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(54) METHOD OF PRODUCING ALUMINUM CAN SHEET

(57) A method for producing aluminum can sheet comprises the steps of providing a body made of an aluminum alloy type AA3004, AA3104 or other aluminum alloy suitable for making aluminum can sheet; homogenizing the body at a homogenization temperature of about 525°C or less; hot rolling the homogenized body in a single stand hot rolling mill to produce a hot rolled sheet, said hot rolled sheet exiting the single stand hot rolling mill at a hot rolling exit temperature lower than the hot rolling starting temperature with a hot mill exit gauge; annealing the sheet to form a recrystallized hot rolled sheet; and cold rolling the recrystallized annealed sheet to apply a cold reduction to produce a cold rolled sheet with a final gauge.

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Description

TECHNICAL FIELD AND PRIOR ART

[0001] The present invention relates to a method of producing aluminum can sheet.

[0002] When aluminum can sheet is formed into cup-shaped articles, a phenomenon known as "earing" usually occurs to some extent. Earing can be observed as a wave-shaped appearance around the top edge of the formed cup. The wave-like protruding portions, also known as "ears", are formed during the deep drawing step in the fabrication of the cup and represent an undesirable feature of the article. In aluminum can body stock (CBS), the cup is subsequently ironed in multiple rings which can accentuate the wavy ears. High earing can create transport problems with the cup as well as insufficient trim after ironing, clipped ears, and trimmer jams. These artefacts are not desirable in aluminum can manufacturing. Thus, it is desired to minimize earing in order to avoid these problems and to increase the quality of the cup.

[0003] It is known that can body stock material such as AA3004, AA3104 or other aluminum alloy is basically suitable for making aluminum can sheet with low earing characteristics provided that a suitable manufacturing process can be established.

[0004] There is a well-known process established in the aluminum industry for producing aluminum strip suitable for can body stock. This process includes hot rolling of an aluminum ingot through a rougher mill and then through a multi stand hot rolling mill, usually exiting at a high temperature to ensure fully recrystallized material obtained through a self-anneal process. This well-known method produces a final product with low earing and desirable mechanical characteristics. However, the installation and operation of such a hot continuous mill requires a major capital expenditure.

[0005] Modifications have already been proposed in the past in order to produce can sheet with commercially acceptable earing characteristics from a single stand reversing mill (see e.g. US 5,362,340 and US 5,362,341). According to the method of US 5,362,340 an aluminum alloy ingot is provided and is heated to a temperature between about 527°C to 571°C. After this, the ingot is hot rolled in a single-stand reversible hot mill to produce an intermediate gauge sheet. The intermediate gauge sheet, which is self-annealed or batch annealed, is then cold rolled to produce a final gauge aluminum can sheet having low earing characteristics. The relative low temperature homogenization (527°C to 571°C, preferably 543°C to 566 °C) is applied in order to avoid uncontrolled recrystallization during hot rolling in the single stand reversing mill.

[0006] Document EP 3 875 692 A1 discloses a method for producing aluminum can sheet, wherein a body made of an aluminum alloy type AA3004, AA3104 or other aluminum alloy suitable for making aluminum can sheet is heated to a homogenization temperature in the range of about 500 to 595°C and then hot rolled in a hot rolling mill to produce a hot rolled sheet, said hot rolled sheet exiting the hot rolling mill at a hot rolling exit temperature selected to substantially avoid recrystallization of the hot rolled sheet. Hot rolling may be performed in a single stand reversing mill. The hot rolled sheet in then cold rolled in a cold rolling mill to apply a cold reduction to produce a cold rolled sheet with a cold mill exit gauge smaller than the hot mill exit gauge, followed by annealing the cold rolled sheet in an intermediate temperature range selected to allow recrystallization of the cold rolled sheet to obtain a recrystallized annealed sheet. The recrystallized annealed sheet is then cold rolled to apply a cold reduction to produce a cold rolled sheet with a final gauge.

[0007] Carbon emissions reduction has taken center stage for aluminum producers over the past few years. Towards this direction, there is an increased demand of the industry for higher recycle content and lower CO_2 footprint of the can sheet production. A possible action is to increase the post-consumer scrap that is used to produce can sheet. The standard practice in the industry is mainly to use UBC (Used Beverage Cans) as the main post-consumer scrap source, mixed with very low quantities of primary aluminum. Also, except the UBC type of scrap, there are also some other post-consumer scrap types (mainly from aluminum foil recycling like household foil, yogurt lids etc.) which could be another possible addition, in order to increase the recycle content.

SUMMARY OF THE INVENTION

[0008] It is an object of the invention to provide a method of producing aluminum can sheet suitable for making aluminum cans using a single stand reversing hot rolling mill, wherein the aluminum sheet may have a higher recycle aluminium content produced with lower energy consumption and exhibits favorable earing characteristics after a deep drawing step and further allows producing stable cans with thin wall thickness.

[0009] This object is solved by a method comprising the features of claim 1. Preferred embodiments are defined in the dependent claims.

[0010] According to the method of producing aluminum can sheet, a body (also denoted as ingot) made of an aluminum alloy is provided. The aluminum alloy is selected so that it is suitable for making aluminum can sheet. Specifically, the aluminum alloy may be based on type AA3004, AA3104 or other aluminum alloy suitable for making aluminum can sheet, such as AA3204 alloy.

[0011] The body can be made of cast aluminum, which has subsequently been scalped to obtain a body suitable for further processing. The body is homogenized at a homogenization temperature in a certain temperature range for a while, then cooled to a hot rolling starting temperature below the homogenization temperature, followed by hot rolling the homogenized body in a single stand hot rolling mill to produce a hot rolled sheet, said hot rolled sheet exiting the single stand hot rolling mill at a hot rolling exit temperature lower than the hot rolling starting temperature with a hot mill exit gauge. The sheet is annealed to form a recrystallized hot rolled sheet by self-annealing or batch annealing depending on the hot rolling exit temperature, i.e. on the exit temperature of the last hot rolling coiling pass. The annealing is followed by cold rolling the recrystallized annealed sheet to apply a cold reduction to produce a cold rolled sheet with a final gauge.

[0012] Typical requirements for aluminum alloys suitable for making aluminum can sheet are described, for example, in the article "AlMn1Mg1 for Beverage Cans" by J. Hirsch in: "Virtual Fabrication of Aluminium Products" Wiley-VCH 2006 (ISBN: 3-527-31363-X), chapter I-4. In general, the material must provide an optimum combination of strength and sufficient forming properties. For aluminium (aluminum) strength is achieved by the combination of appropriate alloy addition for best solid solution hardening (e.g. by Mg and Mn) and pre-deformation (i.e. highly rolled sheet). Furthermore, strength must remain sufficiently high also after the subsequent paint baking cycles. Good formability is achieved by an optimum combination of alloy additions for good work hardening (Mg) with some particle strengthening effects (Mn). The latter also maintains homogeneous deformation and even provides a cleaning effect of the dies, preventing harmful oxide build up and galling. As a consequence, the common aluminium alloys used for the production of can bodies are AlMg1Mn1 = EN-AW 3004 and AlMg1Mn1(Cu) = EN-AW 3104, which meet best the requirements for can strength and formability.

[0013] Inventors have recognized that conventional post-consumer scrap sources of recycled aluminium material (such as UBC (Used Beverage Cans) and aluminum foil recycling like household foil, yogurt lids etc.) tend to result in relatively higher amount of Fe in the alloy when compared to using non-recycled base materials.

[0014] It has been observed that by increasing the Fe content in the alloy, the cube texture developed after intermediate annealing weakens and consequently produces high 45° at the final product. Final product with higher earing at 45° will have increased tear-off cans and low performance at the can-maker.

[0015] The method described in the current invention accounts for this undesirable tendency and overcomes this problem. A significant contribution to the technical solution is the step of homogenizing the ingots at homogenization temperatures of about 525°C or less, which is lower than the homogenization temperatures of the relevant prior art.

[0016] In other words: it appears that lowering the homogenization temperature considerably below the lowest temperature presently considered necessary to obtain low earing aluminium material is an effective measure to counterbalance negative effects caused by relatively higher amount of Fe in the alloy due to use of scrap materials.

[0017] Preferably, the homogenization should be carried out at a temperature range of 460-525°C. Holding times may preferably lie in a range between about 1 hour and about 22 hours holding time, for example.

[0018] Lowering the homogenization temperature ensures that the material will not be recrystallized at the coiling passes in the single stand reversing mill. On the other hand, after annealing the undesirable effect of lower cube density due to higher Fe content is partly or fully compensated in texture development by the effects obtained by using lower homogenization temperatures.

[0019] Homogenizing the ingots at lower temperature, also contributes to lower CO_2 footprint due to the lower energy consumption of the preheating furnace, relative to prior art and relative to the high temperature homogenization (600°C) that is required to the conventional process of can sheet production through a tandem hot mill.

[0020] It is presently considered by the inventors that the following mechanisms may contribute to this surprising positive results.

[0021] Earing of the material at the final gauge is resulting from the texture developed after annealing at the hot rolling band and the amount of cold work to the final gauge. The latter also controls the strength of the final product, and a minimum amount of cold work is required. Therefore, final product earing is mainly affected by the earing achieved after annealing i.e., the texture developed on the annealed hot bands.

[0022] Earing achieved after annealing is a result of the orientation of the new recrystallized grains. In general, grains with cube orientation will produce 0-90° earing while grains with rolling and random texture will produce earing at 45°. The balance between these orientations will define the amount of 0/90° earing of the annealed hot band.

[0023] In the case of can sheet material this amount is very important, and it must be well controlled. If 0/90° earing of the annealed hot band is too low, the final product will have strong 45° earing and the formed can will exhibit a profile with 4 high ears at 45°. On the other hand, if 0/90° earing is too high, the final product will have 8 or 6-ear profile, with two ears at 0-180° significant higher. It is well known from the can-making industry that both cases described above could require excessive trimming and will produce torn cans and should be avoided.

[0024] According to the literature, cube texture grains are in general nucleated at heterogeneities of the microstructure such as transition bands and flattened cube grains that were retained during hot deformation, which as a first approximation are considered constant. However, grains that nucleate at second phase particles larger than about 2μm will promote the development of a random texture at the expense of the cube texture, with the mechanism that is described as PSN (Particle Stimulated Nucleation). Therefore, the higher the amount of second phase particles, the higher the number of recrystallized grains with random orientation, the higher the 45°earing of the final can sheet.

[0025] The amount of second phase particles is influenced by the alloy composition and the homogenization treatment. Increasing the Fe content and/or applying high temperature homogenization will increase the number of the second phase particles capable for PSN mechanism by particle coarsening and will (i) produce higher 45° earing as described above, and (ii) promote recrystallization during the coiling passes. Also, second phase particles coarsen at high temperature homogenization.

[0026] Therefore, by applying a lower temperature homogenization particle coarsening is suppressed and the effectiveness of the PSN mechanism is reduced.

[0027] Homogenization treatment also affects the size of the second phase particles and the dispersoids (i.e. fine particles with sized of about 0,1μm that precipitate during homogenization). Dispersoids play a crucial role in the growth of the nucleated grains by a pinning effect. Depending on the dispersoid size and spacing between them, they could act as obstacles to the grain boundary movement of the new grains, preventing the growth of the new grains and inhibit recrystallization during the coiling passes. According to the literature the pinning effect is stronger when the dispersoid number is high (closed space) and small. These two conditions are favored by applying a lower homogenization temperature.

[0028] It appears that lowering the homogenization temperature contributes to obtaining smaller dispersoid size and spacing thereby enhancing the pinning effect.

[0029] In general, chemical compositions of AA3004, AA3104, AA3204 or other aluminum alloy suitable for making aluminum can sheet as well as other aluminum alloys are known to a person skilled in the art and are available e.g. in the Teal sheets of the Aluminum Association.

[0030] On the other hand, many aluminum alloys optimized for other purposes are not considered suitable for making aluminum can sheet in the context of this application. Those include, for example 1XXX series alloys (essentially pure aluminium with a minimum 99% aluminium content by weight), 2XXX series alloys alloyed with copper as a basic alloying element and capable of being precipitation hardened to strengths comparable to steel, 4XXX series alloys alloyed with silicon as a basic alloying element, 5XXX series alloys alloyed with magnesium as a basic alloying element to offer superb corrosion resistance, 6XXX series alloys alloyed with magnesium and silicon as basic alloying elements, 7XXX series alloys alloyed with zinc as a basic alloying element and capable of precipitation hardening, or 8XXX series are alloyed with other elements which are not covered by other series, such as Aluminium-lithium alloys.

[0031] In preferred embodiments aluminum alloys comprising the following chemical compositions may be used (all numbers in wt%): about 0.05 - 0.60 wt% Si (Silicon), preferably 0.15 - 0.5 wt% Si; about 0.10 - 0.80 wt% Fe (Iron), preferably 0.45 - 0.70 wt% Fe; about 0.70 - 1.50 wt% Mn (Manganese), preferably 0.80 - 1.40 wt% Mn; about 0.80 - 1.50 wt% Mg (Magnesium), preferably 0.90 - 1.30 wt% Mg; about 0.05 - 0.25 wt% Cu (Copper), preferably 0.10 - 0.25 wt% Cu; up to 0.10 wt% Ti (Titanium); up to 0.25 wt% Zn (Zinc); and up to 0.15 wt% impurities, preferably each of the impurities with less than 0.05 wt%; with the remainder as Al (Aluminum).

[0032] In preferred embodiments the Fe content is in the upper end of the range given above, wherein the Fe content may be at least 0,6wt%, preferably more than 0.60 wt% Fe up to 0.80 wt% Fe and/or 0,61wt%Fe or more.

[0033] In some embodiments the aluminium alloy comprises: about 0,20 - 0,40wt% Si, preferably about 0,30wt% Si; about 0,80 - 1,20wt% Mn, preferably about 0,90wt% Mn; about 0,90 - 1,40wt% Mg, preferably about 1,20wt% Mg; about 0,10 - 0,25wt% Cu, preferably about 0,17% Cu, and about 0,55 - 0,70wt% Fe, preferably about 0,60wt% Fe.

[0034] As mentioned above the method may be particularly useful if the alloy contains a relatively high amount of Fe. High Fe amounts can be present in all kinds of post-consumer scrap recycled aluminium material. Those materials can be recycled and used to make the alloy. In some embodiments the step of providing a body made of an aluminium alloy comprises forming an aluminium alloy based on a composition comprising 80% or more aluminium scrap and using this alloy in solidified form as the ingot. Thereby, the final product may contain a high percentage of recycled aluminium material.

[0035] The annealing step may include self-annealing. Self annealing may be caused mechanically by introducing a significanty fast and heavy reduction in thickness during final coiling passes in the single stand reversing mill, thereby increasing the temperature relative to the temperature level in preceding coiling passes without applying extra thermal energy. Temperature of the sheet material may be increased thereby from levels sufficiently low to prevent recrystallization (e.g. temperatures of about 260°C or less) to higher temperatures sufficient to initiate nucleation and growth of new grains (e.g. temperatures of about 330°C or more.)

[0036] In some cases annealing is exclusively performed by self-annealing, thereby saving costs for a separate batch furnace.

[0037] In preferred embodiments the annealing step includes batch annealing, which allows for a better control of the annealing effects. Batch annealing of coiled material may be done in a batch furnace. In this case it is not necessary to obtain self-annealing conditions in the final stages of hot rolling. In some cases self-annealing and subsequent batch annealing may be combined.

[0038] In some embodiments the step of annealing the sheet includes selectively self-annealing or furnace annealing the sheet to form a recrystallized hot rolled sheet, wherein (i) the sheet is self-annealed to a recrystallized annealed state while being coiled in the single stand reversing mill if the hot rolling exit temperature equals or exceeds a threshold temperature and (ii) wherein the hot rolled sheet is transferred from the single stand reversing mill to a batch furnace and annealed in the batch furnace at an annealing temperature in a range at or above the hot rolling exit temperature to allow recrystallization of the hot rolled sheet to obtain a recrystallized annealed sheet, if the hot rolling exit temperature is below the threshold temperature. In some cases the threshold temperature is 330°C.

[0039] Regarding temperature ranges it has been observed that it is beneficial in many cases if the material temperature after the last flat pass is between 290°C and 350°C. Alternatively, or in addition it has been found that good results are more prominent if the material temperature is in a range between about 220°C and about 280°C in all coiling passes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] In the following, embodiments of the invention will be described in detail with reference to the drawings. Throughout the drawings, the same elements will be denoted by the same reference numerals.

Fig. 1 shows a schematic drawing of a portion of an installation configured to manufacture aluminum can sheet suitable for making cup-shaped articles;

Fig. 2 shows a graph illustrating earing of the final product for different production processes, wherein negative earing values correspond to earing at 45° while positive values correspond to 0-90° earing, with respect to the rolling direction.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0041] Sufficiently high strength and formability (incl. limited earing) are amongst the major requirements for aluminum can body sheet. High strength is needed to achieve sufficient structural stability and to avoid buckling of the can base (dome reversal) under high internal pressure. High strength is also needed to obtain stable cans with very thin can wall after ironing. Good Formability is required as the material undergoes heavy forming operations. Anisotropic material flow due to the texture of the sheet - controlled by balancing the hot strip cube and cold rolling texture - always forms an uneven rim of the can during the deep drawing and ironing operations. This unevenness is also known as "earing". Highly uneven cup rims are detrimental for transport of the can bodies or affect the whole process when ears are stretched and clipped off during ironing, leading to machine down time, reducing efficiency.

[0042] Embodiments of the invention are capable of addressing both requirements in a satisfactory way using an economically feasible production process.

[0043] Figure 1 shows a schematic drawing of a portion of an installation 100 configured to manufacture aluminum can sheet suitable for making cup-shaped articles. The schematic figure shows only some of the devices utilized in the production route.

[0044] The production installation typically includes casting devices to produce large cast ingots from aluminum alloy melt. The cast ingots typically consist of coarse grains with dendrite structure and random texture. Precipitates comprising aluminum and other constituents, such as Fe, Mn, and Si are typically distributed inhomogeneously in the cast ingot.

[0045] In some embodiments the aluminium alloy contains considerable amounts of conventional post-consumer scrap sources of recycled aluminium material, such as UBC (Used Beverage Cans) and aluminum foil recycling like household foil, yogurt lids etc.). This tends to cause a relatively higher amount of Fe in the alloy when compared to using non-recycled base materials.

[0046] In a next step, the cast ingots are preheated and thereby homogenized in a homogenization furnace 110 (also denoted as preheating furnace 110) The homogenization treatment is typically accompanied by characteristic changes of the solute content and the precipitation microstructure later affecting recrystallization, grain size and texture during the sheet production.

[0047] The homogenized ingots are then transferred to the hot rolling stage. A single stand reversing mill 120 is used for hot rolling in the installation. The single stand reversing mill 120 is capable of being operated in two different operation modes drawn separately in schematic Fig. 1. In a first operation mode HR-FP (shown on the left hand side of single stand reversing mill 120), the incoming ingots are reduced in thickness using several flat passes where the material is rolled back and forth without being coiled on either side of the rolls. In a second operation mode HR-CP, shown on the right-hand side of the drawing representing the single stand reversing mill 120, coiling reels CR on either side of the mill stand MS are used to coil the sheet SH between coiling passes performed in mutually opposite rolling directions. In either coiling pass, one of the reels is operating as pay-off reel providing an incoming strip to the rolling gap formed in the mill stand. The other reel is used as a tension reel coiling the outgoing strip after the rolling path. Since single-stand reversing mills are generally known in the art, a detailed description is considered as not necessary in this application.

[0048] The process does not require a cold rolling step immediately following the hot rolling step. Instead, the further process steps are dependent from certain conditions determining the recrystallization properties of the material in the process.

[0049] Specifically, the sheet is selectively self-annealed or furnace annealed to form a recrystallized hot rolled sheet. The sheet is self-annealed to a recrystallized annealed state while being coiled in the single stand reversing mill if the hot rolling exit temperature equals or exceeds a threshold temperature, such as for example is 330°C. On the other hand, if the hot rolling exit temperature is below the threshold temperature (e.g. 330°C), then the hot rolled sheet is transferred from the single stand reversing mill 120 to a batch furnace 140 and annealed in the batch furnace at an annealing temperature in a range at or above the hot rolling exit temperature or the threshold temperature to allow recrystallization of the hot rolled sheet to obtain a recrystallized annealed sheet.

[0050] In the embodiment, a batch furnace 140 is arranged downstream of the hot rolling stage 120. The batch furnace is configured to receive multiple coils CL after cold rolling and to perform annealing of the material received from the hot rolling stage to achieve full recrystallization of the sheet material.

[0051] A cold rolling stage 150 is arranged downstream of annealing batch furnace 140 to apply cold rolling to the recrystallized material to obtain cold rolled material at the final gauge desired for further processing steps, The cold rolling mill 150 comprises a single stand in the embodiment of Fig. 1.

[0052] An exemplary process for producing aluminum can sheet on the installation 100 may be performed as follows.

[0053] Aluminum alloy AA3004 or AA3104 or (other aluminum alloy suitable for making aluminum can sheet) ingots is cast. The aluminum alloy used in this process may contain about 0,30% Si, about 0,90% Mn, about 1,20% Mg, about 0,17% Cu. Fe content may be about 0,60% or higher, in order to increase the usage of post-consumer scrap. Post-consumer scrap aluminium was used to produce the alloy with 0,61% Fe content.

[0054] After casting the ingots are scalped to remove the surface irregularities and the shell zone, resulting from the DC casting process.

[0055] The next step is the preheating step, or homogenization step, of the ingot, in the preheating furnace 110. Homogenization may be performed at a temperature around 520°C with a holding time of around 6 hours.

[0056] The preheated (homogenized) ingot is then transferred to the hot rolling single stand reversing mill 120. The hot rolling may start at around 500°C where the ingot thickness may be reduced from 600 mm down to around 30 mm with several flat passes. The ingot temperature after the last flat pass may be around 310°C.

[0057] After the flat passes, thickness reduction may be achieved on the same single stand reversing mill 120, but this time after each pass then material may be coiled (see HR-CP in Fig. 1). Material finishing thickness after hot rolling may be around 2 mm, for example. Preferably, the sheet exit thickness after hot rolling may be from about 1,7mm to about 5mm.

[0058] Hot rolling exit temperature (after the last coiling pass) can vary. If the exit temperature is higher than 330°C then the coil may be self-annealed. If the exit temperature is lower than 330°C, then a batch annealing process in the batch furnace 140 may follow to ensure that the material is in soft condition (fully recrystallized) before cold rolling. Batch annealing temperature may be around 390°C with 3 hours holding time at this temperature.

[0059] The main objective of the hot rolling process is to ensure the absence of recrystallization during the coiling passes. For this reason, the temperature during coiling passes (except last one) may be around 270°C. Regarding the last coiling pass the absence of recrystallization is not so important and the material may also become partially recrystallized (due to <330°C exit temperature) because the next step is batch annealing, where the recrystallization may be completed.

[0060] The recrystallized annealed coil may then be transferred to cold rolling in the cold rolling mill 150, where the material is cold rolled to the final gauge with around 90% total cold reduction.

[0061] An industrial trial was conducted with the proposed homogenization parameters (520°C - 6h) and Fe content of more than 0,6 wt%, specifically with about 0,61wt% Fe. For comparison reasons, the following combinations of homogenization treatment and Fe content were produced:

(A) Typical homogenization (540-560°C - 12h) / Typical Fe (around 0,50%)
(B) Typical homogenization / High Fe
(C) Low temperature homogenization / High Fe

[0062] In the typical homogenization the typical homogenization temperatures were selected to lie within the conventional temperature range disclosed in US 5,362,340, for example.

[0063] The graph in Fig. 2 illustrates the final earing achieved from each combination. The ordinate axis (y-axis) represents the type and amount of earing at final thickness (in percent). The area above the baseline (dashed line at 0% earing) corresponds to 0 - 90° earing, whereas the area below the baseline represents 45° earing. The absolute distance of a data point from the baseline in the y-direction of the diagram represents the amount or strength of the respective earing, meaning that a point on the baseline corresponds to a sheet showing no earing at all. The schematic box plots in Fig. 2 indicate the results of the industrial trials.

[0064] Result A is considered representative for many conventional cases using not too high Fe contents in the alloy and relatively high homogenization temperatures (540°C or more) resulting in very good earing behavior.

[0065] Result B appears to indicate that conventional, relatively high homogenization temperatures (homogenization temperatures about 540°C or more) may not result in good earring behavior if the Fe content in the alloy is in the higher allowable range at about 0.6wt%Fe.

[0066] Result C appears to indicate that a low temperature homogenization as proposed in this application may result in decent earring behavior if the Fe content in the alloy is in the higher allowable range at about

0.6wt%Fe. For high Fe alloys the low temperature homogenization yields significantly better earring behavior than a homogenization at higher temperatures.

[0067] Therefore, it is concluded from the results shown in the graph that by increasing the Fe content only, without changing the homogenization conditions, final earing shifts to significant higher values of earing at 45° direction, which could result in poor performance to the can maker. In contrast, by applying a lower homogenization temperature (here below 520°C) final earing shifts to lower values, close to the typical values of the can sheet.

Claims

1. A method for producing aluminum can sheet comprising:

   providing a body made of an aluminum alloy type AA3004, AA3104 or other aluminum alloy suitable for making aluminum can sheet;
   homogenizing the body at a homogenization temperature of about 525°C or less;
   hot rolling the homogenized body in a single stand hot rolling mill to produce a hot rolled sheet, said hot rolled sheet exiting the single stand hot rolling mill at a hot rolling exit temperature lower than a hot rolling starting temperature with a hot mill exit gauge;
   annealing the sheet to form a recrystallized hot rolled sheet,
   cold rolling the recrystallized annealed sheet to apply a cold reduction to produce a cold rolled sheet with a final gauge.

2. The method according to claim 1, wherein the homogenization is carried out in a homogenization temperature range of 460°C to 525°C, preferably with holding times in a range between about 1 hour and about 22 hours holding time.

3. The method according to claim 1 or 2, wherein the aluminum alloy comprises the following chemical composition (all numbers in wt%): about 0.05 - 0.60 wt% Si (Silicon), preferably 0.15 - 0.5 wt% Si; about 0.10 - 0.80 wt% Fe (Iron), preferably 0.45 - 0.70 wt% Fe; about 0.70 - 1.50 wt% Mn (Manganese), preferably 0.80 - 1.40 wt% Mn; about 0.80 - 1.50 wt% Mg (Magnesium), preferably 0.90 - 1.30 wt% Mg; about 0.05 - 0.25 wt% Cu (Copper), preferably 0.10 - 0.25 wt% Cu; up to 0.10 wt% Ti (Titanium); up to 0.25 wt% Zn (Zinc); and up to 0.15 wt% impurities, preferably each of the impurities with less than 0.05 wt%; with the remainder as Al (Aluminum).

4. The method of claim 3, wherein the aluminium alloy comprises at least 0.6 wt% Fe, preferably more than 0,6 wt% Fe and/or 0,61wt% Fe or more.

5. The method according to one of claims 1 to 4, wherein the aluminium alloy comprises:

   about 0,20 - 0,40wt% Si, preferably about 0,30wt% Si;
   about 0,80 - 1,20wt% Mn, preferably about 0,90wt% Mn;
   about 0,90 - 1,40wt% Mg, preferably about 1,20wt% Mg;
   about 0,10 - 0,25wt% Cu, preferably about 0,17% Cu, and
   about 0,55 - 0,70wt% Fe, preferably about 0,60wt% Fe.

6. The method according to one of claims 1 to 5, wherein the step of providing a body made of an aluminium alloy comprises forming an aluminium alloy based on a composition comprising 80% or more aluminium scrap.

7. The method according to one of claims 1 to 6, wherein the step of annealing the sheet includes selectively self-annealing or furnace annealing the sheet to form a recrystallized hot rolled sheet, wherein

   (i) the sheet is self-annealed to a recrystallized annealed state while being coiled in the single stand reversing mill if the hot rolling exit temperature equals or exceeds a threshold temperature;
   (ii) the hot rolled sheet is transferred from the single stand reversing mill to a batch furnace and annealed in the batch furnace at an annealing temperature in a range at or above the hot rolling exit temperature to allow recrystallization of the hot rolled sheet to obtain a recrystallized annealed sheet, if the hot rolling exit temperature is below the threshold temperature

8. The method of claim 7, wherein the threshold temperature is 330°C.

9. The method of one of claims 1 to 8, claim 3, wherein hot rolling includes a number of flat passes followed by a number of coiling passes.

10. The method of claim 9, wherein the material temperature after the last flat pass is between 290°C and 350°C

11. The method of claim 9 or 10, wherein the material temperature is in a range between about 220°C and about 280°C in all coiling passes.

Amended claims in accordance with Rule 137(2) EPC.

1. A method for producing aluminum can sheet comprising:

   providing a body made of an aluminum alloy type AA3004, AA3104 or other aluminum alloy suitable for making aluminum can sheet, wherein the aluminum alloy comprises the following chemical composition (all numbers in wt%): about 0.05 - 0.60 wt% Si (Silicon); more than 0.60 wt% up to 0.80 wt% Fe (iron); about 0.70 - 1.50 wt% Mn (Manganese); about 0.80 - 1.50 wt% Mg (Magnesium); about 0.05 - 0.25 wt% Cu (Copper), up to 0.10 wt% Ti (Titanium); up to 0.25 wt% Zn (Zinc); and up to 0.15 wt% impurities; with the remainder as Al (Aluminum);
   homogenizing the body at a homogenization temperature of about 525°C or less;
   hot rolling the homogenized body in a single stand hot rolling mill to produce a hot rolled sheet, said hot rolled sheet exiting the single stand hot rolling mill at a hot rolling exit temperature lower than a hot rolling starting temperature with a hot mill exit gauge;
   annealing the sheet to form a recrystallized hot rolled sheet,
   cold rolling the recrystallized annealed sheet to apply a cold reduction to produce a cold rolled sheet with a final gauge.

2. The method according to claim 1, wherein the homogenization is carried out in a homogenization temperature range of 460°C to 525°C, preferably with holding times in a range between about 1 hour and about 22 hours holding time.

3. The method according to claim 1 or 2, wherein the aluminum alloy comprises: 0.15 - 0.5 wt% Si and/or more than 0.60 wt% up to 0.70 wt% Fe and/or 0.80 - 1.40 wt% Mn and/or 0.90 - 1.30 wt% Mg; 0.10 - 0.25 wt% Cu and/or up to 0.10 wt% Ti (Titanium) and/or up to 0.25 wt% Zn (Zinc); and up to 0.15 wt% impurities, each of the impurities with less than 0.05 wt%; with the remainder as Al (Aluminum).

4. The method of claim 3, wherein the aluminium alloy comprises 0,61wt% Fe or more.

5. The method according to one of claims 1 to 4, wherein the aluminium alloy comprises:

   about 0,20 - 0,40wt% Si, preferably about 0,30wt% Si;
   about 0,80 - 1,20wt% Mn, preferably about 0,90wt% Mn;
   about 0,90 - 1,40wt% Mg, preferably about 1,20wt% Mg;
   about 0,10 - 0,25wt% Cu, preferably about 0,17% Cu.

6. The method according to one of claims 1 to 5, wherein the step of providing a body made of an aluminium alloy comprises forming an aluminium alloy based on a composition comprising 80% or more aluminium scrap.

7. The method according to one of claims 1 to 6, wherein the step of annealing the sheet includes selectively self-annealing or furnace annealing the sheet to form a recrystallized hot rolled sheet, wherein

   (i) the sheet is self-annealed to a recrystallized annealed state while being coiled in the single stand reversing mill if the hot rolling exit temperature equals or exceeds a threshold temperature;
   (ii) the hot rolled sheet is transferred from the single stand reversing mill to a batch furnace and annealed in the batch furnace at an annealing temperature in a range at or above the hot rolling exit temperature to allow recrystallization of the hot rolled sheet to obtain a recrystallized annealed sheet, if the hot rolling exit temperature is below the threshold temperature

8. The method of claim 7, wherein the threshold temperature is 330°C.

9. The method of one of claims 1 to 8, claim 3, wherein hot rolling includes a number of flat passes followed by a number of coiling passes.

10. The method of claim 9, wherein the material temperature after the last flat pass is between 290°C and 350°C

11. The method of claim 9 or 10, wherein the material temperature is in a range between about 220°C and about 280°C in all coiling passes.

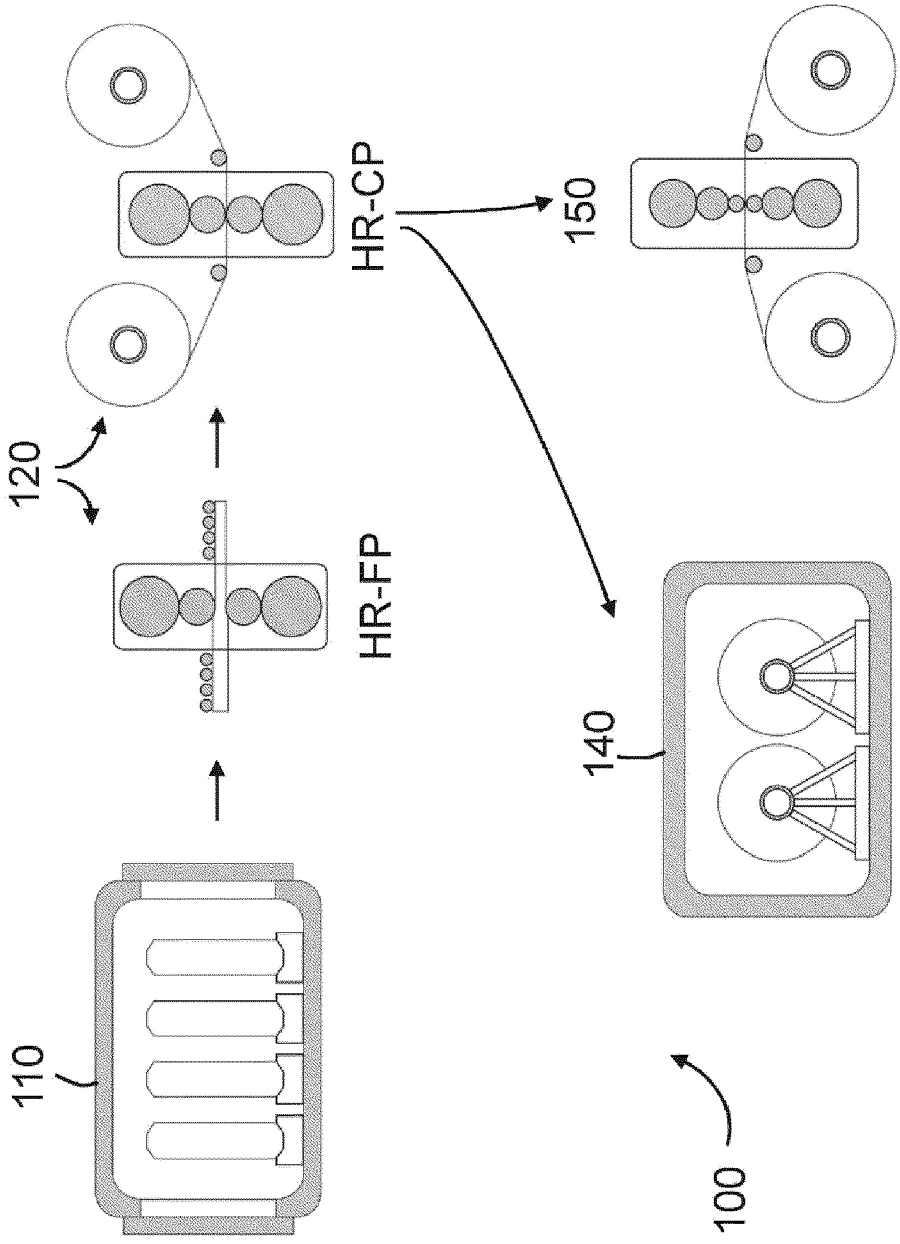
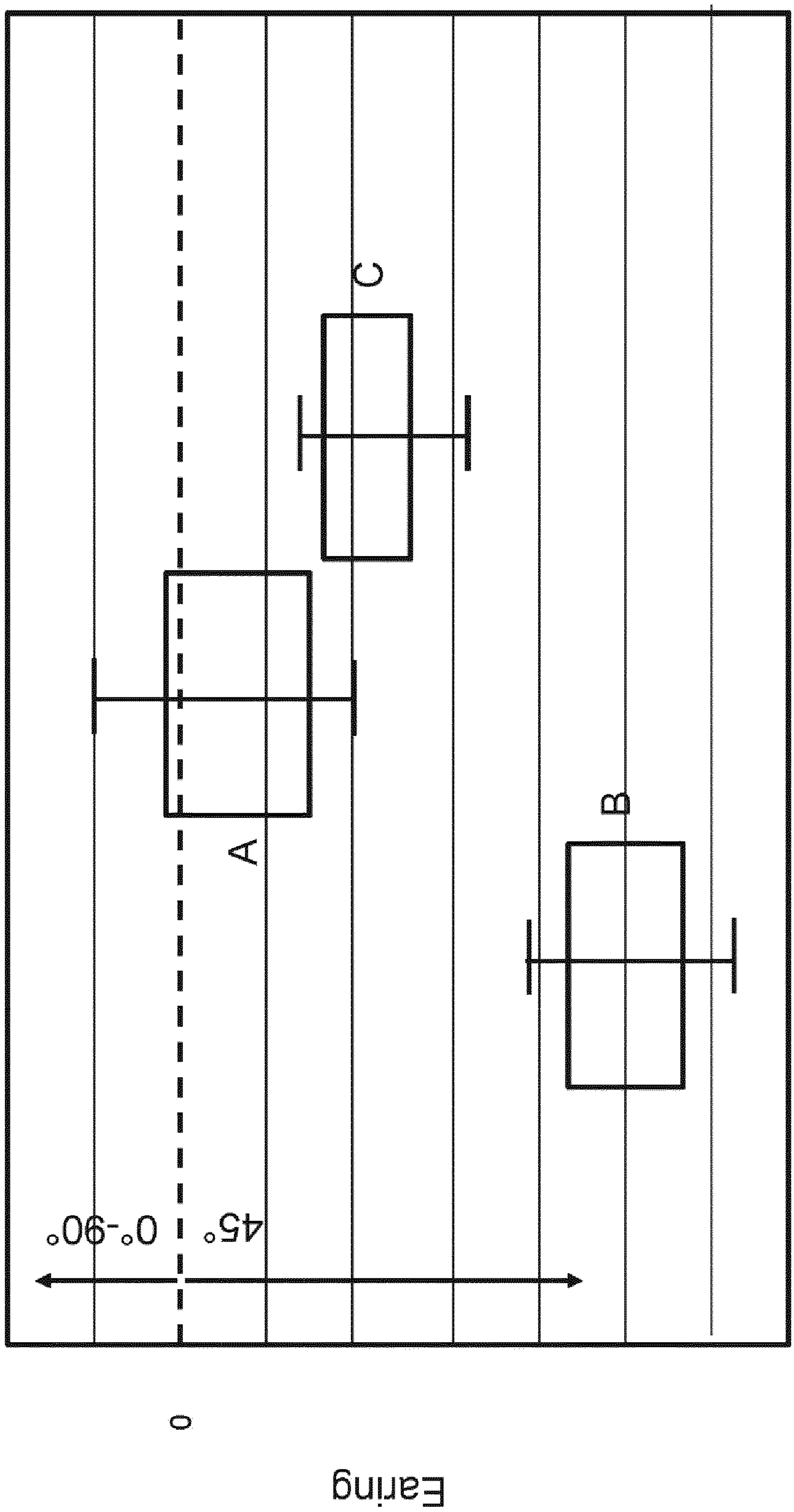


Fig. 1

Fig. 2



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EUROPEAN SEARCH REPORT

Application Number
EP 22 18 4857

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Place of search	Date of completion of the search	Examiner
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