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(54) **HIGH STRENGTH ALUMINUM ALLOY FIN STOCK FOR HEAT EXCHANGER**

AUSGANGSMATERIAL FÜR RIPPEN AUS HOCHFESTER ALUMINIUMLEGIERUNG FÜR
WÄRMETAUSCHER

MATERIEL DE BASE POUR AILETTES EN ALLIAGE D'ALUMINIUM HAUTE RÉSISTANCE, POUR
ÉCHANGEUR DE CHALEUR

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(56) References cited:

EP-A1- 1 717 327 EP-A1- 1 753 885
WO-A1-2013/111884 JP-A- H1 088 265
JP-A- 2002 161 324 JP-A- 2012 126 950
US-A1- 2004 028 940 US-A1- 2008 118 393

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to the fields of material science, material chemistry, metallurgy, aluminum alloys, aluminum fabrication, and related fields. The present invention provides novel aluminum alloys for use in the production of heat exchanger fins, which are, in turn, employed in various heat exchanger devices, for example, motor vehicle radiators, condensers, evaporators and related devices.

BACKGROUND

[0002] There is a need for aluminum alloy fin stock material with high strength, for use in various heat exchanger applications, including radiators for automobiles. There is also a need to obtain aluminum alloy fin stock material with strong pre-braze mechanical properties, good behavior during brazing, i.e., enhanced brazed material sag resistance, and reduced fin erosion, as well as good strength and conductivity characteristics post-braze, for use in high performance heat exchanger applications.

JP 2002-161324 A is directed to an aluminum alloy fin material for a heat exchanger, wherein the aluminum alloy fin material comprises 1.0% to 2.0% Mn, 0.5 to 1.3% Si, 0.1 to 0.8% Fe, 0.21 to 0.5% Cu, 1.1 to 5% Zn, a component ratio of Mn:Si (Mn%/Si%) being 1.0 to 3.5, a component ratio of Zn:Cu (Zn%/Cu%) being 5 to 15, furthermore one or two kinds of 0.05 to 0.3% Zr or 0.05 to 0.3% Cr, the balance being Al with unavoidable impurities and a tensile strength of 160 to 270 MPa.

JP H10-88265 A is directed to an aluminum alloy fin material for heat exchangers, wherein the aluminum alloy has a composition consisting of, by weight, >1.5 to 2.2% Mn, 0.5 to 1.2% Si, 0.1 to 0.6% Fe, >2 to 5% Zn, 0.1 to 0.6% Cu, and the balance Al with inevitable impurities and containing, if necessary, either or both of $\leq 0.05\%$ In and $\leq 0.05\%$ Sn and further containing, if necessary, one or more kinds of $\leq 0.2\%$ Mg, $\leq 0.25\%$ Zr and $\leq 0.25\%$ Cr.

SUMMARY

[0003] The invention is defined in the appended claims. The present invention provides an aluminum alloy fin stock material for use in heat exchanger applications, such as automotive heat exchangers. This aluminum alloy fin stock alloy material was made by direct chill (DC) casting. The aluminum alloy fin stock material according to the embodiments of the present invention has one or more of the following properties: high strength, desirable post-braze mechanical properties, desirable sag resistance, desirable corrosion resistance and desirable conductivity. The aluminum alloy fin stock material according to some embodiments of the present invention displays larger grain dispersoids and improved strength before brazing. Some embodiments of the aluminum alloy fin stock material are produced in a desirable pre-braze temper, for example, H14.

[0004] The improved aluminum alloy fin stock material can be used in various applications, for example, heat exchangers. In one embodiment, the aluminum alloy fin stock material can be used in automotive heat exchangers, such as radiators, condensers and evaporators. In some embodiments, the aluminum alloy fin stock material is useful for high performance, light weight automotive heat exchangers. In some other embodiments, aluminum alloy fin stock material can be used for other brazed applications, including, but not limited to, HVAC applications. Other objects and advantages of the invention will be apparent from the following detailed description of the embodiments of the invention.

DESCRIPTION

[0005] The present invention provides an aluminum alloy fin stock material as defined in claim 1. This aluminum alloy fin stock alloy material was made by direct chill (DC) casting. Some embodiments of the aluminum alloy fin stock material have one or more of improved strength, improved corrosion resistance or improved sag resistance. In some embodiments, the aluminum alloy fin stock material exhibits desirable pre-braze (H14) temper mechanical properties and desirable post-braze mechanical properties, sag resistance, corrosion resistance and conductivity. In some other embodiments, the aluminum alloy fin stock material displays larger grain size after brazing and improved strength pre-brazing. The aluminum alloy fin stock material can be used in various applications, for example, heat exchangers. In one example, the aluminum alloy fin stock material can be used in automotive heat exchangers, such as radiators, condensers and evaporators.

[0006] Compositions of an aluminum alloy fin stock material fall within the scope of the present invention. Some exemplary embodiments of the aluminum alloy fin stock material compositions are described below. All % values used below and throughout this document in reference to the amounts of constituents of the aluminum alloy fin stock material compositions are in weight % (wt%).

[0007] The aluminum alloy fin stock material according to the present invention comprises 0.9-1.3% Si, 0.45-0.75% Fe, 0.10-0.30% Cu, 1.3-1.7% Mn and 1.30-2.2% Zn, remainder aluminum, wherein optionally Cr and/or Zr are present in the aluminum alloy fin stock material in an amount of up to 0.03 wt% each, and wherein further optionally the aluminum alloy fin stock material contains other minor elements in an amount below 0.05 wt%.

[0008] In one embodiment, the aluminum alloy fin stock material comprises 0.9-1.2% Si, 0.50-0.75% Fe, 0.15-0.30% Cu, 1.4-1.6% Mn and 1.4-2.1% Zn, remainder aluminum.

[0009] In another embodiment, the DC fin stock material comprises 0.9-1.1% Si, 0.10-0.25% Cu, 0.45-0.7% Fe, 1.4-1.6% Mn, and 1.4-1.7% Zn with the remainder Al.

[0010] In yet another embodiment, the aluminum alloy fin stock material comprises 0.90-1.0% Si, 0.15-0.25% Cu, 0.5-0.6% Fe, 1.5-1.6% Mn, and 1.5-1.6% Zn, remainder Al.

[0011] In yet another embodiment, the aluminum alloy fin stock material comprises 0.9-1% Si, 0.2% Cu, 0.5-0.6% Fe, 1.5-1.6% Mn, and 1.5-1.6% Zn, remainder Al.

[0012] In yet another embodiment, the aluminum alloy fin stock material comprises 0.9-0.95% Si, 0.2% Cu, 0.5-0.6% Fe, 1.5-1.6% Mn, and 1.5-1.6% Zn, remainder Al.

[0013] In another embodiment, the aluminum alloy fin stock material comprises 0.90-0.95% Si, 0.15-0.20% Cu, 0.55% Fe, 1.5% Mn, and 1.5% Zn, remainder Al.

[0014] In yet another embodiment, the aluminum alloy fin stock material comprises 0.95% Si, 0.15% Cu, 0.55% Fe, 1.5% Mn, and 1.5% Zn, remainder Al.

[0015] In yet another embodiment, the aluminum alloy fin stock material comprises 0.90-0.95% Si, 0.15-0.20% Cu, 0.5-0.6% Fe, 1.5% Mn and 1.5% Zn, remainder Al.

[0016] In yet another embodiment, the aluminum alloy fin stock material comprises 1.0-1.2% Si, 0.2-0.3% Cu, 0.5-0.6% Fe, 1.4-1.55% Mn, and 1.9-2.1% Zn, remainder Al.

[0017] In yet another embodiment, the aluminum alloy fin stock material comprises 0.95 ± 0.05 Si, 0.2 ± 0.05 Cu, 0.6 ± 0.1 Fe, 1.45 ± 0.05 Mn, and 1.55 ± 0.1 Zn, remainder Al.

[0018] In one more embodiment, the aluminum alloy fin stock material comprises 1.15 ± 0.05 Si, 0.25 ± 0.05 Cu, 0.6 ± 0.1 Fe, 1.5 ± 0.05 Mn, and 2.0 ± 0.1 Zn, remainder Al.

[0019] Optionally, Cr and/or Zr or other grain size controlling elements may be present in the aluminum alloy fin stock material compositions in an amount of up to 0.03% each. It is to be understood that the aluminum alloy fin stock material compositions described herein may contain other minor elements, sometimes referred to as unintentional elements, in an amount typically below 0.05%.

[0020] Some embodiments of the aluminum alloy fin stock materials of the present invention display a higher solidus temperature, referred to as onset of melting, leading to improved core shrinkage, a phenomenon in which brazed aluminum alloy units do not have the desired shape. While not wanting to be bound by the following statement, it is believed, based on differential scanning calorimetry (DSC) measurements and Thermo-Calc® software (Stockholm, Sweden) simulations, that lowering the Si content and the Zn content and increasing the Mn content in aluminum alloy fin stock material compositions can lead to higher onset of melting temperature (solidus), which contributes to core shrinkage reduction. In one example, an aluminum alloy fin stock material composition according to the embodiments of the present invention displays a solidus temperature above 617°C and a coarse post braze grain size of about 400 μm. In one more example, limiting the Si content of the alloy to 0.9-1% (preferably to 0.9-0.95%) and the Zn content to 1.5-1.6%, while maintaining the Mn content relatively high (for example, around 1.5%) raises the solidus temperature of the alloy, which, in turn, strengthens the material at the brazing temperature, so that it can resist sag or high temperature creep that can result in core shrinkage.

[0021] Some embodiments of the present invention relate to aluminum alloy fin stock materials having a defined composition and obtained by processes that include defined process steps and conditions. A combination of defined composition and production process can lead to improved properties of the aluminum alloy fin stock materials. One example of such improved properties are improved pre-braze mechanical properties. Improved pre-braze mechanical properties (also referred to as properties "in pre-braze condition") result in improved fin crush resistance during assembly, while maintaining suitable sag resistance and thermal conductivity after brazing (post-brazing).

[0022] The processes of producing aluminum alloy fin stock materials according to embodiments of the present invention involve the step of producing an ingot by a direct chill (DC) casting process, which is commonly used throughout the aluminum industry, whereby a large ingot ~1.5 m x 0.6 m x 4 m is cast from a large holding furnace which supplies metal to a shallow mold or molds supplied with cooling water. The solidifying ingot is continuously cooled by the direct impingement of the cooling water and is withdrawn slowly from the base of the mold until the full ingot or ingots are completed. Once cooled from the casting process, the ingot rolling surfaces are machined to remove surface segregation and irregularities. The machined ingot is preheated for hot rolling. The preheating temperature and duration are controlled to low levels to preserve a large grain size and high strength after the finished fin stock is brazed. Several ingots (about 8 to 30) are charged to a furnace and preheated with gas or electricity to the rolling temperature. The period of maintaining a temperature achieved by pre-heating can also be referred to as "soak" or "soaking". In one embodiment, the minimum

soak time at about 480°C is about 2 hours (in other words, at least 2 hours). In another embodiment, the soak time is 4-16 hours at 480°C. Aluminum alloys are typically rolled in the range of about 450°C to about 560°C. If the temperature is too cold, the roll loads are too high, and if the temperature is too hot, the metal may be too soft and break up in the mill.

[0023] The processes for making of the aluminum alloy fin stock materials involves one or more cold rolling steps. Each of the cold rolling steps may, in turn, involve multiple cold rolling passes. A cold rolling step characterized by "% cold work" or %CW achieved. Generally, % CW can be defined as the degree of cold rolling applied to the aluminum alloy fin stock. As used in the present document, %CW is calculated as:

$$\%CW = \frac{\text{intial gauge} - \text{final gague}}{\text{intial gauge}} * 100\%$$

[0024] Achieving a specified range or value of % CW may be desirable in order to attain the required strength range of the aluminum alloy fin stock material. Some embodiments of the of the aluminum alloy fin stock materials are produced by processes that involve a cold rolling step achieving 25-35 %CW. In some examples, a cold rolling step achieving %CW of 25% or 29% may be employed. In some cases, increasing %CW, for example, to 35% leads to an increase in pre-braze tensile strength of the aluminum alloy fin stock material, which, in turn, beneficially reduces the fin crush during radiator assembly. In some other cases, increasing the %CW, however, may be undesirable, as it may lead to finer post braze grain size due to an increase in the driving force for recrystallization, resulting in reduced sag resistance.

[0025] The processes for making of the aluminum alloy fin stock materials involves an inter-annealing step to attain desired properties of the aluminum alloy fin stock material according to the embodiments of the present invention. The term "inter-annealing" or "inter-anneal" (IA) refers to a heat treatment applied between cold rolling steps. IA temperature may affect the properties of the aluminum alloy fin stock materials according to the embodiments of the present invention. For example, an investigation of the IA temperature used in the processes for making certain embodiments of the aluminum alloy fin stock materials showed that reducing the IA temperature from 400°C to 350°C resulted in coarser post-braze grain size. In some embodiments of the aluminum alloy fin stock materials, a combination of %CW and IA temperature employed in the production process results in desirable properties. In one example, a combination of IA temperature of 350°C and %CW of 35% led to beneficial combination of post-braze grain size and sag resistance the aluminum alloy fin stock material. In another example, a combination of IA temperature of 300°C and %CW of 25% led to beneficial combination of post-braze grain size and sag resistance the aluminum alloy fin stock material. In another example, a combination of IA temperature and %CW during processing of the aluminum alloy fin stock material in H14 temper resulted in improved fin crush resistance. Accordingly, the processes of producing aluminum alloy fin stock materials employing specified IA temperature and %CW, which lead, in some examples, to higher pre-braze tensile strength and improved fin crush resistance during assembly, are included within the embodiments of the present invention.

[0026] Once preheated, the ingot is hot rolled to form a coil which is then cold rolled. The cold rolling process takes place in several steps, and a step of inter-annealing is employed between cold-rolling steps to recrystallize the material prior to the final cold rolling step. IA temperature in the range of 275-400°C is employed. IA temperature in the range of about 300-400°C, 300-450°C, 340-460°C, or 325-375°C may be employed. For example, IA temperature of about 300°C, 350°C or 400°C may be employed in the processes of producing aluminum alloy fin stock materials according to embodiments of the present invention. After inter-annealing, the aluminum alloy fin stock material is cold rolled in the final cold rolling step to obtain the desired final gauge or thickness. After the final cold rolling step, the aluminum alloy fin stock material can be slit into narrow strips suitable for the manufacture of radiators and other automotive heat exchangers. In the processes of producing aluminum alloy fin stock materials %CW employed in the final cold rolling step is 20-35% or 25-35%, for example, about 25% or 29%.

[0027] Various combinations of production parameters may be beneficially employed in the processes for processes of producing aluminum alloy fin stock materials according to embodiments of the present invention. In one example, %CW in the range 25-35% is employed in the final rolling step, resulting in improved pre-braze yield strength and tensile strength of the aluminum alloy fin stock materials, which, in turn, leads to reduction in the fin crush occurrence during assembly. In another example, selecting IA temperature of about 350°C results in larger post-braze grain size. In one more example, using %CW of about 29% during the final cold rolling step further increases post-braze grain size. In yet another example, inter-annealing at 350°C for 4 hours is employed in combination with 29% CW in the final cold rolling step, which results in a material with desirable characteristics of good pre-braze strength and large post-braze grain size, high thermal conductivity and good sag behavior. In yet another example, inter-annealing at 400°C for an average of about 3 hours is employed, followed by applying % cold work (CW) of about 29% to achieve final gauge. In yet another example, soaking at about 480°C for an average of 4 hours is employed during the hot-rolling step, in combination with interannealing at about 300-400°C and % CW in the final cold-rolling step of about 25-35% to final gauge. In yet another example, soaking at 480°C for 4-16 hours in hot rolling step is employed in combination with interannealing at 350°C and %CW of 29% in the final rolling step. In yet another example, soaking at 480°C for 4-16 hours in hot rolling step is

employed in combination with interannealing at 400°C and %CW of 29% in the final rolling step. In one more example, soaking at 480°C for an average of 4 hours in hot rolling step is employed in combination with interannealing at 350°C and %CW of 35% in the final rolling step. In one more example, inter-annealing at 325-375°C and 20-35% CW, such as interannealing at 300°C and CW 25% in the final cold rolling step is employed.

[0028] The aluminum alloy fin stock materials produced according to some embodiments of the present invention are produced as sheets varying in gauge (thickness) between 45 μm and 80 μm . The aluminum alloy fin stock material according to the embodiments of the present invention has one or more of the following properties: minimum ultimate tensile strength (UTS) of 130 MPa (in other words, 130 MPa or more, or at least 130 MPa) measured post-brazing (for example, 134 or 137 MPa); average conductivity value of about 43%, about 41.5%, about 42.7% or about 43.3% (International Annealed Copper Standard (IACS)); an open circuit potential corrosion value vs. Standard Calomel Electrode (SCE) of -680mV or less, -700 mV or less or -740 or less (for example, -710mV, -720 mV, -724 mV, -725 mV, -743 mV, -740mV or -758 mV); a sag value between 7 mm, where the final gauge was 47.5 μm , and 5 mm, where the final gauge was 50 μm , with a cantilevered length of 35 mm. The above properties of aluminum alloy fin stock material sheets are measured after applying a faster braze cycle, whereby the material is heated to a temperature of 605°C and cooled to room temperature in a period of about 20 minutes, to simulate the temperature time profile of a commercial brazing process. The aluminum alloy fin stock material according to the embodiments of the present invention can have UTS pre-brazing in the range of 180-220 MPa (for example, 185 or 190 MPa). The aluminum alloy fin stock material according to the embodiments of the present invention can also have grain size >200 μm for example, 200 or 400 μm .

[0029] The following examples will serve to further illustrate the present invention without, at the same time, however, constituting any limitation thereof.

Example 1

[0030] An aluminum alloy fin stock material was made by a process that involved DC casting, preheating the ingot to 480°C for about 8 hours, followed by hot rolling to about 2.5 mm, cold rolling, and inter-annealing at 350°C for about 2 hours prior to final cold rolling step. The composition range of the aluminum alloy fin stock material was within the following specification: $1.1 \pm 0.1\%$ Si, $0.6 \pm 0.1\%$ Fe, $0.2 \pm 0.05\%$ Cu, $1.4 \pm 0.1\%$ Mn and $1.50 \pm 0.1\%$ Zn, with the remainder Al. The aluminum alloy fin stock material produced varied in gauge between 49 and 83 μm . The aluminum alloy fin stock material had a minimum ultimate tensile strength of ~130MPa. The aluminum alloy fin stock material had an average conductivity after brazing of ~43 IACS and an open circuit potential corrosion value vs. SCE of -741 mV. These values were measured after applying a simulated brazing cycle, whereby the sample was heated to a temperature of 605°C and cooled to room temperature in a period of about 20 minutes to simulate the temperature time profile of a commercial brazing process.

Example 2

[0031] Two samples of aluminum alloy fin stock material were made by a process that involved DC casting, followed by hot rolling with pre-heating at 480°C for 4-16 hours, cold rolling, and inter-annealing at 350°C for the first sample and at 400°C for the second sample, prior to final cold rolling to 29% %CW. The composition of the first sample was: 0.95% Si, 0.6% Fe, 0.2% Cu, 1.45% Mn and 1.55% Zn, with the remainder Al. The composition of the second sample was: 1.15% Si, 0.6% Fe, 0.25% Cu, 1.5% Mn and 2% Zn, with the remainder Al. The aluminum alloy fin stock material had a post-braze ultimate tensile strength of ~134 MPa for the first sample and ~137 MPa for the second sample. The aluminum alloy fin stock material had an average conductivity after brazing of ~42.7 IACS for the first sample and ~43.3 IACS for the second sample. The aluminum alloy fin stock material had an open circuit potential corrosion value vs. SCE of -710 mV for the first sample and -743mV for the second sample. The aluminum alloy fin stock material had a grain size of 400 μm for the first sample and 200 μm for the second sample. The aluminum alloy fin stock material exhibited pre-braze UTS of 185 MPa for the first sample and 190 MPa for the second sample. The comparison between the two samples revealed that both samples produced attractive mechanical properties, but the open circuit potential corrosion value of the first sample was lower, indicating that increase in Zn content may be desirable. The second sample had advantageously lower open circuit potential corrosion value.

Claims

1. An aluminum alloy fin stock material comprising 0.9-1.3 wt% Si, 0.45-0.75 wt% Fe, 0.10-0.3 wt% Cu, 1.3-1.7 wt% Mn and 1.30-2.2 wt% Zn, with the remainder as Al, wherein optionally Cr and/or Zr are present in the aluminum alloy fin stock material in an amount of up to 0.03 wt% each, and wherein further optionally the aluminum alloy fin stock material contains other minor elements in an amount below 0.05 wt%.

2. The aluminum alloy fin stock material of claim 1, comprising 0.9-1.2 wt% Si, 0.5-0.75 wt% Fe, 0.15-0.3 wt% Cu, 1.4-1.6 wt% Mn and 1.4-2.1 wt% Zn, with the remainder as Al or comprising 0.9-1.1 wt% Si, 0.5-0.6 wt% Fe, 0.15-0.25 wt% Cu, 1.5-1.6 wt% Mn and 1.5-1.6 wt% Zn, with the remainder as Al.
3. The aluminum alloy fin stock material of claim 1, comprising 0.90-1.0 wt% Si, 0.55 wt% Fe, 0.15-0.20 wt% Cu, 1.5 wt% Mn and 1.5 wt% Zn, and with the remainder as Al, in particular comprising 0.95 wt% Si and 0.15 wt% Cu.
4. The aluminum alloy fin stock material of claim 1, comprising 1.0-1.2 wt% Si, 0.5-0.6 wt% Fe, 0.2-0.3 wt% Cu, 1.4-1.55 wt% Mn and 1.9-2.1 wt% Zn, with the remainder as Al or comprising 0.95% Si, 0.2% Cu, 0.6% Fe, 1.45% Mn, and 1.55% Zn, remainder Al or comprising 1.15 wt% Si, 0.25 wt% Cu, 0.6 wt% Fe, 1.5 wt% Mn, and 2.0 wt% Zn, remainder Al.
5. A heat exchanger comprising the aluminum alloy fin stock material of any one of claims 1 to 4.
6. The heat exchanger of claim 5, wherein the heat exchanger is an automotive heat exchanger or wherein the heat exchanger is a radiator, a condenser or an evaporator.
7. Use of the aluminum alloy fin stock material of any one of claims 1 to 4 for fabrication of heat exchanger fins.
8. A process for making the aluminum alloy fin stock material of any of claims 1 to 4, comprising direct chill casting an aluminum alloy into an ingot; preheating the ingot to 450-500 °C for 2 to 16 hours; hot rolling the preheated ingot; cold rolling the ingot; inter-annealing at a temperature of 275 to 400°C; and, after inter-annealing, performing a final cold rolling step to achieve % cold work %CW of 20-35%.
9. The process of claim 8, wherein the ingot is preheated at 480°C for 2-16 hours or wherein the ingot is preheated for 2-12 hours.
10. The process of claim 8, wherein the interannealing temperature is 325 to 375°C or wherein the interannealing temperature is 300, 350 or 400°C or wherein the interannealing temperature is 300°C and %CW is 25% or wherein the interannealing temperature is 350°C or 400°C and %CW is 29%.

Patentansprüche

1. Aluminiumlegierungs-Rippenmaterial, umfassend 0,9 - 1,3 Gew.-% Si, 0,45 - 0,75 Gew.-% Fe, 0,10 - 0,3 Gew.-% Cu, 1,3 - 1,7 Gew.-% Mn und 1,30 - 2,2 Gew.-% Zn, wobei der Rest Al ist, wobei gegebenenfalls Cr und/oder Zr in dem Aluminiumlegierungs-Rippenmaterial in einer Menge von bis zu 0,03 Gew.-% jeweils vorhanden sind und wobei weiterhin gegebenenfalls das Aluminiumlegierungs-Rippenmaterial andere kleine Elemente in einer Menge unter 0,05 Gew.-% enthält.
2. Aluminiumlegierungs-Rippenmaterial nach Anspruch 1, umfassend 0,9 - 1,2 Gew.-% Si, 0,5 - 0,75 Gew.-% Fe, 0,15 - 0,3 Gew.-% Cu, 1,4 - 1,6 Gew.-% Mn und 1,4 - 2,1 Gew.-% Zn, wobei der Rest Al ist, oder umfassend 0,9 - 1,1 Gew.-% Si, 0,5 - 0,6 Gew.-% Fe, 0,15 - 0,25 Gew.-% Cu, 1,5 - 1,6 Gew.-% Mn und 1,5 - 1,6 Gew.-% Zn, wobei der Rest Al ist.
3. Aluminiumlegierungs-Rippenmaterial nach Anspruch 1, umfassend 0,90 - 1,0 Gew.-% Si, 0,55 Gew.-% Fe, 0,15 - 0,20 Gew.-% Cu, 1,5 Gew.-% Mn und 1,5 Gew.-% Zn, und wobei der Rest Al ist, insbesondere umfassend 0,95 Gew.-% Si und 0,15 Gew.-% Cu.
4. Aluminiumlegierungs-Rippenmaterial nach Anspruch 1, umfassend 1,0 - 1,2 Gew.-% Si, 0,5 - 0,6 Gew.-% Fe, 0,2 - 0,3 Gew.-% Cu, 1,4 - 1,55 Gew.-% Mn und 1,9 - 2,1 Gew.-% Zn, wobei der Rest Al ist, oder umfassend 0,95 % Si, 0,2 % Cu, 0,6 % Fe, 1,45 % Mn und 1,55 % Zn, wobei der Rest Al ist oder

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umfassend 1,15 Gew.-% Si, 0,25 Gew.-% Cu, 0,6 Gew.-% Fe, 1,5 Gew.-% Mn und 2,0 Gew.-% Zn, wobei der Rest Al ist.

- 5 5. Wärmetauscher, umfassend das Aluminiumlegierungs-Rippenmaterial nach einem der Ansprüche 1 bis 4.
6. Wärmetauscher nach Anspruch 5, wobei der Wärmetauscher ein Kraftfahrzeugwärmetauscher ist oder wobei der Wärmetauscher ein Kühler, ein Kondensator oder ein Verdampfer ist.
- 10 7. Verwendung des Aluminiumlegierungs-Rippenmaterials nach einem der Ansprüche 1 bis 4 zur Herstellung von Wärmetauscher-Rippen.
- 15 8. Verfahren zur Herstellung des Aluminiumlegierungs-Rippenmaterials nach einem der Ansprüche 1 bis 4, umfassend direktes Kokillengießen einer Aluminiumlegierung in einen Barren;
Vorwärmen des Barrens auf 450 - 500 °C für 2 bis 16 Stunden;
Warmwalzen des vorgewärmten Barrens;
Kaltwalzen des Barrens;
Zwischenglühen bei einer Temperatur von 275 - 400 °C; und
nach dem Zwischenglühen Durchführen eines letzten Kaltwalzschriffs, um %-Kaltumformung % CW von 20 - 35% zu erzielen.
- 20 9. Verfahren nach Anspruch 8, wobei der Barren bei 480°C für 2 - 16 Stunden vorgewärmt wird oder wobei der Barren für 2 - 12 Stunden vorgewärmt wird.
- 25 10. Verfahren nach Anspruch 8, wobei die Zwischenglüh-Temperatur 325 bis 375°C ist oder
wobei die Zwischenglühtemperatur 300, 350 oder 400°C ist oder
wobei die Zwischenglühtemperatur 300°C ist und % CW 25% ist oder
wobei die Zwischenglühtemperatur 350°C oder 400°C ist und % CW 29% ist.

30 Revendications

- 35 1. Matériel de base pour ailettes en alliage d'aluminium comprenant 0,9 à 1,3 % en poids de Si, 0,45 à 0,75 % en poids de Fe, 0,10 à 0,3 % en poids de Cu, 1,3 à 1,7 % en poids de Mn et 1,30 à 2,2 % en poids de Zn, le reste étant Al, dans lequel facultativement Cr et/ou Sr sont présents dans le matériel de base pour ailettes en alliage d'aluminium en une quantité de jusqu'à 0,03 % en poids chacun, et dans lequel en outre facultativement le matériel de base pour ailettes en alliage d'aluminium contient d'autres éléments mineurs en une quantité inférieure à 0,05 % en poids.
- 40 2. Matériel de base pour ailettes en alliage d'aluminium selon la revendication 1, comprenant 0,9 à 1,2 % en poids de Si, 0,5 à 0,75 % en poids de Fe, 0,15 à 0,3 % en poids de Cu, 1,4 à 1,6 % en poids de Mn et 1,4 à 2,1 % en poids de Zn, le reste étant Al ou
comprenant 0,9 à 1,1 % en poids de Si, 0,5 à 0,6 % en poids de Fe, 0,15 à 0,25 % en poids de Cu, 1,5 à 1,6 % en poids de Mn et 1,5 à 1,6 % en poids de Zn, le reste étant Al.
- 45 3. Matériel de base pour ailettes en alliage d'aluminium selon la revendication 1, comprenant 0,90 à 1,0 % en poids de Si, 0,55 % en poids de Fe, 0,15 à 0,20 % en poids de Cu, 1,5 % en poids de Mn et 1,5 % en poids de Zn, le reste étant Al,
en particulier comprenant 0,95 % en poids de Si et 0,15 % en poids de Cu.
- 50 4. Matériel de base pour ailettes en alliage d'aluminium selon la revendication 1, comprenant 1,0 à 1,2 % en poids de Si, 0,5 à 0,6 % en poids de Fe, 0,2 à 0,3 % en poids de Cu, 1,4 à 1,55 % en poids de Mn et 1,9 à 2,1 % en poids de Zn, le reste étant Al ou
comprenant 0,95 % de Si, 0,2 % de Cu, 0,6 % de Fe, 1,45 % de Mn et 1,55 % de Zn, le reste étant Al ou
comprenant 1,15 % en poids de Si, 0,25 % en poids de Cu, 0,6 % en poids de Fe, 1,5 % en poids de Mn et 2,0 % en poids de Zn, le reste étant Al.
- 55 5. Echangeur de chaleur comprenant le matériel de base pour ailettes en alliage d'aluminium selon l'une quelconque des revendications 1 à 4.

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6. Echangeur de chaleur selon la revendication 5, lequel échangeur de chaleur est un échangeur de chaleur pour automobile ou lequel échangeur de chaleur est un radiateur, un condensateur ou un évaporateur.
7. Utilisation d'un matériel de base pour ailettes en alliage d'aluminium selon l'une quelconque des revendications 1 à 4 pour la fabrication d'ailettes d'échangeur de chaleur.
8. Procédé pour fabriquer le matériel de base pour ailettes en alliage d'aluminium selon l'une quelconque des revendications 1 à 4, comprenant
la coulée à refroidissement direct d'un alliage d'aluminium en un lingot ;
le préchauffage du lingot à 450-500 °C pendant 2 à 16 heures ;
le laminage à chaud du lingot préchauffé ;
le laminage à froid du lingot ;
le recuit intermédiaire à une température de 275 à 400 °C ; et
après le recuit intermédiaire, la mise en œuvre d'une étape finale de laminage à froid pour obtenir un % de travail à froid %CW de 20 à 35 %.
9. Procédé selon la revendication 8, dans lequel le lingot est préchauffé à 480 °C pendant 2 à 16 heures ou dans lequel le lingot est préchauffé pendant 2 à 12 heures.
10. Procédé selon la revendication 8, dans lequel la température de recuit intermédiaire est de 325 à 375 °C ou dans lequel la température de recuit intermédiaire est de 300, 350 ou 400 °C ou dans lequel la température de recuit intermédiaire est de 300 °C et le %CW est 25 % ou dans lequel la température de recuit intermédiaire est de 350 °C ou 400 °C et le %CW est 29 %.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2002161324 A [0002]
- JP H1088265 A [0002]