BOTTLE-SHAPED CAN MANUFACTURING METHOD AND BOTTLE-SHAPED CAN

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ABSTRACT
A method for manufacturing a bottle-shaped can for holding content having strong metal corrosive properties such as sparkling wine. The method includes shaping a cap into a diametrically reduced bottomed cylindrical can body, forming a shoulder portion and a container mouth on the can body, forming a curled portion, a thread and an annular bead on the container mouth, seaming a can lid to the can trunk, and amorphizing a thermoplastic resin layer covering an inner surface of the container mouth on which the curled portion, the thread and the annular bead are formed.
Fig. 4

(a)  (b)

(c)  (d) Annular Bead is Deformed
BOTTLE-SHAPED CAN MANUFACTURING METHOD AND BOTTLE-SHAPED CAN

TECHNICAL FIELD

[0001] The present invention relates to a method for manufacturing a bottle-shaped can comprised of a can tank, a shoulder portion and a container mouth formed integrally from a metal sheet. More particularly, the present invention relates to a manufacturing method of bottle-shaped can suitable to hold a corrosive content such as sparkling wine, and the bottle-shaped can manufactured thereby.

BACKGROUND ART

[0002] In recent years, a variety of contents have been filled in the bottle-shaped can in a hermetic manner. For example, the bottle-shaped can is filled with beverage such as mineral water, sports drink, Japanese tea, black tea, Chinese tea, coffee, carbonated drink, fruit or vegetable juice, and sold in the market. The bottle-shaped can is also filled with light alcohol such as beer, sour, cocktail, and sold in the market.

[0003] Generally, corrosive substance such as sulfurous acid is added to fermented fruit liquor such as wine for the purpose of avoiding oxidation. Such antioxidant may damage an inner protective coating of the bottle-shaped can by sulfurous acid. Therefore, if the bottle-shaped can filled with wine or the like, corrosion resistance of the bottle-shaped can would be degraded thereby causing a corrosion of a metal surface of the can. In the worst case, a leakage of the content may be caused due to pitting corrosion. Thus, it is difficult to hold the content such as wine in the bottle-shaped can unless decreasing the concentration of sulfurous acid.

[0004] In order to solve the foregoing problem, Japanese Patent Laid-Open No. 2006-264734 discloses a technique to enhance the corrosion resistance of a bottle can made of aluminum. According to the teachings of Japanese Patent Laid-Open No. 2006-264734, an inner surface of an aluminum sheet is covered with a coating having good workability prior to forming a can, and a necking, a flanging or a threading (including a curling) are executed. Then, the inner surface is subjected to a second coating. However, organic solvent may affect human body during or after coating, and may pollute the environment. In addition, since the coating has to be carried out before and after the threading, manufacturing cost of the bottle can will be raised. Therefore, it is preferable to omit the inner coating of the can body.

[0005] Japanese Patent Laid-Open No. 2006-62688 discloses a metal container for holding wine that is prevented from being corroded by sulfurous acid. According to the teachings of Japanese Patent Laid-Open No. 2006-62688, a can body is formed by drawing and ironing a metal sheet, and at least a surface of the metal sheet to be an inner face of the container is coated with a resin layer. In addition, an intermediate layer of acidification agent such as calcium carbonate reacting to sulfurous acid is formed in the resin film covering the inner surface of the can.

[0006] According to the teachings of Japanese Patent Laid-Open No. 2006-62688, therefore, calcium carbonate reacts to sulfurous acid so that the can body is prevented from being corroded by sulfurous acid and flavor of wine held therein is prevented from being deteriorated. That is, the corrosion of the can and the deterioration in flavor of the wine can be prevented without reducing a concentration of sulfurous acid contained in the antioxidant. In addition, since the inner face of the can body is covered with the resin film, the organic solvent will not affect human body and will not pollute the environment. Therefore, the containers taught by Japanese Patent Laid-Open No. 2006-62688 are sold in the market.

DISCLOSURE OF THE INVENTION

Technical Problem to be Solved

[0007] The bottle-shaped can is filled with the content, and an aluminum closure is applied to a container mouth of the bottle-shaped can by a roll-on capping method disclosed e.g., in Japanese Patent Laid-Open No. 2001-270596. Specifically, the closure is applied to the container mouth of the can, and the closure is pressed so that the resin liner is pushed tightly onto an opening end of the container mouth. Thereafter, a thread is rolled on a cylindrical skirt of the closure by pressing a thread roller against the cylindrical skirt, and a lower end of the cylindrical skirt is tightened by pressing a tightening roller (or a lower end tightening roller) against the lower end of the cylindrical skirt.

[0008] Given that the bottle-shaped can thus closed by the closure by the roll-on capping method is filled with wine having strong metal corrosive properties such as champagne or sparkling wine, the container mouth may be corroded by wine, and such problem has not yet been solved.

[0009] Specifically, the bottle-shaped can is closed by a piffler proof closure, and a piffler proof band is detached from a lower end of the closure when the closure is unscrewed and remains around the container mouth. To this end, the lower end portion of the closure is pressed by a plurality of thread rollers to be contacted onto an annular bead formed on the container mouth. As a result, the annular bead may be deformed and a coating layer covering an inner surface of the annular bead may be damaged at the micro level. Therefore, the metal can body is corroded by carbon dioxide and sulfurous acid at such defective site at the micro level.

[0010] Thus, if the bottle-shaped can made of metal is filled with wine having strong metal corrosive properties such as champagne or sparkling wine, the bottle-shaped can may be corroded by carbon dioxide contained in sparkling wine. Consequently, flavor of wine held in the corroded can may be deteriorated. Therefore, the bottle-shaped can has to be improved to hold such wine having strong metal corrosive properties.

[0011] The present invention has been conceived noting the foregoing technical problems, and it is an object of the present invention to provide a manufacturing method of a bottle-shaped can having excellent corrosion resistance and preserving properties to hold sparkling wine having strong metal corrosive properties, and a bottle-shaped can manufactured by the method of the present invention.

Solution to Problem

[0012] In order to solve the above-explained problems, that is, in order to prevent corrosion of the metal sheet by carbon dioxide contained in sparkling wine held in the bottle-shaped can, various kinds of experimentations have been conducted. The experimentations showed that the above-explained problems can be solved by heating and cooling a container mouth before filling the bottle-shaped can with the content, so as to amorphize an inner coating to recover elasticity and ductility thereof. This discovery is utilized in the present invention to solve the above-explained problems. According to one aspect
to the present invention, there is provided a bottle-shaped can manufacturing method comprised of: a cup shaping step of forming a cup by punching out from a metal sheet in which a thermoplastic resin coating layer is formed on at least a surface to be an inner face of the can and a lubricant is applied thereto; a can trunk shaping step of shaping the cap into a diametrically reduced bottomed cylindrical can body; a container mouth shaping step of forming a shoulder portion and a container mouth by diametrically reducing one of the end portions of the bottomed cylindrical can body; and a curling/straightening/heading step of forming a curled portion on a leading end of the container mouth, and forming a thread and an annular bead on the container mouth. In order to solve the above-mentioned problem, the manufacturing method of the present invention is characterized by an amorphization step of amorphizing at least the thermoplastic resin coating layer covering an inner surface of the can body in which the curled portion, the thread and the annular bead are formed on the container mouth situated above the shoulder portion, by heating the thermoplastic resin coating layer covering the inner surface of the can body to a melting point thereof, and immediately cooling the heated thermoplastic resin coating layer.

The container mouth shaping step includes a top dome shape forming a cup and the container mouth by diametrically reducing a bottom side of the bottomed cylindrical can body, and the amorphization step includes a step of amorphizing at least the thermoplastic resin coating layer covering the inner surface of the can body in which the container mouth is opened and a bottom lid is sealed to a lower end of the can trunk on the side opposite to the container mouth.

The amorphization step further includes: an induction heating step of heating the can body through an induction heating apparatus while rotating the can body around an axis of the can; and a cooling step of immediately cooling the heated container mouth by immersing the container mouth into a cooling water held in a cooling tank.

The cooling step includes a step of cooling the container mouth by immersing the container mouth into the cooling water held in the cooling tank while orienting the container mouth downwardly; and the amorphization step includes a blowing step of blowing off the water adhering to the container mouth oriented downwardly.

The amorphization step further includes a cooling step of cooling container mouth of the can body conveyed in a manner to orient the container mouth downwardly, by immersing the container mouth into the cooling water held in the cooling tank while inclining a center axis of the container mouth with respect to the water surface, and thereafter pulling the container mouth out of the cooling tank while inclining the container mouth inversely to that of the case of immersing the container mouth into the cooling water.

The amorphization step further includes a cooling step of cooling container mouth while circulating the cooling water in the tank at a substantially same speed as a conveying speed of the can body and in the same direction as a conveying direction of the can body.

According to another aspect of the present invention, there is provided a bottle-shaped can, that is formed from a metal sheet in which a thermoplastic resin coating layer is formed on at least a surface to be an inner face of the can. In the bottle-shaped can of the present invention, a crystallinity (Cn) of the thermoplastic resin coating film covering an inner surface of a container mouth of the finished can satisfies a following inequality (1):

\[ Cn < 1 \]  

(1)

where Cn is an infrared absorption intensity measured by IR spectroscopy method (reflection infrared spectroscopy method), which can be expressed by the following expression:

\[ Cn = \frac{(a \text{ peak height at 1340 cm}^{-1})}{(a \text{ peak height at } 1578 \text{ cm}^{-1})}. \]

(2)

In the bottle-shaped can of the present invention, a relation between the crystallinity (Cn) of the thermoplastic resin coating film at the inner surface of the container mouth of the finished can, and a crystallinity (Cw) of the thermoplastic resin coating film at an inner surface of the can trunk satisfy a following inequality (2):

\[ Cn/Cw < 1 \]

(2)

where Cw is an infrared absorption intensity measured by the IR spectroscopy method (reflection infrared spectroscopy method), which can be expressed by the following expression:

\[ Cw = \frac{(a \text{ peak height at 1340 cm}^{-1})}{(a \text{ peak height at } 1578 \text{ cm}^{-1})}. \]

(2)

In addition, in the bottle-shaped can of the present invention, the thermoplastic resin coating layer covering an inner surface of the container mouth is subjected to an amorphization treatment to amorphize the thermoplastic resin after forming the container mouth, by heating the thermoplastic resin coating layer to a melting point thereof, and immediately cooling the heated thermoplastic resin.

Advantageous Effects of Invention

Thus, according to the manufacturing method and the bottle-shaped can of the present invention, at least the thermoplastic resin layer covering the inner surface of the container mouth is brought into non-orientation state by heating the container mouth locally and cooling the heated container mouth immediately before filling the bottle-shaped can with the content. Therefore, the thermoplastic resin layer is brought into non-orientation amorphous state thereby recovering defective sites of the layer at the micro level caused during forming the container mouth can be recovered. In addition, elasticity and ductility of the thermoplastic resin layer can be improved. Consequently, impact resistance of the thermoplastic resin layer covering the inner surface of the can body can be enhanced at the portion contacted with a tightening roller during capping (e.g., an annular beads). For this reason, damages of the thermoplastic resin layer covering the inner surface of the annular beads can be minimized so that corrosion resistance of the bottle-shaped can against sparkling wine is improved. Thus, the bottle-shaped can according to the present invention is allowed to be filled with various kinds of contents including sparkling wine having strong metal corrosive properties.

As described, only the container mouth situated above the shoulder portion is heated at the amorphization step after forming the curled portion, the thread and the annular bead on the container mouth. Therefore, at least the thermoplastic resin layer covering the inner surface of the container mouth can be amorphized while maintaining a buckling strength of the can body against a capping pressure. That is, a filling step and a seaming step are allowed to be carried out...
without modifying an existing capping apparatus significantly. Thus, the present invention is economically viable. [0023] In addition, since the amorphization step is carried out after seaming a bottom lid to the can body, a sealing rubber of the bottom lid will not be heated to generate an offensive odor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] FIG. 1 is a side view showing one example of the bottle-shaped can to which the present invention is applied.
[0025] FIG. 2 is a process diagram for explaining a manufacture process for manufacturing the bottle-shaped can according to the present invention.
[0026] FIG. 3 is a sectional close-up view of the container mouth of the bottle-shaped can shown in FIG. 1.
[0027] FIG. 4 is a view schematically showing a deformation of the annular bead during the capping of the manufacturing method according to the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0028] Referring now to the drawings, a preferred example of the present invention will be explained hereinafter.
[0029] [As to a can Body of the Bottle-Shaped Can]
[0030] One example of the bottle-shaped can formed by the manufacturing method of the preferred example is shown in FIG. 1. The bottle-shaped can 1 is comprised of a diametrically large cylindrical can trunk 2, a dome-shaped shoulder portion 3 having an arcuate cross-section situated above the can trunk 2, a diametrically small container mouth 4 formed integrally with the shoulder portion 3, and a bottom lid 5 sealed to a lowest end of the can trunk 2 to close an opening. In addition, a desired printing design (e.g., patterns and/or letters) is applied to a major part of an outer surface of the can trunk 2 including the shoulder portion 3 shadowed in FIG. 1.
[0031] FIG. 2 schematically shows a process for manufacturing the bottle-shaped can 1 shown in FIG. 1 having the bottom lid. According to the method of the preferred example, the bottle-shaped can 1 is formed from a metal sheet prepared by forming a thermoplastic resin coating layer in an amorphous state on both side, and applying lubricant to the coating layers (i.e., a laminated sheet). First of all, a disc-shaped blank is punched out from the laminated metal sheet material at a cup shaping step. Then, the disc-shaped blank is shaped into a cup by a drawing treatment. At a subsequent can trunk shaping step, at least one or more times of re-drawing and an ironing are applied to the cup thereby forming a diametrically reduced bottomed cylindrical can body having a thinned can trunk.
[0032] Then, an open end of the can is trimmed to a predetermined length at a trimming step. The cup thus trimmed is transferred to a printing/coating step, as the customary way of manufacturing a two-piece can. At the printing/coating step, a desired printed decoration (e.g., patterns and/or letters) is printed on the cylindrical can trunk 2. Then, the printed face is coated with a top coating layer, and the printed ink layer and the top coating layer are cured or dried sufficiently at a drying step.
[0033] The can trunk 2 of the bottomed cylindrical can is thus printed (and top coating is applied) is further transmitted to a container mouth shaping step or a top dome shaping step. At the top dome shaping step, the bottom side corner portion (i.e., the bottom portion and the can trunk 2 near the bottom) of the bottomed cylindrical can including the printed portion of the can trunk 2 is preliminarily shaped into a curved shoulder face whose longitudinal section is arcuate, and then, of the drawing is applied to the bottom side of the can plural times to complete the shoulder portion 3 and to form the unopened container mouth 4.
[0034] The can thus prepared is heated by a known heating means such as a furnace and a heating oven so that at least the thermoplastic resin coating layer covering the inner surface of the can is adhered to the metal can surface. At subsequent threading, curling, and bead forming steps, first of all, the leading end of the unopened container mouth 4 is cut out to be opened. Then, as illustrated in the partial sectional view of FIG. 3, an open end portion 11 is curled outwardly to form an annular curled portion 12, and a thread 13 on which the closure is screwed is formed around cylindrical container mouth 4. Further, annular beads 14 and 15 are formed below the thread 13.
[0035] Specifically, a concave bead 15 is formed by depressing the container mouth 4 radially inwardly below the thread 13, and as a result, a convex bead 14 is formed above the concave bead 15. An after-mentioned pilfer-proof band of the closure is pushed tightly onto an inclined face 14a between the beads 14 and 15.
[0036] At a subsequent necking/flanging step, a necking-in and a flanging are sequentially applied to an lower open end portion of the can trunk 2 on the opposite side of the container mouth 4. Then, at a can lid seaming step, a separate bottom lid made of metal is seamed to the flange portion formed on the lower opening portion of the can trunk 2 by a double-seaming method using a (not shown) seamer (i.e., a can lid seaming machine).
[0037] However, a molding strain of the thermoplastic resin coating layer may be caused in the container mouth 4 of the can body as a result of subjecting the can body to the foregoing threading, curling, and bead forming steps. Therefore, if a bottle-shaped can 1 is subjected to a roll-on process to push a skirt portion of the closure mounted on the container mouth 4, a coating layer covering an inner surface of the container mouth 4 may be damaged. As shown in FIG. 4, a tightening roller of a capping apparatus is brought into contact with the concave bead 15 through a closure applied to the container mouth 4 while rolling around the container mouth 4 plurality of times to push a lower end of the closure onto the inclined face 14a. Consequently, the concave bead 15 is deformed inwardly and a thickness thereof is thinned. Specifically, such capping is executed by a plurality of rollers (basically 2 to 3 rollers). Therefore, given that a thickness of the resin coated metal sheet is thinner than 0.3 mm, the concave bead 15 may be thinned while being deformed into an oval or elliptical shape. As a result, the concave bead 15 may remain deformed and a diameter of the container mouth 4 may be reduced approximately 0.1 to 0.4 mm from the original diameter. Therefore, the thermoplastic resin coating layer (or an adhesive layer) covering the inner surface of the concave bead 15 may be thinned and weakened locally by a compression stress and a tensile strength thereby developing defects at the micro level. Such defective sites at the micro level can be found only after storing the bottle-shaped can filled with the contents and closed by the closure for a certain period of time. The bottle-shaped can 1 thus having the defects at the micro level on the thermoplastic resin coating layer will not especially be corroded even if it is filled with the contents such as soft drink including mineral water, sports...
drink, tea, coffee, carbonated drink and fruit or vegetable juice etc., and alcoholic beverages including beer, cocktail etc. However, given that the bottle-shaped can 1 thus having the defects at the micro level on the thermoplastic resin coating layer is filled with wine having strong metal corrosive properties such as champagne or sparkling wine etc., the bottle-shaped can 1 will be corroded at the defective portions of the thermoplastic resin coating layer, and flavor of the content may deteriorated by such corrosion.

[0038] An amount of sulfuric acid to be added to wine during fermentation is defined by Japanese food sanitation act in manner such that sulfuric acid will not remain more than 350 mg per 1 kg (i.e., 350 ppm) of wine. However, sulfuric acid has strong metal corrosive properties to corrode the metal can. Therefore in order to prevent the metal can in storage from being corroded, and to prevent flavor of the content from being deteriorated by hydrogen sulfide resulting from a reaction between sulfuric acid and the metal body, calcium carbonate has been added to a protection layer covering the inner surface of the can for the purpose of trapping sulfuric acid.

[0039] Even if the protection layer has such defects at the micro level, sulfuric acid gas is captured by calcium carbonate contained in the protection layer (i.e., the thermoplastic resin layer or an adhesive layer). Therefore, the metal sheet forming the bottle-shaped can will not be corroded by still wine that does not contain carbonic acid. However, if the bottle-shaped can is filled with sparkling wine having strong metal corrosive properties, carbon dioxide is produced in addition to sulfuric acid gas. The carbon dioxide thus produced penetrates into the protection layer from the defects at the micro level and reacts to calcium carbonate in the protection layer. As a result, trapping efficiency of carbon dioxide to capture sulfuric acid gas will be degraded or deteriorated. Therefore, the metal sheet forming the bottle-shaped can will be corroded by both sulfuric acid gas and carbon dioxide, and flavor of sparkling wine will be deteriorated by hydrogen sulfide resulting from a reaction between sulfuric acid gas and the metal material of the bottle-shaped can. Thus, the bottle-shaped can has not yet been used to hold sparkling wine.

[0040] In order to solve above-explained disadvantage, according to the preferred example, the bottle-shaped can 1 for holding sparkling wine having strong metal corrosive properties is manufactured without using capturing agent such as calcium carbonate more than necessary. To this end, the thermoplastic resin coating layer covering the inner surface of the bottle-shaped can 1 is heated and cooled rapidly at an inner surface of the annular beads 14 and 15 at an amorphization step to reduce crystallinity degree of the thermoplastic resin coating layer on the inner surface of the annular beads 14 and 15 to be lower than that on the inner surface of the can trunk 2. Therefore, the plastic deformation of the annular bead, and deterioration in soundness of the inner coating layer of the annular beads 14 and 15 resulting from the curling, threading and bead forming steps, are recovered before the bottle-shaped can 1 shown in FIG. 1 is finished.

[0041] Metal sheet material for the bottle-shaped can 1 is not limited to specific material. For example, a black plate, a phosphate treated steel sheet, an electrolytic chromate treated steel sheet, an aluminum sheet, a chromate treated aluminum sheet, an aluminum alloy sheet and so on are suitable for forming the bottle-shaped can 1. Above all, the aluminum alloy sheet of 3004 series having a thickness of 0.2 mm to 0.32 mm is especially suitable. If the thickness of the metal sheet is thinner than 0.2 mm, buckling strength against capping pressure cannot be ensured. By contrast, if the thickness of the metal sheet is thicker than 0.32 mm, the buckling strength can be ensured sufficiently but it is too expensive.

[0042] In the preferred example, the thermoplastic resin film made of polyester resin, polypropylene resin or the like can be used to form the coating layer for covering the inner surface of the can body. The polyester resin includes: a homopolymer such as polyethylene terephthalate, polybutylene terephthalate, polyethylene terephthalate etc.; a copolymer prepared by mixing polyethylene terephthalate with polyethylene isophthalate; and a blending resin consisting of copolymers or consisting of the homopolymer and the copolymer. In addition, the thermoplastic resin film may be formed not only into a single layer but also into a multiple layer.

[0043] A thickness of the resin film is preferably within a range of 10 to 50 µm. Specifically, the thickness of the resin film formed on the face of the metal sheet to be the inner face of the can body is determined to prevent a corrosion of the can body after subjecting the bottle-shaped can 1 to the roll-on capping. That is, if the thickness of the resin film is thinner than 10 µm, it would be difficult to ensure the corrosion resistance against the content having strong metal corrosive properties after subjecting the bottle-shaped can 1 to the roll-on capping. By contrast, if the thickness of the resin film is thicker than 50 µm, the corrosion resistance can be ensured sufficiently but it is too expensive. Therefore, the thickness of the resin film is limited within the range of 10 to 50 µm, preferably within the range of 12 to 40 µm to ensure quality of the film while justifying cost economy.

[0044] Optionally, additives such as antioxidant, thermoplasticizer, plasticizer, lubricant may be added to the resin layer. In addition, according to the preferred example, the capturing agent such as calcium carbonate is added to the resin film to react to sulfuric acid contained in wine, except for a region to be contacted with a jig. Therefore, sulfuric acid contained in wine will not penetrate through the coating layer to cause a corrosion of the metal sheet forming the bottle-shaped can 1. In addition, flavor of wine will not be deteriorated by hydrogen sulfide resulting from a reaction between sulfuric acid and the metal sheet. Here, an additive amount of calcium carbonate may be determined in accordance with an amount of sulfuric acid contained in wine.

[0045] The thermoplastic resin film may be bonded directly to the metal sheet by a thermal bonding method. Otherwise, the thermoplastic resin film may be bonded directly to the metal sheet by extruding a melted thermoplastic resin in a T-die onto the preheated metal sheet. Alternatively, a preformed thermoplastic resin film may also be bonded to the metal sheet by a thermal bonding method through an adhesive primer layer, a curable adhesive layer, or a thermally adhesive thermoplastic resin layer.

[0046] A closure (not shown) applied to the bottle-shaped can 1 is a bottomed-cylindrical metal member comprised of a ceiling and a skirt portion. Specifically, the bottle-shaped can 1 is filled with the content from the container mouth 4, and the closure is applied to the container mouth 4. Then, a roll-on capping is carried out using the conventional capping apparatus while pressing the ceiling. In this situation, the skirt portion of the closure is threaded by a threading roller and a lower end (i.e., an opening end) of the skirt portion is tightened by a tightening roller.
[0047] Material of the closure is not limited to specific material, but A1100 alloy or A3105 alloy defined by JIS are especially suitable. In addition, an inner face of the closure is coated with an epoxy-phenol resin or the like.

[0048] Further, a resin sealing liner is affixed to the inner face of the ceiling. The closure is reassemblable even after unscrewing, and a pielfer-proof band is attached to the lower end of the skirt portion through bridges. Therefore, the pielfer-proof band remains around the container mouth after the closure is unscrewed to proof a fact that the closure has been opened. That is, the pielfer-proof closure has a tamper-proof function.

[0049] As described, the closure is applied to the container mouth 4 from above after filling the bottle-shaped can 1 with the content, and a capping pressure is applied to the ceiling of the closure. Then, a female thread is rolled on the skirt portion of the closure along with the male thread 13 of the container mouth 4 by the threading roller while pressing the ceiling. In this situation, as shown in FIG. 4, a lower end 23 of the skirt portion 22 is pushed onto the inclined face 14a of the convex beam 14 by the tightening roller 21. As a result of thus threading and tightening the closure applied to the container mouth 4 by the roll-on method, the annular beads 14 and 15, especially the inclined face 14a may be deformed to have an oval or elliptical cross-sectional shape or the like by a lateral load applied by the tightening roller 21. As also described, the thermoplastic resin film covering the inner surface of the container mouth 4 is amorphized at the annular beads 14 and 15. Such amorphization is closely related to a capping pressure, an impact of the roller, and the lateral load. Such relation will be explained in more detail.

[0050] The amorphization is also carried out before the foregoing curling/threading/heading step, by heating the bottle-shaped can 1 entirely. However, at the amorphization step of the preferred example, the container mouth 4 is heated locally (e.g., by high-frequency induction heating method) to amorphize the thermoplastic resin coating layer covering the inner surface of the annular beads 14 and 15. Consequently, the thermoplastic resin coating layer is thus amorphized is allowed to flexibly cover the inner surface of the annular beads 14 and 15 even if the annular beads 14 and 15 are deformed into an oval or elliptical shape or even if the container mouth 14 is diametrically shrunk by the impact or lateral load of the tightening roller 21 at the roll-on capping. For example, at the amorphization step, a high-frequency induction heating device may be used to heat the container mouth 4 locally. Alternatively, other conventional heating means such as an electric furnace, a gas oven, an infrared heating device etc. may also be used.

[0051] In order to prevent corrosion of the metal sheet by carbon dioxide and sulfuric acid, various kinds of experiments have been conducted. As a result of the experiments, it was found that the corrosion of the metal sheet can be prevented effectively by amorphizing the thermoplastic resin inner coating layer by locally heating and cooling the container mouth 4. However, in order to curb the influence of a softening of the metal material and a thermal history of the thermoplastic resin inner coating layer, it is preferable to cover the shoulder portion 3 by a shield or the like to reduce an impact of heat.

[0052] According to the preferred example, therefore, the roll-on capping can be applied to the container mouth without damaging the thermoplastic resin inner coating layer. For this reason, the inner surface of the bottle-shaped can 1 can be prevented from being corroded by a gaseous layer in a head space of the bottle-shaped can 1, that is, by carbon dioxide and sulfuric acid contained in sparkling wine having a high acid level (i.e., low pH level) and strong metal corrosive properties.

[0053] The amorphization step will be explained in more detail. At the amorphization step, first of all, the annular beads 14 and 15 are heated by the high-frequency induction heating method until a temperature of the thermoplastic resin coating layer covering the inner surface of the annular beads 14, 15 is raised to a melting point thereof or higher. Consequently, the thermoplastic resin coating layer is melted at least on the inner surface of the annular beads 14, 15. After the thermoplastic resin is brought into non-orientation state, the bottle-shaped can 1 is turned upside down to orient the container mouth 4 downwardly to dip the container mouth 4 in the water held in a cooling tank. To this end, pure water at a temperature lower than a crystallization temperature of the thermoplastic resin is held in the cooling tank. As a result, the container mouth 4 is cooled rapidly and the thermoplastic resin coating layer is amorphized and melted at least on the inner surface of the annular beads 14, 15. Then, water adhering to the container mouth 4 is blown off by air. In this preferred example, a degree of amorphization of the thermoplastic resin film covering the inner surface of the bottle-shaped can 1 is measured by measuring a crystallinity of the thermoplastic resin film by an IR spectroscopy method (reflection infrared spectroscopy method).

[0054] Specifically, in order to measure a crystallinity of the thermoplastic resin coating film, the container mouth 4 is immersed in a hydrochloric solution of about 8 percent concentration to isolate the thermoplastic resin inner film from the inner surface of the container mouth 4. Then, absorption peak of polyethylene terephthalate is individually obtained at 1340 cm⁻¹ and at 1578 cm⁻¹ by measuring the crystallinity of an inner surface of the thermoplastic resin film contacted with the content by an ATR method (i.e., an attenuated total reflection method).

[0055] According to the preferred example, the thermoplastic resin coating film covering the inner surface of the annular beads 14, 15 is amorphized to reduce the crystallinity (Cn) thereof to be lower than 1, as expressed by the following inequality:

\[ C_n < 1 \]  \hspace{1cm} (1)

In the above inequality (1), the crystallinity Cn is an infrared absorption intensity measured by IR spectroscopy method, which can be expressed by the following expression:

\[ C_n \approx \frac{\text{a peak height at 1340 cm}^{-1}}{\text{a peak height at 1578 cm}^{-1}}. \]

[0056] In addition, the corrosion resistance of the thermoplastic resin coating film covering the inner surface of the container mouth 4 after capping can be further enhanced while maintaining the buckling strength against the capping pressure, by amorphizing the thermoplastic resin coating film in such a manner that the crystallinity (Cn) of the thermoplastic resin coating film at the inner surface of the container mouth 4 is reduced to be lower than a crystallinity (Cw) of the thermoplastic resin coating film at the inner surface of the can trunk 2, as expressed by the following inequality:

\[ C_n/C_w < 1 \]  \hspace{1cm} (2)
In the above inequality (2), the crystallinity $C_w$ is an infrared absorption intensity measured by IR spectroscopy method, which can be expressed by the following expression:

$$C_w = (\text{a peak height at 1340 cm}^{-1}/\text{a peak height at 1578 cm}^{-1}).$$

[0057] In order to interfere with the development of microorganisms that compromise the safety of the content, the temperature of the pure cooling water held in the cooling tank is maintained within the range from 50 to 70°C, while circulating the cooling water. Most of the microorganisms causing food intoxication are propagative within a temperature range of 10 to 37°C, therefore, in the preferred example, a temperature of the cooling water in the tank is kept to be lower than 50°C. By contrast, there are also microorganisms inhabitable at a temperature higher than 85°C, and an inhabitation of such microorganisms can be prevented by keeping the temperature of the cooling water lower than 70°C.

[0058] At the amorphization step, the cooling water is allowed to be introduced easily into the container mouth 4 by lowering the container mouth 4 into the cooling water while inclining. In this case, the container mouth 4 is pulled out of the water tank while being inclined inversely so that the cooling water can be introduced and discharged to/from the container mouth 4 without resistance of air.

[0059] In order to introduce the cooling water further smoothly into the container mouth 4, the cooling water is circulated in the tank at a (substantially) same speed as the conveying speed of the bottle-shaped can 1 in the same direction as the conveying direction of the bottle-shaped can 1. In addition, the resistance of the cooling water can be reduced so that the container mouth 4 is pulled out of the tank while discharging the cooling water without ruffling the cooling water in the tank. Therefore, the bottle-shaped can 1 is allowed to be conveyed stably in the cooling water held in the tank even if a weight of the bottle-shaped can 1 is light.

[0060] According to the preferred example, the necking and flanging of the lower end of the can trunk 2 is carried out after the curling/threading/beading steps, and then the bottom lid is sealed with the lower end of the can trunk 2. Therefore, the bottle-shaped can 1 is allowed to be held tightly from both sides without causing a deformation of the thinned can trunk 2 so that the bottle-shaped can 1 is rotated around its axis in a stable manner to heat the annular beads 14 and 15 homogeneously by the high-frequency induction heating device.

[0061] As described, the container mouth 4 is inclined when lowered into the cooling water so that the cooling water is introduced smoothly into the container mouth 4 while removing air from the bottle-shaped can 1. Therefore, the container mouth 4 can be cooled rapidly. Likewise, the container mouth 4 is inclined inversely when pulled out of the water tank so that the cooling water is discharged smoothly from the container mouth 4 without causing a pulsation of the cooling water. Therefore, the cooling water can be removed easily from the container mouth 4.

[0062] As also described, the cooling water is circulated in the tank at a substantially same speed and in the same direction as those of the bottle-shaped can 1 being conveyed while being turned upside down. Therefore, the cooling water is allowed to be introduced smoothly into the container mouth 4 and the container mouth 4 is allowed to be pulled out of the tank while discharging the cooling water without ruffling the cooling water in the tank. Therefore, the bottle-shaped can 1 can be conveyed stably in the cooling water held in the tank even if a weight of the bottle-shaped can 1 is light.

[0063] Resin Coated Metal Sheet

[0064] In this experimentation, an aluminum alloy sheet of A3004H19 series having a thickness of 0.285 mm and AB pore stress of 270 N/mm² was used as the metal sheet. Each surface of the metal sheet was covered individually with a film made of mixed resin (PBT:PET=60:40) of polybutylene terephthalate (PBT) and polyethylene terephthalate (PET) having a thickness of 20 μm. Here, the resin film was formed on the face of the metal sheet to be the inner face of the can through an adhesive agent such as epoxy resin containing calcium carbonate.

[0065] Manufacture of the Bottle-Shaped can

[0066] At the cup shaping step, the disc-shaped blank was punched out from the above-explained metal sheet covered with the polyester resin coating, and then shaped into the cup having a height of 42 mm and a diameter of 95 mm by the drawing treatment. The side wall of the cup thus prepared was subjected to the drawing and ironing (total ironing rate: approx. 40%). The open end of the can was trimmed to realize a constant height, and the closure member was further shaped into a bottomed cylindrical member having a trunk diameter 59 mm and a height of 142 mm. Then, a bottom side of the bottomed cylindrical member was subjected to the top doming, and an intermediate body of the bottle-shaped can 1 having a height 174 mm was finished (the upper end had not yet opened).

[0067] The lubricant was removed from the intermediate body, and the intermediate body was subjected to the amorphizing treatment of the resin film. Then, a closed face of the container mouth 4 was cut off to open the container mouth 4, and the open end portion 11 of the container mouth 4 was curled outwardly to form the curled portion 12. After that, the male thread 13 to be engaged with the female thread of the closure was rolled on container mouth 4 below the curled portion 12, and the annular beads 14 and 15 were formed below the thread 13.

[0068] In the container mouth 4 (having outer diameter of 28 mm), thus formed, an outer diameter of the convex bead 14 was 28 mm, an outer diameter of the concave bead 15 was 25.9 mm, and an inclination of the inclined face 14a was formed between the beads 14 and 15 was 45°.

[0069] Specifically, number of ridges of the male thread 13 formed around the container mouth 4 was 8 ridges/inch.

[0070] Consequently, a can body in which the curled portion 12, the thread 13, and the annular beads 14 and 15 are formed on the container mouth 4 was prepared. Then, the necking was applied to the lower open end portion of the can trunk 2 on the opposite side of the container mouth 4, and the separate bottom lid 5 made of metal sheet covered by the thermoplastics resin films on both sides was seamed to the flange portion of the lower opening of the can trunk 2 by a double-seaming method.

[0071] The can body was then passed through a high-frequency induction heating apparatus within a short period while being rotated multiple times. Consequently, a temperature of the can body was raised to a range between 265°C and 300°C.

[0072] In the high-frequency induction heating apparatus, induction heating coils were arranged above a conveyor on both sides of the container mouth 4 of the can body at the same level to locally heat the container mouth 4. To this end, a heat-resistant grip belt conveyor was used to convey the can body. The belt conveyor was adapted to rotate the can body
more than four times during passing the can body through the heating apparatus. Therefore, the container mouth 4 was allowed to be heated to 265°C to 300°C locally and homogeneously within several seconds even if conveying the can body at a speed higher than 30 m/min. In addition, a radiation thermometer was arranged at an outlet of the high-frequency induction heating apparatus to measure the temperature of the can body coming out of the heating region, and a high-frequency transmitter was provided to output a measurement result (those elements not shown). The system thus structured were controlled electrically so that the temperature of the can body was allowed to be raised certainly to a desired temperature even if the conveyor speed was changed. In case of conveying the can body using a turret, an arrangement of the high-frequency induction heating apparatus may be changed flexibly to conform to a configuration of a conveying passage.

[0073] In order to rapidly cool the container mouth 4 thus heated, cooling water at a temperature within a range of 60°C plus or minus 10°C was prepared in a cooling tank. The can body was then transported to the cooling tank within a short time (within 3 seconds, in this experimentation) after coming out of the outlet of the high-frequency induction heating apparatus, and the container mouth 4 whose temperature was lowered approximately to 200°C was immersed in the cooling water. As a result, the thermoplastic resin coating layer was amorphized at least on the inner surface of the annular beads 14, 15 so that the defects of the resin coating layer at the micro level caused during forming the container mouth 4 was recovered. After thus amorphizing the resin coating layer covering the inner surface of the container mouth 4, water adhering to the container mouth 4 as blown off. As a result, the bottle-shaped can 1 was finished. In the finished bottle-shaped can 1 a wall thickness of the concave bead 15 was 0.285 to 0.36 mm, a hardness of the concave bead 15 was Hv 84 to 88 (Hv 92 to 96, before being processed), a height of the bottle-shaped can 1 was 162 mm, and a content of the bottle-shaped can 1 was 300 ml. It was confirmed that the degree of the amorphization of the inner coating layer on the container mouth 4 was higher than that on the can trunk 2.

[0074] In the experimentation, a crystallinity (Cn) of the thermoplastic resin coating layer at the inner surface of the container mouth 4 was measured, and it was 0.25. In the experimentation, a mixed resin of polybutylene terephthalate (PBT) and polyethylene terephthalate (PET) was also used to cover the inner surface of the container mouth 4 instead of the polyethylene terephthalate resin layer. In this case, a crystallinity (Cn) of the amorphized resin coating layer at the inner surface of the container mouth 4 was 0.75. Thus, the crystallinitities (Cn) of both resin layers at the inner surface of the container mouth 4 were less than 1.

[0075] The bottle-shaped can 1 thus prepared was filled with corrosion promotion liquid for sparkling wine (composition; carbonated water 270 g, ethanol 30 g, citric acid 1.5 g, potassium metabisulfite 60 mg), and a closure was applied to the container mouth 4 by the roll-on capping method, with a capping pressure of 80 kgf and a threading roller torque of 3.0 Nm. The bottle-shaped can 1 thus filled with the content was stored in an upright manner for 1.3 month at room temperature of 38°C. However, no abnormality was found on the surface of container mouth 4 (including the curled portion 12, the thread 13, and the annular beads 14 and 15) even after the storage.

[0076] As a comparative example, another can container which was not subjected to the amorphizing treatment of the container mouth (a crystallinity (Cn) of the thermoplastic resin coating layer at the inner surface of the container mouth was 1 to approx. 1.5) was filled with the same content, and closed by the roll-on capping method. The can container of the comparative example was also stored and assessed by the same manner. In this case, damage of the film at the inner surface of the annular beads (i.e., defects at the micro level) was not reduced even if the lateral load of the tightening roller was reduced, and a corrosion of the metal material was confirmed. On the contrary, scarcely any corrosion of the container was found if the container was not subjected to the tightening of the closure by the tightening roller.

[0077] The present invention should not be limited to specific example thus far explained, for example, various kinds of surface treated metal sheets for forming a can such as a metal plated steel sheet and a chemical conversion coated steel sheet such as a TFS sheet may also be used instead of the aluminum alloy sheet. Thus, the metal sheet may be selected arbitrarily from the above-mentioned surface treated metal sheets and steel sheets depending on the content while taking into consideration the corrosion resistance.

[0078] In the above experimentation, the blending resin consisting of PET and PBT was used to form the thermoplastic resin film. However, the thermoplastic resin is also not limited to the blending resin. For example, copolymers such as PET, or a mixed resin consisting of the homopolymers or a mixed resin consisting of the copolymer and homopolymer may also be used.

[0079] As described, according to the preferred example, the resin film covering the inner surface of the container mouth 4 is amorphized after forming the container mouth 4 as expressed by the inequality (1). However, if the crystallinity of the thermoplastic resin coating layer at the inner surface of the container mouth 4 is lower than 1 even without amorphizing, the amorphization steps of the thermoplastic resin coating layer at the container mouth 4 may be omitted. For instance, the crystallinity of the thermoplastic resin coating layer at the inner surface of the container mouth 5 may be lowered to be smaller than 1 by adding copolymerization component to the resin composition to delay a crystallization velocity, or by blowing cooling air of low temperature compulsory to the container mouth at the heating/cooling step after forming the container mouth.

[0080] In the preferred example, the amorphization steps are carried out after the can lid seaming step. For example, the amorphization steps may also be carried out after the curling/threading/banding steps before the can lid seaming step. However, stiffness of the can trunk 2 can be enhanced by seaming the bottom lid 5 to the can trunk 2. Therefore, the can trunk 2 will not be deformed even if held by the belts of both sides while being rotated by running those belts in opposite directions when heating the container mouth 4. That is, the container mouth 4 can be heated homogeneously by the high-frequency induction heating apparatus. Thus, it is desirable to carry out the amorphization steps after the can lid seaming step to heat the container mouth 4 homogeneously and conveying the bottle-shaped can 1 at high speed.

[0081] Given that can body is has a sufficient buckling strength against the capping pressure, the container mouth 4 including the curled portion 12, the thread 13, and the annular beads 14 and 15 is allowed to be heated entirely. However, the thermoplastic resin on the container mouth 4 is damaged most seriously at the portion other than the annular beads 14 and 15 within the region contacted with leading end of the roller at
the roll-on capping. Therefore, it is desirable to amorphize the thermoplastic resin film by heating only the annular beads 14, 15 and vicinity thereof to prevent the can trunk 2 from being thinned excessively and to prevent the thermoplastic resin film from being weakened by the thermal history.

[0082] The container mouth 4 may be cooled not only by being immersed in the cooling water as described in the preferred example but also by blowing the cooling water or cooling air thereto.

[0083] In the preferred example, the present invention is applied to the bottle-shaped can in which the bottom lid is sewn to the lower end of the can trunk. However, the present invention may also be applied to a can body in which the shoulder portion and the container mouth are formed by diametrically reducing an open end side of the cylindrical can body, and in which the can trunk and the bottom lid are formed integrally (i.e., to a monoblock type can body).

[0084] Besides, a manufacturing method taught by an international publication WO01/015829 is suitable for manufacturing a bottle-shaped can having an elongated container mouth. Therefore, flexibility in the shape of the can may be improved by using the manufacturing method taught by an international publication WO01/015829, in comparison with a case of forming the monoblock type by the conventional method.

[0085] Lastly, it is also possible to attach a printed shrink to the can trunk 2 of the bottle-shaped can 1 instead of printing on the can trunk 2.

1. A bottle-shaped can manufacturing method, comprising:
a cup shaping step of forming a cup by punching out from a metal sheet in which a thermoplastic resin coating layer is formed on at least a surface to be an inner face of the can and a lubricant is applied thereto;
a can trunk shaping step of shaping the cap into a diametrically reduced bottomed cylindrical can body;
a container mouth shaping step of forming a shoulder portion and a container mouth by diametrically reducing one of the end portions of the bottomed cylindrical can body;
a curling/threading/beading step of forming a curled portion on a leading end of the container mouth, and forming a thread and an annular bead on the container mouth; and

an amorphization step of amorphizing at least the thermoplastic resin coating layer covering an inner surface of the can body in which the curled portion, the thread and the annular bead are formed on the container mouth situated above the shoulder portion, by heating at least the thermoplastic resin coating layer covering the inner surface of the can body to above a melting point thereof, and immediately cooling the heated thermoplastic resin coating layer.

2. The bottle-shaped can manufacturing method as claimed in claim 1, wherein the container mouth shaping step includes a top dome shaping step of forming the shoulder portion and the container mouth by diametrically reducing a bottom side of the bottomed cylindrical can body; and

wherein the amorphization step includes a step of amorphizing at least the thermoplastic resin coating layer covering the inner surface of the can body in which the container mouth is opened and a bottom lid is sewn to a lower end of the can trunk on the side opposite to the container mouth.

3. The bottle-shaped can manufacturing method as claimed in claim 1, wherein the amorphization step includes:
an induction heating step of letting the can body through an induction heating apparatus while rotating the can body around an axis of the can; and

a cooling step of immediately cooling the heated container mouth by immersing the container mouth into a cooling water held in a cooling tank.

4. The bottle-shaped can manufacturing method as claimed in claim 3, wherein the cooling step includes a step of cooling the container mouth by immersing the container mouth into the cooling water held in the cooling tank while orienting the container mouth downwardly; and

wherein the amorphization step includes a blowing step of blowing off the water adhering to the container mouth oriented downwardly.

5. The bottle-shaped can manufacturing method as claimed in claim 3,

wherein the amorphization step includes a cooling step of cooling container mouth of the can body conveyed in a manner to orient the container mouth downwardly, by immersing the container mouth into the cooling water held in the cooling tank while inclining a center axis of the container mouth with respect to a water surface, and thereafter pulling the container mouth out of the cooling tank while inclining the container mouth inversely to that of the case of immersing the container mouth into the cooling water.

6. The bottle-shaped can manufacturing method as claimed in claim 3,

wherein the amorphization step includes a cooling step of cooling container mouth while circulating the cooling water in the tank at a substantially same speed as a conveying speed of the can body and in the same direction as a conveying direction of the can body.

7. A bottle-shaped can, that is formed from a metal sheet in which a thermoplastic resin coating layer is formed on at least a surface to be an inner face of the can,

wherein a crystallinity (Cn) of the thermoplastic resin coating film covering an inner surface of a container mouth of the finished can satisfies a following inequality (1):

\[ Cn < 1 \]  

(1);

where Cn is an infrared absorption intensity measured by IR spectroscopy method (reflection infrared spectroscopy method), which can be expressed by a following expression:

\[ Cn = (\text{a peak height at } 1340 \text{ cm}^{-1})/(\text{a peak height at } 1578 \text{ cm}^{-1}). \]

8. The bottle-shaped can as claimed in claim 7,

wherein a relation between the crystallinity (Cn) of the thermoplastic resin coating film at the inner surface of the container mouth of the finished can, and a crystallinity (Cw) of the thermoplastic resin coating film at an inner surface of the can trunk satisfy a following inequality (2):

\[ Cn/Cw < 1 \]  

(2);

where Cw is an infrared absorption intensity measured by the IR spectroscopy method (reflection infrared spectroscopy method), which can be expressed by a following expression:
9. The bottle-shaped can as claimed in claim 7, wherein the thermoplastic resin coating layer covering an inner surface of the container mouth is subjected to an amorphization treatment to amorphize the thermoplastic resin after forming the container mouth, by heating the thermoplastic resin coating layer to above a melting point thereof, and immediately cooling the heated thermoplastic resin.

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