the wear resistance. As a ceramic material, it is possible to use chromium nitride (CrN), titanium nitride (TiN), titanium carbide (TiC), hafnium nitride (HfN) or the like.

EXAMPLE 1

[0020] An inert gas atomizing method was used to manufacture a powder of nickel-base alloy which consists of 6.1% Si, 1.1% B, 19.7% Cr, 0.32% C, 2.0% W, 7.6% Fe by weight % with a balance of Ni and incidental impurities. The Ni-base alloy powder having a particle size distribution of 70 to 250 mesh was filled in a container made of a carbon steel S12C which has a hollow cylindrical form whose outside diameter is 145 mm, and inside diameter is 123 mmφ. Compression molding was carried out at a room temperature and then the container was sealed. Thereafter, the hot isostatic press was carried out at a temperature of approximately 950° C., and the hot extrusion was further performed at a temperature of 950° C. The hot extrusion was effected under conditions that an extrusion pressure was approximately 5,000 kg/cm² and a sinter speed was 20 mm/second. The container was processed until the outside diameter became 60 mmφ. Then, machining was applied, and various kinds of test pieces were cut out to carry out various kinds of tests.

[0021] The powders of the nickel-base alloy were metallically bonded with each other. Additionally, the nickel-base alloy powder was metallically bonded with the container made of a carbon steel. Further, a part of the powder bit into the inside of the cylindrical container made of a carbon steel and was firmly bonded with the container. Furthermore, in the nickel-base alloy layer formed on the inner surface of the cylindrical container made of a carbon steel, the compound which was dendritically precipitated in the atomized powder state was segmented to a granular or lumpy compound having a diameter of not more than 10 μm. The compound was mainly formed of a silicide, and a boride was also partially contained.

[0022] For various kinds of tests, the part according to the embodiment was compared with a welded overlay part which is buildup welded with a welding rod cut out from the nickel-base alloy layer manufactured by this embodiment.

[0023] First, the nickel-base alloy layer according to the embodiment of the present invention was superior in the ductility which is threefold or more of that of the welded overlay part. Moreover, the nickel-base alloy layer according to the present invention demonstrated a high impact value which was approximately 2.5-fold in an impact test without a notch and approximately 1.4-fold in a U-notch impact test, as compared with the welded overlay part. The hardness of both the part according to the present invention and the welded overlay part falls within a range of 550 to 600 Hv.

[0024] There was conducted a Strauss test (JIS G0575) in which test pieces were soaked in a boiling water solution containing sulfuric acid and copper sulfate for 72 hours, and cross sections were observed after the test. The layer according to the present invention has a maximum corrosion depth of not more than 10 μm and was superior in the corrosion resistance as compared with the welded overlay part having a maximum corrosion depth of approximately 200 μm.

[0025] A friction coefficient was measured in high-temperature water under conditions that a bearing stress is 2000 kg/cm² and a sliding speed is 300 mm/minute, in which a precipitation hardened stainless steel SUS630 whose surface is coated with a chromium nitride film was used as a wear-proof opposite material. The part according to the present invention demonstrated a friction coefficient of 0.34, whereas the welded overlay part demonstrated 0.43. As a result, it was confirmed that the part according to the present invention is suitable for a use in a shaft of a swing check valve or a butterfly valve, a ball sleeve or the like having a rotary wear-proof portion or a reciprocating wear-proof portion.

EXAMPLE 2

[0026] An inert gas atomized powder formed of a nickel-base alloy which consists of 6.0% Si, 1.6% B, 20.0% Cr, 0.7% C, 1.6% W and 5.0% of Fe by weight % with a balance of Ni and incidental impurities was filled and sealed in a container formed of a low-alloy steel F11A (1.5 Cr-0.5 Mo steel) which has a hollow cylindrical shape whose outside diameter is 145 mmφ, and inside diameter is 123 mmφ. The hot isostatic press and the hot extrusion were carried out at a temperature of approximately 900° C., and the container was processed to have an outside diameter of 70 mmφ. When the cylindrical container was cut by machining, the
inside diameter was 56 mm, and a nickel-base alloy containing dispersed granular or lumpy silicide particles and boride particles or the like having a diameter of not more than 10 μm in a matrix of metallographic structure was stuck. When a shear strength between the cylindrical container formed of the low-alloy steel and the nickel-base alloy stuck therein was measured, it was not less than 15 kg/mm². When the shear strength is low, peeling or the like is apt to occur, and the part is hard to be applied to a ball sleeve of a swing check valve. It was confirmed that the part according to this embodiment is not fractured even if a shear force of 15 kg/mm² is applied on an interface between the alloyed layer and the low-alloy steel and it can withstand a bearing stress of approximately 3,000 atmospheric pressure (3000 kg/cm²) assuming that a friction coefficient with respect to a shaft of a check valve which is a wear-proof opposite part of, e.g., a ball sleeve is 0.5.

A ball sleeve of a swing check valve having an outside diameter of 68 mm, an inside diameter of 50 mm, and a length of 160 mm was manufactured from the part according to this embodiment by machining. A nickel-base alloy layer having a thickness of 3 mm is formed on the inner side of a cylinder made of a low-alloy steel.

On the other hand, as a shaft of the swing check valve, there was produced a shaft with an outside diameter of 50 mm which was obtained by coating a surface of a precipitation hardened stainless steel SUS630 (17-4PH) with a chromium nitride film having a thickness of approximately 10 μm by evaporation.

Additionally, a part having a length of 150 mm was cut out from the part with an outside diameter of 70 mm according to this embodiment, hot press was performed vertically with respect to an axial direction at a temperature of 950 to 1000° C. in order to extend the outside diameter to be not less than 100 mm, and a valve disc bush was manufactured from this member by machining.

The part according to this embodiment is resistant against mechanical impacts, hard to be fractured and has the excellent corrosion resistance as compared with a welded overlay part.

According to the present invention, a metal part having on a surface thereof an alloyed layer containing dispersed granular or lumpy compound particles can be manufactured without using a joining method such as welding.

It should be further understood by those skilled in the art that although the foregoing description has been made on embodiments of the invention, the invention is not limited thereto and various changes and modifications may be made without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. A method for producing a metallic part having on a surface thereof an alloyed layer containing dispersed compound particles, comprising:
   - enclosing a powder of an alloy containing the compound in a cylindrical metallic container;
   - applying at least one hot plastic working selected from hot isostatic press and hot extrusion in that state;

   segmenting the compound by the hot plastic working and metallically bonding the powders with each other and the powder with the metallic container; and

   then applying machining to manufacture a cylindrical metallic part having on an inner surface thereof an alloyed layer containing the dispersed compound particles.

2. The method for producing the metallic part according to claim 1, wherein the alloy containing the compound is formed of a nickel-base alloy, a cobalt-base alloy or an iron-base alloy containing the compound which is formed of at least one selected from a silicide, a boride and a carbide.

3. The method for producing the metallic part according to claim 2, wherein the nickel-base alloy consists of
   - not more than 8 weight % Si
   - 0 to 4 weight % B
   - 7 to 30 weight % Cr
   - not more than 1.2 weight % C
   - 0 to 5 weight % of W
   - not more than 42 weight % of Fe which does not exceed an amount of Ni

   with a balance of Ni.

4. The method for producing the metallic part according to claim 1, wherein the powder consists of an alloy powder manufactured by atomization from a molten metal of the alloy.

5. The method for producing the metallic part according to claim 4, wherein the alloy powder consists of a gas atomized powder manufactured by an inert gas atomization.

6. The method for producing the metallic part according to claim 4, wherein the alloy powder consists of an alloy powder containing a compound dendritically precipitated in a powder production process.

7. The method for producing the metallic part according to claim 1, wherein a gas in the container is evacuated when enclosing the alloy powder in the metallic container.

8. A method for producing a metallic part having on a surface thereof an alloyed layer containing dispersed compound particles, comprising:
   - enclosing a powder of an alloy containing the compound in a container;
   - applying at least one hot plastic working selected from hot isostatic press and hot extrusion in that state;

   segmenting the compound by the hot plastic working and metallically bonding the powder with each other and the powder with the metallic part; and

   then applying machining to manufacture a metallic part having on a surface thereof an alloyed layer containing the dispersed compound particles.

9. The method for producing the metallic part according to claim 8, wherein the alloy containing the compound is formed of a nickel-base alloy, a cobalt-base alloy or an iron-base alloy containing the compound formed of at least one selected from a silicide, a boride and a carbide.
10. The method for producing the metallic part according to claim 9, wherein the nickel-base alloy consists of:
- not more than 8 weight % Si
- 0 to 4 weight % B
- 7 to 30 weight % Cr
- not more than 1.2 weight % C
- 0 to 5 weight % of W
- not more than 42 weight % of Fe which does not exceed an amount of Ni, with a balance of Ni.

11. The method for producing the metallic part according to claim 8, wherein the powder consists of an alloy powder manufactured by atomization from a molten metal of the alloy.

12. The method for producing the metallic part according to claim 11, wherein the alloy powder consists of a gas atomized powder manufactured by an inert gas atomization.

13. The method for producing the metallic part according to claim 11, wherein the alloy powder consists of an alloy powder containing a compound dendritically precipitated in a powder production process.

14. A wear-proof part having on a wearing surface an alloyed layer containing dispersed compound particles, wherein the alloyed layer containing the dispersed compound particles is obtained by at least one hot plastic working selected from hot isostatic press and hot extrusion, and it is integrated with the wear-proof part through the hot plastic working.

15. The wear-proof part according to claim 14, wherein the alloyed layer is formed of a nickel-base alloy, a cobalt-base alloy or an iron-base alloy, and the compound particles comprise at least one selected from a silicide, a boride and a carbide.

16. The wear-proof part according to claim 15, wherein the nickel-base alloy consists of:
- not more than 8 weight % Si
- 0 to 4 weight % B
- 7 to 30 weight % Cr
- not more than 1.2 weight % C
- 0 to 5 weight % of W
- not more than 42 weight % of Fe which does not exceed an amount of Ni, with a balance of Ni.

17. The wear-proof part according to claim 14, wherein the metallic part is formed of one selected from a carbon steel, a low-alloy steel and a stainless steel.

18. The wear-proof part according to claim 14, wherein a surface of the alloyed layer has a coating layer of a ceramic film which is harder than the alloyed layer.

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