(12) STANDARD PATENT (11) Application No. **AU 2010239014 B2**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
High-elongation rate aluminum alloy material for cable and preparation method thereof

(51) International Patent Classification(s)
C22C 21/00 (2006.01) *B21B 37/74* (2006.01)
C22C 1/03 (2006.01) *B22D 21/04* (2006.01)
C22C 1/06 (2006.01) *C21D 1/26* (2006.01)
B21B 1/46 (2006.01) *C22F 1/04* (2006.01)

(21) Application No: **2010239014** (22) Date of Filing: **2010.04.09**

(87) WIPO No: **WO10/121517**

(30) Priority Data

(31) Number	(32) Date	(33) Country
200910116635.7	**2009.04.24**	**CN**

(43) Publication Date: **2010.10.28**
(44) Accepted Journal Date: **2014.06.26**

(71) Applicant(s)
ANHUI JOYSENSES CABLE CO., LTD.

(72) Inventor(s)
Lin, Zemin;Yu, Lehua;Wan, Youmei

(74) Agent / Attorney
Collison & Co, Gpo Box 2556, Adelaide, SA, 5001

(56) Related Art
JP 2001-063232
EP 1138792
US 2008/102404

(12) 按照专利合作条约所公布的国际申请

(19) 世界知识产权组织
国 际 局

(43) 国际公布日
2010 年 10 月 28 日 (28.10.2010)

PCT

(10) 国际公布号
WO 2010/121517 A1

(51) 国际专利分类号:
C22C 21/00 (2006.01) *C21D 1/26* (2006.01)
C22C 1/06 (2006.01) *B22D 21/04* (2006.01)
C22C 1/03 (2006.01) *B21B 37/74* (2006.01)
C22F 1/04 (2006.01) *B21B 1/46* (2006.01)

(21) 国际申请号: PCT/CN2010/071654

(22) 国际申请日: 2010 年 4 月 9 日 (09.04.2010)

(25) 申请语言: 中文

(26) 公布语言: 中文

(30) 优先权:
200910116635.7 2009 年 4 月 24 日 (24.04.2009) CN

(71) 申请人 (对除美国外的所有指定国): 安徽欣意电缆有限公司 (ANHUI JOYSENSES CABLE CO., LTD.) [CN/CN]; 中国安徽省合肥市张洼路 98 号, Anhui 230041 (CN)。

(72) 发明人; 及
(75) 发明人/申请人 (仅对美国): 林泽民 (LIN, Zemin) [CN/CN]; 中国安徽省合肥市张洼路 98 号, Anhui 230041 (CN)。 余乐华 (YU, Lehua) [CN/CN]; 中国安徽省合肥市张洼路 98 号, Anhui 230041 (CN)。 万有梅 (WAN, Youmei) [CN/CN]; 中国安徽省合肥市张洼路 98 号, Anhui 230041 (CN)。

(74) 代理人: 南京经纬专利商标代理有限公司 (NANJING JINGWEI PATENT & TRADEMARK AGENCY CO., LTD.); 中国江苏省南京市中山路 179 号 12 楼 B 座, Jiangsu 210005 (CN)。

(81) 指定国 (除另有指明，要求每一种可提供的国家保护): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW。

(84) 指定国 (除另有指明，要求每一种可提供的地区保护): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), 欧亚 (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), 欧洲 (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)。

本国际公布:
— 包括国际检索报告(条约第 21 条(3))。

(54) **Title**: HIGH-ELONGATION RATE ALUMINUM ALLOY MATERIAL FOR CABLE AND PREPARATION METHOD THEREOF

(54) **发明名称**: 电缆用高延伸率铝合金材料及其制备方法

(57) **Abstract**: A high-elongation rate aluminum alloy material and preparation method thereof. The high-elongation aluminum alloy material contains, in weight percentage, 0.30-1.20% of iron, 0.03-0.10% of silicon, 0.01-0.30% of rare earth elements, namely cerium and lanthanum, and the remaining aluminum and inevitable impurities. The aluminum alloy is made from materials through a fusion casting process and a half-annealing treatment. An aluminum alloy conductor made thereof has a high-elongation rate and good safety and stability in use.

(57) **摘要**:

一种高延伸率铝合金材料及其制备方法，所述铝合金材料含有重量百分比为 0.30-1.20%的铁，0.03-0.10%的硅，0.01-0.30%的稀土元素，所述稀土元素为铈和镧，其余为铝和不可避免的杂质。所述铝合金由原料经过熔铸工艺和半退火处理而制成，由此制成的铝合金导体具有高延伸率且使用的安全稳定性好。

WO 2010/121517 A1

HIGH-ELONGATION RATE ALUMINUM ALLOY MATERIAL FOR CABLE AND PREPARATION METHOD THEREOF

Field of the Invention

The present invention pertains to the field of nonferrous metal materials, in particular to an aluminum alloy material with high elongation for cables and a preparation method for the same.

Background of the Invention

Presently, most wires and cables employ copper as the conductor. However, owing to the rare copper resource, high price of copper material, and high installation cost of copper cables, the development of wires and cables is limited. Due to the fact of abundant aluminum resource and low cost of aluminum material, it will be a trend to replace copper with aluminum as the conductor for wires and cables.

Disclosure of the Invention

Technical Problem

However, if conventional EC-aluminum is used as conductor to replace copper, the elongation, flexibility, and creep resistance of wires and cables are poor, and the safety and stability of use are unsatisfactory. Therefore, replacing copper with conventional EC-aluminum as conductor can not meet the demand for development of wires and cables.

Summary of the Invention

The object of the present invention is to provide an aluminum alloy material with high elongation for cables. With the aluminum alloy material according to the present invention as conductor, the wires and cables have high elongation, and can be used safely and stably.

To achieve the above object, the present invention employs the following technical solution: an aluminum alloy material with high elongation for cables, comprising the following components: Fe: 0.30~1.20wt%, Si: 0.03~0.10wt%, rare earth elements (i.e. Ce and La): 0.01~0.30wt%, and the rest are Al and inevitable impurities.

Another object of the present invention is to provide a method for preparing the aluminum alloy material with high elongation, comprising the following steps:

1) Fusion casting

First, adding Al alloy containing Si and Fe in 92~98 parts by weight (pbw) and Al-Fe alloy in 0.73~5.26 pbw, and heating to 710~750℃ to melt; then, heating to 720~760℃, adding rare earth-Al alloy in 1~3 pbw and B-Al alloy in 0.17~0.67 pbw, wherein, said rare earth-Al alloy is the alloy of Al and rare earth elements (Ce and La); next, adding a refining agent in 0.04~0.06 pbw and refining for 8~20 minutes; then, holding at the temperature for 20~40 minutes, and then casting;

2) Semi-annealing treatment

Holding the aluminum alloy obtained by casting at 280~380℃ for 4~10 hours, and then taking out and cooling naturally to ambient temperature.

Said aluminum alloy material further comprises inevitable impurity elements, the total content of which in the aluminum alloy material is lower than 0.3 wt%.

Furthermore, the content of Ca in the impurities is lower than 0.02 wt%, and the content of any other impurity element is lower than 0.01%, so as to reduce the influence of the impurity elements on the conductivity of the aluminum alloy material.

The aluminum alloy material with high elongation for cables provided in the present invention is a new type Al-Fe alloy material with the following advantages:

1) The content of Fe according to the present invention is controlled within the range of 0.30~1.20%; thus the strength of the aluminum alloy can be increased, and the creep resistance and thermal stability of the aluminum alloy can also be improved. The creep resistance is improved by 300% when compared to the conventional EC-aluminum material; furthermore, Fe can improve the toughness of the aluminum alloy, and the compression factor of the aluminum alloy material in the compression and twisting process can be as high as 0.93 or above, which can not be achieved by the conventional EC-aluminum material. Compared to the conductor made of EC-aluminum material, the compacted conductor made of the aluminum alloy in the same outside diameter has larger sectional area, higher electrical conductivity and higher stability, and is lower in production cost.

2) The content of Si according to the present invention is controlled within the range of 0.03~0.10%, which ensures the enhancement effect of Si to the strength of the aluminum alloy.

3) The rare earth elements according to the present invention can reduce the content of Si, and thereby reduce the influence of Fe, in particular Si on the conductivity of aluminum alloy to a very low level; moreover, the addition of rare earth elements

improves the crystal structure of the aluminum alloy material and thereby improves the processing properties of the aluminum alloy material, and is favorable for processing of the aluminum alloy material.

4) The rare earth elements according to the present invention are mainly Ce and La, which can well attain the performance described in 3).

5) The element B according to the present invention can react with impurity elements such as Ti, V, Mn, Cr, etc., and form chemical compounds, which deposit and then can be removed; therefore, the influence of impurity elements (e.g., Ti, V, Mn, Cr, etc.) on the conductivity of aluminum alloy can be reduced; thus, the conductivity of aluminum alloy can be improved.

6) The alloy material is conducted by semi-annealing treatment when the aluminum alloy is prepared in the present invention; therefore, the adverse effect of stress to the structure of the conductor during the drawing and twisting process can be reduced, so that the conductivity can be up to or even higher than 61% IACS (the criterion for conductivity of conductors made of conventional EC-aluminum is 61% IACS); in addition, the annealing treatment can greatly improve the elongation and flexibility of the aluminum alloy material. Cables made of the aluminum alloy material provided in the present invention can have the elongation as high as 30%, and the flexibility 25% higher than that of the copper cables, and a bending radius as small as 7 times of the outside diameter, while the bending radius of copper cable is 15 times of the outside diameter.

Embodiments

Embodiment 1

I. Fusion casting process

1. Material proportioning

5100kg aluminum ingot (contains 0.07% Si and 0.13% Fe), 40.4kg Al-Fe alloy (contains 22% Fe), 5.6kg rare earth alloy (contains 10% rare earth elements), 8.8kg B-Al alloy (contains 3.5% B), and 2.3kg refining agent (23% $Na_3Al{\cdot}F_6$ + 47% KCl + 30% NaCl).

2. Feeding method

During material feeding, feed the Al-Fe alloy into the cupola furnace in batches evenly with the aluminum ingots, to ensure the components can be distributed evenly as far as possible.

3. Heat preservation process

When the aluminum alloy liquid flows into the holding furnace, control the furnace temperature at 710~750℃; when rare earth-Al alloy and B-Al alloy are added into the aluminum alloy liquid, the furnace temperature is increased to 720~760℃, and not higher than 760℃. Here, increasing the temperature is favorable for melting of the rare earth-Al alloy and B-Al alloy, and thereby the treatment effect of rare earth elements and element B can be improved.

4. Rare earth treatment and boronizing treatment

4.1 Add 1/3 rare earth-Al alloy at 30 minutes before the holding furnace is filled up with the aluminum alloy liquid.

4.2 Add the remaining 2/3 rare earth-Al alloy and B-Al alloy at 5 minutes before the holding furnace is filled up with the aluminum alloy liquid.

Adding rare earth-Al alloy and B-Al alloy in different time periods is to allow the rare earth elements and element B to play a full part, so as to improve the effect.

4.3 The feeding positions of rare earth-Al alloy and B-Al alloy can be evenly distributed in the holding furnace.

5. Refining (slag removal, gas removal, agitation, and slag-off)

5.1 To ensure the composition of the aluminum alloy liquid is homogeneous in the entire furnace, the aluminum alloy liquid including which is located at the corner positions in the furnace should be agitated for 5 minutes.

5.2 When the furnace is filled up with the aluminum alloy liquid, blow 2.3kg powder of refining agent (23% $Na_3Al{\cdot}F_6$ + 47% KCl + 30% NaCl) into the bottom of the aluminum alloy liquid through high-purity nitrogen gas for 3~5 minutes, with the blow nozzle kept moving in the bottom of the aluminum alloy liquid, to force the included slag to flow up with the gas uniformly along the surface of the aluminum alloy liquid. The floating aluminum oxide slag should be completely removed from the furnace, so as to reduce new impurity carried with the refining agent as far as possible.

6. Quick analysis on-the-spot sample and holding and heat preservation

When the Fe content in the aluminum alloy liquid meets the requirements after slag is removed, hold the aluminum alloy liquid for 20~40 minutes.

7. Control of continuous casting and rolling process

7.1 Temperature control

7.1.1 Temperature of casting ladle: 720~730℃

7.1.2 Temperature of strips fed into the rolling machine: 450~490℃

7.1.3 Final rolling temperature of aluminum rods: about 300℃

7.2 Control of cooling water in conticaster

The volume of water inside the casting wheels to that outside the casting wheels: 3: 2; the volume of secondary cooling water should be adjusted according to the temperature of the cast strips.

7.3 Voltage of casting machine: 60~90V

7.4 Current through the rolling machine: 200~280A; speed of rolling machine: 7.5~8.5m/min.

II. Semi-annealing process

Hold the aluminum alloy rods made of aluminum alloy material in an annealing furnace for 10 hours at 280~300℃, and then take out and cool down the rods to the ambient temperature naturally.

The aluminum alloy material obtained in that way contains the following components measured by weight percentage: Fe: 0.3%, Si: 0.03%, Ce: 0.008%, La: 0.002%, B: 0.005%, Ca: 0.015%, Cu: 0.002%, Mg: 0.005%, Zn: 0.002%, Ti: 0.002%, V: 0.005%, Mn: 0.002%, Cr: 0.001%, Al: the remaining part.

Since element B reacts with impurity elements such as Ti, V, Mn, Cr, etc., and forms chemical compounds, which deposit and can be removed, the content of element B in the resulting aluminum alloy material is lower than the amount added actually.

It is seen that the total impurity content in the aluminum alloy material is lower than 0.3%, wherein, the content of any other impurity element is lower than 0.01%, except for the content of Ca, which is lower than 0.02%.

The performance test data of the aluminum alloy material with high elongation in this embodiment is as follows:

Tensile strength and elongation are tested according to the method described in ASTM B577; conductivity is tested according to the method described in ASTM B193, flexibility is tested according to the method of "Partial Discharge Test after Bending Test" described in GB 12706.1, and creep property is tested according to the creep test method described in the manual "Wires and Cables".

The performance data of the aluminum alloy material with high elongation in this embodiment is: tensile strength: 106MPa; elongation: 28%; conductivity: 63.0% IACS; partial discharge test after 6x bending radius test: passed; creep resistance: higher than EC-aluminum by 310%.

Embodiment 2

I. Fusion casting process

1. Material proportioning

5110kg aluminum ingot (contains 0.10% Si and 0.13% Fe), 258kg Al-Fe alloy (contains 23.2% Fe), 166.5kg rare earth alloy (contains 9.8% rare earth elements), 10kg B-Al alloy (contains 3.3% B), and 2.3kg refining agent (23% $Na_3Al{\bullet}F_6$ + 47% KCl + 30% NaCl).

2. Feeding method

During material feeding, feed the Al-Fe alloy into the cupola furnace in batches evenly with the aluminum ingots, to ensure the components can be distributed evenly as far as possible.

3. Heat preservation process

When the aluminum alloy liquid flows into the holding furnace, control the furnace temperature at 710~750℃; when rare earth-Al alloy and B-Al alloy are added into the aluminum alloy liquid, the furnace temperature is increased to 720~760℃, and not higher than 760℃. Here, increasing the temperature is favorable for melting of the rare earth-Al alloy and B-Al alloy, and thereby the treatment effect of rare earth elements and element B can be improved.

4. Rare earth treatment and boronizing treatment

4.1 Add 1/3 rare earth-Al alloy at 30 minutes before the holding furnace is filled up with the aluminum alloy liquid.

4.2 Add the remaining 2/3 rare earth-Al alloy and B-Al alloy at 5 minutes before the holding furnace is filled up with the aluminum alloy liquid.

Adding rare earth-Al alloy and B-Al alloy in different time periods is to allow to the rare earth elements and element B to play a full part, so as to improve the effect.

4.3 The feeding positions of rare earth-Al alloy and B-Al alloy can be evenly distributed in the holding furnace.

5. Refining (slag removal, gas removal, agitation, and slag-off)

5.1 To ensure the composition of the aluminum alloy liquid is homogeneous in the entire furnace, the aluminum alloy liquid including which is located at the corner positions in the furnace should be agitated for 5 minutes.

5.2 When the furnace is filled up with the aluminum alloy liquid, blow 2.3kg powder of refining agent (23% $Na_3Al{\bullet}F_6$ + 47% KCl + 30% NaCl) into the bottom of the aluminum alloy liquid through high-purity nitrogen gas for 3~5 minutes, with the blow nozzle kept moving in the bottom of the aluminum alloy liquid, to force the included slag to flow up with the gas uniformly along the surface of the aluminum alloy liquid. The floating aluminum oxide slag should be completely removed from the furnace, so as to reduce new impurity carried with the refining agent as far as possible.

6. Quick analysis on-the-spot sample and holding and heat preservation

When the Fe content in the aluminum alloy liquid meets the requirements after slag is removed, hold the aluminum alloy liquid for 20~40 minutes.

7. Control of continuous casting and rolling process

7.1 Temperature control

7.1.1 Temperature of casting ladle: 720~730℃

7.1.2 Temperature of strips fed into the rolling machine: 450~490℃

7.1.3 Final rolling temperature of aluminum rods: about 300℃

7.2 Control of cooling water in conticaster

The volume of water inside the casting wheels to that outside the casting wheels: 3: 2; the volume of secondary cooling water should be adjusted according to the temperature of the cast strips.

7.3 Voltage of casting machine: 60~90V

7.4 Current through the rolling machine: 200~280A; speed of rolling machine: 7.5~8.5 m/min.

II. Semi-annealing process

Hold the aluminum alloy rods made of aluminum alloy material in an annealing furnace for 4 hours at 360~380℃, and then take out and cool down the rods to the ambient temperature naturally.

The aluminum alloy material obtained in that way contains the following components measured by weight percentage: Fe: 1.2%, Si: 0.08%, Ce: 0.019%, La: 0.10%, B: 0.004%, Ca: 0.01%, Cu: 0.002%, Mg: 0.004%, Zn: 0.003%, Ti: 0.002%, V: 0.002%, Mn: 0.005%, Cr: 0.002%, Al: the remaining part.

Since element B reacts with impurity elements such as Ti, V, Mn, Cr, etc., and forms chemical compounds, which deposit and can be removed, the content of element B in the resulting aluminum alloy material is lower than the amount added actually.

It is seen that the total impurity content in the aluminum alloy material is lower than 0.3%, wherein, the content of any other impurity element is lower than 0.01%, except for the content of Ca, which is lower than 0.02%.

The performance test data of the aluminum alloy material with high elongation in this embodiment is as follows:

Tensile strength and elongation are tested according to the method described in ASTM B577; conductivity is tested according to the method described in ASTM B193, flexibility is tested according to the method of "Partial Discharge Test after Bending Test" described in GB 12706.1, and creep property is tested according to the creep test method described in the manual "Wires and Cables".

The performance data of the aluminum alloy material with high conductivity, high elongation, high flexibility, and high creep resistance in this embodiment is: tensile strength: 92MPa; elongation: 36%; conductivity: 61.0% IACS; partial discharge test after 7x bending radius test: passed; creep resistance: higher than EC-aluminum by 330%.

Embodiment 3

I. Fusion casting process

1. Material proportioning

5125kg aluminum ingot (contains 0.12% Si and 0.12% Fe), 107kg Al-Fe alloy (contains 21.9% Fe), 118kg rare earth alloy (contains 10.1% rare earth elements), 14.8kg B-Al alloy (contains 3.0% B), and 2.8kg refining agent (23% $Na_3Al{\bullet}F_6$ + 47% KCl + 30% NaCl).

2. Feeding method

During material feeding, feed the Al-Fe alloy into the cupola furnace in batches evenly with the aluminum ingots, to ensure the components can be distributed evenly as far as possible.

3. Heat preservation process

When the aluminum alloy liquid flows into the holding furnace, control the furnace temperature at 710~750℃; when rare earth-Al alloy and B-Al alloy are added into the aluminum alloy liquid, the furnace temperature is increased to 720~760℃, and not higher than 760℃. Here, increasing the temperature is favorable for melting of the rare earth-Al alloy and B-Al alloy, and the treatment effect of rare earth elements and element B can be improved.

4. Rare earth treatment and boronizing treatment

4.1 Add 1/3 rare earth-Al alloy at 30 minutes before the holding furnace is filled up with the aluminum alloy liquid.

4.2 Add the remaining 2/3 rare earth-Al alloy and B-Al alloy at 5 minutes before the holding furnace is filled up with the aluminum alloy liquid.

4.3 The feeding positions of rare earth-Al alloy and B-Al alloy can be evenly distributed in the holding furnace.

5. Refining (slag removal, gas removal, agitation, and slag-off)

5.1 To ensure the composition of the aluminum alloy liquid is homogeneous in the entire furnace, the aluminum alloy liquid including which is located at the corner positions in the furnace should be agitated for 5 minutes.

5.2 When the furnace is filled up with the aluminum alloy liquid, blow 2.8kg powder of refining agent (23% $Na_3Al \cdot F_6$ + 47% KCl + 30% NaCl) into the bottom of the aluminum alloy liquid through high-purity nitrogen gas for 3~5 minutes, with the blow nozzle kept moving in the bottom of the aluminum alloy liquid, to force the included slag to flow up with the gas uniformly along the surface of the aluminum alloy liquid. The floating aluminum oxide slag should be completely removed from the furnace, so as to reduce new impurity carried with the refining agent as far as possible.

6. Quick analysis on-the-spot sample and holding and heat preservation

When the Fe content in the aluminum alloy liquid meets the requirements after slag is removed, hold the aluminum alloy liquid for 20~40 minutes.

7. Control of continuous casting and rolling process

7.1 Temperature control

7.1.1 Temperature of casting ladle: 720~730℃

7.1.2 Temperature of strips fed into the rolling machine: 450~490℃

7.1.3 Final rolling temperature of aluminum rods: about 300℃

7.2 Control of cooling water in conticaster

The volume of water inside the casting wheels to that outside the casting wheels: 3: 2; the volume of secondary cooling water should be adjusted according to the temperature of the cast strips.

7.3 Voltage of casting machine: 60~90V

7.4 Current through the rolling machine: 200~280A; speed of rolling machine: 7.5~8.5 m/min.

II. Semi-annealing process

Hold the aluminum alloy rods made of aluminum alloy material in an annealing furnace for 8 hours at 300~320℃, and then take out and cool down the rods to the ambient temperature naturally.

The aluminum alloy material obtained in that way contains the following components measured by weight percentage: Fe: 0.55%, Si: 0.10%, Ce: 0.15%, La: 0.06%, B: 0.007%, Ca: 0.013%, Cu: 0.003%, Mg: 0.004%, Zn: 0.004%, Ti: 0.002%, V: 0.004%, Mn: 0.003%, Cr: 0.002%, Al: the remaining part.

Since element B reacts with impurity elements such as Ti, V, Mn, Cr, etc., and forms chemical compounds, which deposit and can be removed, the content of element B in the resulting aluminum alloy material is lower than the amount added actually.

It is seen that the total impurity content in the aluminum alloy material is lower than 0.3%, wherein, the content of any other impurity element is lower than 0.01%, except for the content of Ca, which is lower than 0.02%.

The performance test data of the aluminum alloy material with high elongation in this embodiment is as follows:

Tensile strength and elongation are tested according to the method described in ASTM B577; conductivity is tested according to the method described in ASTM B193, flexibility is tested according to the method of "Partial Discharge Test after Bending Test" described in GB 12706.1, and creep property is tested according to the creep test method described in the manual "Wires and Cables".

The performance data of the aluminum alloy material with high elongation in this embodiment is: tensile strength: 106MPa, elongation: 30.2%; conductivity: 62.6% IACS; partial discharge test after 6x bending radius test: passed; creep resistance: higher than EC-aluminum by 330%.

Embodiment 4

I. Fusion casting process

1. Material proportioning

5005kg aluminum ingot (contains 0.08% Si and 0.13% Fe), 182kg Al-Fe alloy (contains 21% Fe), 90.5kg rare earth alloy (contains 9.8% rare earth elements), 30kg B-Al alloy (contains 3.5% B), and 2.0kg refining agent (23% $Na_3Al \bullet F_6$ + 47% KCl + 30% NaCl).

2. Feeding method

During material feeding, feed the Al-Fe alloy into the cupola furnace in batches evenly with the aluminum ingots, to ensure the components can be distributed evenly as far as possible.

3. Heat preservation process

When the aluminum alloy liquid flows into the holding furnace, control the furnace temperature at 710~750℃; when rare earth-Al alloy and B-Al alloy are added into the aluminum alloy liquid, the furnace temperature is increased to 720~760℃, and not higher than 760℃. Here, increasing the temperature is favorable for melting of the rare earth-Al alloy and B-Al alloy, and the treatment effect of rare earth elements and element B can be improved.

4. Rare earth treatment and boronizing treatment

4.1 Add 1/3 rare earth-Al alloy at 30 minutes before the holding furnace is filled up with the aluminum alloy liquid.

4.2 Add the remaining 2/3 rare earth-Al alloy and B-Al alloy at 5 minutes before the holding furnace is filled up with the aluminum alloy liquid.

4.3 The feeding positions of rare earth-Al alloy and B-Al alloy can be evenly distributed in the holding furnace.

5. Refining (slag removal, gas removal, agitation, and slag-off)

5.1 To ensure the composition of the aluminum alloy liquid is homogeneous in the entire furnace, the aluminum alloy liquid including which is located at the corner positions in the furnace should be agitated for 5 minutes.

5.2 When the furnace is filled up with the aluminum alloy liquid, blow 2.0kg powder of refining agent (23% $Na_3Al{\bullet}F_6$ + 47% KCl + 30% NaCl) into the bottom of the aluminum alloy liquid through high-purity nitrogen gas for 3~5 minutes, with the blow nozzle kept moving in the bottom of the aluminum alloy liquid, to force the included slag to flow up with the gas uniformly along the surface of the aluminum alloy liquid. The floating aluminum oxide slag should be completely removed from the furnace, so as to reduce new impurity carried with the refining agent as far as possible.

6. Quick analysis on-the-spot sample and holding and heat preservation

When the Fe content in the aluminum alloy liquid meets the requirements after slag is removed, hold the aluminum alloy liquid for 20~40 minutes.

7. Control of continuous casting and rolling process

7.1 Temperature control

7.1.1 Temperature of casting ladle: 720~730℃

7.1.2 Temperature of strips fed into the rolling machine: 450~490℃

7.1.3 Final rolling temperature of aluminum rods: about 300℃

7.2 Control of cooling water in conticaster

The volume of water inside the casting wheels to that outside the casting wheels: 3: 2; the volume of secondary cooling water should be adjusted according to the temperature of the cast strips.

7.3 Voltage of casting machine: 60~90V

7.4 Current through the rolling machine: 200~280A; speed of rolling machine: 7.5~8.5m/min.

II. Semi-annealing process

Hold the aluminum alloy rods made of aluminum alloy material in an annealing furnace for 6 hours at 340~360℃, and then take out and cool down the rods to the ambient temperature naturally.

The aluminum alloy material obtained in that way contains the following components measured by weight percentage: Fe: 0.80%, Si: 0.04%, Ce: 0.10%, La: 0.06%, B: 0.008%, Ca: 0.011%, Cu: 0.005%, Mg: 0.004%, Zn: 0.006%, Ti: 0.003%, V: 0.003%, Mn: 0.005%, Cr: 0.002%, Al: the remaining part.

Since element B reacts with impurity elements such as Ti, V, Mn, Cr, etc., and forms chemical compounds, which deposit and can be removed, the content of element B in the resulting aluminum alloy material is lower than the amount added actually.

It is seen that the total impurity content in the aluminum alloy material is lower than 0.3%, wherein, the content of any other impurity element is lower than 0.01%, except for the content of Ca, which is lower than 0.02%.

The performance test data of the aluminum alloy material with high elongation in this embodiment is as follows:

Tensile strength and elongation are tested according to the method described in ASTM B577; conductivity is tested according to the method described in ASTM B193, flexibility is tested according to the method of "Partial Discharge Test after Bending Test" described in GB 12706.1, and creep property is tested according to the creep test method described in the manual "Wires and Cables".

The performance data of the aluminum alloy material with high elongation in this embodiment is: tensile strength: 97MPa; elongation: 35.2%; conductivity: 62.0% IACS; partial discharge test after 6x bending radius test: passed; creep resistance: higher than EC-aluminum by 330%.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS

1. An aluminum alloy material with high elongation for cables, comprising the following components measured by weight percentage: Fe: 0.30~1.20%, Si: 0.03~0.10%, rare earth elements (i.e. Ce and La): 0.01~0.30%, and the rest are Al and inevitable impurities.
2. The aluminum alloy material with high elongation for cables according to claim 1, wherein, the total content of impurities in the aluminum alloy measured by weight percentage is lower than 0.3%.
3. The aluminum alloy material with high elongation for cables according to claim 2, wherein, measured by weight percentage, the content of Ca in the impurities is lower than 0.02%, and the content of any other element in the impurities is lower than 0.01%.
4. The aluminum alloy material with high extensibility for cables according to claim 1, wherein, measured by weight percentage, the content of Ce is 0.005~0.20%, and the content of La is 0.001~0.15%.
5. A method for preparing the aluminum alloy material with high elongation for cables according to claim 1, comprising the following steps:

1) Fusion casting

First, adding Al alloy containing Si and Fe in 92~98 parts by weight (pbw) and Al-Fe alloy in 0.73~5.26 pbw, and heating to 710~750℃ to melt state; then, heating to 720~760℃, adding rare earth-Al alloy in 1~3 pbw and B-Al alloy in 0.17~0.67 pbw, wherein, the rare earth-Al alloy is the alloy of Al and rare earth elements (Ce and La); next, adding a refining agent in 0.04~0.06 pbw and refining for 8~20 minutes; then, holding at the temperature for 20~40 minutes, and then casting;

2) Semi-annealing treatment

Holding the resulting aluminum alloy at 280~380℃ for 4~10 hours, and then taking out and cooling naturally to ambient temperature.

6. The method for preparing the aluminum alloy material with high elongation for cables according to claim 5, wherein, the content of Si in said aluminum alloy that contains Si and Fe is 0.07~0.12%, and the content of Fe in said aluminum alloy that contains Si and Fe is 0.12~0.13%; the content of Fe in the Al-Fe alloy is 20~24%, the content of B in the B-Al alloy is 3~4%, and the content of Ce and La in the rare

earth-Al alloy is 9~11%.

7. The method for preparing the aluminum alloy material with high elongation for cables according to claim 5, wherein, the Al and Al-Fe alloy melt and flow into a holding furnace, 1/3 rare earth-Al alloy is added at 30 minutes before the holding furnace is filled up with the aluminum alloy liquid, and B-Al alloy and the remaining 2/3 rare earth-Al alloy are added at 5 minutes before the holding furnace is filled up with the aluminum alloy liquid.

8. The method for preparing the aluminum alloy material with high elongation for cables according to claim 5, wherein, the powder of refining agent comprises 23% $Na_3Al \cdot F_6$ + 47% KCl + 30% NaCl.

9. The method for preparing the aluminum alloy material with high elongation for cables according to claim 5, wherein, in the casting process, the temperature of casting ladle is 720~730℃, the temperature of cast strips fed into the rolling machine is 450~490℃, and the temperature of final rolling is 300℃.