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(54) **ALUMINUM ALLOY WIRE AND PREPARATION METHOD THEREFOR AND USE THEREOF**

(57) The present disclosure relates to the technical field of conducting wires. Provided are an aluminum alloy wire and a preparation method therefor and a use thereof. The aluminum alloy wire is prepared by means of specific raw materials and according to specific contents, which can effectively improve the tensile strength of a single aluminum alloy wire while ensuring the electric conductivity thereof. The tensile strength and other performances of the single aluminum alloy wire can further be im-

proved in combination with the specific preparation method of the present disclosure. The aluminum alloy wire is used for machining a conducting wire, which can improve the overall pull weight ratio of the conducting wire, reduce the sag of the conducting wire, and greatly reduce the investment cost of a pole tower, thereby providing a new conducting wire selection for an energy-saving overhead conducting wire.

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Description**TECHNICAL FIELD**

5 **[0001]** The present disclosure relates to the technical field of overhead power lines, and relates to an aluminum alloy wire, a preparation method therefor and a use thereof.

BACKGROUND

10 **[0002]** In recent years, ultra-high voltage power lines have been vigorously developed in the power grid field. In addition to meeting the transmission capacity of the lines and the reduction of line losses, the conducting wires also need to meet the high requirement of safety. Compared with the traditional steel-cored aluminum stranded wires, the existing medium-strength aluminum alloy stranded wires have a lower tensile breaking force and a small pull weight ratio, which limits the application in some special areas, such as ice-covered areas, and mountainous areas with significant elevation differences, etc. As is known to all, in the production process of aluminum alloy wires, the aluminum alloy wires are contradictory in terms of strength and electric conductivity, and how to find a balance between the two ones is a difficult problem.

SUMMARY

20 **[0003]** The first objective of the present disclosure includes providing an aluminum alloy wire, which can effectively improve the tensile strength of a single aluminum alloy wire while ensuring the electric conductivity thereof.

[0004] The second object of the present disclosure includes providing a preparation method for the above-mentioned aluminum alloy wire, which is simple and easy to operate, and can further improve the tensile strength of the single aluminum alloy wire.

25 **[0005]** The third object of the present disclosure includes providing a use of the above-mentioned aluminum alloy wire, for example, in the machining of a conducting wire.

[0006] The fourth object of the present disclosure includes providing a conducting wire containing the above-mentioned aluminum alloy wire, which can improve the overall pull weight ratio of the conducting wire, reduce the sag of the conducting wire, and greatly reduce the investment cost of a pole tower, thereby providing a new conducting wire selection for an energy-saving overhead conducting wire.

30 **[0007]** To achieve at least one of the above objects of the present disclosure, the present disclosure may adopt the following technical solutions.

[0008] The first aspect of the present disclosure includes providing an aluminum alloy wire, and raw materials for preparing the aluminum alloy wire include an aluminum ingot and master alloy ingots. Aluminum in the aluminum ingot has a mass content of at least 99.7%. The master alloy ingots are used to provide 0.45-0.6% Mg, 0.45-0.55% Si, 0.16-0.22% Fe, 0.018-0.022% Y, 0.01-0.05% Er, 0.04-0.10% La, 0.05-0.15% Ce and 0.005-0.015% Ti of a total mass of the aluminum ingot and master alloy ingots. In some optional embodiments, the master alloy ingots are used to provide 0.47-0.57% Mg, 0.46-0.52% Si, 0.17-0.2% Fe, 0.019-0.02% Y, 0.02-0.04% Er, 0.05-0.08% La, 0.07-0.13% Ce, and 0.005-0.007% Ti of the total mass of the aluminum ingot and the master alloy ingots.

40 **[0009]** In some optional embodiments, the master alloy ingots are used to provide 0.54% Mg, 0.5% Si, 0.2% Fe, 0.02% Y, 0.04% Er, 0.07% La, 0.09% Ce and 0.006% Ti of the total mass of the aluminum ingot and the master alloy ingots.

[0010] In some optional embodiments, when the aluminum alloy wire has a wire diameter of > 2.5 mm and ≤ 3.0 mm, the aluminum alloy wire has a minimum tensile strength of 305MPa; and/or

45 when the aluminum alloy wire has a wire diameter of > 3 mm and ≤ 3.5 mm, the aluminum alloy wire has a minimum tensile strength of 290MPa; and/or

when the aluminum alloy wire has a wire diameter of > 3.5 mm and ≤ 4.0 mm, the aluminum alloy wire has a minimum tensile strength of 280MPa; and/or

50 when the aluminum alloy wire has a wire diameter of > 4 mm and ≤ 5.0 mm, the aluminum alloy wire has a minimum tensile strength of 270MPa.

[0011] In some optional embodiments, the aluminum alloy wire has an electrical conductivity of 57.5-58.5%IACS.

55 **[0012]** In some optional embodiments, the aluminum alloy wire has an electrical resistivity of ≤ 30 n Ω ·m. Further optionally, the aluminum alloy wire has an electrical resistivity of ≤ 29.654 n Ω ·m, and further optionally, the aluminum alloy wire has an electrical resistivity of ≤ 29.454 n Ω ·m.

[0013] The second aspect of the present disclosure includes providing a preparation method for the above-mentioned aluminum alloy wire, including the following steps: performing smelting on raw materials.

[0014] In some optional embodiments, during the smelting process, the aluminum ingot is added firstly and then the master alloy ingots are added.

[0015] In some optional embodiments, the method further includes performing purification on an aluminum alloy liquid obtained by the smelting.

5 **[0016]** Optionally, the purification includes a first purification, and the first purification is carried out in a manner of adsorption purification or non-adsorption purification.

[0017] Optionally, the adsorption purification is carried out by using a refining agent.

[0018] Optionally, the refining agent includes at least one of a powder-injection refining agent and a degassing refining agent.

10 **[0019]** Optionally, the non-adsorption purification is carried out by means of vacuum treatment or ultrasonic treatment.

[0020] Optionally, the first purification is carried out in a holding furnace.

[0021] In some optional embodiments, the purification further includes a second purification, and the second purification is online degassing.

15 **[0022]** Optionally, the online degassing is carried out in a refining furnace. Further optionally, a degassing rotary nozzle is provided in a reaction chamber of an online degassing device. Further optionally, the degassing rotary nozzle is made of a material including graphite.

[0023] Optionally, after the online degassing, the aluminum alloy liquid has a hydrogen content of $\leq 0.15\text{mL}/100\text{gAl}$.

[0024] In some optional embodiments, before the second purification, the method further includes performing standing on the aluminum alloy liquid after the first purification.

20 **[0025]** Optionally, the standing time is 20-40min.

[0026] In some optional embodiments, before the standing, the method further includes sampling the aluminum alloy liquid after the first purification and verifying contents of chemical components in the aluminum alloy liquid.

[0027] In some optional embodiments, the method further includes performing slag removal on the aluminum alloy liquid after the second purification.

25 **[0028]** Optionally, the slag removal is carried out by means of multi-stage filtration.

[0029] Optionally, the multi-stage filtration includes using a filter plate for filtration firstly, and then using an electromagnetic purification device for filtration.

[0030] Optionally, the filtration by the filter plate includes filtering by using a first filter plate and a second filter plate in sequence, where the number of filtration holes in the first filter plate is smaller than that in the second filter plate.

30 **[0031]** Optionally, the number of filtration holes in the first filter plate is 25-35 mesh, and the number of filtration holes in the second filter plate is 35-45 mesh.

[0032] Optionally, the filter plate includes a foam ceramic filter plate, a tubular filter plate or a bed-type filter plate.

[0033] In some optional embodiments, after the slag removal the aluminum alloy liquid is subjected to casting.

[0034] Optionally, a pouring ladle has a temperature of 690-710°C during a casting process.

35 **[0035]** Optionally, the casting is automatic.

[0036] In some optional embodiments, a casted aluminum alloy billet is rolled to obtain an aluminum alloy rod.

[0037] Optionally, the casted billet is heated firstly and then rolled.

[0038] Optionally, the rolled aluminum alloy rod has a temperature controlled between 300-360°C.

40 **[0039]** Optionally, the method further includes performing online quenching on the rolled aluminum alloy rod, and the quenching temperature is controlled between 60-100°C. Further, heat treatment is carried out on the rolled aluminum alloy rod after the online quenching.

[0040] Optionally, the heat treatment is carried out at 160-200°C for 12-24h.

[0041] Further, the aluminum alloy rod after the heat treatment is subjected to drawing treatment.

[0042] Optionally, the drawing treatment is carried out by a single-head or double-head wire drawing machine;

45 **[0043]** Optionally, the drawing treatment is to draw the aluminum alloy rod into a single wire of 1.5-5mm.

[0044] The third aspect of the present disclosure includes providing a use of the above-mentioned aluminum alloy wire in the machining of a conducting wire, where the conducting wire can be an overhead power line.

[0045] The fourth aspect of the present disclosure includes providing a conducting wire including the above-mentioned aluminum alloy wire.

50 **[0046]** In some optional embodiments, the conducting wire is made by layer stranding the aluminum alloy wires.

[0047] The functions and effects of the present disclosure include the following.

[0048] In the present disclosure, the aluminum alloy wire is prepared by cooperating the aluminum ingot with the master alloy ingots containing specific contents of Mg, Si, Fe, Y, Er, La, Ce and Ti, which can effectively improve the tensile strength and electrical property of a single aluminum alloy wire while ensuring the electric conductivity thereof.

55 The tensile strength and other performances of the single aluminum alloy wire can further be improved in combination with the specific preparation method of the present disclosure. The aluminum alloy wire is used for machining a conducting wire, which can improve the overall pull weight ratio of the conducting wire, reduce the sag of the conducting wire, and greatly reduce the investment cost of a pole tower, thereby providing a new conducting wire selection for an energy-

saving overhead conducting wire.

DETAILED DESCRIPTION

[0049] In order to make the objectives, technical solutions and advantages of the disclosure clearer, the technical solutions in the embodiments of the present disclosure will be described clearly and comprehensively below. If the specific conditions are not indicated in the examples, the examples are carried out according to the conventional conditions or the conditions suggested by the manufacturer. The reagents or instruments used without the manufacturer's indication are conventional products that can be purchased from the market.

[0050] At present, the performances of the common domestic and foreign medium strength single aluminum alloy wires are as follows:

[0051] The National Energy Standard NB/T 42042-2014 stipulates that the electrical conductivity of LHA4 alloy is 57% IACS, and its tensile strength decreases with the increase of wire diameter, and the tensile strength value within the range of wire diameter in 02.50-05.0mm is 255MPa-290MPa. The European Union Standard BS EN 50183 stipulates that the electrical conductivity of AL7 alloy is 57.5% IACS, and its tensile strength decreases with the increase of wire diameter, and the tensile strength value within the range of wire diameter in 02.50- 05.0 mm is 255MPa-290MPa.

[0052] Regardless of the domestic LHA4 alloy or the foreign AL7 alloy, the method of reducing the tensile strength to improve the electrical conductivity is currently used, so that the electrical conductivity is $\geq 57\%$ IACS, and the tensile strength is between 255MPa-290MPa. In overhead lines, the stranded aluminum alloy conducting wire with the above properties has a reduced pull weight ratio and increased sag of the conducting wire. In order to ensure the safety of the lines, the height of the iron tower needs to be increased, which greatly increases the investment cost of the lines.

[0053] The inventors have concluded through research that the main reason that the existing medium-strength aluminum alloy stranded wires have lower overall tensile breaking force and lower pull weight ratio than the traditional steel-cored aluminum stranded wires is the lower tensile strength of the single aluminum alloy wire. On this basis, the inventor creatively proposed that, the overall pull weight ratio of the conducting wire can be improved and the sag of the conducting wire can be decreased by improving the tensile strength of the single aluminum alloy wire while ensuring the electric conductivity thereof, so that the investment cost of the pole tower can be greatly reduced, thereby providing a new conducting wire selection for an energy-saving overhead conducting wire.

[0054] In view of this, the present disclosure provides an aluminum alloy wire, and raw materials for preparing the aluminum alloy wire include an aluminum ingot and master alloy ingots. For reference, the master alloy ingots include magnesium ingot, aluminum-silicon alloy ingot, aluminum-iron alloy ingot, aluminum-yttrium alloy ingot, aluminum-erbium alloy ingot, aluminum-lanthanum-cerium alloy ingot, and aluminum-titanium-boron alloy rod.

[0055] The master alloy ingots are used to provide 0.45-0.6% Mg, 0.45-0.55% Si, 0.16-0.22% Fe, 0.018-0.022% Y, 0.01-0.05% Er, 0.04-0.10% La, 0.05-0.15% Ce and 0.005-0.015% Ti of the total mass of the aluminum ingot and master alloy ingots. The mass content of aluminum in the aluminum ingot is at least 99.7%.

[0056] Understandably, taking the total mass of 100 tons of aluminum ingot and master alloy ingots (the purity of aluminum in the aluminum ingot is at least 99.7%) as an example, magnesium-containing alloy is fed at 0.45-0.6 tons of Mg, silicon-containing alloy is fed at 0.45-0.55 tons of Si, iron-containing alloy is fed at 0.16-0.22 tons of Fe, yttrium-containing alloy is fed at 0.018-0.022 tons of Y, erbium-containing alloy is fed at 0.01-0.05 tons of Er, lanthanum-containing alloy is fed at 0.04-0.10 tons of La, cerium-containing alloy is fed at 0.05-0.15 tons of Ce and titanium-containing alloy is fed at 0.005-0.015 tons of Ti.

[0057] For reference, the mass of Mg may account for 0.45%, 0.5%, 0.55% or 0.6 of the total mass of the aluminum ingot and master alloy ingots, or it may be any other mass percentage within the range of 0.45-0.6%.

[0058] The mass of Si can account for 0.45%, 0.5% or 0.55% of the total mass of the aluminum ingot and master alloy ingots, or it may be any other mass percentage within the range of 0.45-0.55%.

[0059] The mass of Fe can account for 0.16%, 0.18%, 0.2% or 0.22% of the total mass of the aluminum ingot and master alloy ingots, or it may be any other mass percentage within the range of 0.16-0.22%.

[0060] The mass of Er can account for 0.01%, 0.02%, 0.03%, 0.04% or 0.05% of the total mass of the aluminum ingot and master alloy ingots, or it may be any other mass percentage within the range of 0.01-0.05%.

[0061] The mass of La can account for 0.04%, 0.06%, 0.08% or 0.10% of the total mass of the aluminum ingot and master alloy ingots, or it may be any other mass percentage within the range of 0.04-0.10%.

[0062] The mass of Ce may account for 0.05%, 0.10% or 0.15% of the total mass of the aluminum ingot and master alloy ingots, or it may be any other mass percentage within the range of 0.05-0.15%.

[0063] The mass of Ti can account for 0.005%, 0.01% or 0.015% of the total mass of the aluminum ingot and master alloy ingots, or it can be any other mass percentage within the range of 0.005-0.015%.

[0064] It is worth noting that, during the specific feeding process, the mass of each master alloy contained in each of the above-mentioned master alloy ingots can be freely combined within their respective ranges.

[0065] In some preferred embodiments, the master alloy ingots are used to provide 0.47-0.57% Mg, 0.46-0.52% Si,

0.17-0.2% Fe, 0.019-0.02% Y, 0.02-0.04% Er, 0.05-0.08% La, 0.07-0.13% Ce and 0.005-0.007% Ti of the total mass of the aluminum ingot and the master alloy ingots.

[0066] In some specific optional embodiments, the master alloy ingots are used to provide 0.54% Mg, 0.5% Si, 0.2% Fe, 0.02% Y, 0.04% Er, 0.07% La, 0.09% Ce and 0.006% Ti of the total mass of the aluminum ingot and the master alloy ingots.

[0067] Among the above chemical components, the addition of Mg and Si can form a Mg_2Si strengthening phase to improve the strength of the matrix. It is worth noting that, according to the amount of Si provided in the present disclosure, after it forms a Mg_2Si strengthened phase with Mg, the amount of Si still remains, and the surplus Si can form a composite strengthened phase with Fe to further improve the structural strength. At the same time, the addition of Fe can reduce the presence of free Si, hinder dislocation climbing at high temperature, and improve the strength stability during operation.

[0068] The addition of rare earth element Y can increase component undercooling, inhibit grain growth by forming Al-Y phase at grain boundaries, refine grains using rare earth element Y as nucleation particles in the grains, improve the plasticity of the matrix, and suppress the increase of brittleness caused by the increase of strength, and improve the alloy process performance and increase the electrical conductivity.

[0069] The addition of rare earth element Er is mainly used to combine with Al to generate Al_3Er precipitation phase. According to the Al-Er phase diagram, the Al- Al_3Er eutectic reaction occurs at the aluminum-rich end. At the same time, because the equilibrium solid solubility of Er is very low, which is almost close to zero, the driving force for the precipitation of Al_3Er phase is very large, and the Al_3Er precipitation phase with L12 structure can be produced by the solidification of the melt or aging of the supersaturated solid solution. A primary Al_3Er phase formed during the solidification process can be used as non-uniform nucleation particles to reduce the dendrite spacing and refine the grains of the as-cast alloy. Al_3Er particles that are uniformly dispersed can be precipitated from the alloy matrix in the supersaturated Er-containing solid solution during the subsequent aging process, and maintain coherence with the aluminum alloy matrix, resulting in a significant precipitation strengthening effect. At the same time, the dispersed distribution of small Al_3Er particles has a pinning effect on dislocations and sub-grain boundaries, thereby inhibiting grain growth.

[0070] The addition of La and Ce is conducive to refining the metamorphism of grains, and reducing the secondary crystal spacing. And at the same time, the addition of La and Ce can purify the melt, reduce the gas content and oxidation inclusions in the alloy, and also reduce the surface tension of the melt, thereby improving the physical and mechanical properties and processing properties of aluminum alloy wires.

[0071] The addition of titanium boron rod can form TiB_2 phase, which becomes a heterogeneous nucleation core during crystallization, and plays a role in refining the casting structure.

[0072] It is worth noting that the addition of four rare earth elements Y, Er, La and Ce together in this application can play the role of optimization and regulation, not only has a certain synergistic effect on the tensile strength of the aluminum alloy wire, but also can improve the mechanical and electrical properties of single aluminum alloy wire.

[0073] As mentioned above, by preparing the aluminum alloy wire with the above components according to the corresponding contents, a high-performance 57.5%IACS aluminum alloy stranded wire can be obtained, which can effectively improve the tensile strength of a single aluminum alloy wire while ensuring the electric conductivity thereof, thereby achieving high strength and electric conductivity of the alloy single wire.

[0074] For reference, according to the test standards of NB/T 43043-2014 and the European BS EN 50183, when the wire diameter of the aluminum alloy wire provided in this application is $>2.5mm$ and $\leq 3.0mm$, the minimum tensile strength is 305MPa. When the wire diameter of the aluminum alloy wire is $>3mm$ and $\leq 3.5mm$, the minimum tensile strength is 290MPa. When the wire diameter of the aluminum alloy wire is $>3.5mm$ and $\leq 4.0mm$, the minimum tensile strength is 280MPa. When the wire diameter of the aluminum alloy wire is $>4mm$ and $\leq 5.0mm$, the minimum tensile strength is 270MPa.

[0075] For the current single LHA4 alloy wire and single AL7 alloy wire, when the wire diameter thereof is $>2.5mm$ and $\leq 3.0mm$, the minimum tensile strength is 290MPa, and when the wire diameter thereof is $>3mm$ and $\leq 3.5mm$, the minimum tensile strength is 275MPa, and when the wire diameter thereof is $>3.5mm$ and $\leq 4.0mm$, the minimum tensile strength is 265MPa, and when the wire diameter thereof is $>4mm$ and $\leq 5.0mm$, the minimum tensile strength is 255MPa.

[0076] The above performance comparisons are summarized as follows:

Range of wire diameter (mm)	Minimum tensile strength of LHA4 alloy wire (MPa)	Minimum tensile strength of AL7 alloy wire (MPa)	Minimum tensile strength of alloy wire of the present application (MPa)
2.5< wire diameter $\leq$ 3.0	290	290	305

(continued)

Range of wire diameter (mm)	Minimum tensile strength of LHA4 alloy wire (MPa)	Minimum tensile strength of AL7 alloy wire (MPa)	Minimum tensile strength of alloy wire of the present application (MPa)
3.0 < wire diameter $\leq$ 3.5	275	275	290
3.5 < wire diameter $\leq$ 4.0	265	265	280
4.0 < wire diameter $\leq$ 5.0	255	255	270

[0077] Therefore, it can be proved that the tensile strength of the aluminum alloy wire provided by the present application is better than that of the existing single LHA4 alloy wire and single AL7 alloy wire under the same wire diameter range.

[0078] In some optional embodiments, the electrical conductivity of the aluminum alloy wire provided by the present application may be 57.5-58.5% IACS. In some optional embodiments, the electrical resistivity of the aluminum alloy wire provided by the present application is $\leq 30\text{n}\Omega\cdot\text{m}$. Further optionally, the electrical resistivity of the aluminum alloy wire is $\leq 29.654\text{n}\Omega\cdot\text{m}$, and further, the electrical resistivity thereof is $\leq 29.454\text{n}\Omega\cdot\text{m}$.

[0079] It can be proved from the above contents that the aluminum alloy wire provided by the present application can indeed improve the tensile strength of the single aluminum alloy wire while ensuring the electrical conductivity thereof.

[0080] Further, the present disclosure also provides a preparation method for the above-mentioned aluminum alloy wire, for example, including the following steps: performing smelting on raw materials.

[0081] In some optional embodiments, during the smelting process, an aluminum ingot is added firstly and then the master alloy ingots are added. That is, the aluminum ingot is melted first, and then respective master alloy ingots are added. The smelting process can be carried out in a smelting furnace.

[0082] Subsequently, purification is carried out on an aluminum alloy liquid obtained by the smelting.

[0083] Optionally, the purification includes a first purification, and the first purification may be carried out in a manner of adsorption purification or non-adsorption purification. The aluminum alloy liquid can be subjected to slagging and gas removal through the first purification.

[0084] For reference, the above adsorption purification may be carried out, for example, by using a refining agent. The refining agent may include at least one of a powder-injection refining agent and a degassing refining agent. The non-adsorption purification is carried out by means of vacuum treatment or ultrasonic treatment. The above-mentioned first purification is also called in-furnace purification or in-furnace refining, and the "furnace" here can be understood as a "holding furnace". The first purification is carried out in the holding furnace.

[0085] In some optional embodiments, the purification further includes a second purification, and the second purification is online degassing. This process is also called out-furnace purification. The "furnace" here refers to the furnace for the first purification, and the second purification is carried out outside the holding furnace. For reference, the process can be carried out in a refining furnace.

[0086] Optionally, the online degassing can be carried out by means of electromagnetic stirring. Correspondingly, a degassing rotary nozzle may be provided in a reaction chamber of an online degassing device. The degassing rotary nozzle may be made of a material which may be but is not limited to graphite. It should be noted that the above-mentioned degassing rotary nozzle can be in the form of single rotation or double rotation.

[0087] Preferably, after the online degassing, the aluminum alloy liquid has a hydrogen content of $\leq 0.15\text{mL}/100\text{gAl}$.

[0088] In some optional embodiments, before the second purification, the method further includes performing standing on the aluminum alloy liquid after the first purification.

[0089] Optionally, the standing time may be 20-40min, such as 20min, 25min, 30min, 35min or 40min, etc. By the standing, some melted gas or oxidation inclusions in the aluminum alloy liquid can be reduced. If the standing time is short, the gas or impurities cannot be discharged relatively cleanly, and if the standing time is long, the refined and clean aluminum liquid will absorb gas again.

[0090] In some optional embodiments, before the standing, the method further includes sampling the aluminum alloy liquid after the first purification and verifying the contents of chemical components in the aluminum alloy liquid.

[0091] Further, the method further includes performing slag removal on the aluminum alloy liquid after the second purification, and this step may also be referred to as the third purification.

[0092] In some optional embodiments, the above-mentioned slag removal process may be carried out by means of multi-stage filtration, for example, it may include using a filter plate for filtration firstly, and then using an electromagnetic purification device for filtration. In addition, various existing filter types can be combined.

[0093] By adopting the online multi-stage filtration technology, the non-metallic impurities in the aluminum liquid can be effectively removed to achieve the purpose of purifying the aluminum liquid, thereby improving the anti-fatigue properties of the product.

[0094] Optionally, the filtration by the filter plate includes filtering by using a first filter plate and a second filter plate in sequence, where the number of filtration holes in the first filter plate is smaller than that in the second filter plate, for example, the number of filtration holes in the first filter plate may be 25-35 mesh, and the number of filtration holes in the second filter plate may be 35-45 mesh. The filter plate may include, but is not limited to, a foam ceramic filter plate, a tubular filter plate or a bed-type filter plate. The condition of electromagnetic purification can be an alternating electromagnetic field type.

[0095] The above-mentioned filtration by the filter plates twice and the electromagnetic purification device once in sequence can achieve the effects of coarse filtration, thin filtration and fine filtration. Among them, the coarse filtration mainly removes the coarse particles with a diameter of more than 15 μ m, the thin filtration mainly removes the medium particles with a diameter range of 10-15 μ m, and the fine filtration removes the fine particles a diameter of less than 10 μ m. Through the above-mentioned multi-stage filtration, the impurities in the aluminum alloy liquid can be thoroughly filtered, and the electrical conductivity of the subsequent rolled products can be guaranteed.

[0096] Further, the aluminum alloy liquid after slag removal is subjected to casting.

[0097] Optionally, a lower ladle may have a temperature of 690-710°C, such as 690°C, 695°C, 700°C, 705°C or 710°C during the casting process. In a preferred embodiment, the casting is automatic, for example, the aluminum alloy liquid can flow through a launder to a ladle mouth for automatic casting.

[0098] Further, the casted aluminum alloy billet is rolled to obtain an aluminum alloy rod.

[0099] For reference, the casted billet is heated by a tube heating device and rolled by an aluminum alloy rolling machine set. During this process, the temperature and flow rate of an emulsion can be adjusted, so that the temperature of the $\varnothing$ 9.5mm aluminum alloy rod after the rolling is completed is controlled at 300-360°C.

[0100] Further, online quenching is carried out on the rolled aluminum alloy rod, and the quenching temperature is 60-100°C, and the temperature of the quenched aluminum alloy rod is controlled at 60-100°C.

[0101] Further, heat treatment is carried out on the rolled aluminum alloy rod after the online quenching.

[0102] Optionally, the heat treatment may be carried out at 160-200°C (such as 160°C, 170°C, 180°C, 190°C or 200°C, etc.) for 12-24h (such as 12h, 15h, 18h, 20h, 22h or 24h, etc.).

[0103] Further, the aluminum alloy rod after the heat treatment is subjected to drawing treatment.

[0104] Optionally, the drawing treatment is carried out by a single-head or double-head wire drawing machine. For reference, the single-head and double-head wire drawing machine may have, but are not limited to, 11-pass dies. The drawing treatment is to draw the aluminum alloy rod into a single wire of 1.5-5mm, such as 1.5mm, 2mm, 2.5mm, 3mm, 3.5mm, 4mm, or 5mm.

[0105] It is worth noting that, the aluminum alloy wire is usually subjected to aging treatment after being drawn into wire at present. The inventor creatively discovered through research that putting aging treatment before drawing, that is, subjecting the aluminum alloy rod to aging treatment firstly, then to drawing can effectively improve the mechanical and electrical properties of the aluminum alloy wire.

[0106] In addition, the present disclosure also provides a use of the above-mentioned aluminum alloy wire, for example, in the machining of a conducting wire. For reference, the above-mentioned conducting wire may be an overhead power line, and in addition, it may also be a general conventional conducting wire.

[0107] Correspondingly, the fourth aspect of the present disclosure includes providing a conducting wire containing the above-mentioned aluminum alloy wire.

[0108] In some optional embodiments, the above-mentioned conducting wire is made by layer stranding aluminum alloy wires. For example, multiple aluminum alloy wires (single wires) are stranded together in a predetermined direction.

[0109] The present disclosure will be described in detail below with reference to the embodiments and the accompanying drawings. However, the following examples should not be construed as limiting the scope of the present disclosure.

Example 1

[0110] An aluminum ingot with a purity of 99.7% is used as a raw material, and is accurately fed in the smelting process, and a magnesium ingot, an aluminum-silicon alloy ingot, an aluminum-iron alloy ingot, an aluminum-yttrium alloy ingot, an aluminum-erbium alloy ingot, an aluminum-lanthanum-cerium alloy ingot and an aluminum-titanium-boron alloy rod are added. The percentages of respective element contents in a smelting furnace to the total mass of the aluminum ingot and the master alloy ingots are as follows: Mg is 0.57%, Si is 0.52%, Fe is 0.20%, Y is 0.02%, Er is 0.04%, and La is 0.08%, Ce is 0.08% and Ti is 0.007%.

[0111] Subsequently, the aluminum alloy liquid obtained after smelting is purified by a powder-injection refining agent in a holding furnace to remove slag and gas. Sampling is then carried out in the holding furnace to verify the contents of respective elements that have been precisely fed. When the content of each element satisfies a preset range, the

corresponding aluminum alloy liquid is allowed to stand for 30 minutes in the holding furnace.

[0112] Subsequently, the aluminum alloy liquid after standing is fed into a refining furnace, and the aluminum alloy liquid is purified for a second time by electromagnetic stirring, and degassed again, so that the hydrogen content measured online is $\leq 0.15\text{ml}/100\text{g Al}$.

[0113] The aluminum alloy liquid after the second purification is separately filtered in a launder with a 30-mesh foam ceramic filter plate, a 40-mesh foam ceramic filter plate and an electromagnetic purification device for three-stage filtration to remove non-metallic impurities.

[0114] Subsequently, the aluminum alloy liquid flows through the launder to a ladle mouth for automatic casting, and the temperature of a lower ladle is 700°C .

[0115] The casted billet obtained is heated by a heating device and rolled by an aluminum alloy rolling machine set, and the temperature and flow rate of an emulsion can be adjusted, so that the temperature of the $\varnothing 9.5\text{mm}$ aluminum alloy rod after the rolling is completed is controlled at 350°C .

[0116] Online quenching is carried out on the aluminum alloy rod, so that the temperature of the quenched aluminum alloy rod is controlled at 80°C .

[0117] Heat treatment is carried out on the rolled aluminum alloy rod after the online quenching in a box-type aging furnace at 172°C for 18 h.

[0118] The above heat-treated $\varnothing 9.5\text{mm}$ aluminum alloy rod is drawn by an 11-die wire drawing machine into a $\varnothing 4.5\text{mm}$ single wire.

[0119] According to the test standards of NB/T 43043-2014 and European Union BS EN 50183 for Al-Mg-Si Alloy Wires for Overhead Conducting Wires, the aluminum alloy wire has an electrical conductivity of 58.3%IACS, an electrical resistivity of $29.574\text{n}\Omega\cdot\text{m}$, and a tensile strength of 278MPa.

Example 2

[0120] An aluminum ingot with a purity of 99.7% is used as a raw material, and is accurately fed in the smelting process, and a magnesium ingot, an aluminum-silicon alloy ingot, an aluminum-iron alloy ingot, an aluminum-yttrium alloy ingot, an aluminum-erbium alloy ingot, an aluminum-lanthanum-cerium alloy ingot and an aluminum-titanium-boron alloy rod are added. The percentages of respective element contents in a smelting furnace to the total mass of the aluminum ingot and the master alloy ingots are as follows: Mg is 0.47%, Si is 0.46%, Fe is 0.17%, Y is 0.019%, Er is 0.02%, and La is 0.05%, Ce is 0.07% and Ti is 0.005%.

[0121] Subsequently, the aluminum alloy liquid obtained after smelting is purified by a powder-injection refining agent in a holding furnace to remove slag and gas. Sampling is then carried out in the holding furnace to verify the contents of respective elements that have been precisely fed. When the content of each element satisfies a preset range, the corresponding aluminum alloy liquid is allowed to stand for 30 minutes in the holding furnace.

[0122] Subsequently, the aluminum alloy liquid after standing is flowed into a refining furnace, and the aluminum alloy liquid is purified for the second time by electromagnetic stirring, and degassed again, so that the hydrogen content measured online is $\leq 0.15\text{ml}/100\text{g Al}$.

[0123] The aluminum alloy liquid after the second purification is separately filtered in a launder with a 30-mesh foam ceramic filter plate, a 40-mesh foam ceramic filter plate and an electromagnetic purification device for three-stage filtration to remove non-metallic impurities.

[0124] In the launder, the 30-mesh, 40-mesh foam ceramic filter plates and the electromagnetic purification device are used for multi-stage filtration to remove non-metallic impurities.

[0125] Subsequently, the aluminum alloy liquid flows through the launder to a ladle mouth for automatic casting, and the temperature of a lower ladle is 700°C .

[0126] The casted billet obtained is heated by a heating device and rolled by an aluminum alloy rolling machine set, and the temperature and flow rate of an emulsion can be adjusted, so that the temperature of the $\varnothing 9.5\text{mm}$ aluminum alloy rod after the rolling is completed is controlled at 360°C .

[0127] Online quenching is carried out on the aluminum alloy rod, so that the temperature of the quenched aluminum alloy rod is controlled at 60°C .

[0128] Heat treatment is carried out on the rolled aluminum alloy rod after the online quenching in a box-type aging furnace at 182°C for 16 h.

[0129] The above heat-treated $\varnothing 9.5\text{mm}$ aluminum alloy rod is drawn by an 11-die wire drawing machine into a $\varnothing 2.6\text{mm}$ single wire.

[0130] According to the same measurement method as in Example 1, the aluminum alloy wire has an electrical conductivity of 58.07% IACS, an electrical resistivity of $29.691\text{n}\Omega\cdot\text{m}$, and a tensile strength of 320MPa.

Example 3

[0131] An aluminum ingot with a purity of 99.85% is used as a raw material, and is accurately fed in the smelting process, and a magnesium ingot, an aluminum-silicon alloy ingot, an aluminum-iron alloy ingot, an aluminum-yttrium alloy ingot, an aluminum-erbium alloy ingot, an aluminum-lanthanum-cerium alloy ingot and an aluminum-titanium-boron alloy rod are added. The percentages of respective element contents in a smelting furnace to the total mass of the aluminum ingot and the master alloy ingots are as follows: Mg is 0.5%, Si is 0.48%, Fe is 0.18%, Y is 0.02%, Er is 0.03%, and La is 0.06%, Ce is 0.13% and Ti is 0.006%.

[0132] Subsequently, the aluminum alloy liquid obtained after smelting is purified by a powder-injection refining agent in a holding furnace to remove slag and gas. Sampling is then carried out in the holding furnace to verify the contents of respective elements that have been precisely fed. When the content of each element satisfies a preset range, the corresponding aluminum alloy liquid is allowed to stand for 35 minutes in the holding furnace.

[0133] Subsequently, the aluminum alloy liquid after standing is flowed into a refining furnace, and the aluminum alloy liquid is purified for the second time by electromagnetic stirring, and degassed again, so that the hydrogen content measured online is $\leq 0.15\text{ml}/100\text{g Al}$.

[0134] The aluminum alloy liquid after the second purification is separately filtered in a launder with a 25-mesh foam ceramic filter plate, a 35-mesh foam ceramic filter plate and an electromagnetic purification device for three-stage filtration to remove non-metallic impurities.

[0135] Subsequently, the aluminum alloy liquid flows through the launder to a ladle mouth for automatic casting, and the temperature of a lower ladle is 700°C .

[0136] The casted billet obtained is heated by a heating device and rolled by an aluminum alloy rolling machine set, and the temperature and flow rate of an emulsion can be adjusted, so that the temperature of the $\varnothing 9.5\text{mm}$ aluminum alloy rod after the rolling is completed is controlled at 360°C .

[0137] Online quenching is carried out on the aluminum alloy rod, so that the temperature of the quenched aluminum alloy rod is controlled at 70°C .

[0138] Heat treatment is carried out on the rolled aluminum alloy rod after the online quenching in a box-type aging furnace at 180°C for 16 h.

[0139] The above heat-treated $\varnothing 9.5\text{mm}$ aluminum alloy rod is drawn by an 11-die wire drawing machine into a $\varnothing 2.6\text{mm}$ single wire.

[0140] According to the same measurement method as in Example 1, the aluminum alloy wire has an electrical conductivity of 58.2% IACS, an electrical resistivity of $29.624\text{n}\Omega\cdot\text{m}$, and a tensile strength of 315MPa .

Example 4

[0141] An aluminum ingot with a purity of 99.85% is used as a raw material, and is accurately fed in the smelting process, and a magnesium ingot, an aluminum-silicon alloy ingot, an aluminum-iron alloy ingot, an aluminum-yttrium alloy ingot, an aluminum-erbium alloy ingot, an aluminum-lanthanum-cerium alloy ingot and an aluminum-titanium-boron alloy rod are added. The percentages of respective element contents in a smelting furnace to the total mass of the aluminum ingot and the master alloy ingots are as follows: Mg is 0.54%, Si is 0.5%, Fe is 0.2%, Y is 0.02%, Er is 0.04%, La is 0.07%, Ce is 0.09% and Ti is 0.006%.

[0142] Subsequently, the aluminum alloy liquid obtained after smelting is purified by a powder-injection refining agent in a holding furnace to remove slag and gas. Sampling is then carried out in the holding furnace to verify the contents of respective elements that have been precisely fed. When the content of each element satisfies a preset range, the corresponding aluminum alloy liquid is allowed to stand for 40 minutes in the holding furnace.

[0143] Subsequently, the aluminum alloy liquid after standing is flowed into a refining furnace, and the aluminum alloy liquid is purified for the second time by electromagnetic stirring, and degassed again, so that the hydrogen content measured online is $\leq 0.15\text{ml}/100\text{g Al}$.

[0144] The aluminum alloy liquid after the second purification is separately filtered in a launder with a 35-mesh foam ceramic filter plate, a 45-mesh foam ceramic filter plate and an electromagnetic purification device for three-stage filtration to remove non-metallic impurities.

[0145] Subsequently, the aluminum alloy liquid flows through the launder to a ladle mouth for automatic casting, and the temperature of a lower ladle is 700°C .

[0146] The casted billet obtained is heated by a heating device and rolled by an aluminum alloy rolling machine set, and the temperature and flow rate of an emulsion can be adjusted, so that the temperature of the $\varnothing 9.5\text{mm}$ aluminum alloy rod after the rolling is completed is controlled at 350°C .

[0147] Online quenching is carried out on the aluminum alloy rod, so that the temperature of the quenched aluminum alloy rod is controlled at 70°C .

[0148] Heat treatment is carried out on the rolled aluminum alloy rod after the online quenching in a box-type aging

furnace at 178°C for 16 h.

[0149] The above heat-treated Ø9.5mm aluminum alloy rod is drawn by an 11-die wire drawing machine drawn into a Ø3.5mm single wire.

[0150] According to the same measurement method as in Example 1, the aluminum alloy wire has an electrical conductivity of 58.25% IACS, an electrical resistivity of 29.599nΩ·m, and a tensile strength of 305MPa.

Example 5

[0151] The difference between this example and Example 4 is that: an aluminum ingot with a purity of 99.85% is used as a raw material, and is accurately fed in the smelting process, and a magnesium ingot, an aluminum-silicon alloy ingot, an aluminum-iron alloy ingot, an aluminum-yttrium alloy ingot, an aluminum-erbium alloy ingot, an aluminum-lanthanum-cerium alloy ingot and an aluminum-titanium-boron alloy rod are added. The percentages of respective element contents in a smelting furnace to the total mass of the aluminum ingot and the master alloy ingots are as follows: Mg is 0.45%, Si is 0.45%, Fe is 0.16%, Y is 0.018%, Er is 0.01%, La is 0.04%, Ce is 0.05% and Ti is 0.005%.

[0152] Subsequently, the aluminum alloy liquid obtained after smelting is purified by a powder-injection refining agent in a holding furnace to remove slag and gas. Sampling is then carried out in the holding furnace to verify the contents of respective elements that have been precisely fed. When the content of each element satisfies a preset range, the corresponding aluminum alloy liquid is allowed to stand for 30 minutes in the holding furnace.

[0153] Subsequently, the aluminum alloy liquid after standing is flowed into a refining furnace, and the aluminum alloy liquid is purified for the second time by electromagnetic stirring, and degassed again, so that the hydrogen content measured online is ≤0.15ml/100g Al.

[0154] The aluminum alloy liquid after the second purification is separately filtered in a launder with a 30-mesh foam ceramic filter plate, a 40-mesh foam ceramic filter plate and an electromagnetic purification device for three-stage filtration to remove non-metallic impurities.

[0155] Subsequently, the aluminum alloy liquid flows through the launder to a ladle mouth for automatic casting, and the temperature of a lower ladle is 700°C.

[0156] The casted billet obtained is heated by a heating device and rolled by an aluminum alloy rolling machine set, and the temperature and flow rate of an emulsion can be adjusted, so that the temperature of the Ø9.5mm aluminum alloy rod after the rolling is completed is controlled at 360°C.

[0157] Online quenching is carried out on the aluminum alloy rod, so that the temperature of the quenched aluminum alloy rod is controlled at 70°C.

[0158] Heat treatment is carried out on the rolled aluminum alloy rod after the online quenching in a box-type aging furnace at 185°C for 16 h.

[0159] The above heat-treated Ø9.5mm aluminum alloy rod is drawn by an 11-die wire drawing machine into a Ø2.5mm single wire.

[0160] According to the test standards of NB/T 43043-2014 and European Union BS EN 50183 for Al-Mg-Si Alloy Wires for Overhead Conducting Wires, the aluminum alloy wire has an electrical conductivity of 57.9%IACS, an electrical resistivity of 29.778nΩ·m, and a tensile strength of 322MPa.

Example 6

[0161] The difference between this example and Example 4 is that: an aluminum ingot with a purity of 99.85% is used as a raw material, and is accurately fed in the smelting process, and a magnesium ingot, an aluminum-silicon alloy ingot, an aluminum-iron alloy ingot, an aluminum-yttrium alloy ingot, an aluminum-erbium alloy ingot, an aluminum-lanthanum-cerium alloy ingot and an aluminum-titanium-boron alloy rod are added. The percentages of respective element contents in a smelting furnace to the total mass of the aluminum ingot and the master alloy ingots are as follows: Mg is 0.6%, Si is 0.55%, Fe is 0.22%, Y is 0.022%, Er is 0.05%, La is 0.1%, Ce is 0.15% and Ti is 0.015%.

[0162] Subsequently, the aluminum alloy liquid obtained after smelting is purified by a powder-injection refining agent in a holding furnace to remove slag and gas. Sampling is then carried out in the holding furnace to verify the contents of respective elements that have been precisely fed. When the content of each element satisfies a preset range, the corresponding aluminum alloy liquid is allowed to stand for 30 minutes in the holding furnace.

[0163] Subsequently, the aluminum alloy liquid after standing is flowed into a refining furnace, and the aluminum alloy liquid is purified for the second time by electromagnetic stirring, and degassed again, so that the hydrogen content measured online is ≤0.15ml/100g Al.

[0164] The aluminum alloy liquid after the second purification is separately filtered in a launder with a 30-mesh foam ceramic filter plate, a 40-mesh foam ceramic filter plate and an electromagnetic purification device for three-stage filtration to remove non-metallic impurities.

[0165] Subsequently, the aluminum alloy liquid flows through the launder to a ladle mouth for automatic casting, and

the temperature of a lower ladle is 700°C.

[0166] The casted billet obtained is heated by a heating device and rolled by an aluminum alloy rolling machine set, and the temperature and flow rate of an emulsion can be adjusted, so that the temperature of the Ø9.5mm aluminum alloy rod after the rolling is completed is controlled at 340°C.

[0167] Online quenching is carried out on the aluminum alloy rod, so that the temperature of the quenched aluminum alloy rod is controlled at 70°C.

[0168] Heat treatment is carried out on the rolled aluminum alloy rod after the online quenching in a box-type aging furnace at 170°C for 18 h.

[0169] The above heat-treated Ø9.5mm aluminum alloy rod is drawn by an 11-die wire drawing machine into a Ø4.75mm single wire.

[0170] According to the test standards of NB/T 43043-2014 and European Union BS EN 50183 for *Al-Mg-Si Alloy Wires for Overhead Conducting Wires*, the aluminum alloy wire has an electrical conductivity of 58.5%IACS, an electrical resistivity of 29.472nΩ·m, and a tensile strength of 275MPa.

Example 7

[0171] The difference between this example and Example 1 is that: the multi-stage filtration is replaced by one-stage filtration, that is, the filtration is only carried out by the first filter plate.

[0172] According to the same measurement method as in Example 1, the aluminum alloy wire has an electrical conductivity of 57.6%IACS, an electrical resistivity of 29.933nΩ·m, and a tensile strength of 278MPa.

Example 8

[0173] The difference between this example and Example 1 is that: the multi-stage filtration is replaced by one-stage filtration, that is, the filtration is only carried out by the electromagnetic purification device.

[0174] According to the same measurement method as in Example 1, the aluminum alloy wire has an electrical conductivity of 57.8%IACS, an electrical resistivity of 29.829nΩ·m, and a tensile strength of 278 MPa.

Example 9

[0175] The difference between this example and Example 1 is that: the multi-stage filtration is two-stage filtration, that is, the filtration is carried out by the first filter plate and the second filter plate in sequence.

[0176] According to the same measurement method as in Example 1, the aluminum alloy wire has an electrical conductivity of 57.65%IACS, an electrical resistivity of 29.909nΩ·m, and a tensile strength of 278MPa.

Example 10

[0177] The difference between this example and Example 1 is that: the multi-stage filtration is two-stage filtration, that is, the filtration is carried out by the first filter plate and the electromagnetic purification device in sequence.

[0178] According to the same measurement method as in Example 1, the aluminum alloy wire has an electrical conductivity of 57.9%IACS, an electrical resistivity of 29.778nΩ·m, and a tensile strength of 278MPa.

Example 11

[0179] The difference between this example and Example 1 is that: the aluminum alloy rod is subjected to aging treatment after being drawn into a single wire.

[0180] According to the same measurement method as in Example 1, the aluminum alloy wire has an electrical conductivity of 57.5%IACS, an electrical resistivity of 29.585nΩ·m, and a tensile strength of 260MPa.

Test example

[0181] Taking the aluminum alloy wires provided in Example 1 as an example, they are stranded in the following manner to form a conducting wire. At the same time, compared with the existing LHA4 type and AL7 type, the specific technical parameters and economic comparison are shown in the table below.

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5	Technical parameter	Single wire type		Unit	LHA4 type	AL7 type	Present invention
		Name of stranded wire			Aluminum alloy stranded wire	Aluminum alloy stranded wire	High performance 57.5% IACS aluminum alloy stranded wire
10		Standard			425	425	425
		Structure	Aluminum alloy	Piece	37/3.83	37/3.83	37/3.83
15	Cross section		Aluminum alloy	mm ²	426.28	426.28	426.28
			Summation	%	426.28	426.28	426.28
20		Diameter		mm	26.81	26.81	26.81
		Mass per unit length		kg/km	1175.7	1175.7	1175.7
25		Rated tensile breaking force		kN	112.96	112.96	112.96
		Comparison of tensile breaking force			reference	100.0%	105.7%
30		Elastic modulus of conducting wire		Gpa	55.00	55.00	55.00
		Thermal expansion coefficient of conducting wire		*10 ⁻⁶ /°C	23.00	23.00	23.00
35		20°C DC resistance		Ω/km	0.07255	0.07196	0.07196
		Comparison of DC resistance			reference	99.2%	99.2%
40		Tensile unit weight ratio		km	9.80	9.80	10.36
		Ambient temperature		°C	40	40	40
45	Loss	Loss of single conducting wire		kw/km	10.07	9.99	9.99
		Comparison of loss			reference	99.2%	99.2%
50	sag of conducting wire at 70 °C	Safety coefficient			2.5	2.5	2.5
		ruling span	L=300m	m	7.07	7.07	6.81
			L=400m	m	11.27	11.27	10.83
			L=500m	m	16.42	16.42	15.76

[0182] It can be seen from the above table that, compared with the LHA4 type aluminum alloy stranded wire, the high-performance 57.5% IACS aluminum alloy stranded wire provided in this embodiment has an increase in tensile breaking force to 105.7%, a decrease in DC resistance to 99.2%, an increase in tensile unit weight ratio from 9.80 to 10.36, and a decrease in sag of the conducting wire at 70 °C from 7.07m to 6.81m, which not only reduces the line loss but also reduces the sag of the conducting wire.

[0183] Compared with the AL7 type aluminum alloy stranded wire, the high-performance 57.5% IACS aluminum alloy stranded wire provided in this embodiment has an increase in tensile breaking force to 105.7%, the DC resistance unchanged, an increase in tensile unit weight ratio from 9.80 to 10.36, and a decrease in sag of the conducting wire at 70 °C from 7.07m to 6.81m, which also reduces the sag of the conducting wire.

[0184] Therefore, the high-performance 57.5% IACS aluminum alloy stranded wire provided by the present disclosure has the advantages of low line loss and good sag characteristics, and its construction and operation requirements are basically the same as those of ordinary conducting wires.

Comparative Example

[0185] Taking Example 1 as an example, comparative examples 1-8 are set. The difference between each comparative example and Example 1 is only that the amounts of the four rare earth elements are different or the types of rare earth elements used are different. The specific amounts and types are shown in the following table. .

	Y	Er	La	Ce	Nd	Eu
Example 1	0.02	0.04	0.08	0.08	-	-
Comparative Example 1	-	0.06	0.08	0.08	-	-
Comparative Example 2	0.06	-	0.08	0.08	-	-
Comparative Example 3	0.02	0.04	-	0.06	-	-
Comparative Example 4	0.02	0.04	0.16	-	-	-
Comparative Example 5	0.055	0.055	0.08	0.08	-	-
Comparative Example 6	0.02	0.04	0.03	0.13	-	-
Comparative Example 7	0.02	0.04	-	0.08	0.08	-
Comparative Example 8	0.02	-	0.08	0.08	-	0.04

[0186] According to the same measurement method as Example 1, the test results of the electrical conductivity, electrical resistivity and tensile strength of the aluminum alloy wire of each comparative example are shown in the table below.

	Electrical conductivity(%IACS)	Electrical resistivity (nΩ·m)	Tensile strength(MPa)
Example 1	58.3	29.574	278
Comparative Example 1	58.05	29.701	265
Comparative Example 2	57.83	29.814	260
Comparative Example 3	58.01	29.721	270
Comparative Example 4	57.95	29.752	267
Comparative Example 5	57.90	29.778	263
Comparative Example 6	58.07	29.691	275
Comparative Example 7	57.52	29.975	268
Comparative Example 8	57.41	30.032	261

[0187] It can be seen from the above table that, the aluminum alloy wire in Example 1 of the present application has higher electrical conductivity than that of Comparative Examples 1-8, lower electrical resistivity, and higher tensile strength.

[0188] It can be seen from the comparison of Example 1 and Comparative Examples 1-4 that, under the condition that the total contents of rare earth elements are the same, the aluminum alloy wire containing Y, Er, La, and Ce simultaneously has higher electrical conductivity, higher tensile strength, and lower electrical resistivity compared to the aluminum alloy wire without simultaneously containing the above four elements, indicating that there is a certain synergy effect between the four rare earth elements used in this application.

[0189] It can be seen from the comparison of Example 1 and Comparative Examples 5-6 that, under the condition that the total contents of rare earth elements are the same, the aluminum alloy wire obtained with the amount of each element within the scope of the present application has higher electrical conductivity, higher tensile strength, and lower electrical resistivity compared to the aluminum alloy wire obtained with the amount of each element not in the scope of the present application, indicating that the ratio between the elements in this application is more conducive to obtaining higher comprehensive performance of the wire.

[0190] It can be seen from the comparison of Example 1 and Comparative Examples 7-8 that, under the condition that the total contents of rare earth elements are the same, the aluminum alloy wires obtained with the rare earth elements in this application replaced with other rare earth elements has lower electrical conductivity, lower tensile strength, and higher electrical resistivity, indicating that the use of rare earth elements in this application is not a conventional choice.

[0191] The above shows and describes the basic principles, key features, and advantages of the present disclosure. It should be understood by those skilled in the art that the present disclosure is not limited by the above-mentioned examples. The above-mentioned examples and descriptions in the specification only illustrate the principles of the present disclosure. Without departing from the spirit and scope of the present disclosure, there will be various changes and improvements in this disclosure, all of which fall within the claimed scope of this disclosure. The scope of protection claimed by the present disclosure is defined by the appended claims and their equivalents.

Industrial Applicability:

[0192] In the present disclosure, the aluminum alloy wire is prepared by cooperating the aluminum ingot with the master alloy ingots containing specific contents of Mg, Si, Fe, Y, Er, La, Ce and Ti, which can effectively improve the tensile strength of a single aluminum alloy wire while ensuring the electric conductivity thereof. The tensile strength and other performances of the single aluminum alloy wire can further be improved in combination with the specific preparation method of the present disclosure. The aluminum alloy wire is used for machining a conducting wire, which can improve the overall pull weight ratio of the conducting wire, reduce the sag of the conducting wire, and greatly reduce the investment cost of a pole tower, thereby providing a new conducting wire selection for an energy-saving overhead conducting wire.

Claims

1. An aluminum alloy wire, **characterized in that**, raw materials for preparing the aluminum alloy wire include an aluminum ingot and master alloy ingots, and the master alloy ingots are used to provide 0.45-0.6% Mg, 0.45-0.55% Si, 0.16-0.22% Fe, 0.018-0.022% Y, 0.01-0.05% Er, 0.04-0.10% La, 0.05-0.15% Ce and 0.005-0.015% Ti of a total mass of the aluminum ingot and the master alloy ingots; aluminum in the aluminum ingot has a mass content of at least 99.7%.
2. The aluminum alloy wire according to claim 1, wherein the master alloy ingots are used to provide 0.47-0.57% Mg, 0.46-0.52% of Si, 0.17-0.2% Fe, 0.019-0.02% Y, 0.02-0.04% Er, 0.05-0.08% La, 0.07-0.13% Ce and 0.005-0.007% Ti of the total mass of the aluminum ingot and the master alloy ingots.
3. The aluminum alloy wire according to claim 2, wherein based on mass percentage, the master alloy ingots are used to provide 0.54% of Mg, 0.5% of Si, 0.2% Fe, 0.02% Y, 0.04% Er, 0.07% La, 0.09% Ce, and 0.006% Ti of the total mass of the aluminum ingot and the master alloy ingots.
4. The aluminum alloy wire according to any one of claims 1-3, wherein when the aluminum alloy wire has a wire diameter of $> 2.5 \text{ mm}$ and $\leq 3.0 \text{ mm}$, the aluminum alloy wire has a minimum tensile strength of 305MPa; or,
 - when the aluminum alloy wire has a wire diameter of $> 3 \text{ mm}$ and $\leq 3.5 \text{ mm}$, the aluminum alloy wire has a minimum tensile strength of 290MPa; or,
 - when the aluminum alloy wire has a wire diameter of $> 3.5 \text{ mm}$ and $\leq 4.0 \text{ mm}$, the aluminum alloy wire has a minimum tensile strength of 280MPa; or,
 - when the aluminum alloy wire has a wire diameter of $> 4 \text{ mm}$ and $\leq 5.0 \text{ mm}$, the aluminum alloy wire has a minimum tensile strength of 270MPa.
5. The aluminum alloy wire according to any one of claims 1-3, wherein the aluminum alloy wire has an electrical conductivity of 57.5-58.5%IACS.

6. The aluminum alloy wire according to any one of claims 1-3, wherein the aluminum alloy wire has an electrical resistivity of $\leq 30 \text{ n}\Omega \cdot \text{m}$, optionally $\leq 29.654 \text{ n}\Omega \cdot \text{m}$, further optionally $\leq 29.454 \text{ n}\Omega \cdot \text{m}$.

7. A preparation method of the aluminum alloy wire according to any one of claims 1-6, **characterized in that**, comprising the following steps: performing smelting on the raw materials;
optionally, the aluminum ingot is added firstly and then the master alloy ingots are added during a smelting process.

8. The preparation method according to claim 7, wherein performing purification on an aluminum alloy liquid obtained by the smelting;

optionally, the purification includes a first purification, and the first purification is carried out in a manner of adsorption purification or non-adsorption purification;
optionally, the adsorption purification is carried out by using a refining agent; optionally, the refining agent includes at least one of a powder-injection refining agent and a degassing refining agent;
optionally, the non-adsorption purification is carried out by means of vacuum treatment or ultrasonic treatment;
optionally, the first purification is carried out in a holding furnace.

9. The preparation method according to claim 8, wherein the purification further includes a second purification, and the second purification is online degassing;

optionally, the online degassing is carried out in a refining furnace; further optionally, a degassing rotary nozzle is provided in a reaction chamber of an online degassing device; further optionally, the degassing rotary nozzle is made of a material comprising graphite;
optionally, after the online degassing, the aluminum alloy liquid has a hydrogen content of $\leq 0.15 \text{ mL}/100 \text{ g Al}$.

10. The preparation method according to claim 9, wherein before the second purification, further comprising performing standing on the aluminum alloy liquid after the first purification;
optionally, standing time is 20-40min.

11. The preparation method according to claim 10, wherein before the standing, further comprising sampling the aluminum alloy liquid after the first purification and verifying contents of chemical components in the aluminum alloy liquid.

12. The preparation method according to any one of claims 9-11, wherein further comprising performing slag removal on the aluminum alloy liquid after the second purification;

optionally, the slag removal is carried out by means of multi-stage filtration;
optionally, the multi-stage filtration includes using a filter plate for filtration firstly, and then using an electromagnetic purification device for filtration;
optionally, the filtration by the filter plate includes filtering by using a first filter plate and a second filter plate in sequence, wherein the number of filtration holes in the first filter plate is smaller than that in the second filter plate;
optionally, the number of filtration holes in the first filter plate is 25-35 mesh, and the number of filtration holes in the second filter plate is 35-45 mesh;
optionally, the filter plate comprises a foam ceramic filter plate, a tubular filter plate or a bed-type filter plate.

13. The preparation method according to claim 12, wherein performing casting on the aluminum alloy liquid after the slag removal;

optionally, a lower ladle has a temperature of 690-710°C during a casting process;
optionally, the casting is automatic.

14. The preparation method according to claim 13, wherein performing rolling on a casted aluminum alloy billet to obtain an aluminum alloy rod;

optionally, the casted billet is heated firstly and then rolled;
optionally, the rolled aluminum alloy rod has a temperature controlled between 300-360°C.

15. The preparation method according to claim 14, wherein performing online quenching on the rolled aluminum alloy

rod, and quenching temperature is controlled between 60-100°C;

optionally, heat treatment is carried out on the rolled aluminum alloy rod after the online quenching;
optionally, the heat treatment is carried out at 160-200°C for 12-24h.

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16. The preparation method according to claim 15, wherein performing drawing treatment on the aluminum alloy rod after the heat treatment;

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optionally, the drawing treatment is carried out by a single-head or double-head wire drawing machine;
optionally, the drawing treatment is to draw the aluminum alloy rod into a single wire of 1.5-5mm.

17. Use of the aluminum alloy wire according to any one of claims 1-6 in the machining of a conducting wire;
optionally, the conducting wire includes an overhead power line.

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18. A conducting wire, **characterized in that**, the conducting wire comprises the aluminum alloy wire according to any one of claims 1-6.

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19. The conducting wire according to claim 18, wherein the conducting wire is made by layer stranding aluminum alloy wires.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2020/142535

A. CLASSIFICATION OF SUBJECT MATTER

C22C 21/00(2006.01)i; C22C 21/08(2006.01)i; C22C 1/03(2006.01)i; C22F 1/04(2006.01)i; C22F 1/043(2006.01)i;
C22F 1/047(2006.01)i; C22F 1/05(2006.01)i; C22C 1/06(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)

C22C; C22F

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)

CNABS; CNTXT; CNKI; VEN; USTXT; WOTXT; EPTXT; ISI Web of Science: 中天铝线, 铝合金, 线材, 导线, 电线, 电缆, 铝锭, 合金锭, 稀土, 镁, Mg, 硅, Si, 铁, Fe, Y, 钇, Er, 钕, La, 镧, Ce, 铈, Ti, 熔炼, 精炼, 净化, 除气, 拉拔, 拉伸, aluminium alloy, wire, cable, ingot, Rare earth, Magnesium, Silicon, Iron, Yttrium, Erbium, Lanthanum, Cerium, Titanium, smelting, refining, purification, stretch

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 106119612 A (JIANGSU HENGTONG POWER SPECIAL WIRE CO., LTD.) 16 November 2016 (2016-11-16) description paragraphs 0008-0054	1-19
Y	CN 102021442 A (ANHUI YANAN CABLE FACTORY) 20 April 2011 (2011-04-20) description, paragraphs 0004-0030	1-19
Y	CN 103820685 A (WUXI HUANENG ELECTRIC CABLE CO., LTD.) 28 May 2014 (2014-05-28) description, paragraphs 0005-0020	1-19
Y	CN 104028961 A (FAR EAST CABLE CO., LTD. et al.) 10 September 2014 (2014-09-10) description, paragraphs [0004]-[0011]	1-19
Y	CN 105976890 A (FAR EAST CABLE CO., LTD. et al.) 28 September 2016 (2016-09-28) description, paragraphs 0005-0024	1-19
A	CN 103103383 A (ANHUI JOY SENSE CABLE CO., LTD.) 15 May 2013 (2013-05-15) entire document	1-19

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

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"&" document member of the same patent family
"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	

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Name and mailing address of the ISA/CN

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 107419141 A (CENTRAL SOUTH UNIVERSITY) 01 December 2017 (2017-12-01) entire document	1-19
10 15 20 25 30 35 40 45 50 55		

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2020/142535

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CN	106119612	A	16 November 2016	None			
CN	102021442	A	20 April 2011	CN	102021442	B	29 August 2012
CN	103820685	A	28 May 2014	CN	103820685	B	18 May 2016
CN	104028961	A	10 September 2014	CN	104028961	B	22 December 2017
CN	105976890	A	28 September 2016	CN	105976890	B	24 November 2017
CN	103103383	A	15 May 2013	WO	2014071875	A1	15 May 2014
CN	107419141	A	01 December 2017	CN	107419141	B	26 March 2019

Form PCT/ISA/210 (patent family annex) (January 2015)