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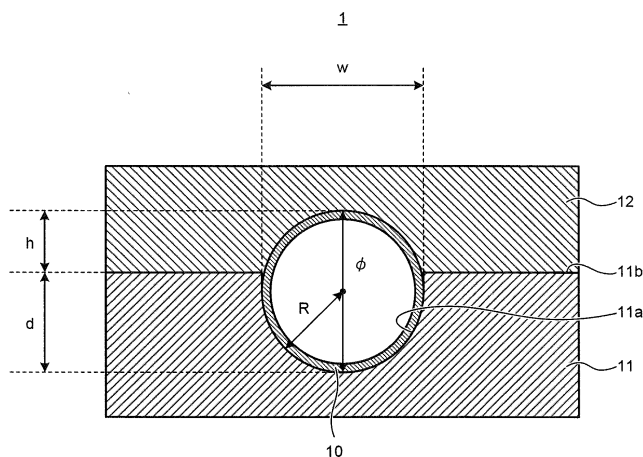
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(54) **STRUCTURE WITH EMBEDDED PIPE AND MANUFACTURING METHOD THEREFOR**

(57) To provide a pipe embedded structure that improves adhesive properties between a pipe that forms a passage and a metal member, and a method of manufacturing the pipe embedded structure. A pipe embedded structure 1 includes a pipe 10, a base material 11, and a deposited layer 12. The pipe 10 is made of a metal or an alloy, and has a periphery that forms a circular shape in a transverse section. The base material 11 is made of a metal or an alloy, in which a recessed portion 11a is formed. The recessed portion 11a allows the pipe 10 to be fitted therein, and has an inner wall on which a part

of the periphery abuts, and a ratio h/R of a protruding amount h by which the pipe 10 protrudes from the upper surface 11b and a curvature R of the periphery is not smaller than 0.3 and not greater than 0.7. The deposited layer 12 is formed such that powder formed of a metal or an alloy is accelerated together with a gas in a state where the pipe 10 is fitted into the recessed portion 11a, and the powder is sprayed and deposited on surfaces of the pipe 10 and the base material 11 while remaining in a solid phase state.

FIG.1



Description

Field

[0001] The present invention relates to a pipe embedded structure in which a pipe is embedded in a metal member, the pipe circulating a temperature adjustment medium, such as a cooling gas or cooling water, and a method of manufacturing the pipe embedded structure.

Background

[0002] Structures (hereinafter, referred to as pipe embedded structures) in which a pipe, which circulates a fluid is embedded in a metal member are used in various uses, such as a process of manufacturing products including semiconductors, liquid crystal display devices, and optical disks. For example, a pipe embedded structure in which a heating medium (coolant) is circulated in the pipe is used as a temperature adjustment device (cold plate, or the like) that adjusts (cools or heats) the temperature of a substrate (for example, see Patent Literature 1). Further, a pipe embedded structure in which a gas containing a predetermined constituent is circulated in a passage is sometimes used as a shower plate that supplies the gas to a substrate.

[0003] Such pipe embedded structures are conventionally manufactured such that the pipe that circulates a fluid, and the metal member in which a recessed portion having a shape corresponding to the pipe is formed by drilling or the like are separately made, and the pipe is fitted into the recessed portion in the metal member.

[0004] Further, in recent years, a technology of embedding a pipe in a metal member by a so-called cold spray method has been proposed, the cold spray method being to spray metal powder on a base material while maintaining a solid phase state of the metal powder, and to deposit the metal on the base material, thereby to form a structure (for example, see Patent Literature 2).

Citation List

Patent Literature

[0005]

Patent Literature 1: Japanese Laid-open Patent Publication No. 2009-13497

Patent Literature 2: Japanese Laid-open Patent Publication No. 2011-238705

Summary

Technical Problem

[0006] In the pipe embedded structures, if a gap exists between the pipe and the metal member, the thermal resistance becomes large, and the thermal conductivity

and the thermal uniformity between the fluid circulated in the pipe and the metal member are deteriorated. Further, a foreign body may enter the gap therebetween, or the pipe may be shaky in the recessed portion due to the gap. However, it is difficult to bond them adhering to each other by only the method of simply fitting the pipe in the recessed portion, which is provided in the metal member, so as not to cause the gap between an inner wall of the recessed portion and an external wall of the pipe.

[0007] On this point, with the cold spray method, a dense metal coating film can be deposited around the pipe. Therefore, a structure having excellent thermal conductivity can be made. However, even in this case, adhesive properties of the metal coating film to the pipe may be deteriorated because a local gap is caused around the pipe, depending on a condition, such as the shape of the pipe or an angle at which the metal powder is sprayed on the pipe and the base material.

[0008] The present invention has been made in view of the foregoing, and an objective is to provide a pipe embedded structure with improved adhesive properties between a pipe that forms a passage and a metal member, and a method of manufacturing the pipe embedded structure. Solution to Problem

[0009] To solve the above-described problem and achieve the object, a pipe embedded structure according to the present invention includes: a pipe made of a metal or an alloy, and having a periphery forming a circular shape in a transverse section; a base material made of a metal or an alloy, including a recessed portion having an inner wall on which a part of the periphery abuts and in which the pipe is fitted; and a deposited layer formed by accelerating powder formed of a metal or an alloy together with a gas in a state where the pipe is fitted into the recessed portion, and spraying and depositing the powder on surfaces of the pipe and the base material while maintaining a solid phase state of the powder, wherein a ratio h/R of a protruding amount h by which the pipe protrudes from the surface of the base material and a curvature R of the periphery is not smaller than 0.3 and not greater than 0.7.

[0010] In the above-described pipe embedded structure, in the transverse section of the pipe, a clearance of the recessed portion and the pipe is not smaller than 0 mm and not greater than 0.05 mm.

[0011] In the above-described pipe embedded structure, the pipe is formed of stainless steel, a copper alloy, a nickel alloy, tantalum, niobium, titanium, aluminum, or an aluminum alloy.

[0012] In the above-described pipe embedded structure, the base material is formed of copper, a copper alloy, aluminum, or an aluminum alloy.

[0013] In the above-described pipe embedded structure, the powder is formed of copper or aluminum.

[0014] A method of manufacturing a pipe embedded structure according to the present invention includes: a base material forming step of forming, in a base material made of a metal or an alloy, a recessed portion having

an inner wall on which a part of a periphery of a pipe abuts, the pipe being made of a metal or an alloy and having the periphery forming a circular shape in a transverse section; and a deposited layer forming step of forming a deposited layer by fitting the pipe into the recessed portion, accelerating powder formed of a metal or an alloy together with a gas, and spraying and depositing the powder on surfaces of the pipe and the base material while maintaining a solid phase state of the powder, wherein the base material forming step causes a ratio h/R of a protruding amount h by which the pipe protrudes from the surface of the base material and a curvature R of the periphery to be not smaller than 0.3 and not greater than 0.7.

[0015] In the above-described method of manufacturing a pipe embedded structure, the base material forming step causes a clearance of a width of the recessed portion in the transverse section of the pipe and an outer diameter of the pipe to be not smaller than 0 mm and not greater than 0.05 mm.

Advantageous Effects of Invention

[0016] According to the present invention, the recessed portion having the ratio h/R not smaller than 0.3 and not greater than 0.7 is formed on the base material, the ratio h/R being a ratio of the protruding amount h of the pipe that forms a passage from the base material, and the curvature R of the periphery of the pipe, the pipe is fitted into the recessed portion, and the deposited layer is formed on the surfaces of the pipe and the base material by a so-called cold spray method. Therefore, a dense deposited layer can be formed around the pipe that protrudes from the base material, and the adhesive properties between the pipe and the metal member can be improved.

Brief Description of Drawings

[0017]

FIG. 1 is a cross sectional view illustrating a structure of a pipe embedded structure according to an embodiment of the present invention.

FIG. 2 is a flowchart illustrating a method of manufacturing the pipe embedded structure illustrated in FIG. 1.

FIG. 3A is a schematic diagram for describing process S1 illustrated in FIG. 2.

FIG. 3B is a schematic diagram for describing process S2 illustrated in FIG. 2.

FIG. 3C is a schematic diagram for describing process S3 illustrated in FIG. 2.

FIG. 4 is a schematic diagram illustrating an overview of a cold spray device.

FIG. 5 is a SEM image illustrating a deposited layer in a first example.

FIG. 6 is a SEM image illustrating a deposited layer

in a second example.

FIG. 7A is a SEM image illustrating a deposited layer in a first comparative example.

FIG. 7B is a schematic diagram illustrating a positional relationship between a pipe and a base material in the first comparative example.

FIG. 8A is a SEM image illustrating a deposited layer in a second comparative example.

FIG. 8B is a schematic diagram illustrating a positional relationship between a pipe and a base material in the second comparative example.

FIG. 9 is an optical photograph illustrating a deposited layer in a third example.

FIG. 10 is an optical photograph illustrating a deposited layer in a fourth example.

FIG. 11 is an optical photograph illustrating a deposited layer in a third comparative example.

Description of Embodiments

[0018] Hereinafter, embodiments for implementing the present invention will be described in detail with reference to the drawings. Note that the present invention is not limited by the following embodiments. Further, the drawings referred in the following description merely schematically illustrate the shape, the size, and the positional relationship to the extent that the content of the present invention can be understood. That is, the present invention is not limited only by the shape, the size, and the positional relationship exemplarily illustrated in the drawings.

(Embodiment)

[0019] FIG. 1 is a cross sectional view illustrating a structure of a pipe embedded structure according to an embodiment of the present invention. As illustrated in FIG. 1, a pipe embedded structure 1 according to the present embodiment includes: a pipe 10 made of a metal or an alloy and having a periphery that forms a circular shape in a transverse section; a base material 11 made of a metal or an alloy, including a recessed portion 11a to which the pipe is fitted; and a deposited layer 12 made of a metal or an alloy and formed on the pipe 10 and the base material 11. Such a pipe embedded structure 1 circulates a desired fluid (a liquid or a gas) in the pipe 10, and is used as a temperature adjustment device (for example, a cold plate), a fluid supply device (for example, a shower plate), or the like.

[0020] The pipe 10 is a pipe having a tube shaped cross section with an outer diameter ϕ and a curvature R of the periphery. Note that the thickness of the pipe 10 is appropriately determined according to the use or the material.

[0021] The shape of the pipe 10 in a length direction (a direction into which the fluid is circulated) is not especially limited, and the planar shape of the pipe 10 as viewed from above of the pipe embedded structure 1 can

be various shapes, such as a linear shape, a spiral shape or a meandering shape.

[0022] The material of the pipe 10 is selected according to the fluid to be circulated in the pipe 10 or the use of the pipe embedded structure 1. For example, when a liquid or a gas having corrosion properties is circulated, a metal or an alloy having corrosion resistance, such as stainless steel, a copper alloy, a nickel alloy, tantalum, niobium, or titanium, is used. Further, when city water or sea water is circulated as cooling water, a material having favorable thermal conductivity, such as stainless steel, of the above-described materials, is used. Meanwhile, when process cooling water (PCW), an organic solvent, an inert gas, or the like is circulated, the corrosion resistance is not essential, and aluminum or an aluminum alloy having excellent thermal conductivity can be used.

[0023] The base material 11 is a bulk material formed of a metal or a metal alloy having favorable thermal conductivity, such as copper, a copper alloy, aluminum, or an aluminum alloy. The recessed portion 11a is formed such that an upper surface 11b of the base material 11 is drilled in a groove manner. Note that the planar shape of the recessed portion 11a on the upper surface 11b corresponds to the planar shape of the pipe 10.

[0024] The recessed portion 11a has an inner wall on which a part of the periphery of the pipe 10 abuts. The transverse section shape of the inner wall of the recessed portion 11a is an arc shape along the periphery of the pipe 10. The depth d of the recessed portion 11a is defined such that a ratio h/R of a height (hereinafter, referred to as protruding amount) h by which the pipe 10 protrudes from the upper surface 11b, and the curvature R of the periphery of the pipe 10 becomes not smaller than 0.3 and not greater than 0.7. Further, the width of the recessed portion 11a has a maximum value w ($w \cong \phi$) at a height corresponding to the curvature R , based on a deepest portion of the recessed portion 11a, and the recessed portion 11a opens from the height to an upper portion while maintaining the maximum value w . Further, a clearance $w - \phi$ of the recessed portion 11a and the pipe 10 falls within a range from 0 to 0.05 mm, both inclusive.

[0025] The deposited layer 12 is formed by a so-called cold spray method. Here, the cold spray method is a coating film forming method, which accelerates powder made of a metal or an alloy together with a gas, and sprays the powder with the gas on a surface of a base (the pipe 10 and the base material 11 in the present embodiment) while maintaining a solid phase state of the powder, thereby to deposit the powder. The deposited layer 12 formed by the cold spray method does not have phase transformation, and oxidization is suppressed. Therefore, the deposited layer 12 has high thermal conductivity. Further, when the powder collides with the base or the coating film deposited on the base before, plastic deformation is caused between the powder and the base, and anchor effect can be obtained. In addition, oxide coating films of both sides are destroyed and metallic

bond by newly formed surfaces is caused. Therefore, the adhesive strength of the powder with the base becomes strong, and a coating film with suppressed thermal resistance can be formed.

[0026] Such a deposited layer 12 is formed of a metal or an alloy having favorable thermal conductivity, such as copper or aluminum.

[0027] Next, a method of manufacturing the pipe embedded structure 1 will be described. FIG. 2 is a flowchart illustrating a method of manufacturing the pipe embedded structure 1. Further, FIGS. 3A to 3C are schematic diagrams for describing the method of manufacturing the pipe embedded structure 1.

[0028] First, in process S1, the groove-shaped recessed portion 11a is formed on a surface of a bulk material 13 made of a metal or an alloy by drilling, and the base material 11 is made, as illustrated in FIG. 3A.

[0029] Next, in process S2, the pipe 10 is fitted into the recessed portion 11a, as illustrated in FIG. 3B.

[0030] Further, in process S3, the deposited layer 12 is formed on the surfaces of the pipe 10 and the base material 11 by the cold spray method, as illustrated in FIG. 3C.

[0031] FIG. 4 is a schematic diagram illustrating an overview of a cold spray device used in process S3. As illustrated in FIG. 4, a cold spray device 20 includes a gas heater 21, a powder supply device 22, a gas nozzle 24, and valves 25 and 26. The gas heater 21 heats a compressed gas. The powder supply device 22 houses powder (hereinafter, may be simply referred to as powder) 28 of the material of the deposited layer 12, and supplies the powder 28 to a spray gun 23. The gas nozzle 24 jets the heated compressed gas and the powder 28 supplied thereto to a base 27. The valves 25 and 26 respectively adjust supply amounts of the compressed gas to the gas heater 21 and to the powder supply device 22.

[0032] As the compressed gas, helium, nitrogen, oxygen, or the like is used. The compressed gas supplied to the gas heater 21 is 50°C or more, for example, and is heated to a temperature in a range lower than a melting point of the powder 28, and is then supplied to the spray gun 23. The heating temperature of the compressed gas is favorably 300 to 900°C. Meanwhile, the compressed gas supplied to the powder supply device 22 supplies the powder 28 in the powder supply device 22 to the spray gun 23 such that the amount of the powder 28 becomes a predetermined discharge amount.

[0033] The heated compressed gas is caused to form ultrasonic flow (about 340 m/s or more) by the gas nozzle 24 having a widening shape from an inlet toward an outlet. The gas pressure of the compressed gas at this time is favorably about 1 to 5 MPa. By adjusting the pressure of the compressed gas to the range, the adhesive strength of the powder (coating film) with respect to the base 27 can be improved. More favorably, the processing is performed at a pressure of about 2 to 4 MPa. The powder 28 supplied to the spray gun 23 is accelerated by being put into the ultrasonic flow of the compressed

gas, collides with the base 27 at a high speed while remaining in the solid phase state, and is deposited on the base 27. Note that the cold spray device is not limited to the cold spray device 20 illustrated in FIG. 4 as long as the device can cause the powder 28 to collide with the base 27 while maintaining the solid phase state of the powder 28, and form a coating film.

[0034] In such a cold spray device 20, as the base 27, the base material 11 obtained such that the pipe 10 is fitted into the recessed portion 11a is arranged, and the coating film is formed on the surfaces of the pipe 10 and the base material 11. At this time, the powder 28 enters regions 14 between vicinities of upper ends of the recessed portion 11a and the pipe 10, and forms the coating film.

[0035] As described above, by forming the deposited layer 12 to have a desired thickness, the pipe embedded structure 1 illustrated in FIG. 1 is completed. Note that, as illustrated in FIG. 3C, a part of the pipe 10 rises more than the upper surface 11b of the base material, and thus the deposited layer 12 has a shape rising on an upper portion of the pipe 10. Therefore, the deposited layer 12 is formed thicker, and then an unnecessary portion is removed by cutting or the like, so that the surface of the deposited layer 12 may be flattened.

[0036] Next, the relationship between the transverse section of the pipe 10 and the recessed portion 11a provided in the base material 11 will be described.

[0037] In the cold spray method, typically, the powder 28, which is jetted through the gas nozzle 24 into one direction, is caused to collide with the base 27, and the coating film is formed. Therefore, the coating film cannot be formed on a shaded portion with respect to the jetting direction of the powder 28. Further, formation of the coating film becomes more difficult as a forming surface of the coating film becomes closer to parallel to the jetting direction of the powder 28. Therefore, the inventors of the present application have diligently performed experiments in order to obtain conditions for forming a dense and uniform deposited layer 12 at side portions of the pipe 10, that is, in the vicinities of interfaces between the pipe 10 and the base material 11 when the deposited layer 12 is formed by the cold spray method.

[0038] As a result, the inventors of the present application have found out that, when manufacturing the pipe embedded structure 1 in which the pipe 10 having a periphery that forms a circular shape in a transverse section is embedded, the inventors can form the dense and uniform deposited layer 12 adhering to the pipe 10 and the base material 11 by providing the recessed portion 11a that satisfies following conditions (1) and (2) to the base material 11.

(1) The ratio h/R of the protruding amount h by which the pipe 10 protrudes from the surface of the base material 11, and the curvature R of the periphery of the pipe 10 is caused to be from 0.3 to 0.7, both inclusive.

(2) The clearance Δ of the recessed portion 11a and the pipe 10 is caused to be from 0 to 0.05 mm, both inclusive.

[0039] According to the present embodiment, the recessed portion defined by the above-described conditions is formed in the base material, the pipe is fitted into the recessed portion, and the deposited layer is formed by the cold spray method, whereby the dense and uniform deposited layer adhering to the pipe and the base material can be formed around the pipe. Therefore, when the pipe embedded structure having the adhesive properties improved as described above is used as a temperature adjustment device or a shower plate, temperature adjustment efficiency can be improved by the favorable thermal conductivity and thermal uniformity. Note that, in this case, it is favorable to use the deposited layer 12 side as a thermal conduction surface.

[Example]

[0040] Hereinafter, examples and comparative examples will be described with reference to FIGS. 5 to 11.

[0041] First, first and second examples and first and second comparative examples will be described. FIGS. 5, 6, 7A, and 8A are SEM images of the pipe 10, the base material 11, and the deposited layer 12 imaged from a direction perpendicular to the transverse section of the pipe 10, when forming the deposited layer 12 while changing the ratio h/R . Note that, in FIGS. 5, 6, 7A, and 8A, an interface between a side surface and an upper surface of the base material 11 is illustrated by a single-dotted chain line. Further, a part of an outer diameter of the pipe 10 is supplemented by a broken line. FIGS. 7B and 8B are schematic diagrams illustrating the positional relationship between the pipe 10 and the base material 11 in the first and second comparative examples.

[0042] Samples were made with following materials and conditions in the first and second examples and the first and second comparative examples.

[0043] The base material: a copper alloy plate having 40 mm x 40 mm and the thickness of 10 mm

[0044] The pipe: a copper alloy having the outer diameter $\phi = 6$ mm and the curvature R of the periphery = 3 mm

[0045] The material of the deposited layer: copper powder having an average particle diameter of 26.18 μm

[0046] The clearance of the recessed portion provided in the base material and the pipe: $\Delta = 0$ mm

(First Example)

[0047] The ratio h/R was 0.67. As a result, the dense and uniform deposited layer 12 having a sufficient thickness at the side portions of the pipe 10 was able to be formed, as illustrated in FIG. 5.

(Second Example)

[0048] The ratio h/R was 0.33. As a result, the dense and uniform deposited layer 12 having a sufficient thickness at the side portions of the pipe 10 was able to be formed, as illustrated in FIG. 6.

(First Comparative Example)

[0049] The ratio h/R was 1 (the protruding amount h = the curvature R), that is, the recessed portion 11a having a depth corresponding to half of the outer diameter ϕ of the pipe 10 was formed in the base material 11, and just half of the pipe 10 was housed in the recessed portion 11a. In this case, as illustrated in FIG. 7B, end portions of the side portions of the pipe 10 that protrudes from the upper surface 11b of the base material 11 were nearly parallel to the jetting direction of the powder, and the powder was not able to adhere to the portions. Therefore, as illustrated in FIG. 7A, the deposited layer 12 was not able to be formed on the side portions of the pipe 10, and cracking was caused between the deposited layer 12 formed on the pipe 10 and the deposited layer 12 formed on the base material 11.

(Second Comparative Example)

[0050] The ratio h/R was 0 (the protruding amount h = 0), that is, the recessed portion 11a having a depth corresponding to the outer diameter ϕ of the pipe 10 was formed in the base material 11, and the entire pipe 10 was housed in the recessed portion 11a. In this case, as illustrated in FIG. 8B, a deep gap was caused between the inner wall of the recessed portion 11a and the pipe 10, and the powder was not able to be sufficiently filled. Therefore, as illustrated in FIG. 8A, a sufficient deposited layer 12 was not be able to be formed on the side portions of the pipe 10, and cracking was caused between the deposited layer 12 formed on the pipe 10 and the deposited layer 12 formed on the base material 11.

[0051] Next, third and fourth examples and a third comparative example will be described. FIGS. 9 to 11 are optical photographs illustrating the deposited layer 12 when the clearance Δ of the recessed portion 11a and the pipe 10 was changed. These optical photographs are polished surfaces of the deposited layer 12 imaged from an upper surface side. The polished surfaces were obtained such that the deposited layer 12 was sufficiently (from an upper end surface of the pipe 10 to the height exceeding 1 mm) formed on the pipe 10, the deposited layer 12 was then cut at the height of 1 mm from the upper end surface of the pipe 10 by milling, and the deposited layer 12 was further polished.

[0052] In the third and fourth examples and the third comparative example, samples were made with following materials and conditions.

[0053] The base material: the copper alloy plate having 40 mm x 40 mm and the thickness of 10 mm

[0054] The pipe: a copper alloy having the outer diameter ϕ = 6 mm and the curvature R of the periphery = 3 mm

[0055] The material of the deposited layer: copper powder having an average particle diameter of 26.18 μ m

[0056] The ratio h/R = 0.5

(Third Example)

[0057] The clearance Δ was 0 mm. As a result, a dense and uniform deposited layer 12 smoothly continuous with a region on the pipe 10 and a region on the base material 11 was able to be formed, as illustrated in FIG. 9.

(Fourth Example)

[0058] The clearance Δ was 0.05 mm. As a result, a dense and uniform deposited layer 12 smoothly continuous with a region on the pipe 10 and a region on the base material 11 was able to be formed, although interface lines of surfaces were observed between the region on the pipe 10 and the region on the base material 11, as illustrated in FIG. 10.

(Third Comparative Example)

[0059] The clearance Δ was 0.10 mm. In this case, cracking was observed between a region on the pipe 10 and a region on the base material 11, as illustrated in FIG. 11. Reference Signs List

[0060]

- | | |
|-----|-------------------------|
| 1 | Pipe embedded structure |
| 10 | Pipe |
| 11 | Base material |
| 11a | Recessed portion |
| 11b | Upper surface |
| 12 | Deposited layer |
| 13 | Bulk material |
| 14 | Regions |
| 20 | Cold spray device |
| 21 | Gas heater |
| 22 | Powder supply device |
| 23 | Spray gun |
| 24 | Gas nozzle |
| 25 | and 26 Valve |
| 27 | Base |
| 28 | Powder |

Claims

1. A pipe embedded structure comprising:

a pipe made of a metal or an alloy, and having a periphery forming a circular shape in a transverse section;

a base material made of a metal or an alloy, comprising a recessed portion having an inner

wall on which a part of the periphery abuts and in which the pipe is fitted; and
 a deposited layer formed by accelerating powder formed of a metal or an alloy together with a gas in a state where the pipe is fitted into the recessed portion, and spraying and depositing the powder on surfaces of the pipe and the base material while maintaining a solid phase state of the powder, wherein
 a ratio h/R of a protruding amount h by which the pipe protrudes from the surface of the base material and a curvature R of the periphery is not smaller than 0.3 and not greater than 0.7.

the recessed portion in the transverse section of the pipe and an outer diameter of the pipe to be not smaller than 0 mm and not greater than 0.05 mm.

2. The pipe embedded structure according to claim 1, wherein, in the transverse section of the pipe, a clearance of the recessed portion and the pipe is not smaller than 0 mm and not greater than 0.05 mm. 15
3. The pipe embedded structure according to claim 1 or 2, wherein the pipe is formed of stainless steel, a copper alloy, a nickel alloy, tantalum, niobium, titanium, aluminum, or an aluminum alloy. 20
4. The pipe embedded structure according to any one of claims 1 to 3, wherein the base material is formed of copper, a copper alloy, aluminum, or an aluminum alloy. 25
5. The pipe embedded structure according to claim 4, wherein the powder is formed of copper or aluminum. 30
6. A method of manufacturing a pipe embedded structure, the method comprising: 35
 - a base material forming step of forming, in a base material made of a metal or an alloy, a recessed portion having an inner wall on which a part of a periphery of a pipe abuts, the pipe being made of a metal or an alloy and having the periphery forming a circular shape in a transverse section; and 40
 - a deposited layer forming step of forming a deposited layer by fitting the pipe into the recessed portion, accelerating powder formed of a metal or an alloy together with a gas, and spraying and depositing the powder on surfaces of the pipe and the base material while maintaining a solid phase state of the powder, wherein 45
 - the base material forming step causes a ratio h/R of a protruding amount h by which the pipe protrudes from the surface of the base material and a curvature R of the periphery to be not smaller than 0.3 and not greater than 0.7. 50
7. The method of manufacturing a pipe embedded structure according to claim 6, wherein the base material forming step causes a clearance of a width of 55

FIG.1

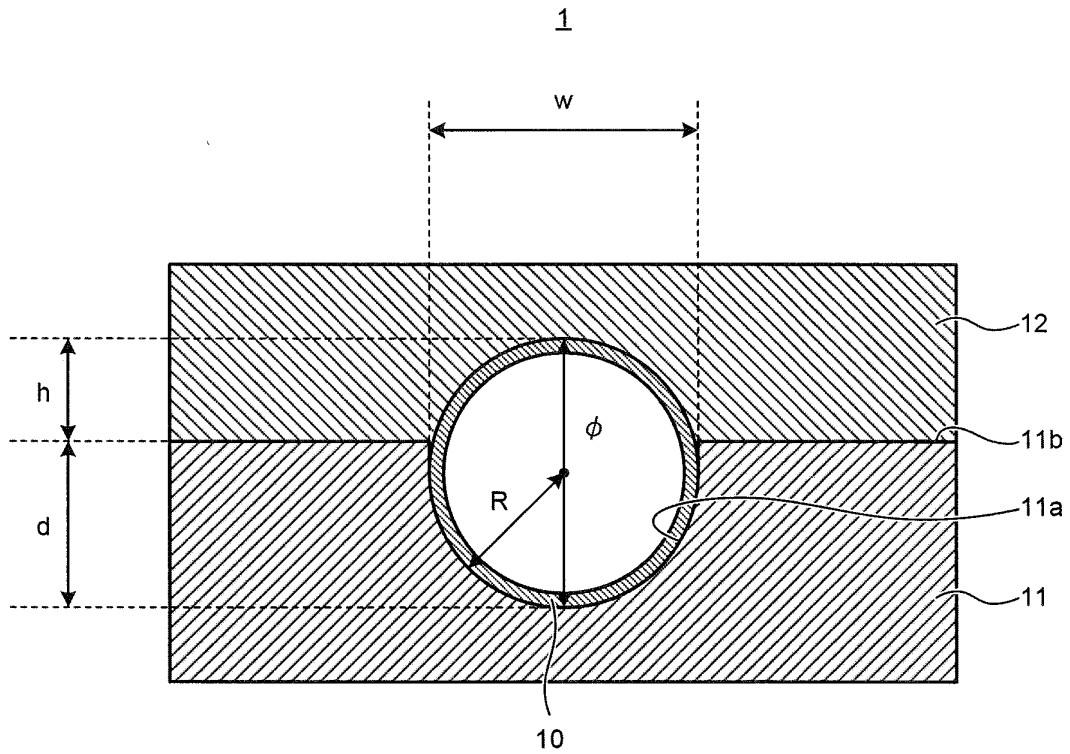


FIG.2

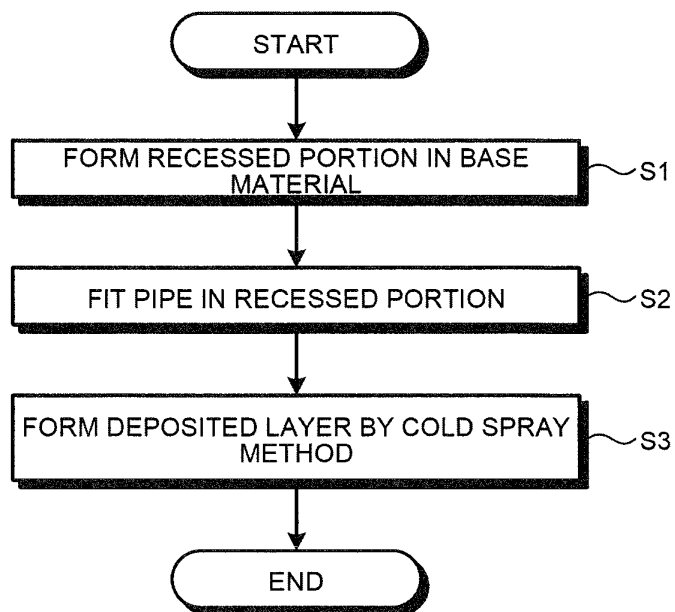


FIG.3A

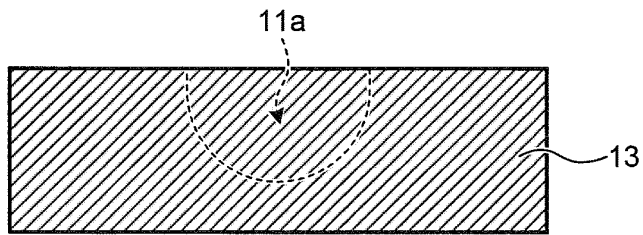


FIG.3B

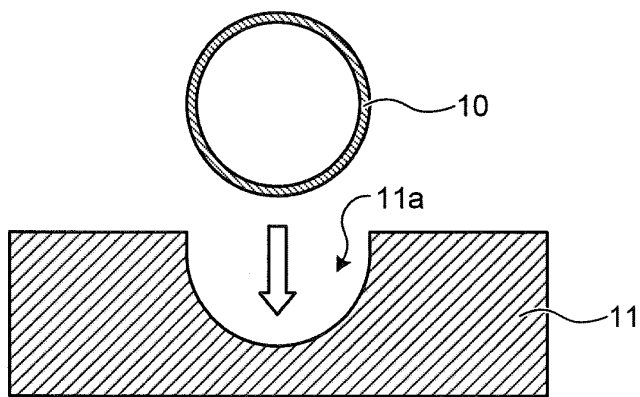


FIG.3C

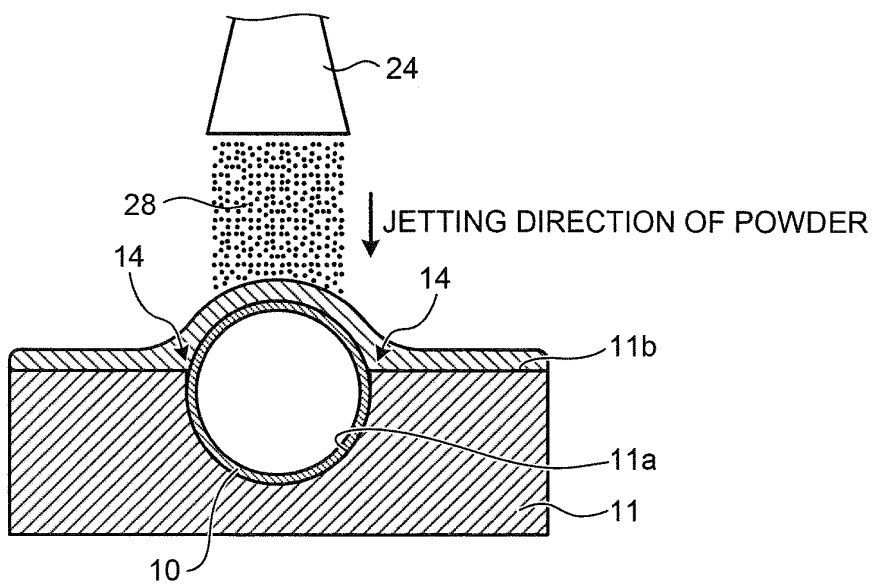


FIG.4

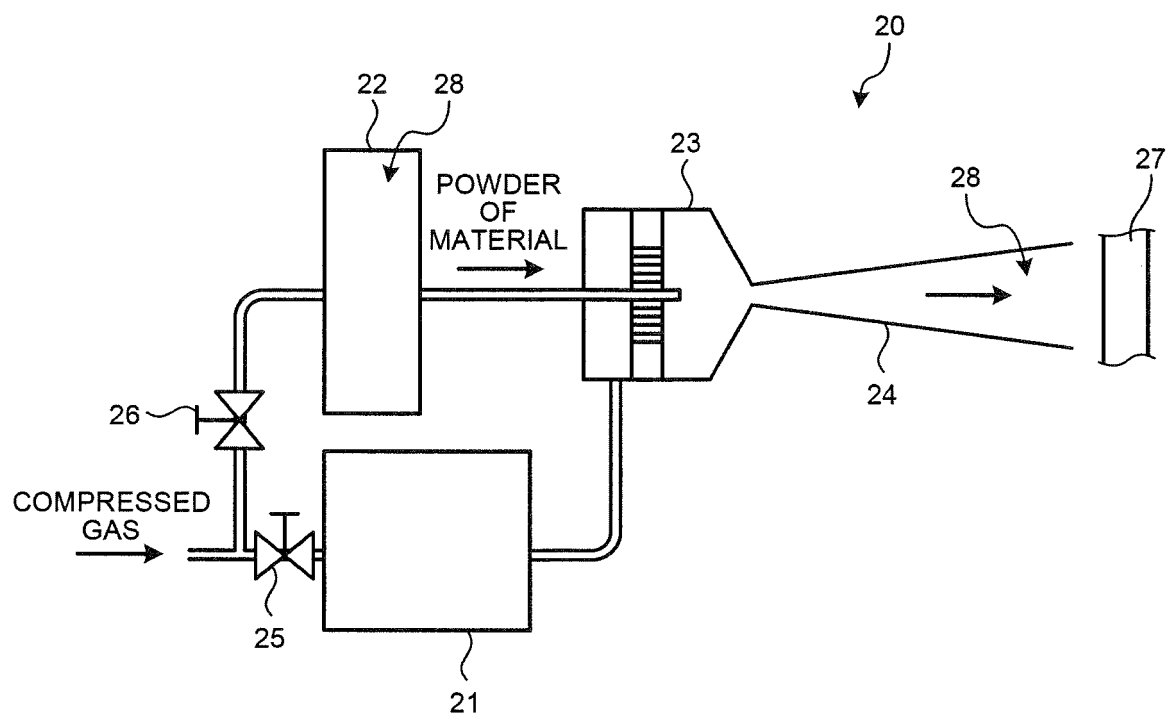


FIG.5

$$\frac{h}{R} = 0.67$$

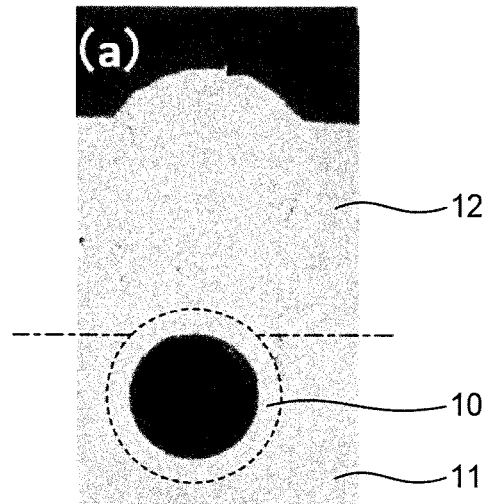


FIG.6

$$\frac{h}{R} = 0.33$$

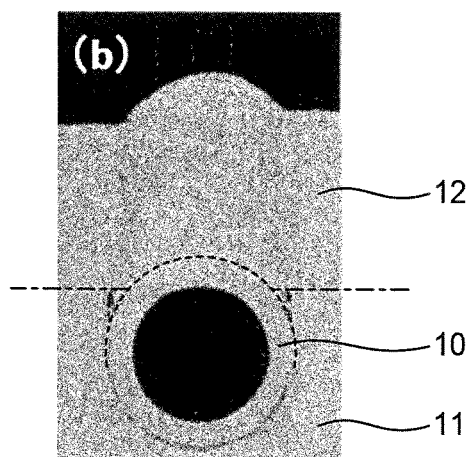


FIG.7A

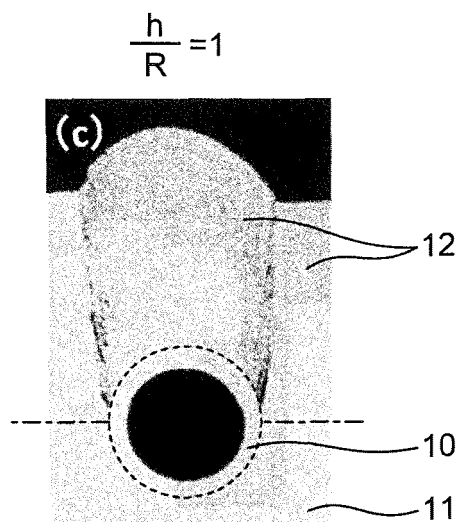


FIG.7B

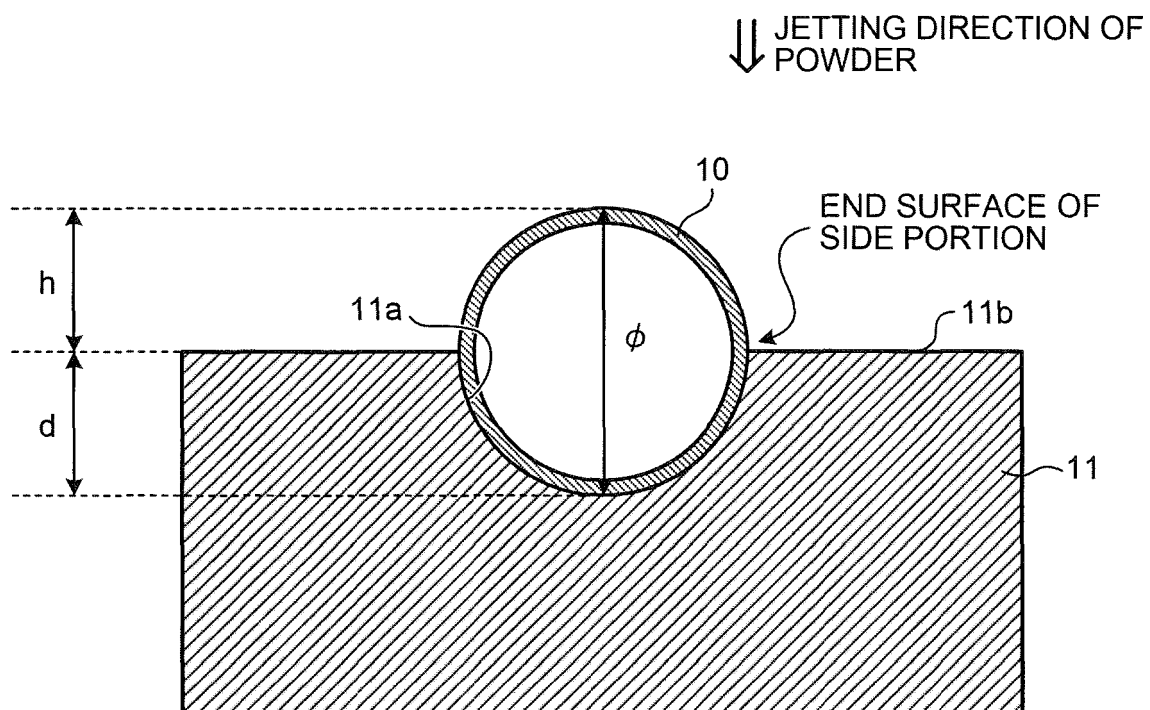


FIG.8A

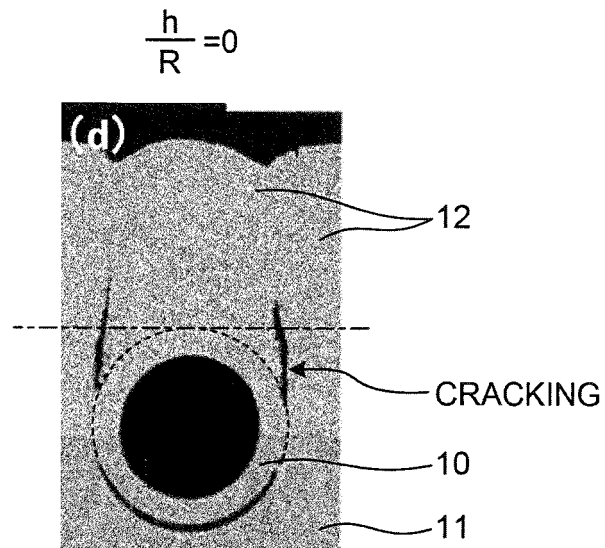


FIG.8B

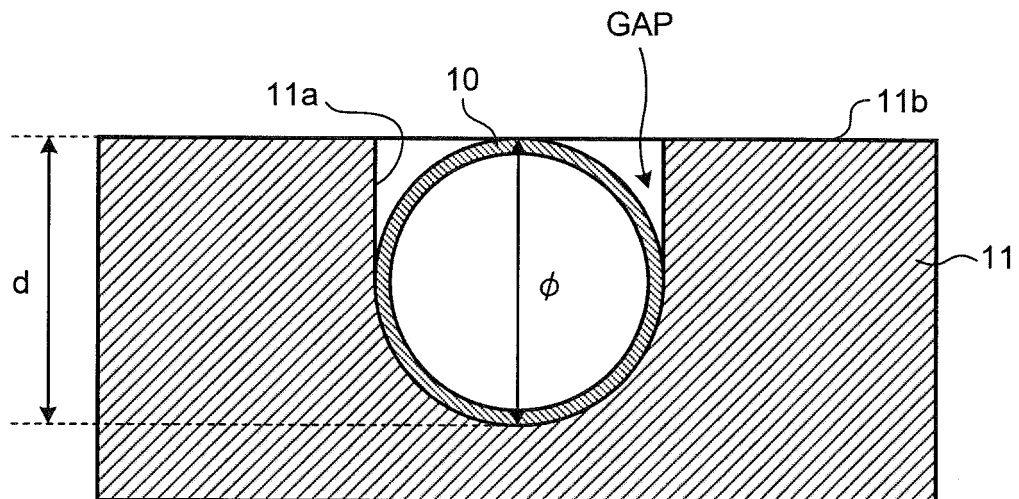


FIG.9

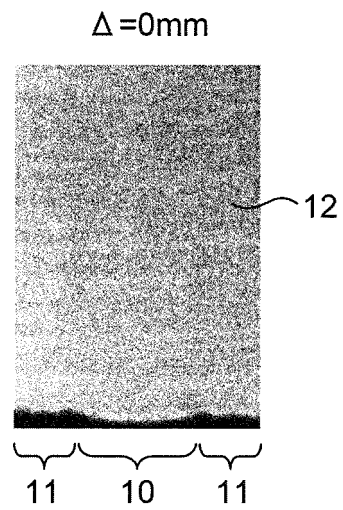


FIG.10

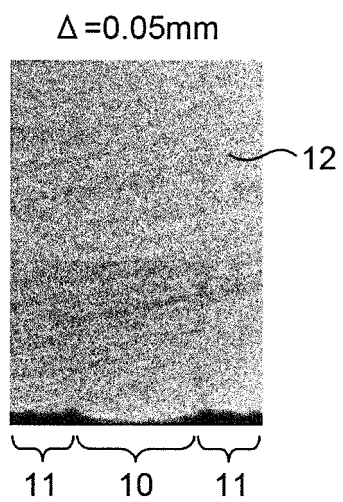
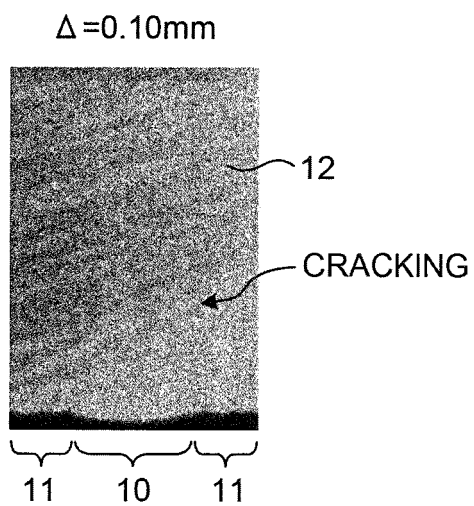


FIG.11



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/068077

A. CLASSIFICATION OF SUBJECT MATTER

C23C24/04(2006.01) i, F16L1/00(2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C23C24/04, F16L1/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2013
 Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2011-238705 A (NHK Spring Co., Ltd.), 24 November 2011 (24.11.2011), entire text & US 2013/0056187 A1 & EP 2568497 A & WO 2011/138899 A1 & CN 102884620 A	1-7
A	JP 2009-083429 A (Kanto Auto Works, Ltd.), 23 April 2009 (23.04.2009), entire text (Family: none)	1-7

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

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Date of the actual completion of the international search
26 July, 2013 (26.07.13)Date of mailing of the international search report
06 August, 2013 (06.08.13)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

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International application No.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2004-510599 A (Mold Masters Ltd.), 08 April 2004 (08.04.2004), entire text & US 2004/0011495 A1 & US 2006/0243412 A1 & EP 1283768 A & WO 2002/028615 A1 & DE 10025588 A & DE 10025588 A1 & AU 8616701 A & CN 1430549 A	1-7

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