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[54] METHOD OF PRODUCING A DEEP DRAWN COMPOSITE ARTICLE

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[58] **Field of Search** 148/11.5, 34, 127; 29/194

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[57] **ABSTRACT**

A method of producing a deep drawn article wherein earing is eliminated or substantially lessened comprising integrally bonding a first metallic component having characteristic 45° earing propensity after deep drawing to a second metallic component having characteristic 90° earing propensity after deep drawing, and deep drawing, and the article produced thereby.

7 Claims, No Drawings

METHOD OF PRODUCING A DEEP DRAWN COMPOSITE ARTICLE

This invention relates generally to sheet metal and sheet metal processing, and more particularly to deep drawing and deep drawn articles.

Deep drawing of flat sheet metal is a long established and well-known method of producing cup-shaped articles from flat sheets, the process sometimes known as "cupping." Depending upon the type of article desired the cupping process may yield the finished article, at least as far as the basic shape is concerned, or only an intermediately shaped item from which other articles are fabricated through further processing of the basic cup, or through additional manufacturing in which the cup is merely a component of an assemblage. In any event, the formation of the cup is a critical step in any of the above processes; hence the nature and practice of the formation of the cup is of vital importance to the art of deep drawing of sheet metal.

This art has long been troubled by a characteristic of sheet metal known an "earing" which manifests itself as a scalloped appearance around the top edge of the formed cup. The scallops, or ears, are formed during the deep drawing step in the fabrication of the cup, and represent an almost universally undesirable feature of the article, whether it be finally shaped or intended for further processing of manufacturing. The result is that the ears must be eliminated in order to present a smooth or flat upper lip on the cup. This of course necessitates machining in the form of shearing or cutting, followed by additional finishing in some situations, with an attendant increase in production costs and higher costs resulting from increased material waste. It is evident, therefore, that the reduction or elimination of earing in the deep drawing of sheet metal represents a major contribution to this art.

To facilitate an understanding of the process of this invention, it becomes necessary to examine the causative aspects of the problem of earing. Generally speaking, earing is the manifestation of property anisotropy caused by crystallographic preferredness or by granular fibrous texturing within sheet or strip materials. More particularly, earing results as a result of the deep drawing of metal sheet or strip in which there exists a preferential directionality of ductility properties as distinguished from isotropy. The directionality of these ductility properties is a function either of atom slippage along slip lines within the normal texture of the metal grains, or of mechanical preferredness of the fibrous grain structure of the metal. The effect of the property anisotropy is that the physical properties of the metal are not the same in all directions, but rather vary in accordance with the directionality of the crystallographic structure or the fibrous grain texturing. The physical manifestation of this affect is that upon subsequent cold work by deep drawing, the metal cannot elongate or stretch as well in one direction relative to the original rolling direction as it can in another, with the result that troughs appear around the upper rim of the cup in those directions where the metal exhibits a greater resistance to stretching. Because of crystallographic symmetry this phenomenon results in ears oriented either paralled and perpendicular to the direction of rolling of the metal referred to as 90° earing, or with the ears oriented intermediate the quadrants defined by the rolling direction, referred to as 45° earing. It is, of course, these ears which make the product commercially uneconomic by necessitating additional processing with concomitant higher material and labor costs in order to provide an acceptable product.

From classical metallurgy it is known that in the face centered cubic metals, such as aluminum, copper, and gamma iron etc., and their alloys, that cold rolling increases the propensity for 45° earing; and that recrystallizing increases the propensity for 90° earing. Nevertheless in certain alloys the alloying elements can produce an overriding effect such that the alloys will display characteristic behavior.

The factors which effect earing within any particular alloy are the composition, the casting practice, preheating practice, hot rolling temperature and technique, slab and strip interannealing, cold rolling reduction and final annealing practices.

The above can be used to predict the ductility directionality of the composite of a multiple alloy system and thereby provide a complex system wherein earing is controlled.

It is therefore a principal object of the present invention to provide a method for producing a deep drawn article wherein earing is eliminated or substantially lessened during deep drawing.

It is a further object of the present invention to provide a new and improved article characterized by the elimination or reduction of earing after deep drawing.

Still further objects and advantages of the present invention will appear hereafter.

The process of the present invention comprises (A) providing a metal component having a characteristic 45° earing propensity, with respect to rolling direction after processing and deep drawing, and a metal component having a 90° characteristic earing propensity, with respect to rolling direction, after processing and deep drawing, (B) integrally bonding together said components to form an integrally bonded composite, (C) cold rolling and annealing said composite in order to assure that the components attain their characteristic earing propensity and (D) deep drawing the composite.

Naturally, the present invention contemplates a multiple component composite wherein the contribution of each component is predictable.

It has been found that a deep drawn article in accordance with the present invention possesses excellent strength characteristics and with earing substantially lessened, or eliminated, thereby promoting increased economy due to reduced trimming operations and attendant generated scrap.

As aforementioned, the type and degree of earing propensity is dependent upon the entire thermal and mechanical treatment of the metal or alloy, and may even vary for the same alloy composition.

Copper, aluminum, iron and alloys thereof, are suitable in the present invention and are the preferred metals. The particular metal or alloy employed is not critical so long as each component will possess different earing propensities after deep drawing. In general, however, the material is selected from the group consisting of copper, aluminum, iron, and alloys thereof.

The earing propensity for any particular metal or alloy may be readily determined by acturally deep drawing various metals and alloys in the cold rolled or annealed condition. Thus, which earing propensities will occur is predetermined for a metal or alloy, having a given history of prior mechanical and thermal treatment, prior to practicing the present invention.

Generally, but not necessarily, bonding is accomplished by hot rolling the components together. The degree of reduction during hot rolling is not especially critical to this invention but must be sufficient to form an integrally bonded composite. Likewise, the thicknesses of the individual components prior to hot rolling are not especially critical to this invention but generally range from 5 mils to 1 inch in thickness, with the proportion of one component to the total thickness of both components ranging from about 5.0 percent to about 50.0 percent.

The degree of reduction of the composite during cold rolling, however, may be critical as having an influence upon the earing propensity during deep drawing, and must be determined experimentally for a given metal or alloy as aforementioned. Generally, however the degree of cold reduction ranges from 10.0 to 80.0 percent.

It is preferred that only one of said components recrystallizes during the annealing step just before deep drawing since this will assure the characteristic 90° earing propensity of this component. Naturally, the annealing temperature is dependent upon the particular metals or alloys employed, and the degree to which they have been cold reduced. In general, however, depending upon which metals or alloys comprise the composite, the composite is annealed at from 300° to 1,400° F for about 1 minute to 5 hours wherein said composite has been cold reduced from about 10.0 to 80.0 percent.

The relative thicknesses of each component of the composite prior to deep drawing should be such as to provide the requisite reduction in earing for a given operation. Naturally a thinner component may be employed wherein a given propensity is low when bonded to a component of greater thickness in which the earing propensity is comparatively higher.

As aforementioned, the degree and type of earing propensity is determined by a variety of factors and therefore the exact alloy to be employed is determined by the prior mechanical working and thermal treatments given to a specified alloy. Naturally therefore a number of permissible alloy combinations of copper, iron or aluminum may be readily applicable to forming the composite.

A secondary purpose may also be served wherein in applications to different environments is easily provided for by the provision of the composite composed of different metals or alloys.

The present invention is more readily apparent from a consideration of the following illustrative examples.

EXAMPLE 1

Copper alloy 110 was integrally bonded to aluminum alloy 1100 in duplicate by hot rolling together and then cold rolling to approximately 60 percent reduction to form two composites approximately 0.061 in. thick. The composites were then annealed at 320° F for 1 hour, wherein the copper components were recrystallized and the aluminum components remained unrecrystallized, followed by deep drawing into articles approximately 1⅛ in. in diameter and 1⅛ in. in length. Duplicate strips of copper alloy 110 and aluminum alloy 1100, of the same prior mechanical and thermal heating were likewise rolled together and annealed, chemically separated, then deep drawn to show the earing propensities of each alloy after deep drawing into articles having the same dimensions. The results of the varying earing propensities of the two composites and of the alloy components after deep drawing are shown in the following table.

TABLE

Sample	Material	Annealing temp., ° F./1 hr.	Thickness, in.	Earing direction,[1] degree	*Ear height,[1] percent
A	Composite of copper alloy 110 bonded to aluminum alloy 1100 (50% copper plus 50% aluminum).	320	0.061	90	3.8
A	Copper alloy 110	320	0.029	90	7.8
A	Aluminum alloy 1100.	320	0.031	45	3.7
B	Composite of copper alloy 110 bonded to aluminum alloy 1100 (50% copper plus 50% aluminum).	320	0.061	45	4.7
B	Copper alloy 110	320	0.029	45	6.3
B	Aluminum alloy 1100.	320	0.031	45	3.4

[1] After deep drawing.
*Percentage of average height of the cup.

It is seen that by the combination of alloys having different earing propensities after heat treating and deep drawing significantly reduces the ear height of the finished article, thereby promoting a reduction in the amount of scrap generated by trimming of the article with a resultant increase in economy.

EXAMPLE 2

A sample of aluminum alloy 1100 was clad to half its width to copper alloy 110 and processed in a manner after samples A in example 1, except that the copper is about 25 percent of the thickness of the composite and the aluminum alloy is about 75 percent of the thickness of the composite wherein these components are bonded. A blanked disc was prepared wherein half of the blank was clad and wherein the thickness of the entire disc was uniform, i.e., the copper was inlaid. The disc was cupped as described above and the results show that the monolithic aluminum portion has high ears; whereas the clad metal has no ears due to the method of the present invention.

This invention may be embodied in other forms or carried out in other ways without departing from the spirt or essential characteristics thereof. The present embodiment is therefore to be considered as in all respects illustrative and not restrictive, the scope of the invention being indicated by the appended claims, and all changes which come within the meaning and range of equivalency are intended to be embraced therein.

What is claimed is:

1. A method of producing a deep drawn article wherein earing is eliminated or substantially lessened, comprising:
   A. providing a metal component having a characteristic 45° earing propensity, with respect to rolling direction after processing and deep drawing, and a metal component having a 90° characteristic earing propensity, with respect to rolling direction after processing and deep drawing,
   B. hot rolling together said components to form an integrally bonded composite,
   C. cold rolling and annealing said composite in order to assure that the components attain their characteristic earing propensity, and
   D. deep drawing the composite.

2. The method of claim 1 wherein said annealing temperature is from 300° to 1,400° F.

3. The method of claim 1 wherein at least one additional metallic component is integrally bonded in step (B) to form a multi-component article.

4. The method of claim 2 wherein said first component and said second component ranges from 5 mils to 1 inch in thickness before step C.

5. The method of claim 4 wherein one of said components is from 5.0 to 50.0 percent of the total thickness of both of said components.

6. The method of claim 5 wherein said first metallic component and said second metallic component are selected from the group consisting of copper, aluminum, iron, and alloys thereof.

7. The method of claim 6 wherein said first metallic component is copper and said second metallic component is aluminum.

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