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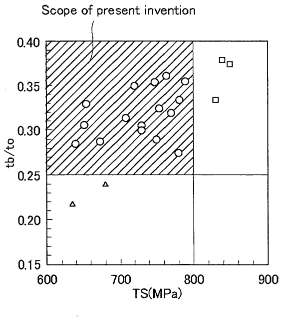
(54) **PROCESS FOR MANUFACTURING DRAWN CAN FOR AEROSOL AND DRAWN CAN FOR AEROSOL**

(57) A laminated steel sheet used as a raw material has a tensile strength TS after forming at an equivalent strain seq of 1.6 is 800 MPa or less and satisfies $0.25 \leq tb/to$ where tb is a sheet thickness at a fracture surface after fracture and to is a sheet thickness before the fracture. In forming the laminated steel sheets, forming is conducted so as to satisfy the relationships below:

$$1.5 \leq h/(R - r),\ 2.8 \leq R/r_1,\ \text{and}\ 1.1 \leq r_2/r_1$$

where h: a height from a can bottom to an opening edge portion; r: an outer diameter of a can body; R: a radius of a circular blank before forming having a weight equivalent to a weight of a final formed can body; r_1: an outer radius of an opening edge portion; and r_2: an outer radius of a bead portion.

Fig.4



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Description

Field of the Invention

[0001] The present invention relates to a method for making aerosol drawn cans used as containers such as various types of sprays and to an aerosol drawn can.

Description of the Related Arts

[0002] In the field of aerosol metal containers, there are welded cans and drawn cans when roughly categorized. A welded can has a can body made of a rectangular plate welded into a cylindrical shape, and a can bottom and a can end (dome top) attached to the can body. When used in spray applications, a mounting cup equipped with a jet nozzle is attached to the dome top.

[0003] A drawn can is prepared by applying diametral reduction to an opening end side of a bottomed cylindrical can body formed by impact forming, drawing-redrawing, drawing-redrawing-ironing, or other suitable forming methods so that the diameter of that portion is smaller than the diameter of the can body, and attaching a mounting cup. Such a drawn can is also called a one-piece can or a mono-block can.

[0004] Since the drawn can has a seamless can body and diametral reduction is performed to create a beautiful and continuous contour from the can body to the mounting cup, the appearance of the drawn can is superior to that of the welded can. Accordingly, drawn cans are used in applications where the appearance of the package is important due to the nature of the product. For example, drawn cans are widely used is usages such as air fresheners, antiperspirants, and hair tonics.

[0005] Regarding the raw materials for these cans, currently, steel sheets are usually used in welded cans and aluminum is usually used in drawn cans. The main reasons for not using steel sheets as the raw material for drawn cans are as follows.

[0006] The first reason is that red rust that occurs with steel sheets does not occur with aluminum. When an aerosol can is put in a wet environment and the can is made of a steel sheet, there is a concern of occurrence of red rust. If red rust occurs, the appearance of the aerosol can is significantly degraded and the commercial value of the product may be lowered.

[0007] The second reason is that since aluminum is softer than the steel sheets, it is relatively easy with aluminum to form a cylindrical can body integrated with bottom by employing impact forming, drawing-redrawing, drawing-redrawing-ironing, or other suitable forming, to conduct diametral reduction on the opening end portion of the can body, and to form a bead portion in the opening end portion to attach a mounting cup.

[0008] Steps for making an aerosol can constituted by a drawn can by using a flat plate as the raw material is shown in Fig. 1 and described below:

1) preparing a circular blank from a flat plate raw material;
2) forming the circular blank into a bottomed cylindrical shape by conducting drawing (ironing may also be performed) a plurality of times so as to form a can body;
3) dome-forming the can bottom portion of the can body so that the can bottom portion protrudes toward the can inner side;
4) trimming the opening end side of the can body;
5) applying diametral reduction to the opening end side of the can body so that the diameter is not more than the outer diameter of the can body (diametral reduction may be conducted a plurality of times); and
6) curling (curling may be conducted a plurality of times) the opening end edge portion to form a bead portion.

[0009] Aerosol cans of various types and sizes are available in the market. In order to conduct forming so that cans of various types and sizes are produced through the above-described process, a particularly high strain level is involved. Thus, in the related art, it has not been easy to conduct such forming using steel sheets.

[0010] Because of this reason, aluminum is currently used in aerosol drawn cans. However, since the strength of aluminum is low, the sheet thickness of aerosol cans whose inner pressure is high needs to be large. While the price of bare aluminum is increasing recently, aluminum aerosol cans are disadvantageous with respect to the raw material cost. In contrast, steel sheets have high strength and are less expensive. If steel sheets are used in aerosol cans, the sheet thickness of the can body can be reduced while maintaining the sufficient strength. Thus it may be possible to reduce the material cost. Under such trends, technology for making aerosol drawn cans by using steel sheets is desired.

[0011] As described above, the first reason for not using steel sheets as the raw material of the drawn cans is that corrosion resistance of the steel sheets is lower than that of aluminum. In this regard, Patent Document 1 discloses a technique for overcoming low corrosion resistance by enhancing the corrosion resistance of the steel sheet itself. Patent

Document 1 discloses a technique of using stainless steel, which has excellent corrosion resistance, as the steel sheet. However, although stainless steel has high corrosion resistance, it is expensive and will increase the cost of cans.

[0012] Patent Document 2 discloses a technique of coating the steel sheet surface with a metal having high corrosion resistance. In particular, the technique uses an aluminum-coated steel sheet so that rusting of the can bottom of the drawn and ironed aerosol can is prevented. According to this technique, rust may be prevented at the can bottom portion where the strain level is low; however, the can body subjected to drawing and ironing may rust because the aluminum coating is damaged.

[0013] Patent Document 3 discloses a technique of enhancing the corrosion resistance by coating the steel sheet surfaces. The technique relates to an inner-coated metal container having a cured polyamideimide-based coating. Although this technique discloses that it is possible to use a steel sheet as the material in making an aerosol can, the examples of the steel sheets are related to welded cans only and sufficient disclosure related to corrosion resistance of drawn cans is not specifically provided. Thus, the effect is not clear. The specification discloses that this technique can be applied to a can body after forming or to a metal sheet before forming; however, in Examples, only aluminum cans in which coating is formed after a can body is formed are disclosed, and no specific example in which a coating is formed on a metal sheet before forming and the metal sheet is then worked is provided. The present inventors have conducted investigations by drawing a steel sheet coated with a thermosetting coating; however, coating was damaged during some forming steps, and sufficient corrosion resistance could not be obtained.

[0014] As the technique for compensating the drawbacks of the coatings, a technique of coating the steel sheet surface with a film is known. Patent Document 4 discloses a technique of obtaining a drawn aerosol can by using a steel sheet laminated with a polyethylene terephthalate biaxially stretched film. According to this technique, since the can body after drawing is coated with an undamaged laminate film, corrosion resistance is high. However, can bodies obtained by this technique maintain the corrosion resistance only when can bodies are not subjected to diametral reduction at the opening end as shown by the examples. Diametral reduction and curing required for making an aerosol can from a flat plate material are not conducted. Thus the resulting cans do not have appealing contours and cannot substitute existing aerosol cans.

[0015] On the other hand, the second reason why the steel sheet has not been used as the raw material for the drawn cans is that the strain level must be significantly high to produce aerosol cans of various types and sizes currently available in the market and that forming such cans using steel sheets has not been easy.

[0016] Regarding a film laminated steel sheet applied to thin-walled deep-drawn and ironed cans requiring a relatively high strain level, Patent Documents 5 and 6 each disclose a technique of increasing the formability by increasing the tensile strength increment in forming at an equivalent strain εeq of 1, to a particular level or higher. This technique assumes a strain level lower than the strain level required for aerosol cans described above. Moreover, the studies by the present inventors have found that if these steel sheets are applied to the laminated steel sheets for drawn cans, troubles will occur during processing. In particular, buckling occurred during diametral reduction where the opening end portion was compressed in the circumferential direction, and the,opening end portion of the can body frequently cracked by processing during formation of the bead portion by curling.

[Patent Document 1] PCT Japanese Translation Patent Publication No. 2003-500306
[Patent Document 2] Japanese Unexamined Patent Application Publication No. 63-168238
[Patent Document 3] Japanese Unexamined Patent Application Publication No. 9-39975
[Patent Document 4] Japanese Unexamined Patent Application Publication No. 1-228567
[Patent Document 5] Japanese Unexamined Patent Application Publication No. 2002-317247
[Patent Document 6] Japanese Unexamined Patent Application Publication No. 2002-317248

Summary of the Invention

[0017] The present invention aims to provide a method for making an aerosol drawn can which can be formed without buckling or cracking and an aerosol drawn can having a satisfactory can body strength and excellent corrosion resistance.

[0018] The present inventors have conducted studies and found that it is not sufficient to merely use a conventional laminated steel sheets for drawing applications in order to make an aerosol drawn can from a steel sheet, and that a laminated steel sheet having excellent corrosion resistance and high formability must be used.

[0019] The present invention has been made on the basis of the above-described findings and is summarized as follows:

[1] A method for making an aerosol drawn can, satisfying relationships below and using, as a raw material, a laminated steel sheet coated with an organic resin film,
wherein
the laminated steel sheet has a tensile strength TS of 800 MPa or less after forming at an equivalent strain εeq of 1.6 and satisfies $0.25 \leq tb/to$ where tb is a sheet thickness at a fracture surface after fracture and to is a sheet

thickness before the fracture:

$1.5 \leq h/(R - r)$
$2.8 \leq R/r_1$
$1.1 \leq r_2/r_1$
where
h: a height from a can bottom to an opening edge portion;
r: an outer diameter of a can body;
R: a radius of a circular blank before forming having a weight equivalent to a weight of a final formed can body;
r_1: an outer radius of an opening edge portion; and
r_2: an outer radius of a bead portion.

[2] The method for making the aerosol drawn according to [1], wherein the laminated steel sheet contains, in terms of percent by mass, C: 0.0005 to 0.09%, Si: 0.1% or less, Mn: 1.0% or less, P: 0.02% or less, S: 0.02% or less, Al: 0.01 to 0.1%, N: 0.0060% or less, and the balance being Fe and inevitable impurities.

[3] The method for making the aerosol drawn according to [2], wherein the laminated steel sheet further contains, in terms of percent by mass, B: 0.0001% to 0.003%.

[4] The method for making the aerosol drawn according to [2], wherein the laminated steel sheet further contains, in terms of percent by mass, at least one of Ti: 0.001% to 0.05% and Nb: 0.001% to 0.05%.

[5] The method for making the aerosol drawn according to [3], wherein the laminated steel sheet further contains, in terms of percent by mass, at least one of Ti: 0.001% to 0.05% and Nb: 0.001% to 0.05%.

[6] The method for making the aerosol drawn according to [1], wherein the tensile strength TS after forming at an equivalent strain εeq of 1.6 is 600 to 800 MPa and $0.25 \leq tb/to \leq 0.40$ is satisfied where tb is a sheet thickness at a fracture surface after tensile fracture and to is a sheet thickness before the tensile fracture.

[7] An aerosol drawn can made by any one of the methods according to [1] to [6].

[0020] It should be noted that in the specification, % indicating the components of the steel is based on mass.
[0021] According to the present invention, an aerosol drawn can can be produced while avoiding buckling at the neck portion and cracking at the curl portion which have been problem in the related art, by using a laminated steel sheet having particular properties and excellent corrosion resistance. Accordingly, cans having excellent corrosion resistance and the size and shape the same as that of existing, commercially available aerosol cans can be formed by using steel sheets as the raw material.

Brief Description of Drawings

[0022]

Fig. 1 includes diagrams showing steps of making an aerosol drawn can.
Fig. 2 shows the relationship among dimensions of the can body of the present invention.
Fig. 3 shows the relationship between dimensions of the can body of the present invention.
Fig. 4 is a graph showing the tensile strength TS and the ratio tb/to, which is the ratio of a sheet thickness tb at a fracture surface after fracture and an original sheet thickness to of the steel sheet.

Embodiments for Carrying Out the Invention

[0023] The present invention will now be described in detail.
[0024] A drawn aerosol can, which is the subject matter of the present invention, is formed through the steps shown Fig. 1 described below:

(1) preparing a circular blank from a flat plate raw material;
(2) forming the circular blank in a shape of cylinder integrated with bottom by drawing (ironing may also be performed) a plurality of times so as to form a can body;
(3) dome-forming a can bottom portion of the can body so that the can bottom portion protrudes toward the can

inner side;

(4) trimming the opening end side of the can body;

(5) applying diametral reduction to the opening end side of the can body so that the diameter is not more than the outer diameter of the can body (diametral reduction may be conducted a plurality of times); and

(6) curling (curling may be conducted a plurality of times) the opening end edge portion to form a bead portion.

[0025] Aerosol cans of various types and sizes are available in the market. In order to conduct forming so that cans of various types and sizes are produced through the above-described process, the forming at a strain level prescribed as follows must be conducted in steps (5) and (6) by using the dimensions shown in Figs. 2 and 3:

a) $1.5 \leq h/(R - r)$
where

h: the height from the can bottom to the opening edge portion;
r: the outer radius of the can body; and
R: the radius of the circular blank before forming having a weight equivalent to the weight of the finished can, $h/(R - r)$ indicating the strain level related to elongation in the height direction of the can body.

b) $2.8 \leq R/r_1$
where r_1: the outer radius of the opening edge portion, r_1/R indicating the strain level related to compression in the circumferential direction of the can body; and
c) $1.1 \leq r_2/r_1$

where r_2: the outer radius of the bead portion, r_2/r_1 indicating the strain level related to expansion during the step of curling the opening end edge portion.

[0026] The conditions of the strain level described above are determined as follows.

[0027] First, the shape and the size of the aerosol can to be produced are determined to be the same as those of commercially available aerosol cans. The shape and size of the commercially available aerosol cans are described in, for example, Federation of European Aerosol Association Standard No. 215, No. 219, and No. 220. The size parameters r, h and r_1 shown in Fig. 2 can be determined from this.
Next, the thickness of the laminated steel sheet used for cans is determined on the basis of the strength, weight, and material costs required for the cans. Then the forming steps shown in Fig. 1 are determined, and the sheet thickness distribution in step (5) is determined. Accordingly, the weight of the finished can is determined.
On the basis of the weight of the finished can, the radius R of the circular blank before forming is determined. Then the shape of the bead portion is determined to determine the size parameter r_2 in Fig. 3. The radius R_0 of the circular blank can be determined by adequately setting the amount of trimming in the trimming step shown in (4) in Fig. 1 . The above-described conditions of the strain level are determined by conducting these operations for the shape and size of the various commercially available aerosol cans.
The relationships a), b), and c) above are determined as such.

[0028] Next, the steel sheet used as the raw material in the present invention is described.

[0029] In order to produce an aerosol drawn can while overcoming the existing problems of buckling at the neck portion and cracking of the curled portion, the present inventors have focused on the laminated steel sheet used as the raw material and conceived to overcome the problems by rendering particular properties to the laminated steel sheet. Thus, steel sheet samples were experimentally produced by varying the chemical composition, hot-rolling conditions, cold-rolling conditions, annealing conditions, temper-rolling conditions, and the like and the experiments were conducted by forming the steel sheet samples to study the problems in making aerosol cans by drawing, i.e., buckling during diametral reduction and cracking during curling for forming the bead portion. The forming conditions are the same as the examples described below. Some samples underwent buckling during diametral reduction or cracking during curling. Then the properties of the raw material that control the diametral reduction property were studied. However, no clear relationship was found between the buckling during diametral reduction and the cracking during curling for forming the bead portion on the basis of one or combination of indices selected from mechanical property values obtained by normal tensile testing for evaluating the steel sheet before forming, i.e., the yield strength, yield point elongation, tensile strength, total elongation, uniform elongation, and local elongation, the Lankford value (r value), the strain hardening exponent (n value), and the hardness test.

[0030] The reason for this is presumably as follows. The strain level evaluated by normal tensile test is usually about 0.3 to 0.4, whereas the strain level required for drawn aerosol cans is higher. Thus, the mechanical properties obtained by the normal tensile test and the like cannot give indices adequate for the high strain level required during diametral reduction and curling.

[0031] The present inventors have studied can bodies obtained by actual forming experiments in detail to search for the factors that cause buckling during diametral reduction and cracking during curling in the can body worked at a high strain level.

[0032] The present inventors have done trial calculations with regard to sizes and shapes of various aerosol cans commercially available and found that the strain level at the opening end portion before diametral reduction, i.e., at step (4) in Fig. 1, is about 1.6 in terms of equivalent strain εeq. The equivalent strain εeq is a value determined from the thickness direction strain ε_t at the wall portion of the can body after forming, the circumferential direction strain εθ, the can height direction strain εϕ by

Thickness direction strain :

$$\varepsilon_t = ln(t / t_0)$$

Circumferential direction strain:

$$\varepsilon_\theta = ln(r / r_0)$$

Height direction strain :

$$\varepsilon_\phi = 1/\{ ln(t / t_0) \cdot ln(r / r_0) \} = -(\varepsilon_t + \varepsilon_\theta)$$

Equivalent strain :

$$\varepsilon_{eq} = \sqrt{\frac{2}{3}\left(\varepsilon_t^2 + \varepsilon_\theta^2 + \varepsilon_\phi^2\right)}$$

[0033] Buckling that occurs during diametral reduction is a phenomenon in which, during diametral reduction of the opening end portion, the opening end portion undergoes buckling by the compression stress in the circumferential direction. It is considered that buckling during forming occurs because the opening end portion is worked at a high strain level and thereby extensively hardens as a result of strain hardening, and the formability is degraded thereby. It is considered necessary to adequately specify the material of the opening end portion in order to suppress occurrence of buckling. Since the strain level at the opening end portion is about εeq = 1.6 in terms of equivalent strain, it is considered necessary to evaluate the material of the portion after the material is subjected to forming at such a degree. Accordingly, the relationship between the mechanical properties of the steel sheet worked at an equivalent strain εeq of 1.6 and buckling occurring during diametral reduction was studied. As a result, it was found that buckling was prevented when the tensile strength TS of the material after being subjected to forming at an equivalent strain of εeq = 1.6 was 800 MPa or less.

[0034] The reason for this is presumably as follows. The buckling during diametral reduction is more suppressed when the material is apt to deform in the circumferential direction by compression deformation, and thus buckling is suppressed at a critical value of the strength, i.e., 800 MPa or more. Note that although the tensile strength TS after forming at an equivalent strain εeq = 1.6 is preferably low from the viewpoint of diametral reduction, the low equivalent strain value leads to a decrease in strength of the material constituting the can body and ultimately to a decreased strength of the can body. In order to retain the strength needed for the can body, the tensile strength TS after forming at an equivalent strain εeq = 1.6 is preferably 600 MPa or more.

[0035] The forming that gives the equivalent strain εeq of 1.6 is most preferably conducted by actual drawing; however, other forming techniques may be used for evaluation as long as the equivalent strain is the same. The present inventors have conducted forming by rolling in addition to the actual can forming process. The equivalent strain during rolling can be determined by replacing the circumferential direction strain in the above-described relationships with the plate width direction strain.

[0036] However, there were cases where cracking occurred during curling although the diametral reduction satisfying the above-described conditions could be conducted. In order to clarify this phenomenon, the state of the opening end edge portion during curling was observed in detail. As a result, it was found that curl cracks occurred when the constriction of the opening end edge portion that occurs as a result of expansion during curling is large. In other words, it was found that the constriction was the start point of cracks and that the cracking can be avoided by reducing the constriction. It was also found that the degree of constriction could be determined on the basis of the relationship between the sheet thickness at the fracture surface after the tensile fracture after forming at an equivalent strain εeq of 1.6 and the thickness of the steel sheet before the tensile test. In particular, the constriction can be reduced and the curl cracks can be prevented under a condition of $0.25 \leq tb/to$ where tb is the sheet thickness at the fracture surface after tensile fracture after forming at an equivalent strain εeq of 1.6 and to is the sheet thickness before tensile fracture. Note that tb/to is the index indicating the constriction caused by fracture of the steel sheet. By adjusting this value to a particular level or higher, local constriction can be suppressed against the tensile force applied during curling, and cracking can be thereby avoided. In order words, when constriction occurs in a concentrated manner at a particular portion of the curl portion, this portion may become the starting point of curl cracks. Thus, it is considered effective against cracking in the curl portion to use a material in which the tensile force can be evenly distributed over the entire curled portion without having the constriction concentrated at a particular portion. Although tb/to is 0.25 or more and preferably large to completely eliminate constriction, the upper limit is 1 as apparent from its definition.

[0037] The results of the study are shown in Fig. 4. In Fig. 4, circular symbols indicate cases in which diametral reduction and curling are performed without any problem, rectangular symbols indicate cases where bucking occurs during diametral reduction, and triangular symbols indicate the cases in which cracking occurs in the curling. Fig. 4 shows that buckling does not occur during diametral reduction and cracking is prevented during curling by controlling the tensile strength TS after forming at an equivalent strain εeq of 1.6 to satisfy $TS \leq 800$ MPa and by controlling the sheet thickness tb at the fracture surface after tensile fracture and the sheet thickness to before tensile fracture to satisfy $0.25 \leq tb/to$. Thus, in the present invention, the properties of the steel sheet are that the tensile strength TS after forming at an equivalent strain εeq of 1.6 satisfies $TS \leq 800$ MPa and that the thickness tb at the fracture surface after tensile fracture and the sheet thickness to before tensile fracture satisfy $0.25 \leq tb/to$.

[0038] It has also been found that the troubles during production of the aerosol drawn cans can be further reduced and an enhanced effect can be achieved by controlling the composition of the steel sheet having the above-described properties. The preferable compositional ranges are described below. Note that % is based on mass. C: 0.0005 to 0.09%

[0039] At a carbon (C) content of less than 0.0005% or more than 0.09%, the probability of entry of foreign matter (entry of scales and entry of inclusions) is increased, and troubles during forming may be induced. This is presumably because at a small C content, the decarbonizing treatment time of the molten steel is long during which the frequency of entry of inclusions or the like increases, and because at a large C content, cracks known as hypoperitectic cracks occur during solidification of the molten steel. Thus, the C content range is preferably 0.0005% or more and 0.09% or less.

Si: 0.1% or less

[0040] Silicon is an element that degrades the surface properties of the steel sheet. A high Si content is not preferred for surface-treated steel sheets, hardens the steel and renders hot-rolling difficult, and hardens a steel sheet as a finished product. From this viewpoint, the Si content is preferably 0.1% or less. In usages where the requirements of the surface properties are stringent, the Si content is more preferably 0.050% or less.

Mn: 1.0% or less

[0041] Manganese (Mn) is an element that hardens the steel. At a high Mn content, the formability is adversely affected, and the surface properties may be degraded as manganese concentrates in the surface layer during annealing. From this viewpoint, the Mn content is preferably 1.0% or less. If the Mn content is less than 0.05%, it is difficult to avoid hot shortness even when the S content is low, thereby leading to problems such as surface cracks. At a Mn content exceeding 0.6%, the transformation point excessively lowers, and it may be difficult to obtain a desirable hot rolled sheet. Thus, more preferably, the Mn content is 0.05% or more and 0.6% or less.

P: 0.02% or less

[0042] Although the corrosion resistance can be enhanced by decreasing the P content, excessive reduction in P content leads to an increase in production cost. Thus, the P content is preferably 0.02% or less. In the case where formability is important, the P content is more preferably 0.01% or less.

S: 0.05% or less

[0043] As the S content increases, the amount of inclusions such as MnS increases and the local ductility decreases, which may cause curl cracks. Thus, the S content is limited to 0.05% or less. The S content is preferably 0.010% or less to significantly improve the formability.

Al: 0.01 to 0.1%

[0044] At an Al content less than 0.01% or more than 0.1%, the probability of entry of foreign matter (entry of scales and entry of inclusions) is increased, and troubles during forming may be induced. Aluminum is added to fix and remove oxygen in the molten metal as alumina. Alumina itself surfaces and is removed from the molten metal as it is absorbed in the slag. At a low Al content, oxygen may not be sufficiently removed, the amount of oxides in the steel may increase, and the frequency of the oxides as the inclusions to enter the steel sheet may increase. At a high Al content, produced alumina may not be sufficiently removed and alumina itself may serve as an inclusion. Thus the Al content is preferably 0.01% or more and 0.1% or less.

N: 0.0060% or less

[0045] At a N content more than 0.0060%, the probability of foreign matter entering the steel sheet (entry of scales, entry of inclusions, etc.) is increased, and problems may occur during forming. At a high N content, the hot ductility after solidification of the molten steel decreases, and the slab is more apt to crack. Thus, the N content range is preferably 0.0060% or less.

[0046] The present inventors have also found that a further advantageous situation can be yielded in making aerosol drawn cans when the elements described below are contained.

B: 0.0001% to 0.003%

[0047] There is observed a clear tendency in which the frequency of occurrence of cracks decreases by incorporation of boron when curling is performed at a high speed. The forming speed of drawn cans is usually indicated in terms of a speed of strokes of the press machine. The forming speed is usually several ten strokes to a hundred and several ten strokes per minute, although the speed may vary depending on the can height. The speed is about 100 strokes per minute on average. When boron is not included, the forming can be conducted sufficiently stably at an average speed and at a higher speed although cracks occur by curling in some cases

where the higher speed is used. When boron is contained, cracks are suppressed even by forming at a speed of 120 strokes per minute and stable operation is made possible. Although the reason for this is not clear, segregation of boron in crystal grain boundaries may be related. This effect is not notable if the B content is less than 0.0001% and will be saturated if the B content is 0.003% or more. Moreover, addition of a large amount of B degrades the hot shortness during the steel sheet production and increases the cost. Thus, the B content range is preferably 0.0001% or more and 0.003% or less.

[0048] At least one of Ti: 0.001% to 0.05% and Nb: 0.001% to 0.05%

[0049] Incorporation of titanium and niobium reduces the problems during forming such as drawing cracks that occur during forming of a steel sheet into a bottomed cylindrical can body. This is presumably because addition of these elements increases the r value of the steel sheets and enhances the drawability. Although these elements are not essential for the present invention, the condition of TS $\leq$ 800 MPa where TS is the tensile strength after forming at an equivalent strain $\varepsilon eq = 1.6$ needed for the steel used in the production process of the present invention can be easily achieved by incorporation of these elements. This is presumably because incorporation of these elements fixes carbon in the steel as the carbides and decreases the amount of dissolved carbon, thereby rendering the steel sheet relatively soft. Since the steel is originally soft, a steel sheet having a relatively low strength is obtained after forming. This effect is not notable if the Ti and Nb contents are less than 0.001% and is saturated if the Ti and Nb contents are more than 0.05%. Moreover, the strength increases excessively and the recrystallization temperature increases when Ti and Nb contents are more than 0.05%, and addition of large amounts of these elements increases the cost. Thus, the range of the Ti and Nb contents is preferably 0.001% or more and 0.05% or less. Titanium and niobium exhibit the above-described effects when used alone but may be used in combination.

[0050] The following elements may also be incorporated in addition to above.

Ni: 0.5% or less, Cr: 0.5% or less, Cu: 0.5% or less

[0051] Nickel, chromium, and copper are elements that lower the transformation point and reduce the size of the structure of the hot rolled steel sheet. Thus, when they are contained in excessive amounts, the hot rolled sheet becomes harder and the load of cold rolling increases, thereby making the production difficult. Moreover, the cost of the steel may increase. Thus, the upper limit of the amounts of these elements is preferably 0.5%.

[0052] The balance is iron and inevitable impurities.

[0053] As described above, the laminated steel sheet used as the raw material for producing aerosol drawn cans of the present invention must have the above-described properties and preferably has the above-described composition. These requirements are most important in the present invention. When the raw material itself has corrosion resistance and sufficient formability such as described above, aerosol drawn cans can be produced even when a significantly high strain level is involved.

[0054] In particular, the conditions of the properties of the steel sheet of the present invention are that the tensile strength TS after forming at an equivalent strain εeq of 1.6 satisfies TS ≤ 800 MPa and that the thickness tb at the fracture surface after tensile fracture and the sheet thickness to before tensile fracture satisfy 0.25 ≤ tb/to. Any material may be used as the black plate of the laminated steel sheet used in the present invention as long as these properties are satisfied. However, as described above, a material containing the above-described components is advantageous for processing.

[0055] The process for making the steel sheet having these properties is not particularly limited. The representative examples of the process are described below.

[0056] An example of the composition of the steel is as follows:

A steel may contain, in terms of percent by mass, C: 0.0005 to 0.09%, Al: 0.01 to 0.1%, and N: 0.0060% or less, at least one of Ti: 0.001% to 0.05% and Nb: 0.001% to 0.05%, B: 0.0001% to 0.003%, Si: 0.1% or less, Mn: 1.0% or less, S: 0.02% or less, P: 0.02% or less, Ni: 0.5% or less, Cr: 0.5% or less, Cu: 0.5% or less. The steel containing these components is melted and continuously casted into a slab. After cooling, the slab is heated to 1100˚C to 1300˚C, hot-rolled at a finishing temperature of Ar3 transformation temperature of higher, and coiled at a coiling temperature of 540˚C to 720˚C. Subsequently, the hot-rolled coil is cooled, pickled, and rolled at a rolling ratio of 80% to 94%.

In order to suppress formation of ears during drawing, the rolling ratio is preferably 85% to 92%. The cold-rolled coil is degreased to remove the lubricant used in cold rolling and then annealed by box annealing or continuous annealing. Annealing is preferably conducted by continuous annealing that offers excellent productivity and material homogeneity. In the continuous annealing process, the steel sheet is heated to a recrystallization temperature or higher, soaked to complete recrystallization, and cooled. In cooling, it is preferable to cool from the soaking temperature to about 400˚C at a cooling rate of about 20 ˚C/s or more and to conduct overaging treatment by retaining the steel at this temperature for a predetermined time.

[0057] The film that constitutes the film-laminated steel sheet used in the present invention is not particularly limited. In order to eliminate the possibility of film damage during processing as much as possible, the film is preferably as follows.

[0058] The film is preferably any resin obtained by polycondensation of a dicarboxylic acid component and a diol component, the dicarboxylic acid component containing terephthalic acid, or terephthalic acid and isophthalic acid, the diol component containing ethylene glycol and/or butylene glycol, in which the molar ratio of the ethylene terephthalate or butylene terephthalate repeating units is 84% or more, the resin being selected from (1) to (5) below:

(1) a polyethylene terephthalate-polyethylene isophthalate copolymer;
(2) polyethylene terephthalate
(3) polybutylene terephthalate-polyethylene terephthalate copolymer
(4) polyethylene terephthalate-polyethylene isophthalate-polybutylene terephthalate copolymer
(5) polybutylene terephthalate

[0059] Preferably, in a laminated resin layer, at least the outermost surface layer includes a main phase composed of a resin mainly composed of a thermoplastic polyester having one of resins (1) to (5) as the main skeleton and an auxiliary phase composed of a mixed resin containing a polyolefin. The polyolefin is preferably at least one selected from a polyethylene, a polypropylene, and an ionomer. When the plane orientation coefficient of the surface resin layer of the laminated resin layer is 0.04 or less, the possibility of film damage can be reduced.

[0060] The laminated steel sheet used in the present invention includes a steel sheet as the substrate. A surface-treated steel sheet subjected to any of various surface treatments is preferably used as the steel sheet. In particular, a surface-treated steel sheet on which a double layer coating including metallic chromium in the lower layer and chromium hydroxide in the upper layer is formed (also known as TFS) is most preferred. The amounts of deposition of the metallic chromium layer and the chromium hydroxide layer of the TFS are not particularly limited. Preferably, the deposition amount of the metallic chromium layer is in the range of 70 to 200 mg/m^2 and the deposition amount of the chromium hydroxide layer is in the range of 10 to 30 mg/m^2 in terms of chromium.

[0061] A process of making an aerosol drawn can of the present invention will now be described.

[0062] The aerosol drawn can of the present invention is made from a laminated steel sheet having the above-described properties and coated with an organic resin film by forming the laminated steel sheet in accordance to the relationships below. The details of each step is as follows:

$$1.5 \leq h/(R - r),\ 2.8 \leq R/r_1,\ \text{and}\ 1.1 \leq r_2/r_1$$

where h: the height from the can bottom to the opening edge portion; r: the outer radius of the can body; R: the radius of the circular blank before forming having a weight equivalent to the weight of the finished can, r_1: the outer radius of the opening edge portion, R_1 is the radius of the circular blank before forming at a position corresponding to the opening edge portion; and r_2: the outer radius of the bead portion.

[0063] Step of Forming a Circular Blank from a Flat Plate Raw Material

[0064] The circular blank is preferably made by a method that uses a circular cutter and a die. Alternatively, the circular blank can be made by the first drawing among a plurality of times of drawing performed after preparation of the circular blank. Note that in order to suppress ear formation during drawing, non-circular blanks slightly deviating from a perfect circle are used in some cases.
Such a method may be employed in the present invention without any problem. The contour of the circular blank need not be a perfect circle.

[0065] Step of Forming a Can Body by Drawing the Circular Blank a Plurality of Times into a Bottomed Cylindrical Shape In order to form the laminated steel sheet into a bottomed cylinder constituting the can body of the drawn can, a technique of drawing the circular blank a plurality of times to obtain a predetermined height is employed. The number of times of drawing and the drawing ratio can be adequately selected. In order to simplify the forming step, the number of times of drawing is preferably small but this requires a low drawing ratio, i.e., extensive forming. In order to simplify the forming step, the number of times of drawing is preferably 10 or less. The drawing ratio is preferably 0.4 or more if the circular blank is drawn for the first time, and 0.5 or more in the subsequent drawing (redrawing).

[0066] In drawing of the present invention, a plurality of times of drawing is performed as a standard operation. However, a drawing-ironing process to which ironing is added may also be employed. In performing drawing a plurality of times, there may be employed a thin-wall drawing process in which the steel is drawn while applying a back tension by the blank holder pressure so that the sheet thickness can be reduced by utilizing the bending/unbending deformation, or a thin-wall drawing-ironing process in which ironing is added in addition to the aforementioned thin-wall drawing process.

[0067] The lubrication conditions affect the drawing process.
Since the coating film of the laminated steel sheet is soft and the surface of the steel sheet is smooth and flat, the laminated steel sheet originally has an enhanced lubricity. Thus, no lubricant is required in drawing. However, a lubricant is preferably used in the cases involving a low drawing ratio, for example. An adequate type of lubricant may be selected to achieve the object described above.

[0068] As the drawing is performed, the thickness of the wall portion of the can body changes relative to the original sheet thickness. When the change in sheet thickness is expressed by the average sheet thickness change rate t/t_0 where t is the average sheet thickness over the entire can height and t_0 is the original sheet thickness, t/t_0 tends to be more than 1 (> 1) in the drawing-redrawing process, and t/t_0 tends to be less than 1 (< 1) in the drawing-ironing process, the thin-wall drawing process, the thin-wall drawing-ironing process, and the like. From the standpoint of avoiding the damage on the laminated steel sheet by forming, the average sheet thickness change ratio is preferably in the range of $0.5 < t/t_0 < 1.5$.

[0069] Step of Dome-Forming a Can Bottom Portion of the Can Body to Protrude toward the Can Inner Side

[0070] The aerosol can desired in the present invention needs to have a compression strength of 15 kgf/cm^2 or more so that a propellant can be charged. In order to achieve this, it is necessary to pay particular attention to the can bottom portion to comply with the increase in pressure inside the can. The pressure inside the can body of the bottomed cylinder works in such a direction that expands the can body in the circumferential direction relative to the can body sidewall. However, the can body component is sufficiently hardened by the drawing process and does not deform by the action of the internal pressure. However, since the internal pressure works on the can bottom portion while the outer peripheral portion of the can bottom is restrained by the can body, the can bottom will deform outward if the internal pressure is high. Thus, the influence of the internal pressure must be taken into account in designing the can bottom. In order to suppress deformation of the can bottom by the internal pressure, it is effective to increase the sheet thickness of the can bottom portion, to increase the strength of the component, and/or to form the can bottom into a dome shape protruding toward the inner side of the can. As for the method for forming a dome, a technique of pressing a die having a dome-like outer shape onto the can bottom is suitable.

Step of Trimming the Opening End Side of the Can Body

[0071] The method of trimming is not particularly limited. Examples thereof include a press method in which trimming is performed with an outer blade with a circular hole and a cylindrical inner blade, a pinching method, and a spinning method in which trimming is performed with a solid cylindrical inner blade (inserted into the interior of the can body) and a disk-shaped outer blade with a sharp edge rotating reciprocally.

[0072] Step of applying diametral reduction to the Opening End Side of the Can Body to a Diameter not more than the Outer Diameter of the Can Body

[0073] The opening end of the aerosol can must be necked to a diameter not more than the diameter of the cylinder in order to mount a mounting cup on the opening of the can body. As for the method for diametral reduction, a die necking method in which the opening end portion is pressed against a die having a tapered inner surface to reduce the diameter, a spin necking method in which a rotary tool is pressed against the can body opening end portion at inner side in the can body radial direction, and other suitable methods may be employed. From the standpoint of eliminating the film damage as much as possible, the dine necking method is suitable. In the die necking method, it is preferable to reduce the diameter from the radius r of the can body to the final radius r_1 after diametral reduction through a plurality of stages. Since the risk of wrinkling by diametral reduction is high if the strain level for one stage is high, the radius reduction ratio (radius after diametral reduction/radius before diametral reduction) is preferably 0.7 or more. Since the laminated steel sheet is coated with a soft film and has a flat and smooth surface, the laminated steel sheet has enhanced lubricity and requires no lubricant in diametral reduction. However, in order to eliminate film damage by the slide with the tool as much as possible, a lubricant is preferably used. The type of lubricant may be any that achieves the above-described object.

[0074] Step of Forming a Bead Portion by Curling the Opening End Edge portion

[0075] In order to attach a mounting cup (having a jet valve for jetting an adequate amount of content) on the aerosol can, a bead portion, which is a structure that allows attachment of the mounting cup on the opening end portion, is formed. The bead portion is made by curl forming. Examples of the curling method that can be employed include a die curl method in which a curl die having a cylindrical insert with a bottom portion having an arcuate curved surface is pressed against the can body opening end portion and a spinning method in which a roll having an arcuate curved surface is pressed against the can body opening end portion.

Heat Treatment

[0076] In the present invention, it is effective to conduct heat treatment during the series of forming steps. The stresses caused by strain applied to the film of the laminated steel sheet during the forming steps can be relaxed by the heat treatment, and the film damage in the subsequent steps can be reduced. As for the conditions of the heat treatment, heating at the glass transition point of the film or higher and not more than 30˚C higher than the film melting point is preferred. Moreover, it is preferable to quench the laminated steel sheet to a temperature below the glass transition point of the film within 30 seconds after completion of the heat treatment.

EXAMPLE 1

[0077] The examples will now be described.

[0078] A drawn can was made through the forming steps below. Step of preparing a circular blank from a flat plate raw material

[0079] Each of the steels having compositions show in Table 1 was formed under the production conditions shown in Table 2 so as to obtain a steel sheet having a thickness of 0.21 mm. A micro polyethylene terephthalate film having a thickness of 25 μm was laminated by a heat lamination method on both sides of a TFS formed using the resulting steel sheet as the black plate so as to obtain a laminated steel sheet. A circular blank was prepared using this laminated steel sheet as the raw material. The blank radius was 86 mm.

Table 1

									(mass%)	
Steel No.	C	Si	Mn	P	S	Al	N	Ti	Nb	B
1	0.036	0.03	0.18	0.012	0.011	0.047	0.0045	-	-	-
2	0.086	0.02	0.52	0.019	0.016	0.021	0.0046	-	-	-
3	0.0026	0.01	0.21	0.014	0.014	0.045	0.0020	-	-	-
4	0.0032	0.02	0.55	0.015	0.005	0.053	0.0023	-	0.028	-
5	0.036	0.03	0.20	0.004	0.014	0.055	0.0028	-	-	-
6	0.024	0.03	0.30	0.008	0.014	0.095	0.0017	-	-	-

(continued)

(mass%)										
Steel No.	C	Si	Mn	P	S	Al	N	Ti	Nb	B
7	0.0017	0.01	0.34	0.015	0.015	0.044	0.0019	-	-	0.0012
8	0.0018	0.01	0.30	0.012	0.011	0.052	0.0018	0.030	-	-
9	0.0016	0.01	0.25	0.015	0.008	0.038	0.0025	0.032	-	0.009
10	0.0021	0.01	0.28	0.011	0.009	0.047	0.0028	-	0.025	0.009
11	0.0016	0.01	0.23	0.011	0.015	0.055	0.0019	0.025	0.020	-
12	0.0019	0.01	0.27	0.013	0.015	0.046	0.0020	0.011	0.012	0.0008
13	0.110	0.02	0.32	0.012	0.015	0.057	0.0031	-	-	-
14	0.036	0.02	0.20	0.016	0.011	0.120	0.0026	-	-	-
15	0.043	0.01	0.15	0.012	0.013	0.007	0.0038	-	-	-
16	0.018	0.01	0.25	0.015	0.015	0.056	0.0065	-	-	-

Table 2

		Hot rolling conditions		Annealing conditions			Secondaryrolling ratio %
Sample material	Steel No.	Finishing temperature ˚C	Coiling temperature ˚C	Annealing method*	Soaking temperature ˚C	Overaging temperature ˚C	
a	1	870	620	CAL	620	-	1.3
b	1	860	620	CAL-OA (BAF)	620	400	1.3
c	2	870	560	BAF	610	-	1.3
d	2	870	620	CAL-OA (BAF)	620	400	1.3
e	3	900	640	CAL	650	-	2.5
f	3	900	640	CAL	700	-	2.5
g	4	900	680	CAL	750	-	3.0
h	4	900	680	CAL	790	-	3.0
i	5	890	640	CAL	650	-	9.0
j	6	890	640	CAL	650	-	9.0
k	6	890	640	CAL-OA	700	400	1.2
l	7	70	620	CAL	680	-	2.0
m	8	900	680	CAL	730	-	1.5
n	9	900	680	CAL	730	-	1.5
o	10	900	650	CAL	760	-	1.5
p	11	900	650	CAL	750	-	1.5
q	12	900	680	CAL	760	-	1.5
r	13	880	620	CAL	650	-	0.8
s	14	870	620	CAL	650	-	0.8
t	15	870	620	CAL	650	-	1.2

(continued)

		Hot rolling conditions		Annealing conditions			Secondaryrolling ratio %
Sample material	Steel No.	Finishing temperature ˚C	Coiling temperature ˚C	Annealing method*	Soaking temperature ˚C	Overaging temperature ˚C	
u	16	870	620	CAL	630	-	1.1
*Annealing methods: CAL :Annealing in continuous annealing line CAL-OA :Annealing in continuous annealing line followed by overaging in box annealing furnace CAL-OA(BAF) :Annealing and overaging in continuous annealing line BAF :Annealing in box annealing furnace							

Step of forming the circular blank into a bottomed cylindrical shape by conducting drawing a plurality of times so as to form a can body

[0080] The circular blank obtained as above was drawn five times to form a drawn can.

[0081] The drawing ratio of each drawing is shown in Table 3.

During the fifth drawing, ironing at a thickness reduction ratio of 20% (the ratio of the decrease in average sheet thickness of the can body in the can height direction after drawing to the original steel sheet black plate thickness excluding the film) was also performed.

Table 3

No. of times of drawing	Drawing ratio
1	0.55
2	0.80
3	0.83
4	0.83
5	0.83

Step of dome-forming the can bottom of the can body so that the can bottom protrudes toward the can inner side

[0082] The can bottom portion was worked to protrude into a hemispherical shape having a depth of 6 mm.

Step of trimming the opening end side of the can body

[0083] A press trimming method that uses an outer blade with a circular hole and a cylindrical inner blade was employed for trimming. The can upper end portion was trimmed for about 2 mm.

Step of applying diametral reduction to the opening end side of the can body so that the diameter is not more than the outer diameter of the can body

[0084] Diametral reduction was performed in 8 stages from the diameter of the can body to the target diameter at diameter reduction ratios shown in Table 4 by a die neck method in which a die having a tapered inner surface was pressed against the opening end upper portion of the can body to reduce the diameter. A drawn can in which $h/(R - r) = 1.9$ and $R/r_1 = 3.8$ was obtained as a result.

Table 4

No. of times of forming	Diameter reduction ratio
1	0.960
2	0.957
3	0.960
4	0.958
5	0.960
6	0.961
7	0.959

(continued)

No. of times of forming	Diameter reduction ratio
8	0.949

Step of curling the opening end edge portion to form a bead portion

[0085] Curling was performed at an expansion ratio r_2/r_1 = 1.3 with respect to the dimensions shown in Fig. 3 by a die curling method in which a die having an arcuate inner face was pressed against the opening end upper portion after diametral reduction so as to perform curling.

[0086] Note that the can body was heated for 5 minutes in a hot air furnace with a furnace temperature of 220˚C and then immediately cooled in a water vessel at a room temperature between the step of dome-forming the can bottom portion to protrude toward the can inner side and the step of trimming so as to avoid film damage of the laminated steel sheet, although this heating has no direct relevancy to the problems during processing in the present invention.

[0087] The series of drawing, dome-forming, trimming, diametral reduction, and curling steps was conducted under a condition in which the stroke speed of the press machine was 80 to 160 strokes per minute.

[0088] The drawn cans obtained as above were subjected to tests described below to evaluate performance.

Tensile strength TS and tb/to

[0089] Each sample material (the above-described laminated steel sheet used as the raw material) was rolled to apply an equivalent strain εeq of 1.6. The rolled sample was processed into a Japanese Industrial Standard No. 13 B specimen and subjected to tensile test in which the specimen was pulled in the rolling direction to determine the tensile strength TS. The pulling rate was 10 mm/min. Since the sample material was a laminated steel sheet and had a laminated film coating the steel sheet surface, the film was removed before the tensile test was conducted. After the tensile test, the original sheet thickness to before the tensile test (before tensile fracture) and the sheet thickness tb at the fracture surface after tensile fracture were measured, and tb/to was calculated.

Diametral reduction property

[0090] A sample was rated ○ when the frequency of occurrence of buckling was 100 ppm or less and a sample was rated X when the frequency of occurrence of buckling was more than 100 ppm during diametral reduction irrespective of the number of times diametral reduction was conducted.

Curling property

[0091] A sample was rated ○ when the frequency of occurrence of cracking was 100 ppm or less and a sample was rated X when the frequency of occurrence of cracking was more than 100 ppm during curling. Since the curling step is performed continuously after the applying diametral reduction step, samples that failed the diametral reduction property evaluation were not evaluated. Moreover, since samples with poor diametral reduction property and curling property cannot be used as the product in operation, the evaluation on the following items was not conducted.

Process defects

[0092] The surface of a finished drawn can was observed to monitor the presence of process defects considered to be attributable to the steel sheet, such as pinholes in the sidewall portion, roll marks in the rolling direction of the steel sheet, and the like. Occurrence of such defects is extremely rare, and the frequency of occurrence is 50 ppm or less. A sample in which process defects occurred at a frequency of 10 to 50 ppm in continuous processing was rated ○ and a sample in which process defects occurred at a frequency of less than 10 ppm was rated ⊙.

High-speed formability

[0093] The processing speed of drawn cans is usually indicated in terms of stroke speed of a press machine. A sample in which the frequency of occurrence of cracking was 50 ppm or less, i.e., the level that does not adversely affect usual operation, during curling at a processing speed of 80 to 120 strokes per minute was rated ○, and a sample in which the frequency of occurrence of cracking was 50 ppm or less during curling at a processing speed of 120 strokes per minute or higher was rated ⊙.

Drawability

[0094] In continuous drawing, cracking not caused by inclusions or the like in the steel sheet may sometimes occur by drawing. Most of such cracks occur in the vicinity of the bottom portion of the can body. Such process defects are extremely rare and can be avoided by adequately adjusting the blank holder pressure during drawing, lubrication conditions, and the like. A sample that could be subjected to continuous forming at a frequency of occurrence of cracking of 50 ppm or less was rated ○, and a sample that could be subjected to continuous forming at a frequency of occurrence of cracking of 10 ppm or less was rated ⊙.

[0095] The results are shown in Table 5.

Table 5

Sample material	Steel No.	TS*1	t_b/t_0*2	Diametral reduction property	Curling property	Process defects	High-speed formability	Drawability
a	1	790	0.36	○	○	◎	○	○
b	1	748	0.35	○	○	◎	○	○
c	2	830	0.34	×	-	-	-	-
d	2	839	0.38	×	-	-	-	-
e	3	652	0.31	○	○	◎	○	○
f	3	635	0.22	○	×	-	-	-
g	4	708	0.31	○	○	◎	○	○
h	4	680	0.24	○	×	-	-	-
i	5	730	0.31	○	○	◎	○	○
j	6	764	0.36	○	○	◎	○	○
k	6	849	0.37	×	-	-	-	-
l	7	674	0.29	○	○	◎	◎	○
m	8	655	0.33	○	○	◎	○	◎
n	9	780	0.28	○	○	◎	◎	◎
o	10	730	0.30	○	○	◎	◎	◎
p	11	640	0.29	○	○	◎	○	◎
q	12	750	0.29	○	○	◎	◎	◎
r	13	782	0.34	○	○	○	○	○
s	14	720	0.35	○	○	○	○	○
t	15	754	0.33	○	○	○	○	○
u	16	770	0.32	○	○	○	○	○

*1 TS : Tensile strength after forming at an equivalent strain ε eq of 1.6
*2 t_b/t_0 : Ratio of the sheet thickness t_b at fracture surface after fracture in tensile test after forming at an equivalent strain E eq of 1.6 to the original thickness of the steel sheet

[0096] Table 5 shows that the examples of the present invention having TS and tb/to within the ranges of the present invention were excellent in all properties. Moreover, the frequency of occurrence of process defects is low when C, Al, and N are within the ranges of the present invention. Samples containing B have excellent high-speed formability and samples containing Ti and/or Nb have excellent drawability.

[0097] Examples r, s, t and u of the present invention have no problem with respect to properties, but since their compositions partly deviate from the preferable ranges, process defects such as pinholes in the sidewall of the drawn can occurred in comparison with the samples of the present invention whose compositions are within the preferable ranges. However, the frequency of defects is 50 ppm or less, which is a level that does not cause any problem in continuous processing. In contrast, comparative examples c, d, and k have TS higher than the range of the present invention, and the diametral reduction property of these examples is poor. Comparative examples f and h have tb/to below the range of the present invention, and the curling property of these examples is poor.

Industrial Applicability

[0098] The present invention is most suited to aerosol drawn cans. The present invention may also be suitable for usages, other than aerosol cans, that involve a high strain level as assumed in the present invention and require can body strength, corrosion resistance, appearance, and the like. The present invention is also applicable to general two-piece cans.

Claims

1. A method for making an aerosol drawn can, satisfying relationships below and using, as a raw material, a laminated steel sheet coated with an organic resin film,
wherein
the laminated steel sheet has a tensile strength TS of 800 MPa or less after forming at an equivalent strain εeq of 1.6 and satisfies $0.25 \leq tb/to$ where tb is a sheet thickness at a fracture surface after fracture and to is a sheet thickness before the fracture:

    $1.5 \leq h/(R - r)$
    $2.8 \leq R/r_1$
    $1.1 \leq r_2/r_1$
    where
    h: a height from a can bottom to an opening edge portion;
    r: an outer diameter of a can body;
    R: a radius of a circular blank before forming having a weight equivalent to a weight of a final formed can body;
    r_1: an outer radius of an opening edge portion; and
    r_2: an outer radius of a bead portion.

2. The method for making the aerosol drawn can according to claim 1, wherein the laminated steel sheet contains, in terms of percent by mass, C: 0.0005 to 0.09%, Si: 0.1% or less, Mn: 1.0% or less, P: 0.02% or less, S: 0.02% or less, Al: 0.01 to 0.1%, N: 0.0060% or less, and the balance being Fe and inevitable impurities.

3. The method for making the aerosol drawn can according to claim 2, wherein the laminated steel sheet further contains, in terms of percent by mass, B: 0.0001% to 0.003%.

4. The method for making the aerosol drawn can according to claim 2, wherein the laminated steel sheet further contains, in terms of percent by mass, at least one of Ti: 0.001% to 0.05% and Nb: 0.001% to 0.05%.

5. The method for making the aerosol drawn can according to claim 3, wherein the laminated steel sheet further contains, in terms of percent by mass, at least one of Ti: 0.001% to 0.05% and Nb: 0.001% to 0.05%.

6. The method for making the aerosol drawn can according to claim 1, wherein the tensile strength TS after forming at an equivalent strain εeq of 1.6 is 600 to 800 MPa and $0.25 \leq tb/to \leq 0.40$ is satisfied where tb is a sheet thickness at a fracture surface after fracture and to is a sheet thickness before the fracture.

7. An aerosol drawn can made by any one of the methods according to Claims 1 to 6.

Fig.1

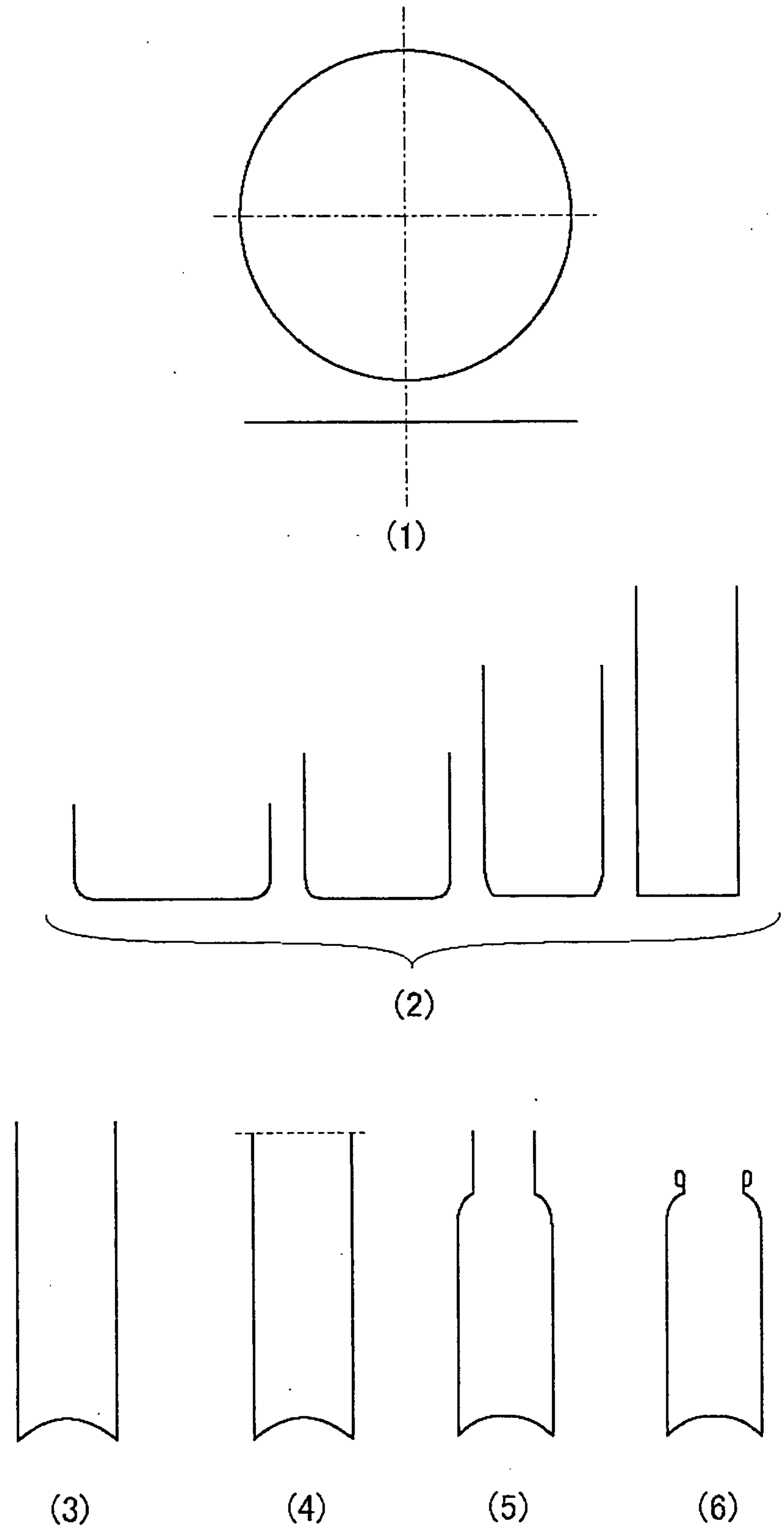


Fig.2

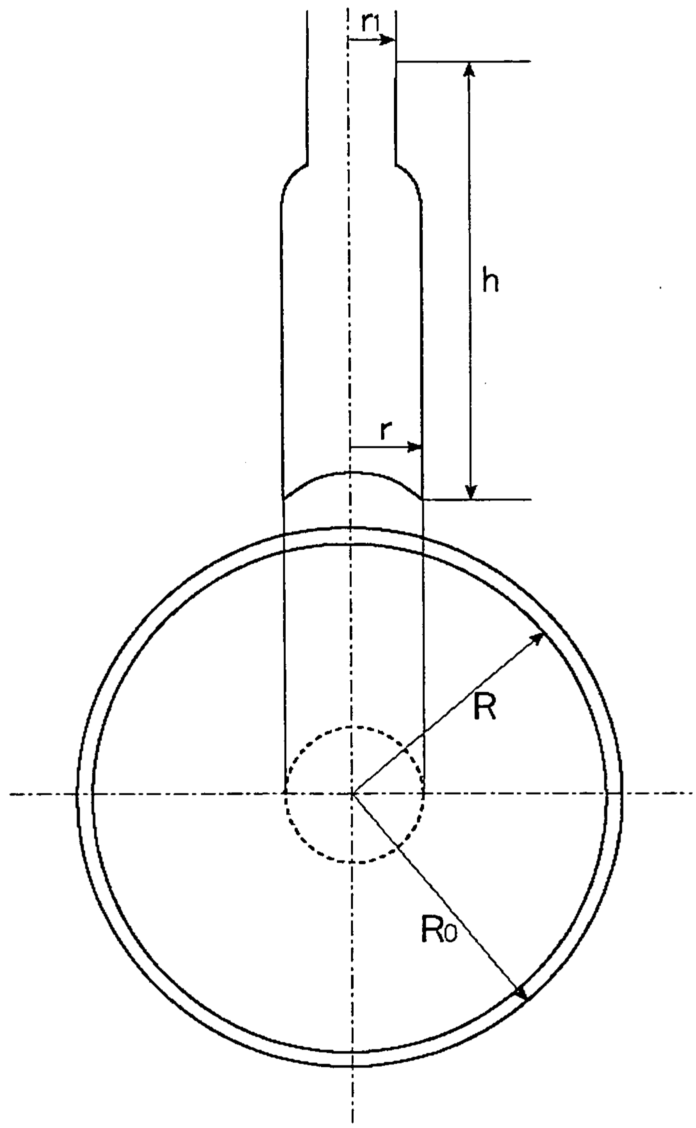


Fig.3

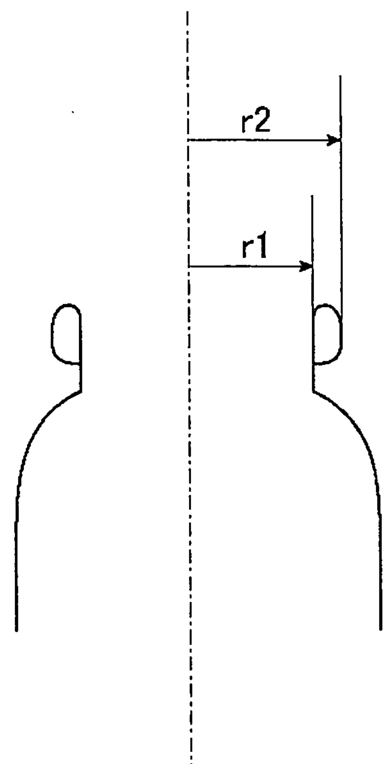
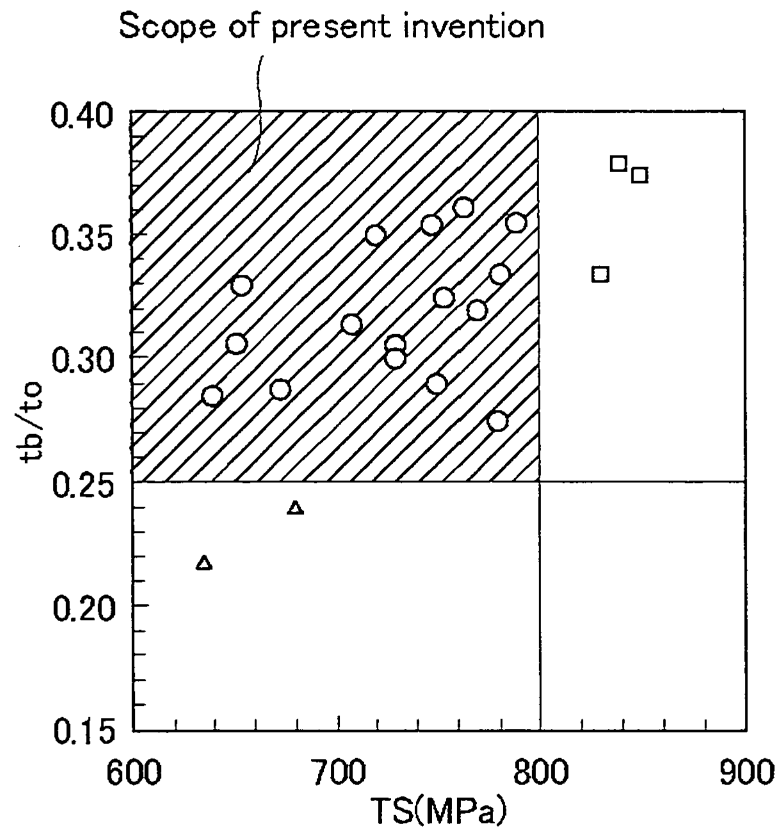


Fig.4


Scope of present invention
0.40
0.35
0.30
0.25
0.20
0.15
tb/to
600
700
800
900
TS(MPa)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/073735

A. CLASSIFICATION OF SUBJECT MATTER
B21D51/26(2006.01)i, *B65D83/38*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B21D51/26, B65D83/38

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2007
Kokai Jitsuyo Shinan Koho	1971-2007	Toroku Jitsuyo Shinan Koho	1994-2007

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.
Y	JP 2002-317248 A (NKK Corp.), 31 October, 2002 (31.10.02), Full text (Family: none)	1-6
Y X	JP 2004-276068 A (Daiwa Can Co.), 07 October, 2004 (07.10.04), Full text (Family: none)	1-6 7
A	JP 8-309465 A (Akira KISHIMOTO), 26 November, 1996 (26.11.96), Full text (Family: none)	1-7

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 December, 2007 (20.12.07)	08 January, 2008 (08.01.08)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

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- JP 2003500306 PCT **[0016]**
- JP 63168238 A **[0016]**
- JP 9039975 A **[0016]**
- JP 1228567 A **[0016]**
- JP 2002317247 A **[0016]**
- JP 2002317248 A **[0016]**