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

(11) EP 4 527 961 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
26.03.2025 Bulletin 2025/13

(21) Application number: **24805751.5**

(22) Date of filing: **30.04.2024**

(51) International Patent Classification (IPC):
C22C 21/00 (2006.01) ***C22C 1/02*** (2006.01)
B22D 11/00 (2006.01) ***B22D 11/114*** (2006.01)
B22D 11/119 (2006.01) ***B21C 37/04*** (2006.01)
H01B 1/02 (2006.01) ***H01B 13/00*** (2006.01)

(86) International application number:
PCT/CN2024/090806

(87) International publication number:
WO 2025/030942 (13.02.2025 Gazette 2025/07)

(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 ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(30) Priority: **07.08.2023 CN 202310991306**

(71) Applicants:
- **Jiangsu Zhongtian Technology Co., Ltd.**
  Nantong, Jiangsu 226463 (CN)
- **Shanghai Zhongtian Aluminum Wire Co., Ltd.**
  Shanghai 201100 (CN)

(72) Inventors:
- **MIAO, Yaojun**
  Nantong
  Jiangsu 226463 (CN)
- **JIANG, Haiyang**
  Nantong
  Jiangsu 226463 (CN)
- **CAO, Tianyao**
  Nantong
  Jiangsu 226463 (CN)
- **WANG, Xinyu**
  Nantong
  Jiangsu 226463 (CN)
- **CAO, Yan**
  Nantong
  Jiangsu 226463 (CN)
- **XU, Aibing**
  Nantong
  Jiangsu 226463 (CN)

(74) Representative: **Withers & Rogers**
Withers & Rogers LLP
2 London Bridge
London SE1 9RA (GB)

(54) LOW-COST AND HIGH-PERFORMANCE ALUMINUM ALLOY MONOFILAMENT AND PREPARATION METHOD THEREFOR

(57) The present disclosure provides a low-cost high-performance aluminum alloy monofilament and a preparation method thereof. Based on the total weight of the aluminum alloy monofilament denoted as 100%, the low-cost high-performance aluminum alloy monofilament comprises the following element composition: Fe accounting for 0.8% to 1.5%, Si accounting for 0.05% or less, and Al and inevitable impurity elements accounting for the balance. The preparation method of the aluminum alloy monofilament comprises the following steps: performing at least smelting, refining, ultrasonic treatment, continuous casting and rolling, and rod drawing on the raw material according to the element composition and their weight percentages of the aluminum alloy monofilament, to prepare and obtain the low-cost high-performance aluminum alloy monofilament. The aluminum alloy monofilament provided by the present disclosure is an aluminum alloy monofilament having low cost, high conductivity and medium strength. The aluminum alloy monofilament has a strength greater than or equal to 280 MPa, an electrical conductivity greater than or equal to 59% IACS, and an elongation greater than or equal to 3%. The preparation process route can meet the requirements for mass production in enterprises.

(Cont. next page)

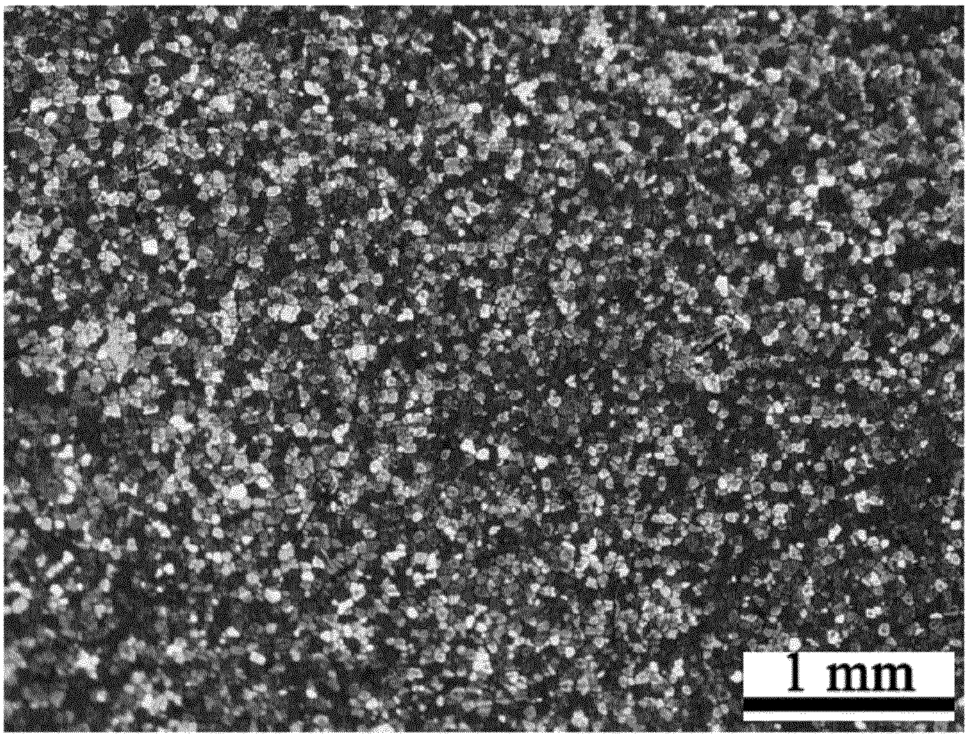

Fig. 1

Description

Technical Field

[0001] The present disclosure relates to a low-cost high-performance aluminum alloy monofilament and a preparation method thereof, and belongs to the technical field of aluminum alloys.

Background Art

[0002] Overhead power transmission lines are energy arteries for economic development. Overhead power transmission lines are mainly composed of ordinary aluminum cable steel reinforced, which leads to high power loss. Using energy-saving conductive wires in replacement of aluminum cable steel reinforced can greatly reduce the power loss of power transmission lines, and has become an important development trend in the field of overhead power transmission. At present, the strengths of high-conductivity aluminum alloy wires having electrical conductivity of 58.5% IACS are only 230 to 250 MPa, and the tensile strengths of wires made of such aluminum alloys are inadequate. It is well known that the strength, elongation and electrical conductivity of Al-Mg-Si alloys are mutually restricted. When the strength is increased, the elongation and the electrical conductivity of the alloys tend to decrease significantly. At present, it is difficult to greatly improve the overall performance with existing Al-Mg-Si alloys and conventional process routes, and the production cost of which is high.

[0003] In the prior art, the process route of medium-strength Al-Mg-Si alloy wires is generally from smelting to continuous casting and rolling, then to drawing, and finally aging treatment, the cost and energy consumption of the alloy materials are high, and it is difficult to further make breakthroughs in the overall performance of alloy monofilaments. A medium-strength aluminum alloy wire without heat treatment and a production process thereof are disclosed in Chinese Patent Application No. CN103996427A. The aluminum alloy wire is made of an alloy mainly containing Fe, and the alloy further contains Mg, Cu, and rare earth elements, etc. The preparation process of the aluminum alloy wire is complicated, and a long-time annealing treatment is required; therefore, the aluminum alloy wire also has the disadvantage of high cost.

[0004] Therefore, it is still an urgent task to develop a low-cost high-performance aluminum alloy monofilament and a preparation method thereof.

Summary of the Invention

[0005] In order to solve the above technical problem, an object of the present disclosure is to provide a low-cost high-performance aluminum alloy monofilament and a preparation method thereof. The aluminum alloy monofilament provided by the present disclosure is an aluminum alloy monofilament having high conductivity and medium strength, and the production cost and energy consumption of the aluminum alloy monofilament are low.

[0006] In order to attain the above object, in a first aspect, the present disclosure provides a low-cost high-performance aluminum alloy monofilament, which, based on the total weight of the low-cost high-performance aluminum alloy monofilament denoted as 100%, comprises the following elements: Fe accounting for 0.8% to 1.5%, Si accounting for 0.05% or less, and Al and inevitable impurity elements accounting for the balance.

[0007] In the low-cost high-performance aluminum alloy monofilament described above, preferably, based on the total weight of the low-cost high-performance aluminum alloy monofilament denoted as 100%, the content of each impurity element in the element composition is less than or equal to 0.005%, and the total content of the impurity elements is less than or equal to 0.02%.

[0008] According to a specific embodiment of the present disclosure, preferably, the low-cost high-performance aluminum alloy monofilament is prepared through at least the following steps: performing at least smelting, refining, ultrasonic treatment, continuous casting and rolling, and rod drawing on the raw material according to the element composition and their weight percentages of the low-cost high-performance aluminum alloy monofilament, to prepare the low-cost high-performance aluminum alloy monofilament;

wherein the ultrasonic treatment comprises: performing in-line ultrasonic treatment on a refined melt with ultrasonic power of 2 to 5 Kw at a frequency of 1.8 to 2.5 KHz;

the continuous casting and rolling comprises: pouring the melt after the ultrasonic treatment into a wheel crystallizer for continuous casting to form a casting blank, feeding the casting blank into a continuous rolling mill for continuous rolling, heating the casting blank with a medium frequency heating device before rolling, controlling the initial rolling temperature at 530 to 550°C, adjusting the preheating temperature of an emulsion to 40 to 60°C and the flow rate of the emulsion to 120 to 180 L/min., and controlling the final rolling temperature at 350°C or above, so as to obtain an aluminum alloy rod after rolling.

[0009] In the low-cost high-performance aluminum alloy monofilament described above, preferably, in the preparation steps of the low-cost high-performance aluminum alloy monofilament, the raw material comprises an aluminum ingot and an iron agent.

[0010] In the low-cost high-performance aluminum alloy monofilament described above, preferably, in the preparation steps of the low-cost high-performance aluminum alloy monofilament, the smelting comprises: adding an aluminum ingot and an iron agent into a smelting furnace according to the element composition and their weight percentages of the low-cost high-performance aluminum alloy monofilament, heating and melting the material while sufficiently stirring.

[0011] In the low-cost high-performance aluminum alloy monofilament described above, preferably, in the preparation steps of the low-cost high-performance aluminum alloy monofilament, the refining comprises in-furnace refining and in-line refining;

the in-furnace refining comprises: transferring a melt obtained through smelting into a tilting heat holding furnace, starting an electromagnetic stirring device at the bottom of the tilting heat holding furnace to sufficiently stir the melt, adjusting the temperature of the melt to 730 to 750°C and refining in the furnace for 10 to 15 minutes, then thoroughly scraping off the scum on the surface of the melt, and then adjusting the temperature of the melt to 720 to 730°C and holding the melt still for 30 to 40 minutes;

the in-line refining comprises: performing in-line degassing and in-line filtering on the melt after the casting is commenced; wherein the in-line degassing employs a rotary blowing degassing box; the in-line filtering employs a two-stage foam ceramic filtering box.

[0012] In the low-cost high-performance aluminum alloy monofilament described above, preferably, in the preparation steps of the low-cost high-performance aluminum alloy monofilament, the melt after the ultrasonic treatment contains an Al_3Fe phase and an Al_6Fe phase.

[0013] In the low-cost high-performance aluminum alloy monofilament described above, preferably, in the preparation steps of the low-cost high-performance aluminum alloy monofilament, the average grain size of the casting blank is smaller than 50 μm.

[0014] In the low-cost high-performance aluminum alloy monofilament described above, preferably, in the preparation steps of the low-cost high-performance aluminum alloy monofilament, the continuous rolling mill employs a three-roller mill; more preferably, the continuous rolling mill employs a three-roller mill having 15 stands.

[0015] In the low-cost high-performance aluminum alloy monofilament described above, preferably, in the preparation steps of the low-cost high-performance aluminum alloy monofilament, the diameter of the aluminum alloy rod is 9 to 10 mm.

[0016] According to the present disclosure, a refined melt is treated through ultrasonic treatment, a local supercooled region is formed in the melt by means of a cavitation effect, so that a large amount of Fe element is precipitated in fine Al_3Fe and Al_6Fe phases, and the grain structures are refined in a casting process, so that the average grain size of the casting blank is smaller than 50 μm, in order to prevent formation of a coarse needle-like iron-rich phase in the alloy, and improve the plasticity of the alloy. In addition, in the present disclosure, the alloy is maintained at a high temperature in the entire rolling process, the rod is cooled by air after the rolling, so that a small amount of Fe element in a solid solution state in the alloy is precipitated by utilizing waste heat.

[0017] In the low-cost high-performance aluminum alloy monofilament described above, preferably, in the preparation steps of the low-cost high-performance aluminum alloy monofilament, the rod drawing comprises: drawing the aluminum alloy rod with a slip drawing machine to obtain the low-cost high-performance aluminum alloy monofilament.

[0018] According to a specific embodiment of the present disclosure, preferably, the diameter of the low-cost high-performance aluminum alloy monofilament is 2.5 to 4 mm.

[0019] According to a specific embodiment of the present disclosure, preferably, the low-cost high-performance aluminum alloy monofilament has a strength greater than or equal to 280 MPa, an electrical conductivity greater than or equal to 59% IACS, and an elongation greater than or equal to 3%.

[0020] In a second aspect, the present disclosure provides a preparation method of the above-mentioned low-cost high-performance aluminum alloy monofilament, which comprises the following steps: performing at least smelting, refining, ultrasonic treatment, continuous casting and rolling, and rod drawing on the raw material according to the element composition and their weight percentages of the low-cost high-performance aluminum alloy monofilament, to prepare and obtain the low-cost high-performance aluminum alloy monofilament;

wherein the ultrasonic treatment comprises: performing in-line ultrasonic treatment on a refined melt with ultrasonic power of 2 to 5 Kw at a frequency of 1.8 to 2.5 KHz;

the continuous casting and rolling comprises: pouring the melt after the ultrasonic treatment into a wheel crystallizer for continuous casting to form a casting blank, feeding the casting blank into a continuous rolling mill for continuous rolling, heating the casting blank with a medium frequency heating device before rolling, controlling the initial rolling temperature at 530 to 550°C, adjusting the preheating temperature of an emulsion to 40 to 60°C and the flow rate of the emulsion to 120 to 180 L/min., and controlling the final rolling temperature at 350°C or above, so as to obtain an aluminum alloy rod after rolling.

[0021] In the preparation method described above, preferably, the raw material comprises an aluminum ingot and an iron agent.

[0022] In the preparation method described above, preferably, the smelting comprises: adding an aluminum ingot and an iron agent into a smelting furnace according to the element composition and their weight percentages of the low-cost high-performance aluminum alloy monofilament, heating and melting the material while sufficiently stirring.

[0023] In the preparation method described above, preferably, the refining comprises in-furnace refining and in-line refining;

the in-furnace refining comprises: transferring a melt obtained through smelting into a tilting heat holding furnace, starting an electromagnetic stirring device at the bottom of the tilting heat holding furnace to sufficiently stir the melt, adjusting the temperature of the melt to 730 to 750°C and

refining in the furnace for 10 to 15 minutes, then thoroughly scraping off the scum on the surface of the melt, and then adjusting the temperature of the melt to 720 to 730°C and holding the melt still for 30 to 40 minutes;

the in-line refining comprises: performing in-line degassing and in-line filtering on the melt after the casting is commenced; wherein the in-line degassing employs a rotary blowing degassing box; and the in-line filtering employs a two-stage foam ceramic filtering box.

[0024] In some specific embodiments of the present disclosure, preferably, the degassing medium of the rotary blowing degassing box is high-purity nitrogen, and the rotation speed of a graphite rotor is 400 to 500 r/min. After the in-line degassing, the hydrogen content in the melt can be less than 0.12 ml / 100 g.

[0025] In some specific embodiments of the present disclosure, preferably, the porosity of the two-stage foam ceramic filtering box is 30/50 PPI. The two-stage foam ceramic filtering box comprises two layers of ceramic foam filter plates, wherein the first layer of filter plate has a larger pore size (30 PPI) and mainly filters large-size inclusions, while the second layer of filter plate has a smaller pore size (50 PPI) and filters small-size inclusions; the two-stage filtering has the advantages of a wider filtering range and a higher filtering accuracy. In the present disclosure, a two-stage foam ceramic filtering box with porosity of 30/50 PPI is employed, so as to remove 5 to 10 μm included particles in the melt in a better way and reduce the adverse effect of the inclusions on the elongation of the alloy monofilament.

[0026] In the preparation method described above, preferably, the melt after the ultrasonic treatment contains an Al_3Fe phase and an Al_6Fe phase.

[0027] In the preparation method described above, preferably, the average grain size of the casting blank is smaller than 50 μm.

[0028] In the preparation method described above, preferably, the continuous rolling mill employs a three-roller mill; more preferably, the continuous rolling mill employs a three-roller mill having 15 stands.

[0029] In the preparation method described above, preferably, the diameter of the aluminum alloy rod is 9 to 10 mm.

[0030] According to a specific embodiment of the present disclosure, in the continuous casting and rolling process, the equipment used for continuous casting and continuous rolling may be the equipment used in the prior art, and the emulsion may be a conventional emulsion used in the continuous aluminum alloy rolling technology.

[0031] In the preparation method described above, preferably, the rod drawing comprises: drawing the aluminum alloy rod with a slip drawing machine to obtain an aluminum alloy monofilament in diameter of 2.5 to 4 mm, which is the low-cost high-performance aluminum alloy monofilament.

[0032] The present disclosure provides a low-cost high-performance aluminum alloy monofilament and a preparation method thereof. The aluminum alloy monofilament provided by the present disclosure is an aluminum alloy monofilament having low cost, high conductivity and medium strength. The aluminum alloy monofilament has a strength greater than or equal to 280 MPa, an electrical conductivity greater than or equal to 59% IACS, and an elongation greater than or equal to 3%. The preparation process route can meet the requirements for mass production in enterprises.

[0033] The technical solution of the present disclosure has at least the following beneficial effects:

(1) The composition of the alloy element in the present disclosure basically contains only Fe, in addition to Al. Therefore, the cost of the alloy material is very low, and the solid solubility of Fe element in the matrix is very low, thus having little effect on the electrical conductivity of the alloy and enabling the alloy to achieve very high electrical conductivity.

(2) In the present disclosure, a large amount of Fe element forms submicron fine and regular Al_3Fe and Al_6Fe precipitates in the melt by means of in-line ultrasonic treatment, so that the alloy can obtain very high strength and the adverse impact on the plasticity of the alloy is minimized; besides, the fine iron-containing phase produces an excellent grain refinement effect during solidification, making the average grain size in a casting state smaller than 50 μm.

(3) The preparation process of the aluminum alloy monofilament in the present disclosure is simple, doesn't require long-term aging treatment, has low energy consumption and high production efficiency, and doesn't require any additional grain refiner, thus further reducing the production cost.

Brief Description of Drawings

[0034] Fig. 1 is a metallograph of the grain structure in a casting state of the casting blank in Example 1.

Embodiments

[0035] In order to provide a clearer understanding on the technical features, objects and beneficial effects of the present disclosure, the technical solution of the present disclosure will be described in detail below, but the description should not be construed as limiting the scope of implementation of the present disclosure.

[0036] According to a specific embodiment of the present disclosure, measured in percentage by weight, the low-cost high-performance aluminum alloy monofilament provided by the present disclosure comprises the following element composition: Fe accounting for 0.8% to 1.5%, Si accounting for 0.05% or less, and Al and inevitable impurity elements accounting for the balance; in addition, the content of each impurity element is less than or equal to 0.005%, and the total content of the impurity elements is less than or equal to 0.02%.

[0037] According to a specific embodiment of the present disclosure, the process flow of the preparation method of the low-cost high-performance aluminum alloy monofilament provided by the present disclosure is as follows:

smelting - in-furnace refining - holding still - casting - in-line degassing - in-line filtering - ultrasonic treatment - continuous casting and rolling - rod drawing.

[0038] Specifically, the preparation method of the low-cost high-performance aluminum alloy monofilament provided by the present disclosure comprises the following steps:

(1) Molten aluminum smelting

[0039] An aluminum ingot at purity higher than 99.7% and an iron agent are added into a smelting furnace according to the element composition and their weight percentages of the low-cost high-performance aluminum alloy monofilament, the material is heated and melted, and the molten aluminum is sufficiently stirred to a homogeneous state;

(2) In-furnace refining

[0040] The melt in the smelting furnace is transferred into a tilting heat holding furnace, an electromagnetic stirring device at the bottom of the tilting heat holding furnace is started to sufficiently stir the melt, the temperature of the melt is adjusted to 730 to 750°C and refining in the furnace is carried out for 10 to 15 minutes, the scum on the surface of the melt is thoroughly scraped off, and then the temperature of the melt is adjusted to 720 to 730°C and the melt is held still for 30 to 40 minutes;

(3) In-line refining

[0041] After the casting is commenced, in-line degassing and in-line filtering are carried out on the melt, a rotary blowing degassing box is employed for the in-line degassing, high-purity nitrogen is used as a degassing medium, and the rotation speed of a graphite rotor is controlled at 400 to 500 r/min.; a two-stage foam ceramic filtering box with porosity of 30/50 PPI is employed for the in-line filtering, so as to remove 5 to 10 μm included particles in the melt in a better way and reduce the adverse effect of the inclusions on the elongation of the alloy monofilament;

(4) Ultrasonic treatment

[0042] In-line ultrasonic treatment is carried out on the refined melt in a trough with ultrasonic power of 2 to 5 Kw at a frequency of 1.8 to 2.5 KHz, a local supercooled region is formed in the melt by means of a cavitation effect, so as to drive a large amount of Fe element to precipitate in the form of a fine Al_3Fe phase and a fine Al_6Fe phase; and the grain structure is refined in the subsequent casting process, so as to prevent formation of a coarse needle-like iron-rich phase in the alloy and improve the plasticity of the alloy;

(5) Continuous casting and rolling

[0043] The melt after the ultrasonic treatment is poured into a wheel crystallizer for continuous casting to form a casting blank having an average grain size smaller than 50 μm, the casting blank is fed into a continuous rolling mill for continuous rolling, and the continuous rolling mill employs a three-roller mill with 15 stands; before the rolling, the casting blank is heated by means of a medium frequency heating device, the initial rolling temperature is controlled at 530 to 550°C, the emulsion preheating temperature is adjusted to 40 to 60°C, and the flow rate of the emulsion is controlled to be 120 to 180 L/min., the final rolling temperature is controlled at 350°C or above; the alloy is maintained at a high temperature in the entire rolling process, so as to drive a small amount of Fe element in the solid solution in the alloy to precipitate; after the rolling, the rod is cooled by air; thus, an aluminum alloy rod in diameter of 9 to 10 mm is obtained;

(6) Rod drawing

[0044] The aluminum alloy rod is drawn on a slip drawing machine to obtain an aluminum alloy monofilament in diameter of 2.5 to 4 mm, which is the low-cost high-performance aluminum alloy monofilament.

Example 1

[0045] In this example, a low-cost high-performance aluminum alloy monofilament is provided. The low-cost high-performance aluminum alloy monofilament is prepared and obtained through the following steps:

(1) An aluminum ingot at purity higher than 99.7% and an iron agent are added into a smelting furnace according to the element composition and their weight percentages of the designed aluminum alloy monofilament, the material is heated and melted, and the molten aluminum is sufficiently stirred to a homogeneous state;

(2) The melt in the smelting furnace is transferred into a tilting heat holding furnace, an electromagnetic stirring device at the bottom of the tilting heat holding furnace is started to sufficiently stir the melt, the temperature of the melt is adjusted to 740°C and refining in the furnace is carried out for 12 minutes, the scum on the surface of the melt is thoroughly scraped off, and then the temperature of the melt is adjusted to 723°C and the melt is held still for 30 minutes;

(3) After the casting is commenced, in-line degassing and in-line filtering are carried out on the melt, a rotary blowing degassing box is employed for the in-line degassing, high-purity nitrogen is used as a degassing medium, and the rotation speed of the graphite rotor is controlled at 450 r/min.; a two-stage foam ceramic filtering box with porosity of 30/50 PPI is employed for the in-line filtering, so as to remove 5 to 10 μm included particles in the melt in a better way and reduce the adverse effect of the inclusions on the elongation of the alloy monofilament;

(4) In-line ultrasonic treatment is carried out on the refined melt in a trough with ultrasonic power of 3 Kw at a frequency of 2.2 KHz, a local supercooled region is formed in the melt by means of a cavitation effect, so as to drive a large amount of Fe element to precipitate in the form of a fine Al_3Fe phase and a fine Al_6Fe phase, refine the grain structure, and prevent formation of a coarse needle-like iron-rich phase in the alloy and improve the plasticity of the alloy;

(5) The melt after the ultrasonic treatment is poured into a wheel crystallizer for continuous casting to form a casting blank having an average grain size smaller than 50 μm, as shown in Fig. 1; the casting blank is fed into a three-roller mill with 15 stands for continuous rolling; before the rolling, the casting blank is heated by means of a medium frequency heating device, the initial rolling temperature is controlled at 540°C, the emulsion preheating temperature is adjusted to 40°C, and the flow rate of the emulsion is controlled to be 150 L/min., the final rolling temperature is controlled at 350°C or above; the alloy is maintained at a high temperature in the entire rolling process, so as to drive a small amount of Fe element in the solid solution state in the alloy to precipitate; after the rolling, the rod is cooled by air; thus, an aluminum alloy rod in diameter of 9.5 mm is obtained;

(6) The aluminum alloy rod is drawn on a slip drawing machine to obtain an aluminum alloy monofilament in diameter of 3.5 mm, which is the low-cost high-performance aluminum alloy monofilament.

[0046] Through analysis and detection, measured in percentage by weight, the low-cost high-performance aluminum alloy monofilament in this example has the following element composition: Fe accounting for 0.94%, Si accounting for 0.05%, and Al and inevitable impurity elements accounting for the balance; and the content of each impurity element is less than or equal to 0.005%, and the total content of the impurity elements is less than or equal to 0.02%.

[0047] The low-cost high-performance aluminum alloy monofilament provided in this example has an average strength of 283 MPa, an elongation of 3.5%, and an electrical conductivity of 59.7% IACS.

Example 2

[0048] In this example, a low-cost high-performance aluminum alloy monofilament is provided. The low-cost high-performance aluminum alloy monofilament is prepared and obtained through the following steps:

(1) An aluminum ingot at purity higher than 99.7% and an iron agent are added into a smelting furnace according to the element composition and their weight percentages of the designed aluminum alloy monofilament, the material is heated and melted, and the molten aluminum is sufficiently stirred to a homogeneous state;

(2) The melt in the smelting furnace is transferred into a tilting heat holding furnace, an electromagnetic stirring device at the bottom of the tilting heat holding furnace is started to sufficiently stir the melt, the temperature of the melt is adjusted to 740°C and refining in the furnace is carried out for 15 minutes, the scum on the surface of the melt is thoroughly scraped off, and then the temperature of the melt is adjusted to 720°C and the melt is held still for 30 minutes;

(3) After the casting is commenced, in-line degassing and in-line filtering are carried out on the melt, a rotary blowing degassing box is employed for the in-line degassing, high-purity nitrogen is used as a degassing medium, and the rotation speed of the graphite rotor is controlled at 450 r/min.; a two-stage foam ceramic filtering box with porosity of 30/50 PPI

is employed for the in-line filtering, so as to remove 5 to 10 μm included particles in the melt in a better way and reduce the adverse effect of the inclusions on the elongation of the alloy monofilament;

(4) In-line ultrasonic treatment is carried out on the refined melt in a trough with ultrasonic power of 3 Kw at a frequency of 2.2 KHz, a local supercooled region is formed in the melt by means of a cavitation effect, so as to drive a large amount of Fe element to precipitate in the form of a fine Al_3Fe phase and a fine Al_6Fe phase, refine the grain structure, and prevent formation of a coarse needle-like iron-rich phase in the alloy and improve the plasticity of the alloy;

(5) The melt after the ultrasonic treatment is poured into a wheel crystallizer for continuous casting to form a casting blank having an average grain size smaller than 50 μm; the casting blank is fed into a three-roller mill with 15 stands for continuous rolling; before the rolling, the casting blank is heated by means of a medium frequency heating device, the initial rolling temperature is controlled at 545°C, the emulsion preheating temperature is adjusted to 40°C, and the flow rate of the emulsion is controlled to be 150 L/min., the final rolling temperature is controlled at 350°C or above; the alloy is maintained at a high temperature in the entire rolling process, so as to drive a small amount of Fe element in the solid solution state in the alloy to precipitate; after the rolling, the rod is cooled by air; thus, an aluminum alloy rod in diameter of 9.5 mm is obtained;

(6) The aluminum alloy rod is drawn on a slip drawing machine to obtain an aluminum alloy monofilament in diameter of 3.8 mm, which is the low-cost high-performance aluminum alloy monofilament.

[0049] Through analysis and detection, measured in percentage by weight, the low-cost high-performance aluminum alloy monofilament in this example has the following element composition: Fe accounting for 1.06%, Si accounting for 0.05%, and Al and inevitable impurity elements accounting for the balance; and the content of each impurity element is less than or equal to 0.005%, and the total content of the impurity elements is less than or equal to 0.02%.

[0050] The low-cost high-performance aluminum alloy monofilament provided in this example has an average strength of 288 MPa, an elongation of 3.3%, and an electrical conductivity of 59.4% IACS.

Example 3

[0051] In this example, a low-cost high-performance aluminum alloy monofilament is provided. The low-cost high-performance aluminum alloy monofilament is prepared and obtained through the following steps:

(1) An aluminum ingot at purity higher than 99.7% and an iron agent are added into a smelting furnace according to the element composition and their weight percentages of the designed aluminum alloy monofilament, the material is heated and melted, and the molten aluminum is sufficiently stirred to a homogeneous state;

(2) The melt in the smelting furnace is transferred into a tilting heat holding furnace, an electromagnetic stirring device at the bottom of the tilting heat holding furnace is started to sufficiently stir the melt, the temperature of the melt is adjusted to 740°C and refining in the furnace is carried out for 15 minutes, the scum on the surface of the melt is thoroughly scraped off, and then the temperature of the melt is adjusted to 720°C and the melt is held still for 30 minutes;

(3) After the casting is commenced, in-line degassing and in-line filtering are carried out on the melt, a rotary blowing degassing box is employed for the in-line degassing, high-purity nitrogen is used as a degassing medium, and the rotation speed of the graphite rotor is controlled at 450 r/min.; a two-stage foam ceramic filtering box with porosity of 30/50 PPI is employed for the in-line filtering, so as to remove 5 to 10 μm included particles in the melt in a better way and reduce the adverse effect of the inclusions on the elongation of the alloy monofilament;

(4) In-line ultrasonic treatment is carried out on the refined melt in a trough with ultrasonic power of 3 Kw at a frequency of 2.2 KHz, a local supercooled region is formed in the melt by means of a cavitation effect, so as to drive a large amount of Fe element to precipitate in the form of a fine Al_3Fe phase and a fine Al_6Fe phase, refine the grain structure, and prevent formation of a coarse needle-like iron-rich phase in the alloy and improve the plasticity of the alloy;

(5) The melt after the ultrasonic treatment is poured into a wheel crystallizer for continuous casting to form a casting blank having an average grain size smaller than 50 μm; the casting blank is fed into a three-roller mill with 15 stands for continuous rolling; before the rolling, the casting blank is heated by means of a medium frequency heating device, the initial rolling temperature is controlled at 545°C, the emulsion preheating temperature is adjusted to 50°C, and the flow rate of the emulsion is controlled to be 150 L/min., the final rolling temperature is controlled at 350°C or above; the alloy is maintained at a high temperature in the entire rolling process, so as to drive a small amount of Fe element in the solid

solution state in the alloy to precipitate; after the rolling, the rod is cooled by air; thus, an aluminum alloy rod in diameter of 9.5 mm is obtained;

(6) The aluminum alloy rod is drawn on a slip drawing machine to obtain an aluminum alloy monofilament in diameter of 3.8 mm, which is the low-cost high-performance aluminum alloy monofilament.

[0052] Through analysis and detection, measured in percentage by weight, the low-cost high-performance aluminum alloy monofilament in this example has the following element composition: Fe accounting for 1.15%, Si accounting for 0.04%, and Al and inevitable impurity elements accounting for the balance; and the content of each impurity element is less than or equal to 0.005%, and the total content of the impurity elements is less than or equal to 0.02%.

[0053] The low-cost high-performance aluminum alloy monofilament provided in this example has an average strength of 295 MPa, an elongation of 3.1%, and an electrical conductivity of 59% IACS.

Comparative Example 1

[0054] In this comparative example, an aluminum alloy monofilament is provided. The aluminum alloy monofilament is prepared and obtained through the following steps:

(1) An aluminum ingot at purity higher than 99.7% and an iron agent are added into a smelting furnace according to the element composition and their weight percentages of the designed aluminum alloy monofilament, the material is heated and melted, and the molten aluminum is sufficiently stirred to a homogeneous state;

(2) The melt in the smelting furnace is transferred into a tilting heat holding furnace, an electromagnetic stirring device at the bottom of the tilting heat holding furnace is started to sufficiently stir the melt, the temperature of the melt is adjusted to 740°C and refining in the furnace is carried out for 15 minutes, the scum on the surface of the melt is thoroughly scraped off, and then the temperature of the melt is adjusted to 720°C and the melt is held still for 30 minutes;

(3) After the casting is commenced, in-line degassing and in-line filtering are carried out on the melt, a rotary blowing degassing box is employed for the in-line degassing, high-purity nitrogen is used as a degassing medium, and the rotation speed of the graphite rotor is controlled at 450 r/min.; a two-stage foam ceramic filtering box with porosity of 30/50 PPI is employed for the in-line filtering, so as to remove 5 to 10 μm included particles in the melt and reduce the adverse effect of the inclusions on the elongation of the alloy monofilament;

(4) The melt after the in-line filtering is poured into a wheel crystallizer for continuous casting to form a casting blank, the casting blank is fed into a three-roller mill with 15 stands for continuous rolling; before the rolling, the casting blank is heated by means of a medium frequency heating device, the initial rolling temperature is controlled at 500°C, the emulsion preheating temperature is adjusted to 30°C and the flow rate of the emulsion is adjusted to 250 L/min., and the final rolling temperature is controlled at 350°C or above; the rod is cooled by air after the rolling; thus, an aluminum alloy rod in diameter of 9.5 mm is obtained.

(5) The aluminum alloy rod is drawn on a slip drawing machine; thus, an aluminum alloy monofilament in diameter of 3.5 mm is obtained after the drawing.

[0055] Through analysis and detection, measured in percentage by weight, the aluminum alloy monofilament in this comparative example has the following element composition: Fe accounting for 1.02%, Si accounting for 0.05%, and Al and inevitable impurity elements accounting for the balance; in addition, the content of each impurity element is less than or equal to 0.005%, and the total content of the impurity elements is less than or equal to 0.02%.

[0056] The aluminum alloy monofilament provided in this comparative example has an average strength of 275 MPa, an elongation of 1.3%, and an electrical conductivity of 58.4% IACS.

Comparative Example 2

[0057] In this comparative example, an aluminum alloy monofilament is provided. The aluminum alloy monofilament is prepared and obtained through the following steps:

(1) An aluminum ingot at purity higher than 99.7% and an iron agent are added into a smelting furnace according to the element composition and their weight percentages of the designed aluminum alloy monofilament, the material is heated and melted, and the molten aluminum is sufficiently stirred to a homogeneous state;

(2) The melt in the smelting furnace is transferred into a tilting heat holding furnace, an electromagnetic stirring device at the bottom of the tilting heat holding furnace is started to sufficiently stir the melt, the temperature of the melt is adjusted to 740°C and refining in the furnace is carried out for 15 minutes, the scum on the surface of the melt is thoroughly scraped off, and then the temperature of the melt is

adjusted to 720°C and the melt is held still for 30 minutes;

(3) After the casting is commenced, in-line degassing and in-line filtering are carried out on the melt, a rotary blowing degassing box is employed for the in-line degassing, high-purity nitrogen is used as a degassing medium, and the rotation speed of the graphite rotor is controlled at 450 r/min.; a two-stage foam ceramic filtering box with porosity of 30/50 PPI is employed for the in-line filtering, so as to remove 5 to 10 μm included particles in the melt and reduce the adverse effect of the inclusions on the elongation of the alloy monofilament;

(4) In-line ultrasonic treatment is performed on the refined melt in a trough with ultrasonic power of 3 Kw at a frequency of 2.2 KHz;

(5) The melt after the ultrasonic treatment is poured into a wheel crystallizer for continuous casting to form a casting blank, the casting blank is fed into a three-roller mill with 15 stands for continuous rolling; before the rolling, the casting blank is heated by means of a medium frequency heating device, the initial rolling temperature is controlled at 550°C, the emulsion preheating temperature is adjusted to 40°C and the flow rate of the emulsion is adjusted to 150 L/min., and the final rolling temperature is controlled at 350°C or above; the rod is cooled by air after the rolling; thus, an aluminum alloy rod in diameter of 9.5 mm is obtained.

(6) The aluminum alloy rod is drawn on a slip drawing machine; thus, an aluminum alloy monofilament in diameter of 3.5 mm is obtained after the drawing.

[0058] Through analysis and detection, measured in percentage by weight, the aluminum alloy monofilament in this comparative example has the following element composition: Fe accounting for 0.57%, Si accounting for 0.05%, and Al and inevitable impurity elements accounting for the balance; and the content of each impurity element is less than or equal to 0.005%, and the total content of the impurity elements is less than or equal to 0.02%.

[0059] The aluminum alloy monofilament provided in this comparative example has an average strength of 246 MPa, an elongation of 3.7%, and an electrical conductivity of 60.2% IACS.

Comparative Example 3

[0060] In this comparative example, an aluminum alloy monofilament is provided. The aluminum alloy monofilament is prepared and obtained through the following steps:

(1) An aluminum ingot at purity higher than 99.7%, an Al-Si alloy, an aluminum-rare earth alloy, and an iron agent are added into a smelting furnace according to the element composition and their weight percentages of the designed aluminum alloy monofilament, the material is heated and melted, a magnesium ingot is added into the molten aluminum, stirred and melted, and the molten aluminum is sufficiently stirred to a homogeneous state;

(2) The melt in the smelting furnace is transferred into a tilting heat holding furnace, an aluminum-boron alloy in a trace amount is added for boronizing treatment, an electromagnetic stirring device at the bottom of the tilting heat holding furnace is started to sufficiently stir the melt, the temperature of the melt is adjusted to 740°C and refining in the furnace is carried out for 15 minutes, the scum on the surface of the melt is thoroughly scraped off, and then the temperature of the melt is adjusted to 730°C and the melt is held still for 30 minutes;

(3) After the casting is commenced, in-line degassing and in-line filtering are carried out on the melt, a rotary blowing degassing box is employed for the in-line degassing, high-purity nitrogen is used as a degassing medium, and the rotation speed of the graphite rotor is controlled at 450 r/min.; a two-stage foam ceramic filtering box with porosity of 30/50 PPI is employed for the in-line filtering, so as to remove 5 to 10 μm included particles in the melt and reduce the adverse effect of the inclusions on the elongation of the alloy monofilament;

(4) When the melt flows through the trough, an Al-Ti-B refiner is added on the line for grain refinement, and the added amount of the refiner is 0.08% based on the total weight of the melt;

(5) The melt is poured into a wheel crystallizer for continuous casting to form a casting blank, the casting blank is fed into a three-roller mill with 15 stands for continuous rolling; before the rolling, the casting blank is heated by means of a medium frequency heating device, the initial rolling temperature is controlled at 500°C, the emulsion preheating temperature is adjusted to 30°C and the flow rate of the emulsion is adjusted to 250 L/min., and the final rolling temperature is controlled at 350°C or above; an aluminum alloy rod in diameter of 9.5 mm is obtained after the rolling, and the rod is quenched on the line with cooling water;

(6) The aluminum alloy rod is drawn on a slip drawing machine; thus, an aluminum alloy monofilament in diameter of 3.5 mm is obtained after the drawing;

(7) The drawn aluminum alloy monofilament is aged

at 155°C for 8 hours to obtain the aluminum alloy monofilament.

[0061] Through analysis and detection, measured in percentage by weight, the aluminum alloy monofilament in this comparative example has the following element composition: Mg accounting for 0.38%, Si accounting for 0.35%, Fe accounting for 0.14%, La accounting for 0.01%, B accounting for 0.004%, Ti accounting for 0.002, and Al and inevitable impurity elements accounting for the balance; and the content of each impurity element is less than or equal to 0.005%, and the total content of the impurity elements is less than or equal to 0.02%.

[0062] The aluminum alloy monofilament provided in this comparative example has an average strength of 264 MPa, an elongation of 5.3%, and an electrical conductivity of 58.2% IACS.

[0063] In summary, the aluminum alloy monofilaments provided in the examples 1 to 3 of the present disclosure are aluminum alloy monofilaments having low cost, high conductivity and medium strength. The aluminum alloy monofilaments have a strength greater than or equal to 280 MPa, an electrical conductivity greater than or equal to 59% IACS, and an elongation greater than or equal to 3%. The preparation process route can meet the requirements for mass production in enterprises. In contrast, the comparative examples 1 to 3, either the element compositions are not within the scope defined by the present disclosure, or the preparation processes are different from the preparation process in the present disclosure; as a result, the obtained aluminum alloy monofilaments have a poor overall performance.

Claims

1. A low-cost high-performance aluminum alloy monofilament, based on the total weight of the low-cost high-performance aluminum alloy monofilament denoted as 100%, comprising the following element composition: Fe accounting for 0.8% to 1.5%, Si accounting for 0.05% or less, and Al and inevitable impurity elements accounting for the balance.

2. The low-cost high-performance aluminum alloy monofilament according to claim 1, wherein, based on the total weight of the low-cost high-performance aluminum alloy monofilament denoted as 100%, the content of each impurity element in the element composition is less than or equal to 0.005%, and the total content of the impurity elements is less than or equal to 0.02%.

3. The low-cost high-performance aluminum alloy monofilament according to claim 1 or 2, wherein the low-cost high-performance aluminum alloy monofilament is prepared and obtained through at least the following steps: performing at least smelting, refining, ultrasonic treatment, continuous casting and rolling, and rod drawing on the raw material according to the element composition and their weight percentages of the low-cost high-performance aluminum alloy monofilament, to prepare and obtain the low-cost high-performance aluminum alloy monofilament;

   wherein the ultrasonic treatment comprises: performing in-line ultrasonic treatment on a refined melt with ultrasonic power of 2 to 5 Kw at a frequency of 1.8 to 2.5 KHz;
   the continuous casting and rolling comprises: pouring the melt after the ultrasonic treatment into a wheel crystallizer for continuous casting to form a casting blank, feeding the casting blank into a continuous rolling mill for continuous rolling, heating the casting blank with a medium frequency heating device before rolling, controlling the initial rolling temperature at 530 to 550°C, adjusting the preheating temperature of an emulsion to 40 to 60°C and the flow rate of the emulsion to 120 to 180 L/min., and controlling the final rolling temperature at or above 350°C, so as to obtain an aluminum alloy rod after rolling.

4. The low-cost high-performance aluminum alloy monofilament according to claim 3, wherein the melt after the ultrasonic treatment contains an Al_3Fe phase and an Al_6Fe phase.

5. The low-cost high-performance aluminum alloy monofilament according to claim 3, wherein the average grain size of the casting blank is smaller than 50 μm.

6. The low-cost high-performance aluminum alloy monofilament according to claim 1, wherein the diameter of the low-cost high-performance aluminum alloy monofilament is 2.5 to 4 mm.

7. The low-cost high-performance aluminum alloy monofilament according to claim 1, wherein the low-cost high-performance aluminum alloy monofilament has a strength greater than or equal to 280 MPa, an electrical conductivity greater than or equal to 59% IACS, and an elongation greater than or equal to 3%.

8. A preparation method of the low-cost high-performance aluminum alloy monofilament according to any of claims 1 to 7, comprising the following steps: performing at least smelting, refining, ultrasonic treatment, continuous casting and rolling, and rod drawing on the raw material according to the element composition and their weight percentages of the low-

cost high-performance aluminum alloy monofilament, to prepare and obtain the low-cost high-performance aluminum alloy monofilament;

wherein the ultrasonic treatment comprises: performing in-line ultrasonic treatment on a refined melt with ultrasonic power of 2 to 5 Kw at a frequency of 1.8 to 2.5 KHz;
the continuous casting and rolling comprises: pouring the melt after ultrasonic treatment into a wheel crystallizer for continuous casting to form a casting blank, feeding the casting blank into a continuous rolling mill for continuous rolling, heating the casting blank with a medium frequency heating device before rolling, controlling the initial rolling temperature at 530 to 550°C, adjusting the preheating temperature of an emulsion to 40 to 60°C and the flow rate of the emulsion to 120 to 180 L/min., and controlling the final rolling temperature at 350°C or above, so as to obtain an aluminum alloy rod after rolling.

9. The preparation method according to claim 8, wherein the smelting comprises: adding an aluminum ingot and an iron agent into a smelting furnace according to the element composition and their weight percentages of the low-cost high-performance aluminum alloy monofilament, heating and melting the material while sufficiently stirring;

preferably, the refining comprises in-furnace refining and in-line refining; the in-furnace refining comprises: transferring a melt obtained through smelting into a tilting heat holding furnace, starting an electromagnetic stirring device at the bottom of the tilting heat holding furnace to sufficiently stir the melt, adjusting the temperature of the melt to 730 to 750°C and refining in the furnace for 10 to 15 minutes, thoroughly scraping off the scum on the surface of the melt, and then adjusting the temperature of the melt to 720 to 730°C and holding the melt still for 30 to 40 minutes; the in-line refining comprises: performing in-line degassing and in-line filtering on the melt after the casting is commenced; wherein the in-line degassing employs a rotary blowing degassing box; and the in-line filtering employs a two-stage foam ceramic filtering box;
preferably, the degassing medium of the rotary blowing degassing box is high-purity nitrogen, and the rotation speed of a graphite rotor is 400 to 500 r/min.; and
preferably, the porosity of the two-stage foam ceramic filtering box is 30/50 **PPI.**

10. The preparation method according to claim 8, wherein the continuous rolling mill employs a three-roller mill; preferably, the continuous rolling mill employs a three-roller mill having 15 stands; and
preferably, the diameter of the aluminum alloy rod is 9 to 10 mm.

11. The preparation method according to claim 8, wherein, the rod drawing comprises: drawing the aluminum alloy rod with a slip drawing machine to obtain an aluminum alloy monofilament in diameter of 2.5 to 4 mm, which is the low-cost high-performance aluminum alloy monofilament.

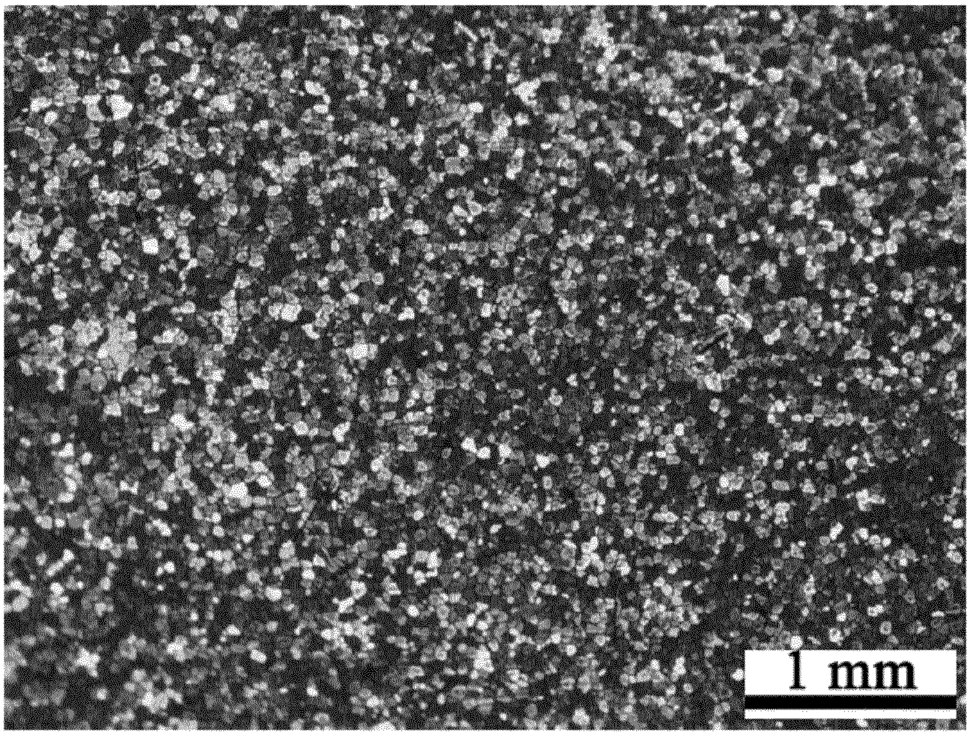

Fig. 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2024/090806

A. CLASSIFICATION OF SUBJECT MATTER

C22C21/00(2006.01)i; C22C1/02(2006.01)i; B22D11/00(2006.01)i; B22D11/114(2006.01)i; B22D11/119(2006.01)i; B21C37/04(2006.01)i; H01B1/02(2006.01)i; H01B13/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC:C22C,B22D,B21C,H01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNKI, CNTXT, CNABS, ENTXTC, DWPI, EPODOC: 铝, 单丝, 电缆, 电线, 铁, 硅, 精炼, 超声, 中频加热, Al, Alumin?um, alloy monofilament, wire?, cable?, iron, silicon, refin+, ultrasonic, intermediat+ frequency heat+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 117004849 A (JIANGSU ZHONGTIAN TECHNOLOGY CO., LTD. et al.) 07 November 2023 (2023-11-07) claims 1-11	1-11
X	CH 524226 A (SOUTHWIRE CO.) 15 June 1972 (1972-06-15) description, column 2 lines 7-28, column 5, and column 7 paragraphs 1-29	1-2, 6
Y	CH 524226 A (SOUTHWIRE CO.) 15 June 1972 (1972-06-15) description, column 2 lines 7-28, column 5, and column 7 paragraphs 1-29	3-5, 7-11
Y	CN 113684388 A (JIANGSU ZHONGTIAN TECHNOLOGY CO., LTD. et al.) 23 November 2021 (2021-11-23) description, paragraphs 8-28	3-5, 7-11
Y	CN 116377294 A (CENTRAL SOUTH UNIVERSITY et al.) 04 July 2023 (2023-07-04) description, paragraphs 28-35	3-5, 7-11
X	CN 103725927 A (ANHUI JOY SENSE CABLE CO., LTD.) 16 April 2014 (2014-04-16) claim 1, and description, paragraph 58	1-2, 6

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "D" document cited by the applicant in the international application
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 July 2024	**30 July 2024**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2024/090806

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 103725927 A (ANHUI JOY SENSE CABLE CO., LTD.) 16 April 2014 (2014-04-16) claim 1, and description, paragraph 58	3-5, 7-11
X	CN 104599736 A (ANHUI HUANA ALLOY MATERIAL TECHNOLOGY CO., LTD.) 06 May 2015 (2015-05-06) claim 1, and description, paragraph 23	1-2, 6
Y	CN 104599736 A (ANHUI HUANA ALLOY MATERIAL TECHNOLOGY CO., LTD.) 06 May 2015 (2015-05-06) claim 1, and description, paragraph 23	3-5, 7-11
X	CN 116371919 A (JIANGSU DAYA ALUMINUM CO., LTD.) 04 July 2023 (2023-07-04) claim 1	1-2
A	CN 104294114 A (ANHUI JOY SENSE CABLE CO., LTD.) 21 January 2015 (2015-01-21) entire document	1-11
A	CN 104294092 A (ANHUI JOY SENSE CABLE CO., LTD.) 21 January 2015 (2015-01-21) entire document	1-11
A	JP 2020059921 A (FUJIKURA LTD.) 16 April 2020 (2020-04-16) entire document	1-11
A	JP S5358915 A (ALUSUISSE) 27 May 1978 (1978-05-27) entire document	1-11

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2024/090806

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	117004849	A	07 November 2023	None			
CH	524226	A	15 June 1972	None			
CN	113684388	A	23 November 2021	None			
CN	116377294	A	04 July 2023	None			
CN	103725927	A	16 April 2014	None			
CN	104599736	A	06 May 2015	None			
CN	116371919	A	04 July 2023	None			
CN	104294114	A	21 January 2015	None			
CN	104294092	A	21 January 2015	None			
JP	2020059921	A	16 April 2020	JP	6853872	B2	31 March 2021
JP	S5358915	A	27 May 1978	IT	1086370	B	28 May 1985
				FR	2365864	A1	21 April 1978
				DE	2742149	A1	23 March 1978
				SE	7710584	L	23 March 1978

Form PCT/ISA/210 (patent family annex) (July 2022)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- CN 103996427 A **[0003]**