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Fukuzuka et al.

[11] **3,820,368**

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[54] **PROCESS FOR PRODUCING DRINKING CANS MADE OF ALUMINUM-PLATED STEEL SHEET**

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[52] **U.S. Cl.** .... **72/47,** 72/349, 113/120 A

[51] **Int. Cl.** **B21c 23/24,** B21d 22/28

[58] **Field of Search** .... 72/46, 47, 347–350, 72/700; 113/120 A; 117/114 C; 220/64

[56] **References Cited**

UNITED STATES PATENTS

2,731,362	1/1956	Brondyke	117/114 C
2,752,268	1/1956	Whitfield et al.	117/114 C
2,926,103	2/1960	Brick	117/114 C
3,203,218	8/1965	Bolt et al.	72/349
3,220,876	11/1965	Moeller	117/114 C
3,360,157	12/1967	Bolt et al.	220/64
R23,095	3/1949	Keller	72/349

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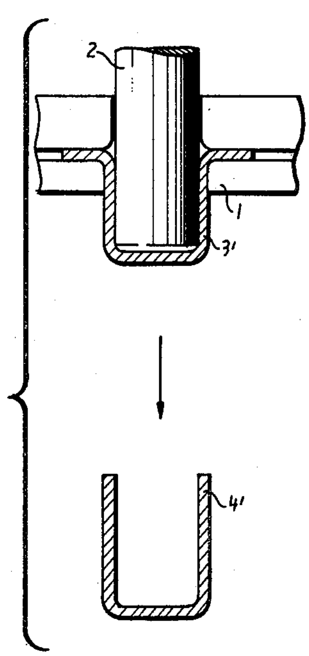
[57] **ABSTRACT**

A process for producing drinking cans made of an aluminum-plated steel sheet which comprises: forming an aluminum-plated steel sheet having a Rockwell H_RB hardeness of 45 to 75; by hot dipping a steel sheet into a molten aluminum bath containing more than 3% silicon to form a plated layer on said steel sheet, wherein said plated layer consists of an alloy layer not more than 5μ thick and an aluminum layer not less than 5μ thick and wherein the total thickness of said aluminum layer and said alloy layer ranges from 8μ to 25μ; drawing and ironing said aluminum-plated steel sheet to form the cup portion of a two-piece drinking can, wherein said drawing initially is conducted at an ironing rate ranging from 0 to 15 percent and said ironing is conducted in three or four successive stages at ironing rates progressively lower than the ironing rate used initially for said first stage.

2 Claims, 4 Drawing Figures



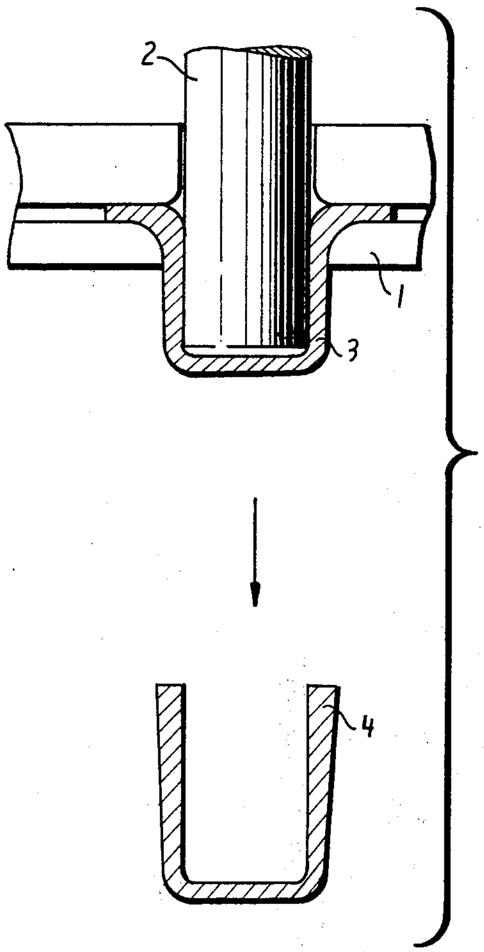


FIG. 1

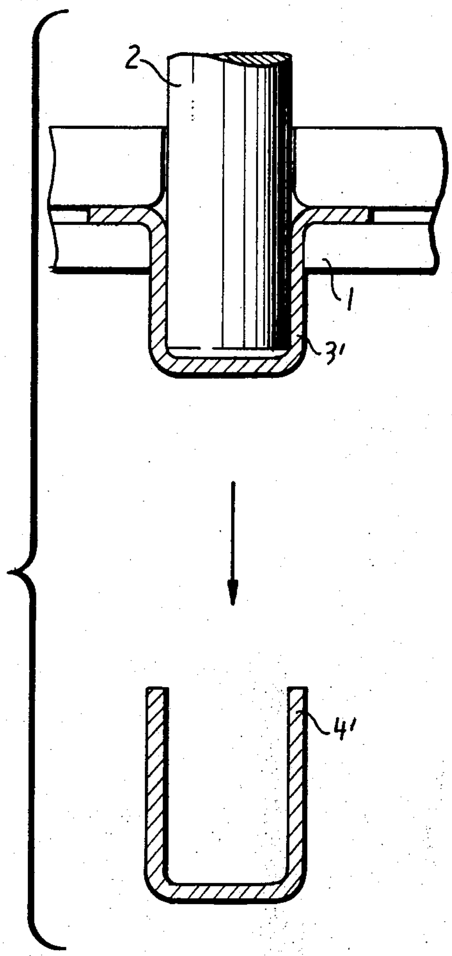


FIG. 2

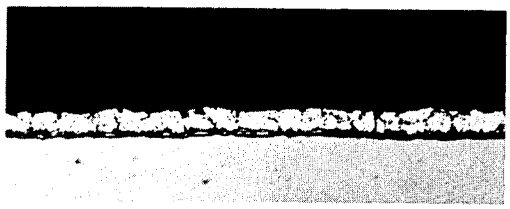


FIG. 3

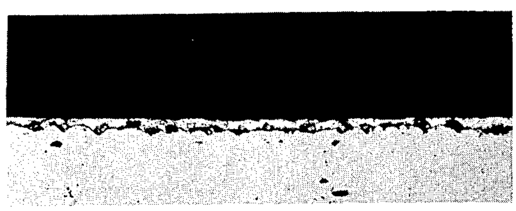


FIG. 4

PROCESS FOR PRODUCING DRINKING CANS MADE OF ALUMINUM-PLATED STEEL SHEET

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a process for producing drinking cans made of an aluminum-plated steel sheet, and more particularly to the combined steps of hot dipping a steel sheet into a molten aluminum bath followed by drawing and ironing the same into a two-piece drinking can.

2. Description of the Prior Art

Hitherto, drinking cans for beer and various kinds of juices, have been fabricated by first forming a shell portion and a bottom portion of the can, and then joining a separately formed top cover over said shell portion by a welding technique to produce a three-piece drinking can from a tin sheet. Recently, the need for a two-piece drinking can having a shell portion and a bottom portion integral therewith has resulted in the development of a drawing and ironing process which uses an aluminum sheet to form the cup portion of the can with the top cover joined over said shell portion. Because of the excellent corrosion resistance, good appearance and light weight, aluminum drinking can production has been greatly accelerated to meet the demand for the cans in the market.

The drawing and ironing process for producing aluminum cans has an advantage over the process for forming conventional three-piece cans in that the former process can save working costs considerably. However, the former process suffers from shortcomings in that the cans produced fail to afford a sufficient strength required for the cans in service because of the condition of the aluminum sheet. In addition, higher material costs accrue for the two-piece cans over the conventional three-piece cans because if a sufficient strength is to be achieved for the aluminum drinking cans made from two aluminum pieces, aluminum sheets thicker than those used in the conventional process are required.

A need therefore, exists for a process for fabricating improved two-piece aluminum drinking cans at lower material costs.

SUMMARY OF THE INVENTION

One object of the present invention is to provide the cup portion of a two piece drinking can which is made from an aluminum plated steel sheet by using the combined steps of hot dipping, and drawing and ironing the aluminized steel plate.

It is another object of the invention to provide two-piece drinking cans which have a good appearance, good strength and good corrosion resistance at a low cost.

Yet another object of the invention is to provide a process for forming an aluminum plated layer on a sheet followed by a drawing and ironing process of the plated sheet which provides a two-piece drinking can possessing the aforementioned advantages.

These objects and other objects of the invention as hereinafter will become apparent are attained by a process which comprises the combined steps of hot dipping a steel sheet into a molten aluminum bath to form a plated layer of a specific construction which includes an alloy layer not more than 5μ thick and an aluminum layer not less than 5μ thick, wherein the total thickness of said two layers is in the range from 8μ to 25μ and wherein the resultant Rockwell hardness of the aluminum-plated steel plate produced ranges from H_RB 45 to 75; and subsequently drawing and ironing the plated sheet to form the cup portion of the two-piece drinking can, wherein said ironing process during the drawing step is conducted at a rate ranging from 0 to 15 percent, and wherein the successive ironing rates of the at least three ironing stages used in the ironing step are gradually decreased from that used for the first stage as the ironing proceeds.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawing, wherein;

FIG. 1 is a schematic cross sectional view of a sheet blank as it is drawn by the conventional drawing process.

FIG. 2 is a similar schematic cross sectional view of a sheet blank as it is drawn and ironed by the process of the present invention.

FIGS. 3 and 4 show, respectively, a cross sectional view (×400) of the plated layer preparatory to working by drawing and ironing (8μ aluminum layer, 2μ alloy layer) and a cross sectional view (×400) thereof subsequent to said working (3μ plated layer).

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The thickness of the iron-aluminum alloy layers on the steel plate should be as thin as possible so that it may be suitable for the drawing and ironing steps, and so that separation and cracking of the plated layer can be prevented. Thus, the thickness of the layer is preferably 5μ. To obtain an iron-aluminum alloy layer less than 5μ thick, more than 3 percent silicon must be added to the aluminum bath.

The total thickness of the 8μ thick iron-aluminum alloy layer and the aluminum layer is the minimum value which maintains satisfactory corrosion resistance after working. As indicated earlier a thickness of 25μ is the maximum value allowable which permits satisfactory working of the plate without promoting cracking in- and separation of the plated layers from the base metal. Thus, the total thickness of the iron-aluminum alloy layer plus the aluminum layer should fall within the range from 10μ to 15μ. Furthermore, the thickness of the aluminum layer plated on the surface of the iron-aluminum alloy layer should be at least 5μ. The reason for this is that, as shown in Photograph 2, there is a tendency for the plated layer subsequent to the ironing step to cause the alloy layer to separate from the surface of the base steel sheet. This appears as dispersed islands which are covered by the aluminum layer. In this particular instance, however, if the thickness of the aluminum layer is less than 5μ, the aluminum layer fails to completely cover the dispersed islands which results in exposure of the alloy layer to the atmosphere. This, in turn, spoils the appearance of the product, and adversely affects the corrosion resistance of the plate.

These phenomena are very well illustrated in photographs 1 and 2 (FIGS. 3 and 4, respectively) which show respectively the cross sectional area of a plated layer preparatory to working by drawing and ironing and the cross sectional area thereof subsequent to said working, of a can formed from an aluminum-plated steel sheet, which sheet includes an iron-aluminum alloy layer of about 2μ thickness with the total thickness of the alloy layer and aluminum layer being 10μ thick.

Turning now to the drawing and ironing working process, it is obvious that the provision of the plated layer on the surface of a steel sheet aids in the fabrication of the sheet, as opposed to the instances where cold rolled steel sheets are not plated. However, insofar as maintaining the desired lubricating condition is concerned, the ironing workability depends on the mechanical properties of the material. In other words, the lower the hardness of the material, the greater its elongation. This results in better ironing workability of the material. Too high a hardness and too low an elongation will result in poor workability, and many difficulties in working.

Hardness of the material should desirably range from H_RB 45 to 75 and, most preferably, range from H_RB 50 to 60. Hardness over H_RB 75 results in difficult working, while production of aluminum plated steel sheets having a hardness less than H_RB 45 is not practicable from the viewpoint of technical consideration and thus is not necessary for practical purposes. Material having a hardness of from H_RB 50 to 60 is well suited for the formation of the cup portion of the can by the ironing working process.

In the working of materials having preferable ranges of plated layer thicknesses and hardness, not only can the limited drawing ratio (LDR) be raised, but also the workability during the drawing and ironing stages can be materially improved by adding a small degree of ironing to the drawing step. In conventional drawing procedures, a clearance is set between the inner diameter of the die 1 and the outer diameter of the punch 2, wherein the clearance is the sum of the thickness of the blank plus a certain amount of allowance. As is clear from FIG. 1, the amount of the flanged portion which flows or is drawn increases as drawing proceeds. Thus, the wall thickness of the cup portion 3 increases as the edge of the blank is approached. Because the wall thickness continuously thickens as the edge of the blank is approached, the cup 4 appears as an inverted conically shaped object as shown in FIG. 1. Ironing of a cup portion produced in this manner will give rise to an increase in the ironing rate as working proceeds. This leads to cracking or failure at the edges of the cup, with the accompanying disadvantage that the metal pieces produced present obstacles to continuous operation of the process. To overcome these shortcomings, it has been found effective to add a small degree of ironing to the drawing operation to obtain a uniform wall thickness for the cup portion 3' of the blank and the product cup 4' (FIG. 2).

The ironing rate as used herein is represented by the following formula:

$$\text{ironing rate} = T_0 - T_1/T_0$$

wherein T_0 represents the initial thickness of the blank and T_1 represents the thickness of the blank after it is ironed. Desirably, the ironing rate during drawing should be in the range from 0 to 15 percent, preferably from 5 to 10 percent. An ironing rate below 0 percent affords no advantage, and a rate over 15 percent will reduce the limited drawing ratio (LDR), which adversely effects the drawing.

In the ironing step, the optimum selection of the ironing rate may contribute to a great degree of workability. In other words, it is recommended to set the ironing rate as high as possible in the initial stages of the ironing by the tandem dies, after which, as working proceeds in the manner of the first and then the second ironing steps, the ironing rate should be decreased. Thus, smooth working and a great degree of workability can be achieved. A uniform distribution of the ironing rate, or a small degree of ironing in the initial stage of ironing followed by a gradual decrease of the ironing rate will lead to unsatisfactory results.

A test for drawing and ironing the aluminum-plated steel sheet reveals that the preferable thickness of the shell portion of the can should be in the range of from 0.08 to 0.15 mm. A wall thickness of the shell portion of the can less than 0.08 mm may not give a sufficient strength as required for cans of this kind. If the wall thickness is greater than 0.15 mm, the cost of the starting materials will be too high and these thicknesses are not necessary in practice.

As is apparent from the foregoing description, the two-piece aluminum drinking cans produced according to the process of the prevent invention, present a good appearance and have fewer joining portions compared to the conventional three-piece cans. These cans are obtainable because of the use of the ironing step with all of the attendant advantages of providing an extremely thin shell portion. Thus, considerable costs are saved because less expensive steel sheets are used.

Having now generally described the invention, a further understanding can be obtained by reference to certain specific examples which are provided herein for purposes of illustration only and are not intended to be limiting unless otherwise specified.

EXAMPLE 1

A steel sheet 0.32 mm thick which had been subjected, in turn, to a cold rolling, annealing, normalizing and rolling process was hot-dipped in a molten aluminum bath containing 7.2 percent silicon. An aluminum plated steel sheet was obtained which had a plated layer including an alloy layer 4μ thick and an aluminum layer on top of the alloy layer 17μ thick. The resulting plate has an H_RB hardness of 67.

The steel sheet thus prepared was then punched to give a blank having a diameter of 140 mm which in turn was subjected to ironing under the conditions shown in the following steps:

Drawing step (two stages)

Stage	Diameter of punch (mm)	Diameter of die (mm)
1st drawing	80.0	80.7
2nd drawing	64.1	64.8

Ironing step (continuous ironing in three stages)

Stage	Diameter of punch (mm)	Diameter of die (mm)	Ironing Rates (%)
1st ironing	64.0	64.50	28.6
2nd ironing	64.0	64.36	28.0
3rd ironing	64.0	64.26	27.8

The can produced had a bottom portion 0.36 mm thick with the metallic silver-white appearance inherent to aluminum-plated sheets, a shell portion with a 0.13 mm wall thickness and a plated layer about 8μ thick.

EXAMPLE 2

A cold rolled steel sheet 0.34 mm thick was annealed according to the in-line annealing system incorporated in the continuous aluminum hot dipping line, and then passed through a molten aluminum bath containing 8 percent silicon. After the treatment, the thickness of the plated layer was adjusted by a gas wiping process. An aluminum plated steel sheet was obtained having a plated layer which included an alloy layer 2μ thick and an aluminum layer on the surface of said alloy layer 8μ thick. The resulting plate had an H_RB hardness of 56.

The steel sheet thus prepared was then punched to give a blank having a diameter of 140 mm which in turn was subjected to ironing under the conditions in the following steps.

Drawing step (two stages)

Stage	Diameter of punch (mm)	Diameter of die (mm)
1st drawing	80.0	80.70
2nd drawing	64.1	64.80

Ironing step (continuous ironing step in four stages)

Stage	Diameter of of punch (mm)	Diameter of die (mm)	Ironing Rate (%)
1st ironing	64.0	64.47	32.9
2nd ironing	64.0	64.34	27.7
3rd ironing	64.0	64.26	23.5
4th ironing	64.0	64.20	23.1

The can produced had a bottom portion 0.36 mm thick with the metallic silver-white appearance inherent to aluminum-plated sheets, a shell portion with a 0.10 mm wall thickness and a plated layer about 3μ thick.

The test results are illustrative of the superb combination of steps which have been adapted for the production of drinking cans made from aluminum-plated steel sheets. The combination comprises hot dipping said steel sheet into a molten aluminum bath followed by drawing and ironing the steel sheet prepared. Both steps are characteristic of specific ranges of operational or working factors.

Having now fully described the invention, it will be apparent to one of ordinary skill in the art that many changes and modifications can be made there to without departing from the spirit or scope of the invention as set forth herein.

What is new and intended to be covered by Letters Patent is:

1. A process for producing drinking cans made of an aluminum-plated steel sheet which comprises:

forming an aluminum-plated steel sheet having a Rockwell H_RB hardness of 45 to 75 by hot dipping a steel sheet into a molten aluminum bath to form a plated layer on said steel sheet, wherein said plated layer consists of an alloy layer not more than 5μ thick and an aluminum layer not less than 5μ thick and wherein the total thickness of said aluminum layer and said alloy layer ranges from 8μ to 25μ; and

drawing and ironing said aluminum-plated steel sheet to form the cup portion of a two-piece drinking can, wherein said drawing step is initially conducted at an ironing rate ranging from 0 to 15 percent, and said ironing step is conducted in at least first, second and third successive stages, the ironing rates for said second and third stages being progressively lower than the ironing rate of said first ironing stage.

2. The process of claim **1**, wherein said ironing step further includes a fourth successive stage having an ironing rate lower than the ironing rate used for said third stage.

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