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(54) ALUMINIUM ALLOY FOR AEROSOL CANS MANUFACTURED BY THE IMPACT EXTRUSION AND THE PROCESS FOR PREPARATION THEREOF

(57) The subject of the invention is aluminium alloy for manufacturing of aerosol cans by impact extrusion and the procedss for its preparation. Aluminium alloy provides constant mechanical properties before and after polymerization and solves the problem of mechanical properties decrease after the drying process of the internal colour (after polymerization). Polymerization of aerosol cans takes place at around 250 °C, which causes decrease of mechanical properties up to 15 %. At such high temperatures the process of recrystallization starts which has negative influence on mechanical properties.

Alloy according to the invention contains alloying elements in mass percent: 0.1-0.55 % Fe, 0.05-0.2 % Si, do 0.01 % Mg, do 0.01 % Cu, do 0.02 % Zn, do 0.03 % Ti, 0.01-0.6 % Mn, 0.05-0.2 % Zr, the rest is Al. Chemical composition of the alloy ensures the move of the recrystallization threshold to the higher temperatures and maintains mechanical properties. With the alloy aerosol cans with 5 bar higher deformable and burst pressure can be produced. Aluminium alloy is prepared in the melting furnace from where it is poured into the casting furnace, where alloying and processing of alloy is done. From the alloy the aluminium narrow strip is casted by the "rotary strip caster" method and from said strip the slugs are stamped, which are used in the production of aerosol cans by impact extrusion.

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Description

Field of Technology

[0001] Aluminium alloys; »rotary strip caster system«; alloying elements; element zirconium; recrystallization threshold; slugs.

Technical Problem

[0002] The manufacturing process of aerosol cans is composed of several stages. First the body of aerosol cans is formed from the slug by the impact extrusion. After the impact extrusion the colouring of the internal surface of aerosol can and polymerization of the colour at around 250 °C follows. In the next step colouring of the external surface follows and drying at around 150 °C, printing and drying of the print at around 150 °C, lacquering of the external surface and drying at around 190 °C. The last step is the formation of the can neck in the multi-die necking machine.

[0003] Aerosol cans are generally made from the aluminium alloys series 1XXX and also from the alloys series 3XXX. The problem that arises with manufacturing of aerosol cans is the decrease of mechanical properties up to 15 % after polymerization of internal colour. At such high temperatures the process of recrystallization starts, which causes the decrease of mechanical properties.

State of the Art

[0004] Aluminium aerosol cans are manufactured from aluminium slugs by impact extrusion from the alloys series 1XXX and also from the series 3XXX, which are previously stamped from the aluminium narrow strip. Marks 1XXX in 3XXX are summarized from international labelling system. The first number indicates the group of alloys, the second number indicates a possible version of the original alloy, the last number in series 1 XXX represents the purity of aluminium, and in other series, a combination of alloying elements.

[0005] In the first step the body of aerosol can by the impact extrusion from slug is formed. In the next step the aerosol cans are internally coated and dryed (polymerization) at around 250 °C. After polymeritzation the external coating, printing and lacquering follow. Drying of the external colour, printing and lacquering takes place at around 150 - 190 °C. In the last step the neck of the aerosol can on the multi-die necking machine is formed.

[0006] Aluminium alloys from series 1XXX are used for production of aerosol cans because they have good manufacturability at impact extrusion. New aluminium alloys from Al-Mg-Si system were developed, which enable production of aerosol cans.

[0007] Aluminium alloy for production of aerosol cans from the system Al-Mg-Si, according to the patent FR-A-2457328 is composed from the next alloying elements:

- 0.19 weight % Fe (iron)
- < 0.01 weight % Zr (zirconium)
- 0.3 weight % Si (silicon)
- 0.34 weight % Mg (magnesium)
- < 0.01 weight % Cu (cooper)
- < 0.01 weight % Zn (zinc)
- < 0.01 weight % Zn (nickel)
- 0.017 weight % Ti (titanium)
- < 0.01 weight % Mn (manganese)
- < 0.01 weight % Cr (chromium),

the rest is Al (aluminium).

[0008] Alloy for aerosol cans production from system Al-Mg-Si according to the patent US 7,520,044 B2 is composed from the next alloying elements:

- 0.12 do 0.20 weight % Fe (iron)
- 0.35 do 0.45 weight % Si (silicon)
- 0.25 do 0.40 weight % Mg (magnesium)
- 0.05 do 0.15 weight % Mn (manganese),

the rest is Al (aluminium).

Description of the invention

[0009] The subject of the invention is aluminium alloy for the production of aerosol cans by the impact extrusion and the process for its preparation and solves the technical problems of:

- casting of the aluminium narrow strip with high casting speed by the "rotary strip caster" method and with the excellent surface and with minimal defects,
- preservation of mechanical properties after polymerization, which is expressed in higher deformable and burst pressure of the aerosol can,
- providing good transformation and the provision of adequate surface of aerosol can after impact extrusion.

[0010] The subject of the invention is aluminium alloy which has the following alloying elements:

- 0.1 to 0.55 weight % Fe (iron)
- 0.05 to 0.2 weight % Si (silicon)
- < 0.01 weight % Mg (magnesium)
- < 0.01 weight % Cu (cooper)
- < 0.02 weight % Zn (zinc)
- 0.0 do 0.03 weight % Ti (titanium)
- 0.01 do 0.6 weight % Mn (manganese)
- 0.05 do 0.2 weight % Zr (zirconium).

the rest is Al (aluminium).

[0011] Aluminium narrow strip for the production of the slugs, from which aerosol cans are made, is produced by "rotary strip caster" method. Alloy according to the invention enables the casting of the aluminium narrow strip at high casting speeds, excellent surface and minimal defects on the surface or in the strip.

[0012] With this method, the melt is poured into the groove of the copper or steel casting wheel surrounded by a continuous steel belt. The belt closes the groove and prevents the outflow of the melt.

[0013] Aluminium alloy melt is produced in a melting furnace which is fed with the T-form blocks of electrolytic aluminium or with the electrolytic aluminium and with the process scrap obtained from stamping. When aluminium in the furnace is in liquid form with the temperature of approximately 720 °C, dross is removed from the melt and melt is poured into the holding furnace, where alloying of aluminium melt is performed.

[0014] In accordance with the required chemical composition of the alloy, alloying elements, such as manganese (Mn), iron (Fe), silicon (Si), titanium (Ti) and zirconium (Zr) are added. The majority of alloying elements are added into the aluminium melt in the form of tablets, small blocks or wire. Master alloys AlTi75% and AlFe75% are added in the form of tablets, while manganese as the master alloy AlMn25% is added in the form of blocks or ingots. The number and the % written next to the reference of the master alloy indicate the mass fraction of added alloying element to aluminium. For example, the indication AlFe75% means that the master alloy contains approximately a 75% mass fraction of iron. Silicon is added into the melt in the form of metallurgical pure silicon. Master alloy AlTi5B1 (5% titanium; 1% boron (B) is added in the form of wire, which also serves to refine the microstructure of the alloy. Zirconium (Zr) is added into the aluminium alloy in the form of master alloy, for example in the form of master alloy AlZr20%. To obtain the optimal effect of Zr, Zr is added within the limits 0.08 to 0.2 of mass fraction. In case of alloying with manganese, iron or zirconium, care must be taken to ensure that they are alloyed at least in 15-minute intervals, otherwise complex intermetallic phases may be formed between alloying elements.

[0015] After alloying, gases must be removed from the melt. Gases are removed from the melt already in the melting and casting/holding furnace with the so - called porous plugs. In the melting and casting/holding furnace the porous plugs are installed on the bottom, which serve for degassing of the melt with the inert gas argon. Argon filter fitted between the casting furnace and the casting machine is used in the manufacturing process. It is installed in a sink consisting of the mixing and the flow chamber. Argon (Ar) is injected into the melt through a graphite stirrer, in the flow chamber. Behind this sink is ceramic foam filter, used to remove metal and non metal inclusions from the melt.

[0016] In the melting furnace, in the casting furnace and in the mixing chamber of the filter Argon is dispersed in the melt in the form of small gas bubbles diffused with hydrogen (H). This process continues until the partial pressures of hydrogen and the gas bubble are equal. As a result of buoyancy, bubbles rise to the surface, where hydrogen combusts. When hydrogen and other undesired impurities are removed from the melt, the melt travels from the flow filter through the ceramic filter where inclusions of oxides, slag residues and impurities from the melting furnace are removed.

[0017] Purified melt then travels to the casting machine, consisting of a casting wheel and a steel belt. Melt flows from the casting launder into the area between the continuous steel belt and the water-cooled wheel. The casting wheel is made from copper or steel alloy. The aluminium strip may reach a temperature of 530 °C at the casting wheel outlet. The aluminium strip travels to the hot rolling mill and then to the cold rolling mill through a roller track.

[0018] The process of strip rolling is performed by the reduction of the input narrow strip with minimal transverse deformation. Longitudinal rolling is a continuous forming operation that reduces the cross-section of the material between the counter rotating rollers.

[0019] Reduction in the hot rolling mill is 40-70% of the strip thickness, while in the cold rolling mill it reaches 30-50%. Aluminium narrow strip is casted with the casting speed up to 10 m/min.

[0020] Rolled aluminium alloy narrow strip then travels to the stamping line, where slugs are stamped using a stamping machine. Stamping machines usually has from 60 to 625 strokes per minute.

[0021] Stamped slugs fall on the conveyor belt below the stamping machine. From here, they are led into the annealing containers and into the annealing furnaces, where the slugs are softened and the oil, which remained from stamping, is burned off.

[0022] After the annealing, the slugs are surface-treated by sandblasting, vibrating or tumbling, since a certain degree of roughness is required for impact extrusion in order to retain oil on the surface of slugs during the impact extrusion process.

[0023] Slugs are then transported to packaging manufacturers, where aluminium aerosol cans are manufactured by impact extrusion.

[0024] The manufacturing process of aerosol cans is composed of several stages. First the body of the aerosol cans is formed from the slug by the impact extrusion. After impact extrusion colouring of the internal surface of aerosol can and polymerization of the colour at around 250 °C follows. The colouring of the external surface follows and drying at around 150 °C follows in the next step. After external colouring, printing and drying of the print at around 150 °C follows and after that, lacquering of the external surface and drying at around 190 °C. In the last stage formation of the can neck and the dome in the multi-die necking machine takes place.

[0025] The problem that arises at manufacturing of aerosol cans is the decrease in mechanical properties after polymerization of the internal colour up to 15 % which occurs at around 250 °C. The process of recrystallization, i.e. the growth of the grain size starts at such high temperatures, which causes the decrease in mechanical properties. With the addition of zirconium into Al alloy within the above mentioned mass fraction limits, tensile strength is maintained or improved and deformable and burst pressure is increased.

[0026] With the addition of Zr, the recrystallization threshold of the material rises up above 300°C, other elements like Fe, Mn, Ti and Si in the form of intermetallic phases strengthen the aluminium matrix and enable the achievement of higher mechanical properties. Higher mechanical properties are reflected in high deformable and burst pressures.

[0027] Aluminium alloy according to the invention enables the manufacturing of aerosol cans with the minimal decrease in mechanical properties or with the same mechanical properties as the starting material, i.e. alloy with the mass fraction minimal 99.7 % Al (Al 99.7 %). Aerosol cans made from aluminium alloys of the invention achieve 3-5 bar higher deformable and burst pressure compared with the alloy Al 99.7 %.

[0028] Figure 1 presents the changes in the tensile strength during different steps of the manufacturing process of aerosol cans in relation to the composition of Al alloy. 1 refers to series 1XXX, i.e. A199.7% alloy, 2 refers to series 1XXX, i.e. Al99.5% alloy with the addition of 0,11 % Zr, 3 refers to series 3XXX, i.e. AlMn0.3 alloy with the addition of 0,11 % Zr, 4 refers to series 3XXX, i.e. AlMn0.6 alloy with the addition of 0,11 5 Zr. The label AlMn0.3 refers to the alloys with the content of Mn from 0.3 to 0.45 mass fraction, the label AlMn0.6 refers to the alloys with the content of Mn from 0.5 to 0.6 mass fraction.

[0029] Figure 1 presents the tensile strengths of aluminium alloys according to the invention compared to the alloy A199.7% during most important phases in the manufacturing process of aerosol cans. It is evident that the decrease in mechanical properties after polymerization is significantly lower in comparison with A199.7 % alloy. Mechanical properties remain within the desired tolerance during the whole manufacturing process.

[0030] With the variation of alloying elements Fe, Mn, Ti and Zr high mechanical properties are achieved and are maintained within the desired tolerance during the whole manufacturing process of aerosol cans. With the correct selection of alloying elements the tensile strength of aluminium alloy of the invention is higher at the end of the process compared to the tensile strength of A199.7% after extrusion.

[0031] The invention is further explained below with the description of the embodiment.

Embodiment:

[0032] The manufacturing process of aluminium aerosol cans is composed of several stages, such as formation of the can body, hot colouring/lacquering, polymerization, printing, drying at high temperatures and formation of the neck of the can. Polymerization of the internal colour occurs at 250 °C.

[0033] In the presented embodiment the chemical composition of aluminium alloy according to the invention is:

- 0.35 weight % Fe (iron)
- 0.17 weight % Si (silicon)
- 0.0003 weight % Mg (magnesium)
- 0.003 weight % Cu (cooper)
- 0.015 weight % Zn (zinc)
- 0.009 weight % Ti (titanium)
- 0.45 weight % Mn (manganese)
- 0.11 weight % Zr (zirconium),

the rest is Al (aluminium).

[0034] Aluminium alloy according to the invention is used for manufacturing of aerosol cans by the impact extrusion of the slugs for cosmetics and food industry.

[0035] Aluminium narrow strip is casted from aluminium alloy of the invention by the "rotary strip caster" method and enables the casting of narrow strip also with 10 m/min without defects on the surface of the strip.

[0036] Aluminium alloy melt is produced in a melting furnace which is fed with the electrolytic aluminium. When liquid aluminium, heated to approximately 720 °C, is formed in the furnace, slag is removed from the melt and the melt is poured into the holding furnace, where alloying of aluminium melt is performed.

[0037] Gases must be removed from the melt by purging of melt with inert gas Ar. Purified melt then travels to the casting machine. Melt flows from the casting channel into the area between the continuous steel belt and the water-cooled wheel made of steel alloy. The aluminium strip is made which may reach a temperature of 530 °C at the casting wheel outlet. The aluminium strip is led to the hot rolling mill and then to the cold rolling mill through a roller track.

[0038] The process of strip rolling is performed by the reduction of the input narrow strip with minimal transverse deformation. Reduction in the hot rolling mill is 60% of strip thickness, while in the cold rolling mill it reaches 40%.

[0039] Rolled narrow aluminium strip then travels to the stamping line, where slugs are stamped using a stamping machine. Stamped slugs fall on the conveyor belt below the stamping machine. From here, they are led into the annealing containers and into the annealing furnaces, where slugs are softened and the rest oil, which remained from stamping, is burned off. After the annealing, the slugs are surface-treated by sandblasting. Slugs are then transported to packaging manufacturers, where aluminium aerosol cans are manufactured by impact extrusion.

[0040] Chemical composition of the aluminium alloy of the invention maintains the mechanical properties after polymerization on the level of the starting material. This is reflected in achieving 5 bars higher deformable and burst pressures compared with the alloy A199.7%. With improvement of mechanical properties of aerosol can material it is possible to produce aerosol cans with thinner walls and reduced weight or to increase the content in the aerosol cans in the cosmetic and food industry.

[0041] It is self-evident that the above described invention can also be used in other particular form not changing the substance of the invention.

Claims

1. Aluminium alloy for manufacturing of aluminium aerosol cans by impact extrusion **characterized in that**, the alloy contains in weight percent: 0.1-0.55 % Fe, 0.05-0.2 % Si, <0.01 % Mg, <0.01 % Cu, <0.02 % Zn, 0.0 -0.03 % Ti, 0.01-0.6 % Mn, 0.05-0.2 % Zr and the rest is Al.

2. Aluminium alloy according to claim 1 **characterized in that** the alloy contains in weight percent: 0.35 % Fe, 0.17 % Si, 0.0003 % Mg, 0.003 % Cu, 0.015 % Zn, 0.009 % Ti, 0.45 % Mn, 0.11 % Zr and the rest is Al.

3. Aluminium alloy according to claims 1 and 2 **characterized in that** the addition of zirconium raises the recrystallization threshold of the material above 300 °C.

4. Aluminium alloy according to claims 1 to 3 **characterized in that** alloying elements Fe, Mn, Ti and Si form intermetallic phases and strengthen the aluminium matrix and enable the achievement of higher mechanical properties.

5. A process for the production of aluminium alloy of claims 1 to 4 for aerosol cans by impact extrusion **characterized in that** a melt of aluminium alloy is prepared, followed by alloying and processing of the aluminum melt and casting of aluminium narrow strip by the "rotary strip caster" method from which slugs are stamped for manufacturing aerosol cans.

6. The process according to claim 5 **characterized in that** the aluminium melt is produced in a melting furnace which is fed with the T-form blocks of electrolytic aluminium or with the electrolytic aluminium and with the process scrap obtained from stamping.

7. The process according to claims 5 to 6 **characterized in that** alloying and processing of the melt is performed in the holding furnace.

8. The process according to claims 5 to 7 **characterized in that** the master alloys AlTi75% and AlFe75% are added in the form of tablets.

9. The process according to claims 5 to 8 **characterized in that** the master alloy AlTi5B1 (5% titanium; 1% boron (B) is added in the form of wire.

10. The process according to claims 5 to 8 **characterized in that** the master alloy AlMn25% is added in the form of blocks or ingots.

11. The process according to claims 5 to 10 **characterized in that** alloying with manganese, iron or zirconium is performed at least in 15-minute intervals to prevent formation of complex intermetallic phases between alloying elements.

12. The process according to claims 5 to 11 **characterized in that** after alloying, gases are removed from the melt.

13. The process according to any claims 5 to 12 **characterized in that** after alloying, gases are removed with the porous plugs.

14. The process according to claims 5 to 13 **characterized in that** the aluminium narrow strip is casted with the casting speed up to 10 m/min with minimal defects.

15. The process according to claims 5 to 14 **characterized in that** the addition of Zr raises the recrystallization threshold of the material above 300 °C and alloying elements Fe, Mn, Ti and Si form intermetallic phases which strengthen the aluminium matrix, by which higher mechanical properties and up to 5 bar higher deformable and burst pressure on final aerosol cans is achieved.

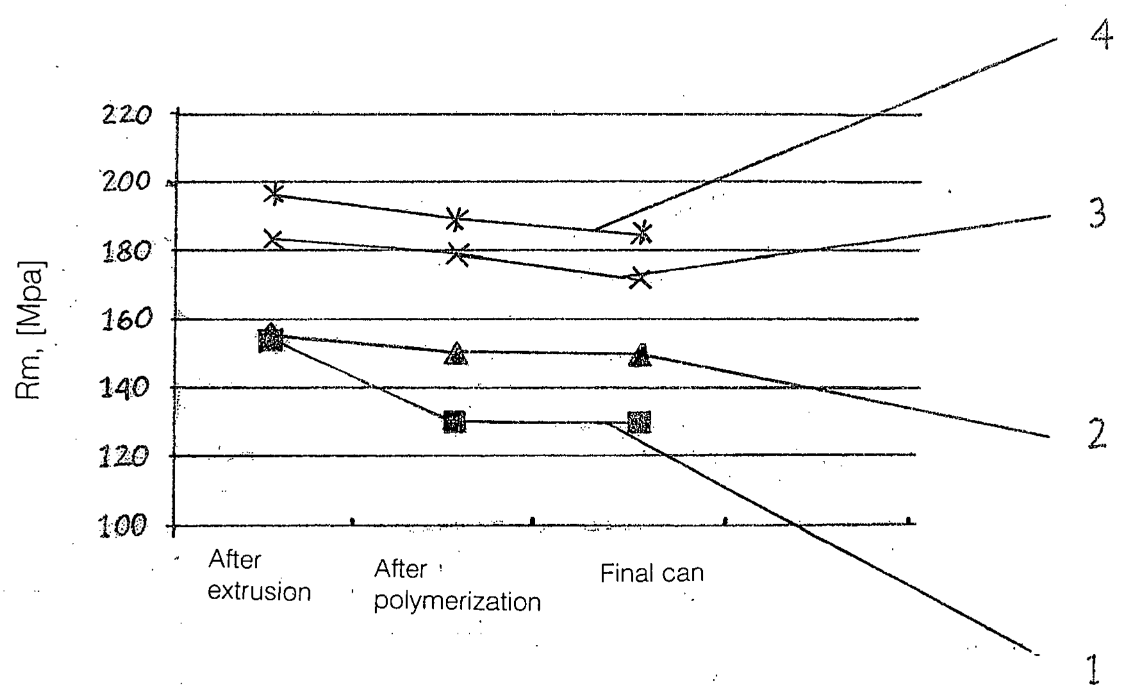
4
220
200
180
160
140
120
100
Rm, [Mpa]
3
2
After extrusion
After polymerization
Final can
1

Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 16 00 0721

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	12 August 2016	Abrasonis, Gintautas

CATEGORY OF CITED DOCUMENTS

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EUROPEAN SEARCH REPORT

Application Number
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