(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 636 366 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
15.04.2020 Bulletin 2020/16

(21) Application number: **18382712.0**

(22) Date of filing: **09.10.2018**

(51) Int Cl.:
B22D 11/00 (2006.01) ***B22D 11/06*** (2006.01)
B21B 1/46 (2006.01) ***B21B 3/00*** (2006.01)
B21H 8/00 (2006.01) ***C22C 21/00*** (2006.01)
C22F 1/04 (2006.01) ***C22F 1/047*** (2006.01)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(54) PROCESS FOR THE MANUFACTURE OF AN ALUMINUM TREAD SHEET

(57) It is provided a process for the manufacture of an aluminum tread sheet comprising the steps of continuously casting the alloy in a continuous caster into an aluminum slab having a thickness of 14 to 20 mm and being at a temperature from 400 °C to 550 °C; hot rolling in a continuous process the obtained aluminum slab to form a tread sheet which has a thickness of 1.3 mm to 5.0 mm, wherein hot rolling is carried out in a hot rolling mill having at least two stands comprising at least one hot rolling stand and one pattern rolling stand, and wherein the pattern rolling stand is placed after the at least one hot rolling stand; and subjecting the obtained tread sheet to annealing; and wherein the process is carried out without performing any homogenizing, cold rolling, or annealing step before the pattern rolling step.

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Description

Technical Field

[0001] The present invention relates to a process for the manufacture of non-skid aluminum tread sheets. More particularly, the process comprises continuously casting, hot rolling, pattern rolling, and annealing an aluminum alloy.

Background Art

[0002] Non-skid aluminum tread sheets show a regular pattern that protrudes or is embedded in the material on at least one of its faces. The figures that generate the relief of the sheet can present different morphologies, normally including diamond shapes, almond or chopsticks. It is a material used in a wide range of applications among which stand out the manufacture of surfaces with high grip to avoid slips, such as stairs or industrial floors, but they are also used in decorative applications, tool boxes, truck floors, wall coverings, and so on. In all these applications the material must provide sufficient mechanical stability and a shiny surface with good surface quality, according to the customer's requirements. Factors such as lightness make the manufacture in aluminum alloys of non-slip tread sheets is especially required in industries such as automotive.

[0003] Aluminum alloys currently offered in the market include the ones of 1000, 3000, 5000, 6000, and 7000 series. Within these, alloys typically employed for the manufacture of aluminum tread sheets are the following: EN AW-1050A, EN AW-3003, EN AW-3103, EN AW-5026, EN AW-5052, EN AW-5083, EN AW-5086, EN AW-5754, EN AW-6061, EN AW-6082, and EN AW-7020, in accordance with EN 573-3.

[0004] The manufacture of aluminum from the Hazelett twin belt continuous casting is a reliable process commonly used for the manufacture of aluminum series with narrow solidification ranges, which include series 1XXX, 3XXX and in development 5XXX. The continuous casting of twin belts offers the possibility of a high productivity compared to conventional direct chill (DC) casting systems working with very high solidification speeds, which allow maintaining aluminum band productivity in 14 to 20 mm at a speed typically between 7.0 and 11 m/min at the pouring outlet.

[0005] Continuous casting (CC) of aluminum alloys can result in substantial energy savings and total conversion cost savings. However, in continuous casting the alloy composition and the processing steps must be carefully controlled to obtain a final product with the mechanical and aesthetic properties required for the specific use. This is particularly relevant when using aluminum scraps, which are non-heat-treatable aluminum alloys, namely are hardenable by cold working, but not by heat treatment.

[0006] When the final product is a tread sheet, processes disclosed in the prior art incorporate one or more steps selected from an homogenizing step, a cold rolling step, or an annealing step before the pattern rolling. Therefore, known processes for the preparation of aluminum tread sheets are discontinuous.

[0007] Thus, there is a need for the development of an improved and more economically advantageous process for the manufacture of non-skid aluminum tread sheets meeting the customer's requirements, particularly from non-heat-treatable alloys.

Summary of Invention

[0008] Inventors have developed a new process for the manufacture of non-skid aluminum tread sheets which is carried out in a system (called herein "Hazelett compact mini-plant" or simply "compact mini-plant") wherein an aluminum alloy is continuously casted into a slab, which is subjected to hot rolling in a hot rolling mill having at least two stands where the last stand works as pattern rolling in a continuous process. No homogenizing, cold rolling, or annealing step is performed before the pattern rolling step.

[0009] Advantageously and surprisingly, the process of the present disclosure allows manufacturing aluminum tread sheets or coils into a single production line with reduced casting and rolling times, while allows obtaining a product fulfilling the market requirements, namely according to the UNE 1386 standard. This results in substantial energy savings and total conversion cost savings.

[0010] Thus, an aspect of the invention is a process for the manufacture of an aluminum tread sheet comprising the steps of:

a) providing a molten aluminum alloy;
b) continuously casting the alloy in a continuous caster into an aluminum slab having a thickness from 14 mm to 20 mm, such as of 19 mm, and being at a temperature from 400 °C to 550 °C;
c) hot rolling in a continuous process the aluminum slab obtained in step b) to form a tread sheet which has a thickness from 1.3 mm to 5.0 mm, wherein hot rolling is carried out in a hot rolling mill having at least two stands comprising at least one hot rolling stand and one pattern rolling stand, and wherein the pattern rolling stand is placed

after the at least one hot rolling stand; and
d) subjecting the tread sheet obtained in step d) to annealing;

wherein the process is carried out without performing any homogenizing, cold rolling, or annealing step before the pattern rolling step.

Detailed description of the invention

[0011] As used herein, the term "hot rolling" means a process to reduce the thickness of an aluminum strip or sheet at a temperature above about 180 °C.
[0012] As used herein, the term "neutral point" refers to the point where the velocity of working rolls and sheet velocity are equal.
[0013] As used herein, the term "crown" refers to the geometrical shape of the working rolls including concavity, convexity or flat shape.
[0014] As used herein, the term "set up conditions" refers to all the arrangements to guarantee a successful start of the casting.
[0015] As used herein, the term "set up load for the gap between the rolls calibration" refers to the load applied to the working rolls in order to set the zero value of the gap between the rolls.
[0016] As used herein, the term "rolling conditions" refers to the stabilized conditions of the system which led to obtain good mechanical and aesthetic properties.
[0017] As used herein, the term "emulsion oil concentration (%)" refers to the percentage of the oil emulsified with the water used as lubrication and refrigeration.
[0018] As used herein, the term "initial overspeed" refers to the increase in speed of the working rolls in comparison to the slab speed during the initial biting process.
[0019] As used herein, the term "belt wrapper tension" refers to the tension of the wrapper that embrace the sheet when treading in the coiler.
[0020] As used herein, the term "speed of blowing air at hot rolling exit" refers to the air exit speed at the nozzle pointing to the aluminum sheet at the exit of the pattern rolling.
[0021] As used herein, the term "reduction at stand 3 (%Red)" refers to the proportion of the modification of the thickness according to:

$$\%Red = \frac{thickness_{stand\ 2} - thickenss_{stand\ 3}}{thickness_{stand\ 2}} \times 100$$

[0022] As used herein, the term "specific tension between stands 2 and 3" refers to the tension between the pattern rolling stand and the hot rolling stand 2.
[0023] As used herein, the term "specific coiler tension" refers to the tension that the coiler applies to the sheet during the winding.
[0024] As used herein, the term "roll bend load application" refers to the load applied at the housings of the working rolls in order to separate them.
[0025] As mentioned above, the process of the present disclosure for the manufacture of aluminum tread sheets comprises continuously casting an aluminum alloy into an aluminum slab, hot rolling the aluminum slab to form an aluminum sheet, pattern rolling the aluminum sheet in order to obtain a tread sheet, and subjecting the tread sheet to annealing. The process is carried out in specific conditions in order to get a sheet product with the required thickness, and the required mechanical and aesthetic properties.
[0026] In an embodiment of the process of the invention, in step c), after the at least one hot rolling stand, an aluminum sheet having a thickness from 1.9 mm to 7.1 mm and being at a temperature from 300 °C to 230 °C is obtained and is subsequently carried to the pattern rolling stand.
[0027] In another embodiment, optionally in combination with one or more features of the particular embodiments defined above, the tread sheet obtained in step d) is at a temperature from 250 °C to 200 °C.
[0028] In an embodiment, optionally in combination with one or more features of the particular embodiments defined above, the aluminum alloy is derived from aluminum scrap. Aluminum scrap include, without being limited to, non-heat-treatable aluminum alloys such as, for example, Aluminum Association (AA) alloys 1XXX, 3XXX and 5XXX.
[0029] According to the Aluminum Association Inc., in North America, wrought aluminum alloys of the 1XXX series relates to controlled unalloyed (pure) composition having a minimum of 99.0% aluminum; the ones of the 3XXX series relates to alloys in which manganese is the principal alloying element; and the ones of the 5XXX series relates to alloys

in which magnesium is the principal alloying element.

[0030] The herein called "compact mini-plant system" used in the process of the present disclosure includes the continuous casting of twin belt together with a hot rolling mill in which the solidified aluminum band is fed directly, allowing the residual heat of the band to be used as a source for hot rolling. Additionally, after hot rolling, pattern rolling is carried out in a continuous process.

[0031] The manufacture of tread sheets, particularly in the form of coils, begins with the fusion of the aluminum alloy. As an example, contaminated aluminum scrap (presence of paint, oils, and so on) can be used and it is fused in the rotary furnaces. The aluminum alloy is transferred to a melting and holding furnace where fusion is completed, optionally, with the addition of clean aluminum scrap or internal aluminum cuts generated by the process. The molten aluminum alloy is then degassed and filtered in degassing and filtering devices to reduce dissolved gases and inclusions in the molten aluminum alloy.

[0032] As mentioned above, in the process of the present disclosure, a molten aluminum alloy is continuously cast in a continuous caster in order to form an aluminum slab having the required thickness. The aluminum slab can be prepared by any continuous casting technique well known to those skilled in the art such as by a twin belt casting.

[0033] In an embodiment, optionally in combination with one or more features of the particular embodiments defined above, the continuous caster is a Hazelett twin belt caster.

[0034] As an example, temperature of the metal at the entrance to the caster, particularly of the Hazelett caster, is usually from 675 to 690 °C. The metal is solidified in the machine of twin belt that is be internally cooled with water.

[0035] The solidified aluminum slab leaves the caster at a speed from 7.0 to 11.0 m/min, a thickness of 14 to 20 mm, such as of 19 mm, and a temperature from 400 to 550 °C, depending on the conditions of the furnaces, casting, and transverse position of the measure.

[0036] The aluminum band passes on its way to the hot rolling mill through a pinch roll that applies a lower speed of advance with respect to the casting system to cause a better compaction of the metal inside the machine. Particularly, the reduction of the speed of advance is from 0.01 m/min to 0.07 m/min.

[0037] The aluminum sheet at its exit from the pinch-roll is driven by an inlet table to the hot rolling mill. Then, through several stands, wherein the last one is a pattern rolling stand, the aluminum sheet thickness is progressively reduced from the initial thickness, such as of 19 mm, to the final thickness of the tread sheet at the exit from the pattern rolling mill.

[0038] Thus, in an embodiment, optionally in combination with one or more features of the particular embodiments defined above, the aluminum alloy is of the 3XXX series and tread sheet thickness is from 2.0 to 4.0 mm; or the aluminum alloy is of the 5XXX series and the tread sheet thickness is from 2.3 to 3.5 mm; or the aluminum alloy is of the 1XXX series and tread sheet thickness is from 1.3 to 5.0 mm at the exit from the pattern rolling mill.

[0039] In an example, the thickness of the aluminum sheet during pattern rolling is reduced from 20% to 40%. Additionally, the thickness of the aluminum slab during hot rolling and before entering the pattern rolling stand can be reduced a total of 40% to 92%.

[0040] In an example, before the pattern rolling stand (stand 3) there are two hot rolling stands (stands 1 and 2), wherein the aluminum slab is transformed in the stand 1 to an aluminum sheet having a first thickness and it is subsequently passed through the stand 2 to obtain an aluminum sheet having a second thickness, and wherein the thickness of the aluminum slab is reduced a 35-70% in the stand 1 and thickness of the aluminum sheet that exits from stand 1 is reduced a 35-70% in the stand 2.

[0041] During the rolling steps, a lubricant can be applied. The temperature of the aluminum sheet decreases progressively by contact with the air and by the irrigation of a lubricant acting as well as a cooling system. Particularly, oil-in-water emulsions can be used as lubricants.

[0042] The oil content of the lubrication-cooling system in form of an emulsion can be adjusted depending on the alloy series to be treated, particularly emulsions with an oil content of 3.5 to 4.0% for the 3XXX series, of 3.0 to 3.5% for the 1XXX series, and of 4.0 to 4.5% for the 5XXX series.

[0043] Oil-in-water emulsions useful as lubricants in the process of the present disclosure are known by those skilled in the art and are commercially available. As an example, oil-in-water emulsions can comprise several components selected from the group consisting of mineral oils, emulsifier, esters, fatty acids, detergents, and high pressure additives, and mixtures thereof.

[0044] As it passes through the different rolling boxes, due to the contact with the lubricant emulsion, the aluminum sheet progressively loses temperature until it reaches a temperature from 180 to 250 °C at the exit of the pattern rolling stand. The application of the lubricating emulsion is maintained with low flow at the edges of the sheet and with high flow in the central zone in order to achieve adequate product flatness, in combination with the other rolling conditions.

[0045] Thus, in a particular embodiment, optionally in combination with one or more features of the particular embodiments defined above, during the pattern rolling step, a lubricant which is an oil-in-water emulsion is applied over the aluminum sheet, the aluminum sheet having edges and a central area, wherein the lubricant is applied in an amount at the edges of the sheet is lower than the amount of lubricant applied at the center area.

[0046] In order to avoid an excess of lubricant retained on the surface of the sheet, air blowing at maximum speed can be applied on the surface of the aluminum sheet at the the outlet of the last rolling stand, i.e. of the pattern rolling stand.

[0047] In another particular embodiment, optionally in combination with one or more features of the particular embodiments defined above, when setting up the starting conditions, overspeed of the pattern rolling stand is set at a maximum of 0.5 m/s, i.e. from 0 to 0.5 m/s, to allow the centering of the aluminum band, what is necessary to drive the sheet to the coiler.

[0048] In an example, hot and pattern rolling can be performed in a 3-stand tandem mill, wherein the third stand (stand 3) is provided with embossing rolls in order to obtain the tread sheet product. Thus, in an embodiment, optionally in combination with one or more features of the particular embodiments defined above, the hot rolling mill has three stands, namely, stand 1, stand 2, and stand 3. In stands 1 and 2, hot rolling itself is carried out, and the aluminum sheet exiting stand 2 is subjected to pattern rolling in a continuous process in stand 3.

[0049] In order to get the thickness of the aluminum sheet as defined above at the exit of each stand, among the starting conditions, the set up load for the gap between rolls calibration is from 100 to 300 tones (t). Additionally, the starting thickness of the different boxes is set up accordingly. In an example of a 3-stand tandem mill, the starting thickness of the different stands for aluminum alloys of the 3XXX series can be fixed to 5.5 to 6.5 mm in the second hot rolling stand (stand 2), and to 4.7 to 5.3 mm in the pattern rolling stand (stand 3); for aluminum alloys of the 1XXX series can be fixed to 5.5 to 6.5 mm in the second hot rolling stand (stand 2), and to 4.4 to 5.0 mm in the pattern rolling stand (stand 3); and for aluminum alloys of the 5XXX series can be fixed to 6.4 to 7.0 mm in the second hot rolling stand (stand 2), and to 5.0 to 5.5 mm in the pattern rolling stand (stand 3).

[0050] Particularly, during rolling steps, the neutral point position should remain closer than usual towards the bite site. Thus, in a particular embodiment, optionally in combination with one or more features of the particular embodiments defined above, the hot rolling is carried out in a hot rolling mill having two hot rolling stands (stands 1 and 2) and one pattern rolling stand (stand 3), and one of the hot rolling stands (stand 2) is next to the pattern rolling stand, and when the aluminum alloy is of the 3XXX and 5XXX series, the process comprises applying a specific tension of 0.20 to 0.23 Kg/mm^2 between the hot rolling stand which is placed next to the pattern rolling stand and the pattern rolling stand, and a pattern rolling stand output specific tension from 1.3 to 2.0 Kg/mm^2, such as of 1.8 mm^2, and when the aluminum alloy is of 1XXX series, the process comprises applying a specific tension of 0.08 to 0.10 Kg/mm^2 between the hot rolling stand which is placed next to the pattern rolling stand and the pattern rolling stand, and a pattern rolling stand output specific tension of 1.0 to 1.7 Kg/mm^2, such as of 1.5 Kg/mm^2.

[0051] The embossing roll in the pattern rolling stand can have a roughness of 0.3 to 0.9 μm, such as 0.7 μm, and a flat mechanical crown.

[0052] Roughness of rolls of the hot rolling stands is usually from 1.0 to 1.3 μm. Additionally, rolls of the hot rolling stands usually have a negative crown. These parameters in combination with one or more features of the particular embodiments defined above define additional embodiments.

[0053] In another particular embodiment, optionally in combination with one or more features of the particular embodiments defined above, annealing of the tread sheet is carried out at a temperature of 400 to 480 °C, particularly of up to 450 °C for 1XXX and 5XXX series, and up to 480 °C for 3XXX series.

[0054] In another particular embodiment, optionally in combination with one or more features of the particular embodiments defined above, the annealing step is carried out under an inert gas, such as nitrogen, having an oxygen level below 2000 ppm during a minimum of 1 hour, and then the oxygen level is increased until reaching the atmospheric levels for at least 1 or 2 hour while maintaining the temperature as mentioned above.

[0055] The final annealed product is usually produced in coiled form. Thus, after the pattern rolling step the obtained tread sheet can be coiled before the annealing step in order to produce an annealed product in form of a coil. Advantageously, the process of the present disclosure take advantage of the residual latent heat of the pattern rolled and, optionally, coiled product in the annealing step. After annealing, the tread sheet or coil is cooled down at room temperature such as by air.

Examples

[0056] A molten aluminum alloy was continuously casted in a Hazelett twin belt caster at a temperature from 675 to 690 °C. A solidified aluminum slab having a thickness of 19 mm, and temperature from 420 to 550 °C leaved the caster at a speed of 7.4 to 8.5 m/min.

[0057] On its way to the hot rolling mill, the aluminum band was passed through a pinch roll and, subsequently, was driven by an inlet table to a 3-stand tandem mill. Hot rolling itself was performed in the first two stands (stands 1 and 2) and pattern rolling was performed in a third stand (stand 3) having embossing rolls, in order to obtain an aluminum tread sheet.

[0058] Several parameters both in the rolling steps and in the heat treatment were adjusted.

[0059] Overspeed of stand 3 was set at 0.5 m/s.

[0060] In Table 1 the main process parameters and the corresponding value ranges are shown for Examples of the present disclosure and comparative examples.

Table 1

		1XXXX		3XXX		5XXX	
		Comp. Ex. 1	**Example 1**	**Comp. Ex. 2**	**Example 2**	**Comp. Ex. 3**	**Example 3**
		Regular Coil	Tread Plate	Regular Coil	Tread Plate	Regular Coil	Tread Plate
Hot Rolling							
Tread Plate Roll (Stand 3)	Roughness (μm)	1.2 - 1.4	0.3 - 0.9	1.3 - 1.6	0.3 - 0.9	1.3 - 1.6	0.3 - 0.9
	Crown (μm)	-0.15 (Negative)	0 (Flat)	-0.15 (Negative)	0 (Flat)	-0.15 (Negative)	0 (Flat)
Set Up Conditions	Set Up Load for Gap Between Rolls Calibration (t)	300	100-300	300	100-300	300	100-300
	Emulsion Oil Concentration (%)	4.0	3.0 - 3.5	4.5	3.5 - 4.0	5.0	4.0 - 4.5
	Stand 1 Working Roll Roughness (μm)	1.3 - 1.6	1.0 - 1.3	1.3 - 1.6	1.0 - 1.3	1.3 - 1.6	1.0 - 1.3
	Stand 2 Working Roll Roughness(μm)	1.3 - 1.6	1.0 - 1.3	1.3 - 1.6	1.0 - 1.3	1.3 - 1.6	1.0 - 1.3
	Stand 2 Exit Thickness (mm)	6.0	5.5-6.5	6.8	5.5-6.5	7.2	6.4-7.0
	Stand 3 Exit Thickness (mm)	4.2	4.4-5.0	4.5	4.7-5.3	5.0	5.0-5.5
	Stand 3 Initial Overspeed (m/s)	0.8	0-0.5	1.0	0-0.5	1.2	0-0.5
	Belt Wrapper Tension (bar)	65	80 - 100	65	80 - 100	65	80 - 100
Rolling	Flow of Blowing Air at Hot Rolling Exit	Regular	High	Regular	High	Regular	High

(continued)

			1XXXX		3XXX		5XXX	
			Comp. Ex. 1	**Example 1**	**Comp. Ex. 2**	**Example 2**	**Comp. Ex. 3**	**Example 3**
			Regular Coil	Tread Plate	Regular Coil	Tread Plate	Regular Coil	Tread Plate
Hot Rolling								
Conditions	Reduction at Stand 3 (%)		30-60	20 - 40	30-60	20 - 40	30-60	20 - 40
	Stand 3 Neutral Point Position (achieved though tension between stands 2 and 3 and the coiler tension)	Position	Regular	Displaced towards Stand 3	Regular	Displaced towards Stand 3	Regular	Displaced towards Stand 3
		Specific coiler tension between stands 2 and 3	0.12	0.08 - 0.10	0.23	0.20 - 0.23	0.28	0.20 - 0.23
		Coiler tension (Kg/mm^2)	1.8	1.0-1.7	2.2	1.3 - 2.0	2.2	1.3 - 2.0
	Roll Bend Load Application		Yes	No	Yes	No	Yes	No
	Stand 1,2,3 Emulsion Spray	Edges	High	Low	High	Low	High	Low
		Center	Low	High	Low	High	Low	High
	Stand 3 Exit Thickness (mm)		1.4-5.0	1.3-5.0	1.4-4.0	2.0-4.0	2.0-4.6	2.3-3.5
Heat Treatment								
Set Point Temperature (°C)			180-380	400 - 450	180-450	400 - 480	180-450	400 - 450
O_2 Concentration (ppm)			2000	Variable	2000	Variable	2000	Variable
Heating Slope (°C/h)			50	10-20	50	10-20	50	10-20

[0061] At the exit of the rolling process, including the pattern rolling, the aluminum tread sheet is led to the coiler where the wrapper belt begins to wind the coil with a pressure of 80 bar.

[0062] Coils of 8.5 t manufactured at a time of 16-18 min per unit were then subjected to a heat treatment at a temperature of 400 °C in a controlled atmosphere by injection of an inert gas (nitrogen having an oxygen level below 2000 ppm) during a minimum of 1 h. Then, the oxygen level were increased until reaching the atmospheric levels and the temperature was maintained for at least 1 hours, such as for 2 hours. Coils were left to cool at room temperature. Finally, coils were subjected to a process of cutting edges to eliminate the lateral cracks formed during the hot rolling process and adapt the width of the coil to the requirements demanded by the market.

[0063] Throughout the description and claims the word "comprise" and variations of the word, are not intended to exclude other technical features, additives, components, or steps. Furthermore, the word "comprise" encompasses the case of "consisting of". Additional objects, advantages and features of the invention will become apparent to those skilled in the art upon examination of the description or may be learned by practice of the invention. The following examples are provided by way of illustration, and they are not intended to be limiting of the present invention. Furthermore, the present invention covers all possible combinations of particular and preferred embodiments described herein.

Citation List

[0064]

1. UNE 1386 standard

Claims

1. A process for the manufacture of an aluminum tread sheet comprising the steps of:

a) providing a molten aluminum alloy;
b) continuously casting the alloy in a continuous caster into an aluminum slab having a thickness of 14 to 20 mm and being at a temperature from 400 °C to 550 °C;
c) hot rolling in a continuous process the aluminum slab obtained in step b) to form a tread sheet which has a thickness of 1.3 mm to 5.0 mm, wherein hot rolling is carried out in a hot rolling mill having at least two stands comprising at least one hot rolling stand and one pattern rolling stand, and wherein the pattern rolling stand is placed after the at least one hot rolling stand; and
d) subjecting the tread sheet obtained in step d) to annealing;

wherein the process is carried out without performing any homogenizing, cold rolling, or annealing step before the pattern rolling step.

2. The process according to claim 1, wherein in step c), after the at least hot rolling stand, an aluminum sheet having a thickness from 1.9 to 8.3 mm and being at a temperature from 300 °C to 230 °C is obtained, and is subsequently carried to the pattern rolling stand.

3. The process according to claims 1 or 2, wherein the tread sheet obtained in step d) is at a temperature from 250 °C to 200 °C.

4. The process according to any one of claims 1 to 3, wherein step c) further comprises applying in the pattern rolling stand over the aluminum sheet a lubricant, the aluminum sheet having edges and a central area, wherein the lubricant is an oil-in-water emulsion and is applied in an amount at the edges of the sheet that is lower than the amount of lubricant applied at the central area.

5. The process according to any one of claims 1 to 4, wherein the continuous caster is a Hazelett twin belt caster.

6. The process according to any one of claims 1 to 5, wherein overspeed of the pattern rolling stand is from 0 to 0.5 m/s.

7. The process according to any one of claims 1 to 6, wherein the hot rolling mill has three stands.

8. The process according to any one of claims 1 to 7, wherein the aluminum alloy is a non-heat-treatable aluminum alloy.

9. The process according to claim 8, wherein the non-heat treatable aluminum alloy is selected from AA 1XXX, 3XXX and 5XXX series.

10. The process according to claim 9, wherein the aluminum alloy is 3XXX or 5XXX series, wherein the hot rolling is carried out in a hot rolling mill having two hot rolling stands and one pattern rolling stand, one of the hot rolling stand is next to the pattern rolling stand, and the process comprises applying a specific tension of 0.20 to 0.23 Kg/mm^2 between the hot rolling stand which is placed next to the pattern rolling stand and the pattern rolling stand, and a pattern rolling stand output specific tension of 1.3 to 2.0 mm^2.

11. The process according to claim 9, wherein the aluminum alloy is 1XXX series, wherein the hot rolling is carried out in a hot rolling mill having two hot rolling stands and one pattern rolling stand, one of the hot rolling stand is next to the pattern rolling stand, and the process comprises applying a specific tension of 0.08 to 0.10 Kg/mm^2 between the hot rolling stand which is placed next to the pattern rolling stand and the pattern rolling stand, and the pattern rolling stand output specific tension of 1.0 to 1.7 Kg/mm^2.

12. The process according to any one of claims 9 or 10, wherein the aluminum alloy is the 3XXX series and the tread sheet thickness is from 2.0 to 4.0 mm, or the the aluminum alloy is the 5XXX series and the the tread sheet thickness is from 2.3 to 3.5 mm.

13. The process according to any one of claims 9 or 11, wherein the aluminum alloy is the 1XXX series and the tread sheet thickness is from 1.3 to 5.0 mm.

14. The process according to any one of claims 1 to 13, wherein the annealing of the tread sheet is carried out at a temperature of 400 to 480 °C.

15. The process according to any one of claims 1 to 14, wherein the annealing is carried out under an inert gas having an oxygen level below 2000 ppm during a minimum of 1 hour, and then the oxygen level is increased until reaching the atmospheric levels for at least 1 hour.

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European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 18 38 2712

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2009/082495 A1 (COMMW IND INC [US]; PLATEK PAUL [US]; KELLER CHRISTOPHER [US]; DING SH) 2 July 2009 (2009-07-02) * paragraphs [0002], [0019], [0040], [0043], [0135], [0138], [0139], [0140], [0150], [0153], [0155], [0156], [0157], [0159]; claims 1,3,4,25; figures 1,3 *	1-15	INV. B22D11/00 B22D11/06 B21B1/46 B21B3/00 B21H8/00 C22C21/00 C22F1/04 C22F1/047
A	US 2015/321232 A1 (STEWART PATRICIA [US] ET AL) 12 November 2015 (2015-11-12) * paragraphs [0089], [0091] *	4	
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TECHNICAL FIELDS SEARCHED (IPC)

B22D
C22C
C22F
B21B
B21H
B21L

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
The Hague	7 February 2019	Momeni, Mohammad

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