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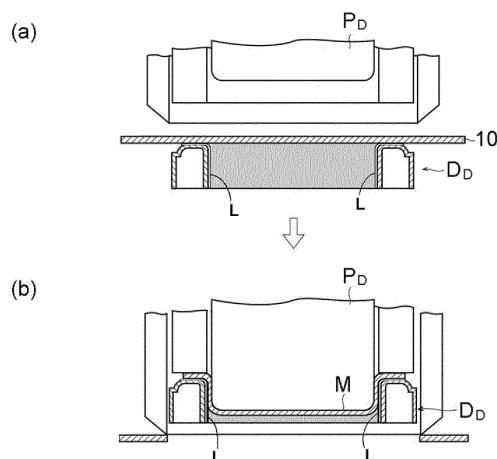
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(54) **METHOD FOR MANUFACTURING BOTTOMED CYLINDRICAL BODY**

(57) Provided is a manufacturing method of a bottomed cylindrical body, which can achieve both severe can making processing such as conventional drawing and ironing, and cost reduction and environmental load reduction in a washing step. A manufacturing method of a bottomed cylindrical body includes a drawing step of drawing a metal sheet by use of forming members each of which has a hardness of Hv 1500 to 12000 at its processing surface, and an ironing step of ironing a workpiece into the bottomed cylindrical body via a coolant by use of forming members each of which has a carbon film at its processing surface, and the coolant is a water-soluble coolant or a coolant having a boiling point of lower than 300°C, or a manufacturing method of a bottomed cylindrical body includes a drawing step of drawing a metal sheet by use of a drawing die, which has a hardness of more than Hv 1500 to 12000 at its processing surface, and a drawing punch, which has a hardness of Hv 1000 to 12000 at its processing surface, and an ironing step of ironing a workpiece into the bottomed cylindrical body via a coolant by use of forming members each of which has a hardness of Hv 1500 to 12000 at its processing

surface, and the coolant satisfies at least any one of (a) a coolant of lower than 4.0 vol% concentration of contained oil, (b) a water-soluble coolant, and (c) a coolant having a boiling point of lower than 300°C.

FIG. 1



Description

[Technical Field]

5 **[0001]** The present invention relates to a manufacturing method of a bottomed cylindrical body, and more specifically to a manufacturing method of a metal-made, bottomed cylindrical body by drawing and ironing.

[Background Art]

10 **[0002]** A metal-made, bottom cylindrical body, for example, a generally-called seamless can body is manufactured through drawing and ironing by a pressing die set.

[0003] Punch portions and die portions for use in the above-described drawing and ironing are generally placed under severe environment, so that die sets as proposed, for example, in PTL 2 to PTL 5 have been proposed. Described specifically, it has been proposed to improve the durability of a die set by covering its processing surfaces with a carbon film such as a diamond film or a DLC (diamond-like carbon) film.

15 **[0004]** When manufacturing a seamless can body by use of, for example, an aluminum alloy material, on the other hand, it has heretofore been common to perform forming under wet environment while using a lubricant and a coolant. In this case, a washing step (washer step) is indispensable after the can making processing to wash off such processing oil, lubricant, coolant, and the like with a washing solution or a chemical.

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[Citation List]

[Patent Literature]

25 **[0005]**

[PTL 1]
JP-6012804-B1

30 [PTL 2]
JP-H10-137861-A

[PTL 3]
JP-H11-277160-A

[PTL 4]
JP-2013-163187-A

35 [PTL 5]
WO-2017/033791-A1

[Summary]

40 [Technical Problems]

[0006] In the above-described conventional manufacturing methods of seamless can bodies, however, there are a problem that the washing step needs a great deal of energy and cost, and a problem that generates high environmental load.

45 **[0007]** It has hence been desired, for example, to reduce the cost and environmental load for massive water used in the washing step, to reduce the environmental load generated by a chemical used in the washing step, to decrease the energy needed when heating a washing solution in the washing step, and so on.

[0008] As a result of a great deal of diligent study, the present inventors have now also found that, when bottomed cylindrical bodies are manufactured under specific conditions by use of a coolant, the conventional severe processing such as drawing and ironing, and cost reduction and environmental load reduction in the washing step can both be achieved, leading to the present invention.

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[Solution to Problems]

55 **[0009]** To achieve the above-described desires, a manufacturing method of a bottomed cylindrical body in an embodiment of the present invention includes (1) a drawing step of drawing a metal sheet by use of forming members each of which has a hardness of more than Hv 1500 to 12000 at a processing surface thereof, and an ironing step of ironing a workpiece into the bottomed cylindrical body via a coolant by use of forming members each of which has a carbon film

at a processing surface thereof, and the coolant is a water-soluble coolant and/or a coolant having a boiling point of lower than 300°C.

[0010] In (1) described above, (2) the bottomed cylindrical body is preferably a seamless can body.

[0011] In (1) or (2) described above, (3) the metal sheet is preferably an aluminum alloy.

[0012] In any of (1) to (3) described above, (4) the carbon film is preferably a diamond film.

[0013] In any of (1) to (4) described above, (5) preferably, there is included, before the drawing step of drawing the metal sheet, a lubricant application step of applying, to the metal sheet, a water-soluble lubricant and/or a lubricant having a boiling point of lower than 300°C, and the hardness of the processing surface of each forming member in the drawing step is Hv 1500 to 12000.

[0014] In any of (1) to (5) described above, (6) the coolant preferably contains a preservative and/or a corrosion inhibitor.

[0015] The manufacturing method of the bottomed cylindrical body in the embodiment of the present invention preferably further includes, in any of (1) to (6) described above, (7) a washing step of removing a lubricant and/or the coolant attached on a surface of the bottomed cylindrical body.

[0016] The manufacturing method of the bottomed cylindrical body in the embodiment of the present invention preferably further includes, in any of (1) to (7) described above, (8) a purification step of purifying effluent discharged in the ironing step and/or a washing step.

[0017] To achieve the above-described desires, a manufacturing method of a bottomed cylindrical body in another embodiment of the present invention includes (9) a drawing step of drawing a metal sheet by use of a drawing die, which has a hardness of more than Hv 1500 to 12000 at a processing surface thereof, and a drawing punch, which has a hardness of Hv 1000 to 12000 at a processing surface thereof, and an ironing step of ironing a workpiece into the bottomed cylindrical body via a coolant by use of forming members each of which has a hardness of Hv 1500 to 12000 at a processing surface thereof, and the coolant satisfies at least any one of (a) a coolant of lower than 4.0 vol% concentration of contained oil, (b) a water-soluble coolant, and (c) a coolant having a boiling point of lower than 300°C.

[0018] In (9) described above, (10) the bottomed cylindrical body is preferably a seamless can body.

[0019] In (9) or (10) described above, (11) the metal sheet is preferably an aluminum alloy.

[0020] In any of (9) to (11) described above, (12) a carbon film is preferably formed on the processing surface of each forming member in the drawing step, and/or on the processing surface of each forming member in the ironing step.

[0021] In any of (9) to (12) described above, (13) preferably, there is included, before the drawing step, a lubricant application step of applying a lubricant to surfaces of the metal sheet, and the hardness of the processing surface of the drawing die in the drawing step is Hv 1000 to 12000.

[0022] In any of (9) to (13), (14) it is preferred to further include a purification step of purifying effluent discharged in the ironing step or a washing step after the ironing step.

[Advantageous Effects of Invention]

[0023] According to the manufacturing method of the bottomed cylindrical body in the present invention, there is included the step of performing ironing with the forming members (for example, a punch and a die) each of which has the carbon film at the processing surface thereof.

[0024] Even if the water-soluble coolant and/or the coolant having the boiling point of lower than 300°C is used as the coolant for use in the ironing step, the bottomed cylindrical body can therefore be obtained with an ironing ratio similar to or higher than a conventional one.

[0025] According to the manufacturing method of the bottomed cylindrical bodies in the present invention, there is also included a step of performing drawing with the forming members (for example, the punch and die) each of which has the hardness higher than the predetermined value at the processing surface thereof. It is therefore possible to omit a lubricant application step that applies to surfaces of the metal sheet (flat sheet) before the drawing.

[0026] In the present invention, there may also be included, before the drawing, a step of applying, to the surfaces of the metal sheet (flat sheet), a water-soluble lubricant and/or a lubricant having a boiling point of lower than 300°C. In this case, processability similar to or higher than conventional processability can be obtained even if a lower limit value of the hardness of the processing surface of each forming member in the drawing step is reduced.

[0027] Also, according to this embodiment, the water-soluble lubricant and coolant and the lubricant and coolant each having the boiling point of lower than 300°C are used in the drawing step and ironing step, respectively, so that washing is possible with water or hot water without using a washing solution in the washing step. Otherwise, the concentration of a washing ingredient in a washing solution can be lowered.

[0028] As a further alternative, it is also possible to remove the lubricant, coolant and the like, which have attached on the can body, by drying them after the can making processing without including the washing step.

[0029] Environmental load reduction and cost reduction in the washing step can be achieved accordingly.

[0030] Also, according to the manufacturing method of the bottomed cylindrical body in the present invention, there is also included the steps of drawing and ironing with the forming members (for example, punches and dies) each of

which has a hardness of a predetermined value or greater at the processing surface thereof.

[0031] The bottomed cylindrical body can therefore be obtained with an ironing ratio similar to or higher than a conventional one in the case of using a coolant that satisfies at least any one of (a) a coolant of lower than 4.0 vol% concentration of contained oil, (b) a water-soluble coolant, and (c) a coolant having a boiling point of lower than 300°C.

[0032] Also, according to each embodiment, it is also possible to omit an application step of a processing oil or a lubricant to surfaces of the metal sheet (flat sheet) before the drawing. Further, as the coolant for use in the ironing step, it is possible to use a coolant that satisfies at least any one of (a) a coolant of lower than 4.0 vol% concentration of contained oil, (b) a water-soluble coolant, and (c) a coolant having a boiling point of lower than 300°C. Washing is hence possible with water or hot water without using a washing solution in the washing step. As an alternative, it is also possible to remove the lubricant ingredient, coolant, and the like, which have attached on the can body, without including the washing step by drying them after the can making processing.

[0033] Environmental load reduction and cost reduction in the washing step can be achieved accordingly.

[Brief Description of Drawings]

[0034]

[FIG. 1]

FIG. 1 depicts schematic diagrams illustrating a drawing step in a manufacturing method of a bottomed cylindrical body in an embodiment of the present invention.

[FIG. 2]

FIG. 2 depicts schematic diagrams illustrating an ironing step in the manufacturing method of the bottomed cylindrical body in the embodiment of the present invention.

[FIG. 3]

FIG. 3 is a schematic diagram illustrating a flow of the manufacturing method of the bottomed cylindrical body in the embodiment of the present invention.

[FIG. 4]

FIG. 4 is a schematic diagram illustrating a flow of a manufacturing method of a bottomed cylindrical body in another embodiment of the present invention.

[Description of Embodiments]

[Manufacturing Method of Bottomed Cylindrical Body]

[0035] The applicants of the present invention have found such manufacturing methods of a seamless can body as disclosed in the specification of JP-2018-204896-A and the specification of JP-2018-204823-A. Described specifically, it has been found that, if pressing is performed with the content of oil in a coolant set at a predetermined level while using a die set having a diamond film or the like of high slip characteristics formed on each processing surface thereof, a degree of processing (for example, a limit ironing ratio) comparable with or higher than those of press-formed articles manufactured by use of a conventional amount of a lubricant is obtained even when severe processing such as ironing is performed.

[0036] In addition, the present inventors have now found a manufacturing method of a bottomed cylindrical body, which relates to the above-described manufacturing methods of the seamless cylindrical body.

[0037] The manufacturing method of the bottomed cylindrical body in this invention will hereinafter be specifically described with reference to the drawings as needed. It is to be noted that the following embodiments indicate examples of the present invention and describe their details, and are not intended to limit the present invention. In the embodiments to be described below, the description will be made, taking seamless can bodies as examples of the bottomed cylindrical body, and is not intended to limit the present invention.

(First Embodiment)

[0038] A description will first be made about a manufacturing method of a bottomed cylindrical body according to a first embodiment. FIG. 1 depicts schematic diagrams illustrating a drawing step in the manufacturing method of the bottomed cylindrical body according to the first embodiment. Further, FIG. 2A depicts schematic diagrams illustrating an ironing step in the manufacturing method of the bottomed cylindrical body according to the first embodiment. Furthermore, FIG. 3 is a schematic diagram illustrating a flow of the manufacturing method of the bottomed cylindrical body according to the first embodiment.

<Metal Sheet>

[0039] No particular limitation is imposed on a metal sheet as a material to be processed in this embodiment, as far as it is one subjected to general metal pressing. For example, a variety of known metal sheets such as not only aluminum, copper, iron, steel, titanium, and moreover, pure metals, but also their alloys can be adopted. Of these, an aluminum alloy sheet is particularly suited when a seamless can body is formed.

[0040] No particular limitation is imposed on the thickness of the metal sheet in this embodiment, and thicknesses that are common upon manufacture of seamless can bodies can each be adopted. As an example of the thickness of the metal sheet when can making processing is performed by use of, for example, an aluminum alloy sheet, an original sheet thickness (the thickness of an original sheet) is from 0.1 mm to 0.5 mm.

<Lubricant Application Step>

[0041] In the manufacturing step of the bottomed cylindrical body in this embodiment, a lubrication application step that applies a lubricant to surfaces of the metal sheet may be included. As known in common, the application of the lubricant enables processing of the metal sheet into a desired shape such as a bottomed cylindrical body without damage on or rupture in the metal sheet even if severe drawing and ironing are applied in a subsequent drawing step and ironing step. It is to be noted that, in this embodiment, the lubricant application step is not an essential step, and can be omitted as desired.

[0042] As the kind of the lubricant in this embodiment, it is preferred to use a water-soluble lubricant and/or a lubricant having a boiling point of lower than 300°C.

[0043] The water-soluble lubricant in this embodiment is defined to be a lubricant that is soluble in water. The use of the water-soluble lubricant is preferred because an attached lubricant ingredient can be removed after can making without using a chemical (acid, alkali, surfactant, or the like). It is to be noted that, in this embodiment, a lubricant ingredient and a coolant ingredient are removed preferably to such an extent as not to cause troubles such as irregularities and repellency of a coating composition in printing as a subsequent step, for example, even if washing is performed with water in a washing step to be described subsequently herein.

[0044] It is to be noted that, in this embodiment, the expression "a water-soluble lubricant and/or a lubricant having a boiling point of lower than 300°C" means that either "a water-soluble lubricant" or "a lubricant having a boiling point of lower than 300°C" or both of them may be encompassed. It is also meant that as a lubricant, one having a characteristic of either "water solubility" or "a boiling point of lower than 300°C" may be used, or one having characteristics of both "water solubility" and "a boiling point of lower than 300°C" may be used.

[0045] Further, as a rationale for the preference for the lubricant having the boiling point of lower than 300°C in this embodiment, such a lubricant enables vaporization and removal of an attached lubricant ingredient at relatively low temperatures after can making steps. In addition, the boiling point of the lubricant is more preferably lower than 250°C from viewpoints of equipment cost, energy cost, and the like.

[0046] As the lubricant in this embodiment, it is possible to use specifically a wash-free oil commercially available as a volatile lubricant.

[0047] It is to be noted that, as a coat amount and an application method of the lubricant, a known amount and a known method can be used.

<Drawing Step>

[0048] A description will next be made about a drawing step in this embodiment.

[0049] In the drawing step in this embodiment, processing surfaces of forming members (for example, the drawing die and drawing punch) in the drawing step preferably have a predetermined hardness or more. Described specifically, the processing surfaces are needed to have a hardness of more than Hv 1500 to 12000 in terms of Vickers hardness. In addition, if the lubricant application step is included before the above-mentioned drawing step, a lower limit of the hardness of the processing surface of each forming member in the drawing step can be set at Hv 1500.

[0050] Its rationale is as follows.

[0051] Specifically describing an example of the drawing step of the metal sheet with reference to FIG. 1, with a metal sheet 10 interposed between a drawing die D_D and a drawing punch P_D , drawing is applied by the drawing punch P_D , so that a shallow drawn cup M is made. As strong impact load acts on the drawing die D_D and drawing punch P_D during the drawing, they are considered to need high durability and abrasion resistance of such a degree that they can withstand mass production.

[0052] In this embodiment, the lubricant to be applied in the lubricant application step is preferably a water-soluble lubricant and/or a lubricant having a boiling point of lower than 300°C as mentioned above to achieve environmental load and cost reduction in the washing step. With such a lubricant, there is a need to impart still higher hardness or slip

characteristics to a die set so that damage on or rupture in a metal sheet by the forming members is avoided.

[0053] As a result of endeavors by the present inventors through trial and error from the above-described viewpoints, it has been found in this embodiment that, if the hardness of the processing surface of each forming member is set at more than Hv 1500 to 12000 in terms of Vickers hardness, no problem arises from the viewpoints of durability, abrasion resistance, and damage of the metal sheet, and the like even if severe drawing is applied.

[0054] In this embodiment, the forming members (dies) in the drawing step may be made from a base material formed of a known material or may be those having a surface treatment film L (see FIG. 1) formed on processing surfaces of such a base material as far as their processing surfaces have the above-described hardness.

[0055] As the material of the base material for the dies, a superhard alloy obtained by sintering a mixture of tungsten carbide (WC) and a metal binder such as cobalt; a cermet obtained by sintering a mixture of a metal carbide such as titanium carbide (TiC) or a titanium compound such as titanium carbonitride (TiNC) and a metal binder such as nickel or cobalt; ceramics; or the like can be exemplified.

[0056] As the surface treatment film L to be formed on the base material, on the other hand, a carbon film, a ceramic film, or the like can preferably be used, for example.

[0057] As the carbon film, a diamond film, a DLC film, or the like can be exemplified. No particular limitation is imposed on a method for formation of such a carbon film, and a chemical vapor deposition (CVD) process, a physical vapor deposition (PVD) process, or the like can be used.

[0058] As the ceramic film, on the other hand, examples include hard ceramics such as silicon carbide (SiC), silicon nitride (Si_3N_4), alumina (Al_2O_3), zirconia (ZrO_2), titanium nitride (TiN), titanium carbide (TiC), and chromium nitride (CrN), and the like.

[0059] As the combination of the kinds of the forming members for use in the drawing step in this embodiment, the same kind of material or surface treatment films of the same kind may be used, or materials or surface treatment films of different kinds may be used, in both the drawing die and the drawing punch. For example, both the drawing die and the drawing punch may be made from a superhard alloy, or one of the drawing die or the drawing punch may be made from a superhard alloy. As an alternative, a carbon film may be formed on the processing surface of each of the drawing die and the drawing punch, or a carbon film may be formed on the processing surface of one of the drawing die or the drawing punch.

[0060] It is to be noted that, if the surface treatment film on one of the drawing die and the drawing punch is a diamond film, the surface treatment film on the other is preferably other than a diamond film from standpoints of dimension control between the dies and suppression of breakage or damage between the dies.

[Ironing Step]

[0061] A description will next be made about the ironing step in this embodiment.

[0062] In the ironing step in this embodiment, carbon films may preferably be formed on processing surfaces of forming members (for example, the ironing die and ironing punch) in the ironing step.

[0063] More specifically describing the ironing step in this embodiment with reference to the drawings, there is included, as illustrated in FIGS. 2(a) and 2(b), a step of using, for example, an ironing die D_1 with a diamond film 20 formed on a processing surface thereof and an ironing punch P_1 with a surface treatment film 30, which is different in kind from the diamond film, formed on a processing surface thereof, and ironing the shallow drawn cup M between the processing surfaces of the die D_1 and punch P_1 with a coolant C interposed therebetween.

[0064] In the ironing, the ironing die D_1 and punch P_1 are considered to need high durability and abrasion resistance of such a degree that they can withstand mass production. Also, in this embodiment, the coolant C is considered to need to be a water-soluble coolant and/or a coolant having a boiling point of lower than 300°C . For reasons such as avoiding damage on or rupture in the workpiece (the metal sheet 10 and the shallow drawn cup M), it is therefore considered to be necessary that a carbon film having both hardness and slip characteristics is formed on either the processing surface of the ironing die D_1 or the processing surface of the ironing punch P_1 . As the carbon film, a diamond film, a DLC film, or the like can be exemplified. No particular limitation is imposed on a method for formation of such a carbon film, and a chemical vapor deposition (CVD) process, a physical vapor deposition (PVD) process, or the like can be used.

[0065] It is to be noted that, in this embodiment, the expression "a water-soluble coolant and/or a coolant having a boiling point of lower than 300°C " means that either "a water-soluble coolant" or "a coolant having a boiling point of lower than 300°C " or both of them may be encompassed. It is also meant that, as a coolant, one having a characteristic of either "water solubility" or "a boiling point of lower than 300°C " may be used, or one having characteristics of both "water solubility" and "a boiling point of lower than 300°C " may be used.

[0066] It is to be noted that, in this embodiment, especially in the ironing step, a diamond film having a Vickers hardness of Hv 8000 to 12000 or so is preferably formed on the processing surface of any one of a core and a cavity of the die set.

[0067] Described specifically, as illustrated in FIG. 2, the diamond film 20 of high hardness is formed on the processing surface of the ironing die D_1 , and the surface treatment film 30 different in kind from the diamond film may be formed on

the processing surface of the ironing punch P_1 , or the way round, although not illustrated.

[0068] It is to be noted that the diamond film 20 is preferably formed especially on the processing surface of the ironing die because severe processing load is generally applied more often to an ironing die than to an ironing punch.

[0069] As the thickness of the diamond film 20, preferred is from 5 μm to 30 μm . A thickness of smaller than 5 μm is not preferred, as the resulting diamond film is prone to crack formation and delamination. A thickness of greater than 30 μm , on the other hand, is not preferred, as the diamond film is prone to delamination due to increased internal stress.

[0070] On the other hand, the surface roughness R_a (JIS-B-0601-1994) of the diamond film 20 in this embodiment is preferably 0.12 μm or less from the viewpoint that such a surface roughness can impart high slip characteristics to the die set. Setting of R_a at 0.08 μm or less is more preferred, because the workpiece (for example, the can body) can be provided with an appearance of a mirror surface or a smooth surface close to a mirror surface.

[0071] In this case, the friction coefficient μ between the diamond film 20 and the workpiece during the pressing is preferably lower than 0.1.

[0072] A description will next be made about the coolant for use in the ironing step in this embodiment.

[0073] As the coolant for use in this embodiment, oil may be contained as its component. It is however preferred that the coolant can easily be washed off in the subsequent washing step or can be removed by drying even if such a washing step is not included. The coolant in this embodiment is therefore considered necessary to be a water-soluble coolant and/or a coolant having a boiling point of lower than 300°C.

[0074] It is to be noted that the water-soluble coolant is defined to be a coolant soluble in water. The use of the water-soluble coolant is preferred because an attached coolant ingredient can be removed after can making without using a chemical (acid, alkali, surfactant, or the like). It is to be noted that, in this embodiment, a lubricant ingredient and a coolant ingredient are removed preferably to such an extent as not to cause troubles such as irregularities and repellency of a coating composition in printing as a subsequent step, for example, even if washing is performed with water in the washing step to be described subsequently herein.

[0075] Further, as a rationale for the preference for the coolant having the boiling point of lower than 300°C, such a coolant enables vaporization and removal of as attached coolant ingredient at relatively low temperatures after can making steps. In addition, the boiling point of the coolant is more preferably lower than 250°C from the viewpoints of equipment cost, energy cost, and the like.

[0076] As the coolant in this embodiment, it is possible to use specifically a wash-free oil commercially available as a volatile lubricant.

[0077] In the coolant in this embodiment, one or more additives may also be contained as far as the characteristic(s) of water solubility and/or the boiling point of lower than 300°C is/are not impaired. For example, one or more of water, surfactants, rust preventives, extreme pressure additives, coupling agents, nonferrous metal corrosion inhibitors, preservatives, corrosion inhibitors, defoaming agents, chelating agents, colorants, fragrances, and the like may be contained as desired.

[0078] For the coolant in this embodiment, it is particularly preferred to contain a preservative and/or a corrosion inhibitor. This is based on the following rationale.

[0079] Described specifically, in the case of a water-soluble coolant, it abundantly contains substances that serve as nutrients for microorganisms such as bacteria and mold. There are accordingly problems that, after dilution, the coolant is prone to rotting, and processing equipment is prone to rusting at places where it comes into contact with the coolant.

[0080] It is to be noted that the expression "a preservative and/or a corrosion inhibitor" in this embodiment means that either one or both "a preservative" and "a corrosion inhibitor" may be contained. It also means that a substance having the characteristic of either "preservation" or "corrosion inhibition" or a substance having both of the characteristics of "preservation" and "corrosion inhibition" may be used.

[0081] If rotting of the coolant proceeds, a lubrication function and a cooling function as functions of the coolant are reduced, and moreover, an offensive smell due to the rotting also gives rise to a problem. Rust, if occurs, also leads to problems such as a significant reduction in the service life of a processing machine and damage to a workpiece.

[0082] Further, a problem in the cost aspect also arises due to an increase of the frequency of coolant replacement by the occurrence of rotting and rusting. Furthermore, mold and rust, if occur, also cause pipe clogging in a circulation system such as a pump.

[0083] As the preservative and corrosion inhibitor, known substances can be used as desired as far as the coolant remains water-soluble and/or to have a boiling point of lower than 300°C. For example, a formaldehyde-releasing substance or phenolic substance, or an amine-based substance may be added as desired.

[0084] In the manufacturing method of this embodiment, it is possible, as described above, to suppress a forming failure or the like at the time of can making and as a consequence to improve the forming stability even if the water-soluble coolant and/or the coolant having a boiling point of lower than 300°C is used.

[0085] As the water-soluble coolant and/or the coolant having a boiling point of lower than 300°C is used in this embodiment as mentioned above, it is also possible to perform washing with a chemical or water of low environmental load in the below-mentioned washing step. As an alternative, the washing step itself can be omitted, so that the load on

the environment can be reduced.

[0086] Further, the treatment of effluent after the washing is facilitated. If the effluent is recycled and circulated, the recycle rate can hence be improved, thereby enabling reduction of the cost and the load on the environment.

[0087] It is to be noted that the ironing step in this embodiment preferably includes an ironing step of forming a can body by ironing the metal sheet such that the ironing ratio (thickness decrement ratio) reaches 10% or higher. It is also to be noted that the ironing step may be repeated a plurality of times and the ironing ratio may be changed every time. For example, the ironing ratio of the first ironing step may be set at 10% or higher, and the ironing ratio of the last ironing step may be set at 30% or higher.

[0088] The ironing ratio in this embodiment is expressed by the following equation:

$$\text{Ironing ratio (\%)} = 100 \times (t_0 - t_1) / t_0$$

where t_0 represents a thickness before ironing, and t_1 represents a thickness (a 60-mm portion from a can bottom) after the ironing.

<Washing Step>

[0089] A description will next be made about the washing step in this embodiment.

[0090] The washing step in this embodiment is a step that brings a washing solution into contact with the bottomed cylindrical body obtained through the above-mentioned drawing step and ironing step to remove the lubricant and/or coolant attached on an inner surface and outer surface of the bottomed cylindrical body. It is to be noted that, in this embodiment, the washing step is not an essential step, and can be omitted as desired.

[0091] As a method for bringing the washing solution into contact with the bottomed cylindrical body, a known method can be used as desired. For example, the bottomed cylindrical body may be dipped in the washing solution, or the washing solution may be ejected as a spray or shower.

[0092] As the washing solution for use in this embodiment, water can be used beside known alkali washing solutions, acid washing solutions and neutral washing solutions.

[0093] As the alkali washing solutions, examples include aqueous solutions of inorganic compounds such as sodium carbonate, potassium carbonate, sodium bicarbonate, sodium hydroxide, and potassium hydroxide. As the acid washing solutions, examples can include aqueous solutions of inorganic acids such as sulfuric acid, nitric acid, hydrochloric acid, and hydrofluoric acid. As the neutral washing solutions, surfactants and the like can be used.

[0094] It is to be noted that, after performing washing treatment with an alkali washing solution, acid washing solution or neutral washing solution, water on the surfaces of the metal sheet is preferably removed, as known, by a method such as air blowing or drying in hot air after performing water washing treatment to remove the washing solution remaining on the surfaces of the metal sheet.

[0095] It is to be noted that, when an alkali washing solution, an acid washing solution, or the like is used, the concentration of the washing ingredient in the washing solution is preferably 3.0 vol% or lower from the viewpoints of suppressing cost and environmental load.

[0096] In the washing step in this embodiment, the temperature of the washing solution to be used is preferably lower than 70°C. Described specifically, in this embodiment, both the lubricant in the drawing step and the coolant in the ironing step are water-soluble and/or have a boiling point of lower than 300°C, so that the oil on the inner surface and outer surface of the bottomed cylindrical body can sufficiently be removed even if the temperature of the washing solution is lower than 70°C.

[0097] As a lower limit of the temperature of the washing solution, on the other hand, room temperature (for example, 20°C) is preferred.

[0098] When processing oil or the like is washed off in metal pressing, a washing solution is generally heated and used to improve the washing performance. However, certain commensurate energy is consumed to heat the washing solution. When a washing solution is used in this embodiment, it can hence be used at room temperature from the viewpoints of cost reduction and environmental load reduction as far as the washing performance is not lowered.

[0099] In this embodiment, it is also preferred, from the viewpoints of cost reduction and environmental load reduction, to set the washing time for 45 seconds or shorter in the washing step. Described specifically, in this embodiment, both the lubricant in the drawing step and the coolant in the ironing step are water-soluble and/or have a boiling point of lower than 300°C, so that the inner surface and outer surface of the bottomed cylindrical body can sufficiently be washed even if the washing time is 45 seconds or shorter.

[0100] It is to be noted that no particular limitation is imposed on a lower limit of the washing time, but as a lower limit of the washing time that causes no problem on the performance of effluent treatment, a washing time of longer than 10 seconds is preferred, for example. If, as a washing method, the washing solution is ejected as a spray or shower, on

the other hand, the ejection rate of the washing solution is preferably 60 to 70 mL/sec per can.

[0101] In the washing step in this embodiment, the lubricant and coolant attached on the inner surface and outer surface of the bottomed cylindrical body are removed with the washing solution. A change therefore occurs in the weight of the bottomed cylindrical body after the washing. This weight change is preferably less than 10 mg/m².

[0102] Described specifically, in this embodiment, it is hence possible to decrease the amounts of the lubricant and coolant attached on the inner surface and outer surface of the bottomed cylindrical body after processing through the can making steps (drawing step and ironing step), because both the lubricant in the drawing step and the coolant in the ironing step are water-soluble and/or have the boiling point of lower than 300°C as mentioned above.

[0103] The setting of the weight change of the bottomed cylindrical body before/after the washing at less than 100 mg/m² therefore can also decrease the amounts of the lubricant and coolant contained in the effluent that occurs in the washing step, and can hence reduce the environmental load.

<Drying Step>

[0104] As mentioned above, the washing step can be omitted as desired in this embodiment. In the case, it is preferred to include a drying step to remove the lubricant and coolant attached on the inner surface and outer surface of the bottomed cylindrical body.

[0105] Described specifically, as the lubricant in the drawing step and the coolant in the ironing step in this embodiment, it is preferred to use those which are both water-soluble and/or both have a boiling point of lower than 300°C. The lubricant and coolant attached on the inner surface and outer surface of the bottomed cylindrical body can therefore be removed through the drying step after the can making steps (drawing step and ironing step) without inclusion of the washing step.

[0106] In the drying step in this embodiment, the lubricant and coolant attached on the inner surface and outer surface of the bottomed cylindrical body can be removed by performing heating, specifically at approximately 150 to 300°C for 30 to 180 seconds, for example, in a dryer oven.

<Purification Step>

[0107] A description will next be made about a purification step that purifies effluent discharged in the ironing step and/or washing step in the above-mentioned manufacturing method of the bottomed cylindrical body in this embodiment.

[0108] It is to be noted that, in this embodiment, the expression "effluent discharged in the ironing step and/or washing step" means either one or both "effluent discharged in the ironing step" and "effluent discharged in the washing step."

[0109] Described specifically, in the manufacturing method of the bottomed cylindrical body in this embodiment, ironing is performed via the coolant in the ironing step as mentioned above. In the washing step, on the other hand, in addition to main washing that removes with the washing solution the lubricant and coolant attached on the surfaces of the bottomed cylindrical body, prewashing with water, and rinsing, which removes the washing solution with water after the main washing, are also performed. A great deal of effluent hence occurs in the washing step.

[0110] In the manufacturing method of the bottomed cylindrical body in this embodiment, the purification step that purifies the effluent may therefore be further included as illustrated in FIG. 3. Here, the purified effluent is preferably reused (recycled) again as purified water in the ironing step and washing step as described above for reasons to be mentioned later.

[0111] Described specifically, in the manufacturing method of the bottomed cylindrical body in this embodiment, the lubricant applied in the lubricant application step is water-soluble and/or has a boiling point of lower than 300°C as mentioned above. On the other hand, the coolant used in the ironing step is also a water-soluble coolant and/or has a boiling point of lower than 300°C as mentioned above. The oil in the effluent discharged in the ironing step and washing step is therefore lowered to less than a predetermined value.

[0112] The effluent occurred in the ironing step and/or washing step can hence be purified by a relatively simple method. The treatment through the purification step can achieve further environmental load reduction and cost reduction.

[0113] As a purification method of the effluent in the purification step, a known method can be used as desired. Described specifically, purification can be performed by appropriately combining methods such as filtration, neutralization, boiling, precipitation, flotation, biotreatment, UV sterilization, and the like. Further, a flocculant, a disinfectant, an antiseptic and/or the like may also be added as needed.

[0114] According to the above-described manufacturing method of the bottomed cylindrical body in this embodiment, the following advantageous effects can be exhibited.

(A) The forming members in the ironing step have the carbon films on the processing surfaces thereof, so that the coolant for use in the ironing step can be water-soluble and/or can have a boiling point of lower than 300°C.

(B) The hardness of the processing surfaces of the forming members in the drawing step are set at the predetermined

value or higher, so that the lubricant application step that applies to the surfaces of the metal sheet (flat sheet) before drawing can be omitted.

(C) As a consequence of the foregoing, it is possible to suppress the heating of the washing solution in the washing step, and/or to shorten the washing time. It is also possible not to include the washing step.

(D) Consequently, it is possible to achieve environmental load reduction and cost reduction.

[0115] If the purification step is further performed in this embodiment, the following advantageous effects can further be exhibited.

(E) The purification treatment of effluent discharged in the ironing step and/or washing step can be facilitated.

(F) The effluent can be purified and reused (recycled), so that cost and environmental load can be reduced.

(Second Embodiment)

[0116] A description will next be made about a manufacturing method of a bottomed cylindrical body according to a second embodiment. The schematic diagrams presented in FIG. 1 can also be applied in the second embodiment. The schematic diagrams presented in FIG. 2 can also be applied in the second embodiment as well. Further, FIG. 4 is a schematic diagram illustrating a flow of the manufacturing method of the bottomed cylindrical body according to the second embodiment.

<Metal Sheet>

[0117] No particular limitation is imposed on a metal sheet as a material to be processed in this embodiment, as far as it is one subjected to general metal pressing. For example, a variety of known metal sheets such as not only aluminum, copper, iron, steel, titanium, and moreover, pure metals, but also their alloys can be adopted. Of these, an aluminum alloy sheet is particularly suited when a seamless can body is formed.

[0118] No particular limitation is imposed on the thickness of the metal sheet in this embodiment, and thicknesses that are common at the time of manufacture of seamless can bodies can each be adopted. As an example of the thickness of the metal sheet when can making processing is performed by use of, for example, an aluminum alloy sheet, an original sheet thickness (the thickness of an original sheet) is from 0.1 mm to 0.5 mm.

<Lubricant Application Step>

[0119] In the manufacturing step of the bottomed cylindrical body in this embodiment, a lubrication application step that applies a lubricant to surfaces of the metal sheet (flat sheet) before drawing may be included. It is to be noted that the term "lubricant" in this embodiment should also encompass oil generally called "metal processing oil" or "metal cutting oil."

[0120] As known in common, the application of a known processing oil or lubricant before drawing enables processing of the metal sheet into a desired shape such as a bottomed cylindrical body without damage on or rupture in the metal sheet even if severe drawing and ironing are applied to the metal sheet in a subsequent drawing step and ironing step. In this embodiment, however, this step is not an essential step for reasons to be mentioned below.

[0121] As the kind of the lubricant in this embodiment, lubricants such as those to be described hereinafter can be exemplified.

[0122] For example, mineral oils formed of fatty acid esters, fatty acid alcohols, fatty acids, or the like can be used.

[0123] As an alternative, a water-soluble lubricant or a lubricant having a boiling point of lower than 300°C can also be used.

[0124] The water-soluble lubricant in this embodiment is defined to be a lubricant that is soluble in water. The use of the water-soluble lubricant is preferred because an attached lubricant ingredient can be removed after can making without using a chemical (acid, alkali, surfactant, or the like). It is to be noted that, in this embodiment, a lubricant ingredient and a coolant ingredient are removed preferably to such an extent as not to cause troubles such as irregularities and repellency of a coating composition in printing as a subsequent step, for example, even if washing is performed with water in a washing step to be described subsequently herein.

[0125] As the lubricant that has the boiling point of lower than 300°C, it is possible to use, specifically a wash-free oil commercially available as a volatile lubricating oil. As a rationale for the preference for the lubricant having the boiling point of lower than 300°C, such a lubricant enables vaporization and removal of an attached lubricant ingredient at relatively low temperatures after can making steps. In addition, the boiling point of the lubricant is more preferably lower than 250°C from the viewpoints of equipment cost, energy cost, and the like.

[0126] It is to be noted that, in this step, as the coat amount and the application method of the lubricant, a known

amount and a known method can be used.

[0127] In this embodiment, the viscosity of the lubricant is preferably lower than 200 mPa·s from the viewpoints of the objects of the present invention, that is, environmental load and cost reductions in the washing step. A lubricant viscosity of 200 mPa·s or higher is not preferred as such a lubricant may not be sufficiently washed off and removed in a subsequent washing step and drying step. More preferably, the viscosity of the lubricant is lower than 100 mPa·s.

<Drawing Step>

[0128] A description will next be made about a drawing step in this embodiment.

[0129] In the drawing step in this embodiment, processing surfaces of forming members (for example, the drawing die and drawing punch) in the drawing step preferably have a predetermined hardness or more. Described specifically, the processing surfaces are needed to have a hardness of Hv 1000 to 12000 in terms of Vickers hardness. Described specifically, the manufacturing method of the bottomed cylindrical body in this embodiment is characterized in that the hardness of the processing surface of the drawing die is more than Hv 1500 to 12000 and the hardness of the processing surface of the drawing punch is Hv 1000 to 12000.

[0130] Its rationale is as follows.

[0131] Specifically describing an example of the drawing step of the metal sheet with reference to FIG. 1, with a metal sheet 10 interposed between the drawing die D_D and the drawing punch P_D , drawing is applied by the drawing punch P_D , so that a shallow drawn cup M is made. As strong impact load acts on the drawing die D_D and drawing punch P_D during the drawing, they are considered to need high durability and abrasion resistance of such a degree that they can withstand mass production.

[0132] Also, in this embodiment, the application step of processing oil or lubricant to the surfaces of the metal sheet (flat sheet) before drawing can be omitted to achieve environmental load and cost reductions in the washing step. In the case, there is a need to impart still higher hardness or slip characteristics to a die set so that damage on or rupture in the metal sheet by the forming members is avoided.

[0133] As a result of endeavors by the present inventors through trial and error from the above-described viewpoints, it has been found in this embodiment that, if, as the hardness of the processing surfaces of the forming members in the drawing, the hardness of the processing surface of the drawing die is set at more than Hv 1500 to 12000 in terms of Vickers hardness and the hardness of the processing surface of the drawing punch is set at Hv 1000 to 12000 in terms of Vickers hardness, no problem arises from the viewpoints of durability, abrasion resistance, and damage on the metal sheet, and the like even if severe drawing and ironing are applied to the metal sheet.

[0134] It is to be noted that, in this embodiment, the forming members (dies) in the drawing step may be made from a base material formed of a known material or may be those having a surface treatment film L (see FIG. 1) formed on processing surfaces of such a base material as far as their processing surfaces have the above-described hardness.

[0135] As the material of the base material for the die set, a superhard alloy obtained by sintering a mixture of tungsten carbide (WC) and a metal binder such as cobalt; a cermet obtained by sintering a mixture of a metal carbide such as titanium carbide (TiC) or a titanium compound such as titanium carbonitride (TiNC) and a metal binder such as nickel or cobalt; or the like can be exemplified.

[0136] As the surface treatment film L to be formed on the base material, on the other hand, a carbon film, a ceramic film, a fluororesin film, or the like can be preferably used, for example.

[0137] As the carbon film, a diamond film of Hv 8000 to 12000 or so in terms of Vickers hardness, a DLC film of Hv 3000 to 7000 or so in terms of Vickers hardness, or the like can be exemplified. No particular limitation is imposed on a method for formation of such carbon films, and a chemical vapor deposition (CVD) process, a physical vapor deposition (PVD) process, or the like can be used.

[0138] As the ceramic film, on the other hand, examples include hard ceramics such as silicon carbide (SiC), silicon nitride (Si_3N_4), alumina (Al_2O_3), and zirconia (ZrO_2).

[0139] As the combination of the kinds of the forming members for use in the drawing step in this embodiment, the same kind of material or surface treatment films L of the same kind may be used, or materials or surface treatment films L of different kinds may be used, in both the drawing die and the drawing punch. For example, both the drawing die and the drawing punch may be made from a superhard alloy, or one of the drawing die or the drawing punch may be made from a superhard alloy. As an alternative, a carbon film may be formed on the processing surface of each of the drawing die and the drawing punch, or a carbon film may be formed on the processing surface of one of the drawing die or the drawing punch. Described specifically, the surface treatment film L is formed on the processing surface of the drawing die D_D , but no surface treatment film L is formed on the processing surface of the drawing punch P_D , although the present invention should not be limited to such configurations.

[0140] It is to be noted that, in this embodiment, the carbon film may preferably be formed on the processing surface of at least one of a core and a cavity at the time of drawing. If a drawing die is used as the cavity and a drawing punch is used as the core, for example, it is preferred that the carbon film is formed on the processing surface of at least one

of them.

[0141] Described more specifically, a DLC film may be formed on the processing surface of each of the drawing die and the drawing punch, or a diamond film may be formed on one of the drawing die or the drawing punch, and a DLC film may be formed on the other one.

[0142] If the surface treatment film on one of the drawing die and the drawing punch is a diamond film, the other preferably has a surface treatment film other than a diamond film, especially from the viewpoints of dimension control between the dies and suppression of breakage and damage between the dies. In this case, it is more preferred that the diamond film is formed especially on the drawing die on which higher processing load is applied. It is to be noted that the diamond film may be formed on the above-described processing surface of at least the die portion but may also be formed on another portion or other portions.

[0143] As the thickness of the diamond film, preferred is from 5 μm to 30 μm . A thickness of smaller than 5 μm is not preferred, as the resulting diamond film is prone to crack formation and delamination. A thickness of greater than 30 μm , on the other hand, is not preferred, as the diamond film is prone to delamination due to increased internal stress.

[0144] If the surface treatment film on one of the drawing die and the drawing punch is the diamond film, on the other hand, the thickness of the surface treatment film formed on the other is preferably 0.1 to 10 μm or so, and especially preferably, is set to be smaller than the thickness of the diamond film.

[0145] This is for the following rationale. Described specifically, if the thickness of the surface treatment film formed on the drawing punch is set to be smaller than the diamond film formed on the drawing die, for example, a dimension error itself associated with the formation of the film can be made small because it is a thin film. In addition to this, the Vickers hardness of the surface treatment film is soft compared with the diamond film, and therefore, easy polishing is possible with known diamond abrasive grains, thereby not only enabling reduction of the processing cost but also enabling target die dimensions to be finished with high accuracy.

[Ironing Step]

[0146] A description will next be made about the ironing step in this embodiment.

[0147] The ironing step in this embodiment is characterized in that the hardness of processing surfaces of forming members (for example, an ironing die and a punching die) are Hv 1500 to 12000.

[0148] More specifically describing the ironing step in this embodiment by using the drawings, there is included, as illustrated in FIGS. 2(a) and 2(b), a step of using, for example, an ironing die D_1 with a diamond film 20 formed on a processing surface thereof and an ironing punch P_1 with a surface treatment film 30, which is different in kind from the diamond film, formed on a processing surface thereof, and ironing the shallow drawn cup M between the processing surfaces of the die D_1 and punch P_1 with a coolant C interposed therebetween.

[0149] In the ironing, the ironing die D_1 and punch P_1 are considered to need high durability and abrasion resistance of such a degree that they can withstand mass production. In this embodiment, it is also considered to be needed that the concentration of oil contained in the coolant C is lower than 4.0 vol% or the coolant C is a water-soluble coolant or a coolant having a boiling point of lower than 300°C. For reasons such as avoiding damage on or rupture in the workpiece (the metal sheet 10 and the shallow drawn cup M), it is therefore considered to be necessary that the hardness of the processing surfaces of the ironing die D_1 and ironing punch P_1 are set at Hv 1500 to 12000.

[0150] In the foregoing, it is particularly preferred that a carbon film is formed on any one of the processing surfaces of the ironing die D_1 and ironing punch P_1 . As the carbon film, examples include a diamond film of Hv 8000 to 12000 or so in terms of Vickers hardness, a DLC film of Hv 3000 to 7000 or so in terms of Vickers hardness, and the like. No particular limitation is imposed on a method for formation of such a carbon film, and a chemical vapor deposition (CVD) process, a physical vapor deposition (PVD) process, or the like can be adopted.

[0151] It is to be noted that, in this embodiment, especially a diamond film is preferably formed on the processing surface of either a core or a cavity of a die set. Described specifically, as illustrated in FIG. 2, the diamond film 20 of high hardness is formed on the processing surface of the ironing die D_1 , and the surface treatment film 30 different in kind from the diamond film may be formed on the processing surface of the ironing punch P_1 , or the way round.

[0152] It is to be noted that the diamond film 20 is preferably formed especially on the processing surface of the ironing die because severe processing load is generally applied more often to an ironing die than to an ironing punch.

[0153] As the thickness of the diamond film 20, preferred is from 5 μm to 30 μm . A thickness of smaller than 5 μm is not preferred, as the resulting diamond film is prone to crack formation and delamination. A thickness of greater than 30 μm , on the other hand, is not preferred, as the diamond film is prone to delamination due to increased internal stress.

[0154] As the thickness of the surface treatment film 30 different in kind from the diamond film 20, on the other hand, it is preferably 0.1 to 10 μm or so, and especially preferably, is set to be smaller than the thickness of the diamond film 20.

[0155] This is for the following rationale. Described specifically, if the thickness of the surface treatment film 30 is set to be smaller than the thickness of the diamond film 20, a dimension error itself associated with the formation of the film can be made small because it is a thin film.

[0156] The surface roughness Ra (JIS B-0601-1994) of the diamond film 20 in this embodiment is preferably 0.12 μm or less from the viewpoint that such surface roughness can impart high slip characteristics to a die set. Setting of Ra at 0.08 μm or less is more preferred, because the workpiece (for example, the can body) can be provided with an appearance of a mirror surface or a smooth surface close to a mirror surface.

[0157] In this case, the friction coefficient μ between the diamond film 20 and the workpiece during the pressing is preferably lower than 0.1.

[0158] A description will next be made about the coolant for use in the ironing step in this embodiment.

[0159] As the coolant for use in this embodiment, oil may be contained as its component. It is however preferred that the coolant can be easily washed off in the subsequent washing step or can be removed by drying even if such a washing step is not included. The coolant in this embodiment is therefore preferred to satisfy at least any one of (a) the content of oil is lower than 4.0 vol%, (b) it is a water-soluble coolant, and (c) it is a coolant having a boiling point of lower than 300°C.

[0160] In the case of the coolant (a) that the content of oil is lower than 4.0 vol%, the oil can be one contained in general water-soluble metal processing oil compositions. The oil may be natural oil, or can be synthetic oil.

[0161] As the natural oil, examples include mineral oils such as paraffinic oil, naphthenic oil, and aromatic oil. Aliphatic acid glyceride can also be exemplified as natural oil.

[0162] As the synthetic oil, examples include hydrocarbon oil such as polyolefins, ester oil such as fatty acid esters, ether oil such as polyalkylene glycols, fluorine-containing oil such as perfluorocarbon, phosphorus-containing oil such as phosphate esters, silicon-containing oil such as silicate esters, and the like.

[0163] The oils exemplified above may be used either singly or in combination of two or more.

[0164] Described specifically, examples can include water-soluble metal processing oil compositions of the type A1 (emulsion type) or the type A2 (soluble type) specified in JIS K 2241, and the like. Also, although not specified in the JIS standards, water-soluble metal processing oil compositions called "generally-called synthetic type (metal processing oil compositions that are free of mineral oil and contain a chemically synthesized oil)" can also be exemplified.

[0165] In this embodiment, the concentration of the oil in the coolant is preferably lower than 4.0 vol%.

[0166] In the case, a coolant in which the concentration of oil is lower than 4.0 vol% may be prepared by first preparing a stock solution with the oil contained at a content of 4.0 vol% or higher, and diluting the stock solution with a solvent such as water when the coolant is used. The concentration of the oil in the coolant is therefore needed to be lower than 4.0 vol% in use.

[0167] Next, the water-soluble coolant (b) as the coolant for use in this embodiment is defined to be a coolant that is soluble in water. The use of the water-soluble coolant is preferred because an attached coolant ingredient can be removed after can making without using a chemical (acid, alkali, surfactant, or the like). It is to be noted that, in this embodiment, a lubricant ingredient and a coolant ingredient are removed preferably to such an extent as not to cause troubles such as irregularities and repellency of a coating composition in printing as a subsequent step, for example, even if washing is performed with water in the washing step to be described subsequently herein.

[0168] Further, as the coolant (c) having a boiling point of lower than 300°C in this embodiment, it is possible to adopt specifically a wash-free oil commercially available as a volatile lubricant. As a rationale for the preference for the coolant having the boiling point of lower than 300°C, such a coolant enables vaporization and removal of an attached coolant ingredient at relatively low temperatures after can making steps. In addition, the boiling point of the coolant is more preferably lower than 250°C from the viewpoints of equipment cost, energy cost, and the like.

[0169] It is to be noted that, as the coolant in this embodiment, the above-described coolants (a), (b) and (c) may be used as a mixture. As a further alternative, a coolant having a plurality of characteristics of (a), (b) and (c) may also be used.

[0170] In the coolant in this embodiment, one or more additives may also be contained as far as the characteristics of at least any one of (a) a coolant of lower than 4.0 vol% concentration of contained oil, (b) a water-soluble coolant, and (c) a coolant having a boiling point of lower than 300°C is not impaired. For example, one or more of water, surfactants, rust preventives, extreme pressure additives, coupling agents, nonferrous metal corrosion inhibitors, preservatives, corrosion inhibitors, defoaming agents, chelating agents, colorants, fragrances, and the like may be contained as desired.

[0171] For the coolant in this embodiment, it is particularly preferred to contain a preservative and/or a corrosion inhibitor. This is based on the following rationale.

[0172] Described specifically, in the case of a water-soluble coolant, it abundantly contains substances that serve as nutrients for microorganisms such as bacteria and mold. There are accordingly problems that, after dilution, the coolant is prone to rotting, and processing equipment is prone to rusting at places where it comes into contact with the coolant.

[0173] It is to be noted that the expression "a preservative and/or a corrosion inhibitor" in this embodiment means that either one or both "a preservative" and "a corrosion inhibitor" may be contained. It also means that a substance having the characteristic of either "preservation" or "corrosion inhibition" or a substance having both of the characteristics of "preservation" and "corrosion inhibition" may be used.

[0174] If rotting of the coolant proceeds, the lubrication function and the cooling function as the functions of the coolant are reduced, and moreover, an offensive smell due to the rotting also gives rise to a problem. Rust, if occurs, also leads to a problem such as damage to a workpiece.

[0175] Further, a problem in the cost aspect also arises due to an increase of the frequency of coolant replacement by the occurrence of rotting and rusting. Furthermore, mold and rust, if occur, also cause pipe clogging in a circulation system such as a pump.

[0176] As the preservative and/or corrosion inhibitor, known substances can be used as desired as far as the characteristic of the coolant, that is, at least any one of (a) a coolant of lower than 4.0 vol% concentration of contained oil, (b) a water-soluble coolant, and (c) a coolant having a boiling point of lower than 300°C is not impaired. For example, a formaldehyde-releasing substance or phenolic substance, and an amine-based substance may be added as desired.

[0177] In the manufacturing method of this embodiment, it is possible, as mentioned above, to suppress a forming failure or the like at the time of can making and as a consequence to improve the forming stability if the coolant in the ironing is at least any one of (a) a coolant of lower than 4.0 vol% concentration of contained oil, (b) a water-soluble coolant, and (c) a coolant having a boiling point of lower than 300°C.

[0178] As such a coolant as mentioned above is used in this embodiment, it is also possible to perform washing with a chemical or water of low environmental load in the below-mentioned washing step. As an alternative, the washing step itself can be omitted, so that the load on the environment can be reduced.

[0179] Further, the treatment of effluent after the washing is facilitated. If the effluent is recycled and circulated, the recycle rate can hence be improved, thereby enabling reduction of the cost and the load on the environment.

[0180] It is to be noted that the ironing step in this embodiment preferably includes an ironing step of forming a can body by ironing the metal sheet such that the ironing ratio (thickness decrement ratio) reaches 10% or higher. It is also to be noted that the ironing step may be repeated a plurality of times and the ironing ratio may be changed every time. For example, the ironing ratio of the first ironing step may be set at 10% or higher, and the ironing ratio of the last ironing step may be set at 30% or higher.

[0181] The ironing ratio in this embodiment is expressed by the following equation:

$$\text{Ironing ratio (\%)} = 100 \times (t_0 - t_1) / t_0$$

where t_0 represents a thickness before ironing, and t_1 represents a thickness (a 60 mm portion from a can bottom) after the ironing.

<Washing Step>

[0182] A description will next be made about the washing step in this embodiment.

[0183] The washing step in this embodiment is a step that brings a washing solution into contact with the bottomed cylindrical body obtained through the above-mentioned drawing step and ironing step to remove the lubricant and coolant attached on an inner surface and outer surface of the bottomed cylindrical body. It is to be noted that, in this embodiment, the washing step is not an essential step, and can be omitted as desired.

[0184] As a method for bringing the washing solution into contact with the bottomed cylindrical body, a known method can be used as desired. For example, the bottomed cylindrical body may be dipped in the washing solution, or the washing solution may be ejected as a spray or shower.

[0185] As the washing solution for use in this embodiment, water can be used beside known alkali washing solutions, acid washing solutions and neutral washing solutions.

[0186] As the alkali washing solutions, examples include aqueous solutions of inorganic compounds such as sodium carbonate, potassium carbonate, sodium bicarbonate, sodium hydroxide, and potassium hydroxide.

[0187] As the acid washing solutions, examples can include aqueous solutions of inorganic acids such as sulfuric acid, nitric acid, hydrochloric acid, and hydrofluoric acid.

[0188] It is to be noted that, after performing washing treatment with an alkali washing solution or an acid washing solution, water on the surfaces of the metal sheet is preferably removed, as known, by a method such as air blowing or drying in hot air after performing water washing treatment to remove the washing solution remaining on the surfaces of the metal sheet.

[0189] It is to be noted that, when an alkali washing solution, an acid washing solution or the like is used, the concentration of the washing ingredient in the washing solution is preferably 2.0 to 5.0 wt% from the viewpoints of suppressing cost and environmental load while maintaining washing performance.

[0190] In the washing step in this embodiment, the temperature of the washing solution to be used is preferably lower than 70°C. Described specifically, in this embodiment, the application step of processing oil or lubricant to the surfaces of the metal sheet (flat sheet) before drawing can be omitted, and as the coolant in the ironing step, at least one of (a) a coolant of an oil content of lower than 4.0 vol%, (b) a water-soluble coolant, and (c) a coolant having a boiling point of lower than 300°C is used. The oil on the inner surface and outer surface of the bottomed cylindrical body can therefore be sufficiently removed even if the temperature of the washing solution is lower than 70°C.

[0191] As the lower limit of the temperature of the washing solution, on the other hand, room temperature (for example, 20°C) is preferred. When processing oil or the like is washed off in metal pressing, a washing solution is generally heated and used to improve the washing performance. However, certain commensurate energy is consumed to heat the washing solution. When a washing solution is used in this embodiment, it can hence be used at room temperature from the viewpoints of cost reduction and environmental load reduction as far as the washing performance is not lowered.

[0192] In this embodiment, it is also preferred, from the viewpoints of cost reduction and environmental load reduction, to set the washing time for 45 seconds or shorter in the washing step. Described specifically, in this embodiment, both of the lubricant in the drawing step and the coolant in the ironing step are water-soluble and/or have a boiling point of lower than 300°C, so that the inner surface and outer surface of the bottomed cylindrical body can sufficiently be washed even if the washing time is 45 seconds or shorter.

[0193] It is to be noted that no particular limitation is imposed on the lower limit of the washing time, but as a lower limit of the washing time that causes no problem on the performance of effluent treatment, a washing time of longer than 10 seconds is preferred, for example. If, as a washing method, the washing solution is ejected as a spray or shower, on the other hand, the ejection rate of the washing solution is preferably 60 to 70 mL/sec per can.

[0194] In the washing step in this embodiment, the lubricant and coolant attached on the inner surface and outer surface of the bottomed cylindrical body are removed with the washing solution. A change therefore occurs in the weight of the bottomed cylindrical body after the washing. This weight change is preferably less than 10 mg/m².

[0195] Described specifically, in this embodiment, it is possible to decrease the amounts of the lubricant and coolant attached on the inner surface and outer surface of the bottomed cylindrical body after processing through the can making steps (drawing step and ironing step).

[0196] The setting of the weight change of the bottomed cylindrical body after the washing at less than 100 mg/m² therefore can also decrease the amounts of the lubricant and coolant contained in the effluent that occurs in the washing step, and can hence reduce the environmental load.

<Drying Step>

[0197] As mentioned above, the washing step can be omitted as desired in this embodiment. In the case, it is preferred to include a drying step to remove the lubricant and coolant attached on the inner surface and outer surface of the bottomed cylindrical body.

[0198] Described specifically, in this embodiment, the application step of processing oil or lubricant to the surfaces of the metal sheet (flat sheet) before drawing can be omitted, and as the coolant in the ironing step, at least any one of (a) a coolant of an oil content of lower than 4.0 vol%, (b) a water-soluble coolant, and (c) a coolant having a boiling point of lower than 300°C is used.

[0199] If the application of processing oil or lubricant to the surfaces of the metal sheet (flat plate) before drawing is not performed, and as the coolant in the ironing step, the coolant (c) having a boiling point of lower than 300°C is used out of these coolants, the lubricant and coolant attached on the inner surface and outer surface of the bottomed cylindrical body can be removed through the drying step, even if no washing step is included after the can making steps (the drawing step and ironing step).

[0200] In the drying step in this embodiment, the lubricant and coolant attached on the inner surface and outer surface of the bottomed cylindrical body can be removed by performing heating, specifically at approximately 150 to 300°C for 30 to 180 seconds, for example, in a dryer oven.

<Purification Step>

[0201] A description will next be made about a purification step in this embodiment. The manufacturing method of the bottomed cylindrical body in this embodiment may include, as illustrated in FIG. 3, the purification step that purifies effluent discharged in the above-mentioned ironing step and/or washing step.

[0202] Described specifically, in the manufacturing method of the bottomed cylindrical body in this embodiment, ironing is performed via the coolant in the ironing step as mentioned above. In the washing step, on the other hand, the coolant ingredient attached on the surfaces of the bottomed cylindrical body is removed with the washing solution. A great deal of effluent hence occurs in both the steps.

[0203] In the manufacturing method of the bottomed cylindrical body in this embodiment, the purification step that purifies the effluent may therefore be further included as illustrated in FIG. 3. Here, the purified effluent is preferably reused (recycled) again as purified water in the ironing step and washing step as described above for reasons to be mentioned later.

[0204] In the manufacturing method of the bottomed cylindrical body in this embodiment, the application step of processing oil or lubricant to the surfaces of the metal sheet (flat sheet) before drawing can be omitted as mentioned above. Also, as the coolant in the ironing step, at least any one of (a) a coolant of an oil content of lower than 4.0 vol%,

(b) a water-soluble coolant, and (c) a coolant having a boiling point of lower than 300°C is used as mentioned above.

[0205] The effluent occurred in the ironing step and/or washing step can hence be purified by a relatively simple method. The treatment through the purification step can achieve further environmental load reduction and cost reduction.

[0206] As a purification method of the effluent in the purification step, a known method can be used as desired. Described specifically, purification can be performed by appropriately combining methods such as filtration, neutralization, boiling, precipitation, flotation, biotreatment, UV sterilization, and the like. Further, a flocculant, a disinfectant, an antiseptic and/or the like may also be added as needed.

[0207] According to the above-described manufacturing method of the bottomed cylindrical body in this embodiment, the following advantageous effects can be exhibited.

(A) The hardness of each of the processing surfaces of the forming members in the drawing step is set at the predetermined value or higher, so that the lubricant application step to the surfaces of the metal sheet (flat sheet) before drawing can be omitted.

(B) The hardness of each of the processing surfaces of the forming members in the ironing step is set at the predetermined value or higher, so that as the coolant in the ironing step, a coolant which satisfies at least any one of (a) a coolant of an oil content of lower than 4.0 vol%, (b) a water-soluble coolant, and (c) a coolant having a boiling point of lower than 300°C can be used.

(C) As a consequence of the foregoing, it is possible to set the concentration of the washing ingredient to be low and to suppress the heating of the washing solution, and/or to shorten the washing time, in the washing step. In addition, it is also possible to omit the washing step.

(D) Consequently, it is possible to achieve environmental load reduction and cost reduction.

[0208] Also, if the purification step is further performed in this embodiment, the following advantageous effects can further be exhibited.

(E) The purification treatment of effluent discharged in the ironing step and/or washing step can be facilitated.

(F) The effluent can be purified and reused (recycled), so that cost and environmental load can be reduced.

Examples

[0209] The present invention will hereinafter be described in further detail by use of Examples, but the present invention should not be limited to the following Examples.

(Example 1)

[0210] By the procedures presented below, a drawn and ironed can (DI can) of 350 mL internal volume was manufactured.

[0211] First, an aluminum alloy sheet (JIS H 4000 3104 material, 0.28 mm) was prepared. To both surfaces of the aluminum alloy sheet, a water-soluble lubricant was then applied at 1.0 to 1.3 g/m² as a lubricant at a time of drawing.

[0212] By a drawing machine, the aluminum alloy sheet was then punched into a disc shape of 160 mm diameter, immediately followed by drawing into a cup body of 90 mm diameter. It is to be noted that the processing surface hardness of each processing member in the drawing was Hv 1500.

[0213] The resulting cup body was transferred to a body maker (can body making machine), and was subjected to redrawing into a shape of 66 mm diameter. By use of a coolant, ironing was then performed into a shape of 66 mm diameter and 130 mm height.

[0214] As an ironing die in the ironing, one having a diamond film of approximately 10 μm average thickness formed on a surface thereof was used. The surface hardness of the diamond film was Hv 10000.

[0215] As an ironing punch used, on the other hand, one having a diamond-like carbon film of approximately 0.5 μm thickness formed on a surface thereof was used. The surface hardness of the diamond-like carbon film was Hv 3000.

[0216] The ironing ratio for the ironing was set as presented in Table 1. A water-soluble coolant was used in the ironing. In the coolant, a known surfactant, rust preventive, extreme pressure additive, and preservative were added.

[0217] To the DI can thus obtained, washing was applied to remove the lubricant and the coolant ingredient attached on an inner surface and outer surface thereof. As a washing solution for use in the washing, sulfuric acid (concentration: 3.0 vol%) was employed. Further, upon washing, the temperature of the washing solution was set at 20°C, and the washing time was set for 30 seconds.

(Example 2)

[0218] The procedures of Example 1 were repeated similarly except that, as the lubricant in the drawing, a lubricant having the boiling point presented in Table 1 was used. The results are presented in Table 1.

(Example 3)

[0219] The procedures of Example 1 were repeated similarly except that the processing surface hardness of each forming member in the drawing was as presented in Table 1. The results are presented in Table 1.

(Example 4)

[0220] The procedures of Example 1 were repeated similarly except that the processing surface hardness of the drawing die in the drawing was as presented in Table 1. The results are presented in Table 1.

(Example 5)

[0221] The procedures of Example 1 were repeated similarly except that the processing surface hardness of the drawing punch in the drawing was as presented in Table 1. The results are presented in Table 1.

(Example 6)

[0222] As an ironing die in ironing, one having a diamond-like carbon film of approximately 0.5 μm average thickness formed on a surface thereof was used. The surface hardness of the diamond-like carbon film was Hv 3000. Except for the foregoing, the procedures of Example 1 were repeated similarly. The results are presented in Table 1.

(Example 7)

[0223] As an ironing punch in ironing, one having a diamond film of approximately 10 μm average thickness formed on a surface thereof was used. The surface hardness of the diamond film was Hv 10000. Except for the foregoing, the procedures of Example 1 were repeated similarly. The results are presented in Table 1.

(Example 8)

[0224] As a coolant for use in ironing, one having the boiling point presented in Table 1 was employed. Except for the foregoing, the procedures of Example 1 were repeated similarly. The results are presented in Table 1.

(Example 9)

[0225] The procedures of Example 1 were repeated similarly except that, as the washing solution for use in the washing, pure water was employed. The results are presented in Table 1.

(Example 10)

[0226] The procedures of Example 1 were repeated similarly except that, in lieu of the washing step after the drawing and ironing, drying (300°C, 30 sec) was performed. The results are presented in Table 1.

(Example 11)

[0227] As a coolant for use in ironing, one having the boiling point presented in Table 1 was employed. Except for the foregoing, the procedures of Example 2 were repeated similarly. The results are presented in Table 1.

(Example 12)

[0228] The procedures of Example 2 were repeated similarly except that, as the washing solution for use in the washing, pure water was employed. The results are presented in Table 1.

(Example 13)

[0229] The procedures of Example 2 were repeated similarly except that, in lieu of the washing step after the drawing and ironing, drying (300°C, 30 sec) was performed. The results are presented in Table 1.

(Example 14)

[0230] The procedures of Example 8 were repeated similarly except that, as the washing solution for use in the washing, pure water was employed. The results are presented in Table 1.

(Example 15)

[0231] The procedures of Example 8 were repeated similarly except that, in lieu of the washing step after the drawing and ironing, drying (300°C, 30 sec) was performed. The results are presented in Table 1.

(Example 16)

[0232] The procedures of Example 11 were repeated similarly except that, as the washing solution for use in the washing, pure water was employed. The results are presented in Table 1.

(Example 17)

[0233] The procedures of Example 11 were repeated similarly except that, in lieu of the washing step after the drawing and ironing, drying (300°C, 30 sec) was performed. The results are presented in Table 1.

(Example 18)

[0234] Subsequent to a washing step after drawing and ironing, drying (300°C, 30 sec) was further performed. Except for the foregoing, the procedures of Example 14 were repeated similarly. The results are presented in Table 1.

(Example 19)

[0235] Subsequent to a washing step after drawing and ironing, drying (300°C, 30 sec) was further performed. Except for the foregoing, the procedures of Example 12 were repeated similarly. The results are presented in Table 1.

(Example 20)

[0236] The procedures of Example 3 were repeated similarly except that no lubricant was performed in the drawing and that the ironing ratio at the time of the ironing was set at the value presented in Table 1. The results are presented in Table 1.

(Comparative Example 1)

[0237] The procedures of Example 1 were repeated similarly except that, as the lubricant in the drawing, a water-insoluble lubricant was applied. The results are presented in Table 1.

(Comparative Example 2)

[0238] The procedures of Example 1 were repeated similarly except that, as the lubricant in the drawing, a lubricant having the boiling point presented in Table 1 was used. The results are presented in Table 1.

(Comparative Example 3)

[0239] The procedures of Example 1 were repeated similarly except that the processing surface hardness of the drawing die in the drawing was as presented in Table 1, but the can body ruptured in the drawing step. The results are presented in Table 1.

(Comparative Example 4)

[0240] As an ironing die and ironing punch in ironing, those made of a superhard alloy (Hv 1000) were used. Except for the foregoing, the procedures of Example 1 were repeated similarly. The results are presented in Table 1.

(Comparative Example 5)

[0241] The procedures of Example 1 were repeated similarly except that the coolant for use in the ironing was changed to a water-insoluble coolant. The results are presented in Table 1.

(Comparative Example 6)

[0242] The procedures of Example 1 were repeated similarly except that the coolant used in the ironing was changed to one having the boiling point presented in Table 1, and in lieu of the washing step after the drawing and ironing, drying (300°C, 30 sec) was performed. The results are presented in Table 1.

(Comparative Example 7)

[0243] The procedures of Example 1 were repeated similarly except that the coolant used in the ironing was changed to a water-insoluble coolant, and in lieu of the washing step after the drawing and ironing, drying (300°C, 30 sec) was performed. The results are presented in Table 1.

(Comparative Example 8)

[0244] The procedures of Example 1 were repeated similarly except that no lubricant was performed in the drawing, but the can body ruptured in the drawing step. The results are presented in Table 1.

[Evaluations]

[0245] On the DI cans obtained by the above-described procedures, evaluations were conducted by the following methods. The results are presented in Table 1.

[Ironing Processability]

[0246] Visually observed for three items of (i) the presence or absence of rupture at the time of ironing, (ii) bleed-through (black streaks) on an opening portion of each resulting DI can or discoloration on an outer surface of its can body portion, and (iii) damage on the outer surface of the can body portion. The ironing processability was ranked as follows. "A" represents as being excellent with no problem in any of the above-described three items, "B" represents as being capable of withstanding practical use although a problem arose in any of the items, or "D" represents as being having a problem in any of the items and incapable of withstanding practical use.

[Printability]

[0247] Subsequent to application of a water-based coating composition to a can surface after washing had been performed on each resulting DI can, baking was performed by a known method, and an evaluation was made for any irregularities of the coating composition. The printability of each DI can visually determined to have no irregularities of the coating composition was ranked as "B," whereas the printability of each DI can visually determined to have developed irregularities due to repellency or the like of the coating composition was ranked as "D." It is to be noted that, if irregularities of a coating composition occur, a lubricant and/or a coolant used in a drawing step or ironing step can be evaluated to remain.

[Effluent Treatment Performance]

[0248] By use of the washing solution, spray washing was applied to each DI can. After rinsing it with water, effluent was filled in a beaker, and its chemical oxygen demand (COD) was measured by a known method. The effluent treatment performance was determined as "B" (good effluent treatment performance) if the COD was lower than 200 ppm, whereas the effluent treatment performance was determined as "D" (poor effluent treatment performance) if the COD was 200 ppm or higher. The results are presented in Table 1.

[Table 1]

	Lubricant application step		Drawing step		Ironing step					Washing step	Drying step	Evaluations		
	water-soluble or water-in-soluble	Boiling point	Die surface hardness	Punch surface hardness	Kind of die surface	Kind of punch surface	Ironing ratio (%)	Type of coolant	Boiling point of coolant	Ingredient of washing agent	Drying temperature	Ironing processability	Printability	Effluent treatment performance
Example 1	Water-soluble	-	1500	1500	Diamond film	DLC film	40	Water-soluble	-	Sulfuric acid	-	A	B	D
Example 2	-	299	1500	1500	Diamond film	DLC film	40	Water-soluble	-	Sulfuric acid	-	A	B	D
Example 3	Water-soluble	-	10000	10000	Diamond film	DLC film	40	Water-soluble	-	Sulfuric acid	-	A	B	D
Example 4	Water-soluble	-	12000	1500	Diamond film	DLC film	40	Water-soluble	-	Sulfuric acid	-	A	B	D
Example 5	Water-soluble	-	1500	12000	Diamond film	DLC film	40	Water-soluble	-	Sulfuric acid	-	A	B	D
Example 6	Water-soluble	-	1500	1500	DLC film	DLC film	40	Water-soluble	-	Sulfuric acid	-	B	B	D
Example 7	Water-soluble	-	1500	1500	Diamond film	Diamond film	40	Water-soluble	-	Sulfuric acid	-	A	B	D
Example 8	Water-soluble	-	1500	1500	Diamond film	DLC film	40	-	299	Sulfuric acid	-	A	B	D
Example 9	Water-soluble	-	1500	1500	Diamond film	DLC film	40	Water-soluble	-	Water	-	A	B	B
Example 10	Water-soluble	-	1500	1500	Diamond film	DLC film	40	Water-soluble	-	-	300°C, 30 sec	A	D	-
Example 11	-	299	1500	1500	Diamond film	DLC film	40	-	299	Sulfuric acid	-	A	B	D
Example 12	-	299	1500	1500	Diamond film	DLC film	40	Water-soluble	-	Water	-	A	D	B

(continued)

	Lubricant application step		Drawing step		Ironing step					Washing step	Drying step	Evaluations		
	water-soluble or water-insoluble	Boiling point	Die surface hardness	Punch surface hardness	Kind of die surface	Kind of punch surface	Ironing ratio (%)	Type of coolant	Boiling point of coolant	Ingredient of washing agent	Drying temperature	Ironing processability	Printability	Effluent treatment performance
Example 13	-	299	1500	1500	Diamond film	DLC film	40	Water-soluble	-	-	300°C, 30 see	A	D	-
Example 14	Water-soluble	-	1500	1500	Diamond film	DLC film	40	-	299	Water	-	A	D	B
Example 15	Water-soluble	-	1500	1500	Diamond film	DLC film	40	-	299	-	300°C, 30 see	A	D	-
Example 16	-	299	1500	1500	Diamond film	DLC film	40	-	299	Water	-	A	D	B
Example 17	-	299	1500	1500	Diamond film	DLC film	40	-	299	-	300°C, 30 see	A	B	-
Example 18	Water-soluble	-	1500	1500	Diamond film	DLC film	40	-	299	Water	300°C, 30 see	A	B	B
Example 19	-	299	1500	1500	Diamond film	DLC film	40	Water-soluble	-	Water	300°C, 30 see	A	B	B
Example 20	-	-	10000	10000	Diamond film	DLC film	41	Water-soluble	-	Sulfuric acid	-	A	B	D
Comparative Ex. 1	Water-insoluble	-	1500	1500	Diamond film	DLC film	40	Water-soluble	-	Sulfuric acid	-	A	B	D
Comparative Ex. 2	-	350	1500	1500	Diamond film	DLC film	40	Water-soluble	-	Water	-	A	D	B
Comparative Ex. 3	Water-soluble	-	1000	1500	Forming was impossible in drawing step (ruptured)							D	-	-
Comparative Ex. 4	Water-soluble	-	1500	1500	Superhard alloy	Superhard alloy	40	Water-soluble	-	Sulfuric acid	-	D	B	D

(continued)

	Lubricant applica- tion step		Drawing step		Ironing step					Washing step	Drying step	Evaluations		
	water-sol- uble or water-in- soluble	Boiling point	Die sur- face hard- ness	Punch surface hardness	Kind of die surface	Kind of punch sur- face	Ironing ratio (%)	Type of coolant	Boiling point of coolant	Ingredient of washing agent	Drying tem- perature	Ironing proc- essability	Printability	Effluent treatment performance
Comparative Ex. 5	Water- soluble	-	1500	1500	Diamond film	DLC film	40	Water-in- soluble	-	Water	-	A	D	B
Comparative Ex. 6	Water- soluble	-	1500	1500	Diamond film	DLC film	40	-	350	-	300°C, 30 see	A	D	-
Comparative Ex. 7	Water- soluble	-	1500	1500	Diamond film	DLC film	40	Water-in- soluble	-	-	300°C, 30 see	A	D	-
Comparative Ex. 8	-	-	1500	1500	Forming was impossible in drawing step (ruptured)					D			-	-

(Example 21)

[0249] By the procedures presented below, a drawn and ironed can (DI can) of 350 mL internal volume was manufactured.

[0250] First, an aluminum alloy sheet (JIS H 4000 3104 material, 0.28 mm) was prepared. Application of a lubricant to both surfaces of the aluminum alloy sheet was not performed.

[0251] By a drawing machine, the aluminum alloy sheet was then punched into a disc shape of 160 mm diameter, immediately followed by drawing into a cup body of 90 mm diameter. It is to be noted that the processing surface hardness of each processing member in the drawing was as presented in Table 1.

[0252] The resulting cup body was transferred to a body maker (can body making machine), and was subjected to redrawing into a shape of 66 mm diameter. By use of a coolant, ironing was then performed into a shape of 66 mm diameter and 130 mm height.

[0253] As an ironing die in the ironing, one having a diamond film of approximately 10 μm average thickness formed on a surface thereof was used. The surface hardness of the diamond film was as presented in Table 1.

[0254] As an ironing punch used, on the other hand, one having a diamond-like carbon film of approximately 0.5 μm thickness formed on a surface thereof was used. The surface hardness of the diamond-like carbon film was as presented in Table 1.

[0255] The ironing ratio for the ironing was set as presented in Table 1. The content of oil in the coolant was as presented in Table 1. In the coolant, a known surfactant, rust preventive, extreme pressure additive and preservative were added.

[0256] To the DI can thus obtained, washing was applied to remove the lubricant and the coolant ingredient attached on an inner surface and outer surface thereof. As a washing solution for use in the washing, sulfuric acid (concentration: 3.0%) was employed. Further, upon washing, the temperature of the washing solution was set at 50°C, and the washing time was set for 30 seconds.

(Example 22)

[0257] The procedures of Example 21 were repeated similarly except that the processing surface hardness of the ironing die in the ironing was as presented in Table 2. The results are presented in Table 2.

(Example 23)

[0258] The procedures of Example 21 were repeated similarly except that the processing surface hardness of the ironing die in the ironing was as presented in Table 2. The results are presented in Table 2.

(Example 24)

[0259] The procedures of Example 21 were repeated similarly except that the processing surface hardness of the ironing punch in the ironing was as presented in Table 2. The results are presented in Table 2.

(Example 25)

[0260] As a coolant for use in ironing, one having the oil content presented in Table 2 was employed. Except for the foregoing, the procedures of Example 21 were repeated similarly. The results are presented in Table 2.

(Example 26)

[0261] A coolant for use in ironing was one having the boiling point presented in Table 2. Except for the foregoing, the procedures of Example 21 were repeated similarly. The results are presented in Table 2.

(Example 27)

[0262] The procedures of Example 21 were repeated similarly except that, as the washing solution for use in the washing, pure water was employed. The results are presented in Table 2.

(Example 28)

[0263] The procedures of Example 21 were repeated similarly except that, as a coolant for use in ironing, one having

the boiling point presented in Table 2 was employed, and in lieu of the washing step after the drawing and ironing, drying (300°C, 30 sec) was performed. The results are presented in Table 2.

(Example 29)

[0264] The procedures of Example 27 were repeated similarly except that the processing surface hardness of each of the punches and dies in the drawing step and ironing step was as presented in Table 2. The results are presented in Table 2.

(Example 30)

[0265] The procedures of Example 27 were repeated similarly except that the processing surface hardness of each of the punches and dies in the drawing step and ironing step was as presented in Table 2. The results are presented in Table 2.

(Example 31)

[0266] The procedures of Example 28 were repeated similarly except that the processing surface hardness of each of the punches and dies in the drawing step and ironing step was as presented in Table 2. The results are presented in Table 2.

(Example 32)

[0267] The procedures of Example 21 were repeated similarly except that the processing surface hardness of each of the punches and dies in the drawing step and ironing step was as presented in Table 2. The results are presented in Table 2.

(Example 33)

[0268] The procedures of Example 27 were repeated similarly except that a water-soluble lubricant was applied before the drawing step, and the processing surface hardness of each of the drawing punch and drawing die in the drawing step was as presented in Table 2. The results are presented in Table 2.

(Example 34)

[0269] The procedures of Example 21 were repeated similarly except that the processing surface hardness of the drawing punch in the drawing step was as presented in Table 2. The results are presented in Table 2.

(Example 35)

[0270] The procedures of Example 34 were repeated similarly except that a water-soluble lubricant was applied before the drawing step. The results are presented in Table 2.

(Example 36)

[0271] The procedures of Example 21 were repeated similarly except that the processing surface hardness of each of the punches in the drawing step and ironing step was as presented in Table 2. The results are presented in Table 2.

(Example 37)

[0272] The procedures of Example 34 were repeated similarly except that the processing surface hardness of the punch in the ironing step was as presented in Table 2. The results are presented in Table 2.

(Comparative Example 9)

[0273] The procedures of Example 21 were repeated similarly except that the processing surface hardness of the drawing die in the drawing was as presented in Table 2, but the can body ruptured in the drawing step. The results are presented in Table 2.

(Comparative Example 10)

[0274] The procedures of Example 21 were repeated similarly except that the processing surface hardness of each of the drawing die and drawing punch in the drawing was as presented in Table 2, but the can body ruptured in the drawing step. The results are presented in Table 2.

(Comparative Example 11)

[0275] The procedures of Example 21 were repeated similarly except that the processing surface hardness of each of the ironing die and ironing punch in the ironing was as presented in Table 2. The results are presented in Table 2.

(Comparative Example 12)

[0276] The procedures of Comparative Example 11 were repeated similarly except that a water-soluble lubricant was applied before the drawing step. The results are presented in Table 2.

(Comparative Example 13)

[0277] The procedures of Example 21 were repeated similarly except that, in lieu of the washing step after the drawing and ironing, drying (300°C, 30 sec) was performed. The results are presented in Table 2.

(Comparative Example 14)

[0278] The processing surface hardness of each of punches and dies in a drawing step and ironing step was as presented in Table 2, and the content of oil in a coolant used in ironing was as presented in Table 2. Except for the foregoing, the procedures of Example 27 were repeated similarly. The results are presented in Table 2.

(Comparative Example 15)

[0279] The content of oil in a coolant used in ironing was as presented in Table 2. Except for the foregoing, the procedures of Example 21 were repeated similarly. The results are presented in Table 2.

(Comparative Example 16)

[0280] The procedures of Comparative Example 13 were repeated similarly except that a water-soluble lubricant was applied before the drawing step. The results are presented in Table 2.

[Evaluations]

[0281] On the DI cans obtained by the above-described procedures, evaluations were conducted by the following methods. The results are presented in Table 1.

[Ironing Processability]

[0282] Visually observed for three items of (i) the presence or absence of rupture at the time of ironing, (ii) bleed-through (black streaks) on an opening portion of each resulting DI can, and (iii) damage on an outer surface of the can body portion. The ironing processability was ranked as follows. "A" represents that the can surface is a mirror surface with no problem in any of the above-described four items. "B" represents as being excellent with no problem in any of the items. "C" represents as being capable of withstanding practical use although a problem arose in any of the items. "D" represents as having a problem in any of the items and incapable of withstanding practical use.

[Printability]

[0283] Subsequent to application of a water-based coating composition to a can surface after washing had been performed on each resulting DI can, baking was performed by a known method, and an evaluation was made for any irregularities of the coating composition. The printability of each DI can visually determined to have no irregularities of the coating composition was ranked as "B," whereas the printability of each DI can visually determined to have developed irregularities due to repellency or the like of the coating composition was ranked as "D." It is to be noted that, if irregularities

of a coating composition occur, a lubricant and/or a coolant used in a drawing step or ironing step can be evaluated to remain.

[Effluent Treatment Performance]

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[0284] By use of the washing solution, spray washing was applied to each DI can. After rinsing it with water, effluent was filled in a beaker, and its chemical oxygen demand (COD) was measured by a known method. The effluent treatment performance was determined as "B" (good effluent treatment performance) if the COD was lower than 200 ppm, whereas the effluent treatment performance was determined as "D" (poor effluent treatment performance) if the COD was 200
10 ppm or higher. The results are presented in Table 2.

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[Table 2]

	Lubricant application step	Drawing step		Ironing step				Washing step	Drying step	Evaluations		
		Diesurface hardness	Punch surface hardness	Diesurface hardness	Punch surface hardness	Type of coolant	Ironing ratio (%)			Ironing processability	Printability	Effluent treatment performance
Example 21	None	12000	1500	12000	8000	Water-soluble	40	Sulfuric acid	-	A	B	D
Example 22	None	12000	1500	2000	8000	Water-soluble	40	Sulfuric acid	-	C	B	D
Example 23	None	12000	1500	5000	8000	Water-soluble	40	Sulfuric acid	-	B	B	D
Example 24	None	12000	1500	12000	2000	Water-soluble	40	Sulfuric acid	-	A	B	D
Example 25	None	12000	1500	12000	8000	Oil content 3.9 vol%	40	Sulfuric acid	-	A	B	D
Example 26	None	12000	1500	12000	8000	Boiling point 299°C	40	Sulfuric acid	-	A	B	D
Example 27	None	12000	1500	12000	8000	Water-soluble	40	Water	-	A	B	B
Example 28	None	12000	1500	12000	8000	Boiling point 299°C	40	-	300°C, 30 see	A	B	B
Example 29	None	10000	10000	10000	8000	Water-soluble	40	Water	-	A	B	B
Example 30	None	5000	5000	10000	8000	Water-soluble	40	Water	-	A	B	B
Example 31	None	5000	5000	10000	8000	Boiling point 299°C	40	-	300°C, 30 see	A	B	B

(continued)

	Lubricant application step	Drawing step		Ironing step				Washing step	Drying step	Evaluations		
		Diesurface hardness	Punch surface hardness	Diesurface hardness	Punch surface hardness	Type of coolant	Ironing ratio (%)			Ironing processability	Printability	Effluent treatment performance
Example 32	None	12000	1500	2000	12000	Water-soluble	40	Sulfuric acid	-	C	B	D
Example 33	Included (water-soluble)	1500	1500	12000	8000	Water-soluble	40	Water	-	A	B	B
Example 34	None	12000	1000	12000	8000	Water-soluble	40	Sulfuric acid	-	A	B	D
Example 35	Included (water-soluble)	12000	1000	12000	8000	Water-soluble	40	Sulfuric acid	-	A	B	D
Example 36	None	12000	1000	12000	1500	Water-soluble	40	Sulfuric acid	-	C	B	D
Example 37	Included (water-soluble)	12000	1000	12000	1500	Water-soluble	40	Sulfuric acid	-	A	B	D
Comparative Ex. 9	None	1500	1500	-	-	-	-	-	-	-	-	-
Comparative Ex. 10	None	1500	12000	-	-	-	-	-	-	-	-	-
Comparative Ex. 11	None	12000	1500	1500	1500	Water-soluble	40	Sulfuric acid	-	D	B	D
Comparative Ex. 12	Included (water-soluble)	12000	1500	1500	1500	Water-soluble	40	Sulfuric acid	-	D	B	D
Comparative Ex. 13	None	12000	1500	12000	8000	Water-soluble	40	-	300°C, 30 sec	A	D	B

(continued)

	Lubricant application step	Drawing step		Ironing step				Washing step	Drying step	Evaluations		
		Diesurface hardness	Punch surface hardness	Diesurface hardness	Punch surface hardness	Type of coolant	Ironing ratio (%)			Ironing processability	Printability	Effluent treatment performance
Comparative Ex. 14	None	12000	1500	10000	8000	Oil content 3.9 vol%	40	Water	-	A	D	B
Comparative Ex. 15	None	12000	1500	12000	8000	Oil content 5.0 vol%	40	Sulfuric acid	-	A	B	D
Comparative Ex. 16	Included (water-soluble)	12000	1500	12000	8000	Oil content 5.0 vol%	40	Sulfuric acid	-	A	B	D

[0285] According to the manufacturing method of the bottomed cylindrical body in the first embodiment, it has become possible to obtain a bottomed cylindrical body at an ironing ratio similar or higher than the conventional one even if a coolant for use in an ironing step is set to be water-soluble and/or to have a boiling point of lower than 300°C.

[0286] According to the first embodiment, it has also become possible to further include a lubricant application step to apply a lubricant to surfaces of a metal sheet (flat sheet) before drawing, so that processability similar to or higher than the conventional one has become available even if the lubricant is set to be water-soluble and/or to have a boiling point of lower than 300°C.

[0287] In the first embodiment, a water-soluble lubricant and coolant, and a lubricant and coolant having a boiling point of lower than 300°C are used in a drawing step and ironing step, and therefore washing is possible with water or hot water in a washing step without using a washing solution.

[0288] As an alternative, the lubricant, coolant and/or the like attached on a can body can be removed by drying them after can making processing without inclusion of the washing step.

[0289] It is also clear that the effluent occurred in the ironing step and washing step can be reused (recycled) again in the ironing step and washing step by way of a purification step that purifies the effluent.

[0290] According to the manufacturing method of the bottomed cylindrical body in the second embodiment, it has become possible to obtain a bottomed cylindrical body at an ironing ratio similar or higher than the conventional one even if a coolant for use in an ironing step is one capable of satisfying at least one of (a) a coolant of lower than 4.0 vol% concentration of contained oil, (b) a water-soluble coolant, and (c) a coolant having a boiling point of lower than 300°C.

[0291] In the second embodiment, owing to the use of the coolant described above, washing is possible with water or hot water in a washing step without using a washing solution.

[0292] As an alternative, the lubricant, coolant and/or the like attached on a can body can be removed by drying them after can making processing without inclusion of a washing step.

[0293] It is also clear that the effluent occurred in the ironing step and washing step can be reused (recycled) again in the ironing step or washing step by way of a purification step that purifies the effluent.

[Industrial Applicability]

[0294] The present invention can suitably be used in the field of metal pressing, where consideration is paid to the environment while maintaining processability and forming stability.

[Reference Signs List]

[0295]

D_D: Drawing die
P_D: Drawing punch
D_I: Ironing die
P_I: Ironing punch
C: Coolant
M: Shallow drawn cup
10: Metal sheet
20: Diamond film
30: Surface treatment film

Claims

1. A manufacturing method of a bottomed cylindrical body, comprising:

a drawing step of drawing a metal sheet by use of forming members each of which has a hardness of more than Hv 1500 to 12000 at a processing surface thereof; and
an ironing step of ironing a workpiece into the bottomed cylindrical body via a coolant by use of forming members each of which has a carbon film at a processing surface thereof,
wherein the coolant is a water-soluble coolant and/or a coolant having a boiling point of lower than 300°C.

2. The manufacturing method according to claim 1,
wherein the bottomed cylindrical body is a seamless can body.

3. The manufacturing method according to claim 1 or 2,
wherein the metal sheet is an aluminum alloy.

4. The manufacturing method according to any one of claims 1 to 3,
wherein the carbon film is a diamond film.

5. The manufacturing method according to any one of claims 1 to 4, further comprising:

before the drawing step of drawing the metal sheet, a lubricant application step of applying, to the metal sheet,
a water-soluble lubricant and/or a lubricant having a boiling point of lower than 300°C,
wherein the hardness of the processing surface of each forming member in the drawing step is Hv 1500 to 12000.

6. The manufacturing method according to any one of claims 1 to 5,
wherein the coolant contains a preservative and/or a corrosion inhibitor.

7. The manufacturing method according to any one of claims 1 to 6, further comprising:
a washing step of removing a lubricant and/or the coolant attached on a surface of the bottomed cylindrical body.

8. The manufacturing method according to any one of claims 1 to 7, further comprising:
a purification step of purifying effluent discharged in the ironing step and/or a washing step.

9. A manufacturing method of a bottomed cylindrical body, comprising:

a drawing step of drawing a metal sheet by use of a drawing die, which has a hardness of more than Hv 1500
to 12000 at a processing surface thereof, and a drawing punch, which has a hardness of Hv 1000 to 12000 at
a processing surface thereof; and

an ironing step of ironing a workpiece into the bottomed cylindrical body via a coolant by use of forming members
each of which has a hardness of Hv 1500 to 12000 at a processing surface thereof,

wherein the coolant satisfies at least any one of (a) a coolant of lower than 4.0 vol% concentration of contained
oil, (b) a water-soluble coolant, and (c) a coolant having a boiling point of lower than 300°C.

10. The manufacturing method according to claim 9,
wherein the bottomed cylindrical body is a seamless can body.

11. The manufacturing method according to claim 9 or 10,
wherein the metal sheet is an aluminum alloy.

12. The manufacturing method according to any one of claims 9 to 11,
wherein a carbon film is formed on the processing surface of each forming member in the drawing step, and/or on
the processing surface of each forming member in the ironing step.

13. The manufacturing method according to any one of claims 9 to 12, further comprising:

before the drawing step, a lubricant application step of applying a lubricant to surfaces of the metal sheet,
wherein the hardness of the processing surface of the drawing die in the drawing step is Hv 1000 to 12000.

14. The manufacturing method according to any one of claims 9 to 13, further comprising:
a purification step of purifying effluent discharged in the ironing step or a washing step after the ironing step.

FIG. 1

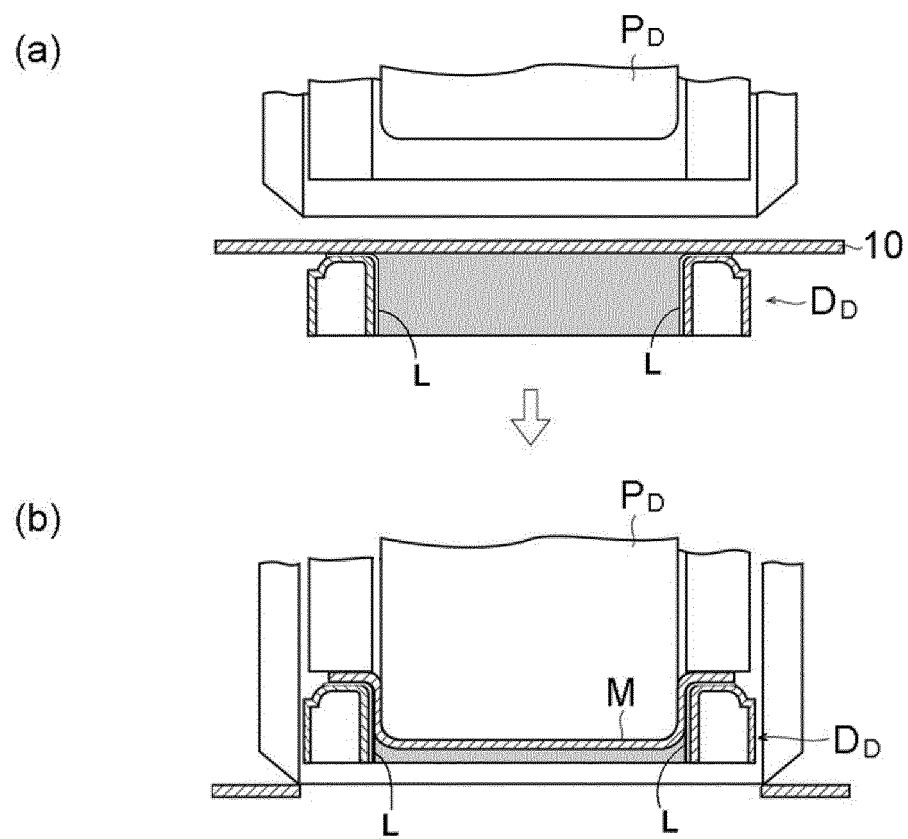


FIG. 2

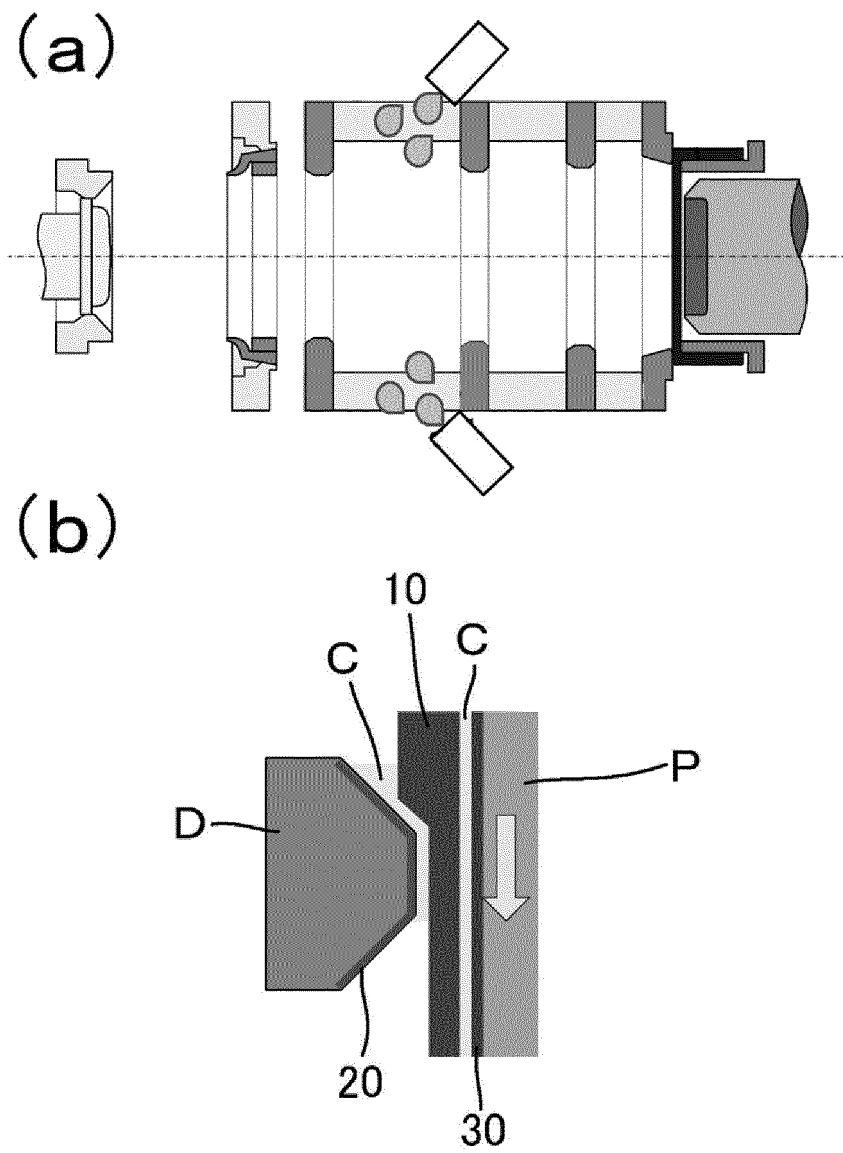


FIG. 3

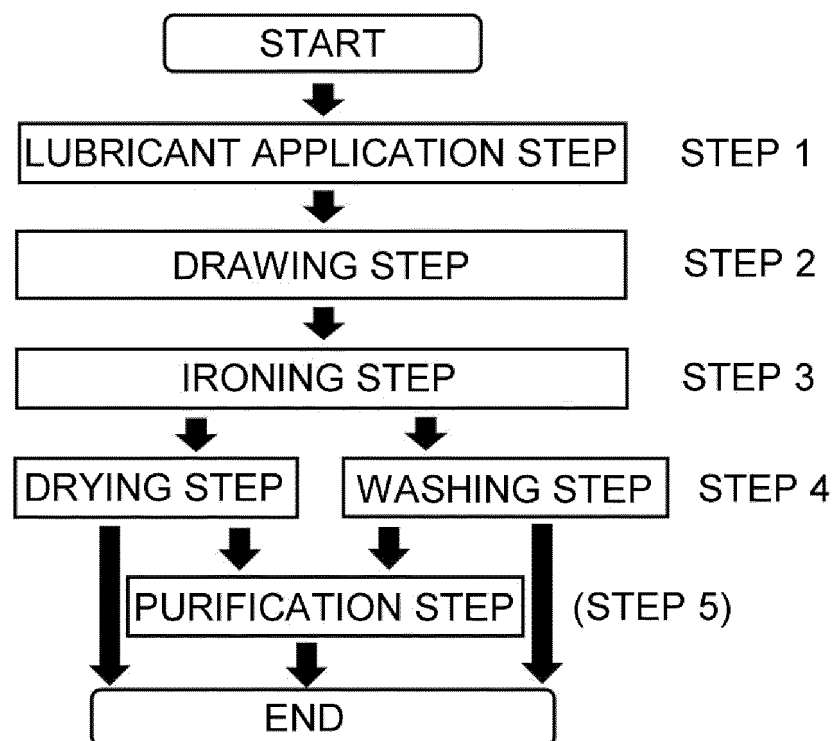
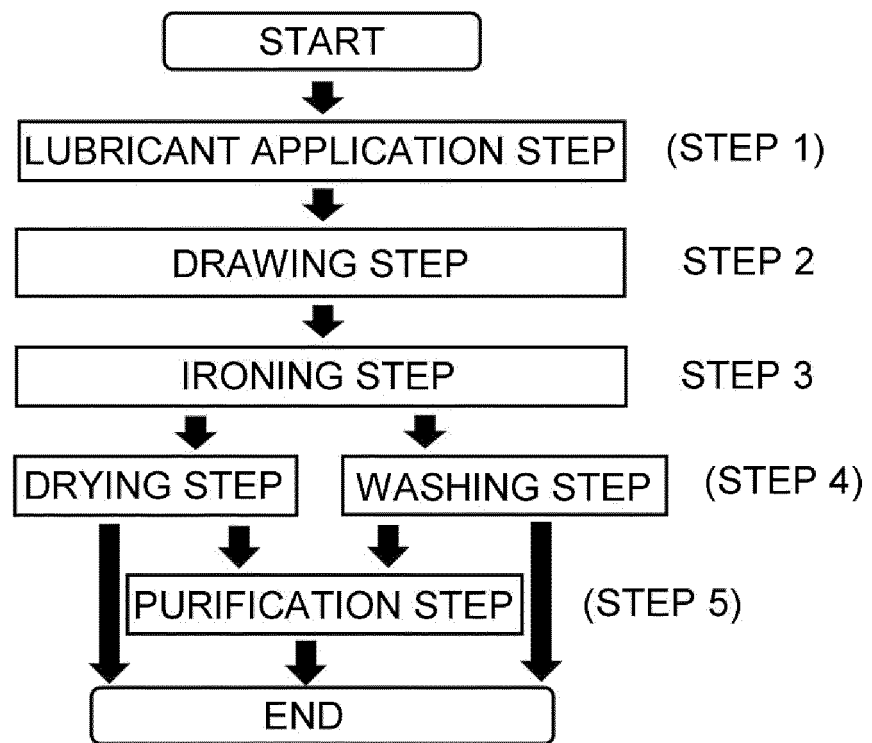


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/009418

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. B21D22/28 (2006.01) i, B21D22/30 (2006.01) i, B21D51/26 (2006.01) i
 FI: B21D22/28 H, B21D22/28 B, B21D22/28 L, B21D22/30 B, B21D51/26 X

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)

Int. Cl. B21D22/28, B21D22/30, B21D51/26

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

Published examined utility model applications of Japan 1922-1996
 Published unexamined utility model applications of Japan 1971-2021
 Registered utility model specifications of Japan 1996-2021
 Published registered utility model applications of Japan 1994-2021

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.
X	JP 10-137861 A (SKY ALUMINIUM KK) 26 May 1998,	1-5
Y	paragraphs [0001], [0019]-[0021], [0034]-[0036], [0039]-[0042]	6-14
Y	JP 9-285826 A (SKY ALUMINIUM KK) 04 November 1997, paragraphs [0040]-[0043], [0050]	6-8
Y	JP 60-28497 A (TOYO SEIKAN KAISHA, LTD.) 13 February 1985, p. 3, lower right column, line 10 to p. 4, upper left column, line 9	8, 14
Y	JP 2013-163187 A (MITSUBISHI MATERIALS CORP.) 22 August 2013, paragraph [0018], fig. 1	9-14



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
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/009418

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 9-287044 A (TOYO KOHAN CO., LTD.) 04 November 1997, paragraph [0021]	1-14

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2021/009418

Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
JP 10-137861 A	26.05.1998	(Family: none)	
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JP 60-28497 A	13.02.1985	US 4581152 A column 4, line 47 to line 68 EP 133030 A2 US 2013/0205862 A1 paragraph [0030], fig. 1 CN 103639288 A	
JP 2013-163187 A	22.08.2013		
JP 9-287044 A	04.11.1997	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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- JP H10137861 A [0005]
- JP H11277160 A [0005]
- JP 2013163187 A [0005]
- WO 2017033791 A1 [0005]
- JP 2018204896 A [0035]
- JP 2018204823 A [0035]