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

(11) EP 3 093 376 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
21.03.2018 Bulletin 2018/12

(21) Application number: **16162541.3**

(22) Date of filing: **29.03.2016**

(51) Int Cl.:
C25D 5/10 $^{(2006.01)}$
C25D 7/06 $^{(2006.01)}$
C25D 3/38 $^{(2006.01)}$
C25D 5/44 $^{(2006.01)}$
C25D 3/32 $^{(2006.01)}$

(54) PROCESS FOR CONTINUOUS ELECTROCHEMICAL TINNING OF AN ALUMINIUM WIRE

VERFAHREN ZUR KONTINUIRLICHEN ELEKTROCHEMISCHEN VERZINNUNG VON ALUMINIUMDRÄHTEN

PROCÉDÉ D’ÉTAMAGE ÉLECTROCHIMIQUE EN CONTINU DE FILS D’ALUMINIUM

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

(30) Priority: **11.05.2015 IT UB20150022**

(43) Date of publication of application:
16.11.2016 Bulletin 2016/46

(73) Proprietor: **BTICINO S.P.A.**
21100 Varese, (IT)

(72) Inventors:
- **Mazzocchi, Caterina**
  25128 Brescia BS (IT)
- **Lauro, Gianluigi**
  25080 Muscoline BS (IT)

(74) Representative: **Perani & Partners S.p.A.**
Piazza Armando Diaz, 7
20123 Milano (IT)

(56) References cited:
WO-A1-94/13866
GB-A- 1 464 048
US-A- 2 509 117
US-A- 3 622 470

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Printed by Jouve, 75001 PARIS (FR)

Description

FIELD OF APPLICATION

[0001] The object of the present invention is a process for continuous electrochemical tinning of an aluminum wire.

Description of the prior art

[0002] In the prior art it is known to use copper as an electrical conductor, in particular for making electrical wires and cables. Thanks to its conductive properties, copper is used in numerous fields, especially where high performance is required in the transmission of electric current.

[0003] In detail, ETP copper used in the electrical field has the following electrical characteristics: IACS conductivity >99%, specific weight of 8.93 Kg/dm^3. Considering the continuous increase in the cost of copper, there is a need to seek alternative materials capable of offering a good compromise between cost and conductive properties.

[0004] In the state of the art, aluminum is the material considered most suitable due to its electrical characteristics (IACS 50-63.8% depending on the alloy), its mechanical characteristics, its workability, its low specific weight (2.7 Kg/dm^3), its low cost, its abundance and wide availability in nature. Therefore, currently aluminum is the only commercial alternative to copper in the electrical field.

[0005] Aluminum is used as conductor in high and medium power busbars, where the conductors consist of bars. In low power busbars, where wires are generally used as conductors, the material used is copper.

[0006] Given that copper and aluminum have a different electrical conductivity, it is necessary to correctly size the conductive aluminum wire in order to obtain the same performance as an equivalent copper wire. For example, in order to obtain an aluminum wire with the same performance as a copper wire, it is necessary to increase the diameter of the aluminum wire by 30% with respect to the diameter of the copper wire. Such an increase in diameter is, however, compensated by the lower specific cost of aluminum. Indeed, the linear weight of an aluminum conductor is roughly half that of a copper conductor having the same diameter.

Problem of the prior art

[0007] In the prior art, the difficulty of using aluminum wire is linked to the need to treat the wire itself in order to avoid problems of oxidation especially in contact areas. Indeed, although aluminum is a highly corrosion-resistant material, it reacts very easily with oxygen due to its position in the electrochemical series.

[0008] The resistance of aluminum to corrosion is linked to the formation of a very compact layer of aluminum oxide Al_2O_3, known as alumina, which protects the material from further corrosion attacks. Such an oxide constitutes a very stable layer that coats the aluminum providing a passivating effect that impedes the attack of the oxide with regard to the underlying metal.

[0009] In order to improve contact resistance and prevent it from raising because of the formation of the aluminum oxide, which has low electrical conductivity, it is possible to tin the contact area. Indeed, tinning protects the material from oxidation and makes it possible to have a better interface in the contact area. WO 9413866 and GB 1464048, US 2509117and US 3622470 disclose processes for tinning or bronzing aluminum wires.

SUMMARY OF THE INVENTION

[0010] The aim of the subject invention is to make an aluminum wire for applications in the electrical field that has suitable electrical and mechanical characteristics and that allows a copper wire to be replaced.

[0011] Such an aim is accomplished by a process according to claim 1.

Advantages of the invention

[0012] Thanks to an embodiment, it is possible to make an aluminum wire that has a tinning over its entire surface, protects the material from oxidation and makes it possible to have a better interface in the electrical contact area.

[0013] Thanks to an embodiment, it is possible to make a process that allows the aluminum wire to be treated continuously.

[0014] Thanks to an embodiment, the process of the present invention makes it possible to make an aluminum wire that can also be used in low power ducts.

[0015] Thanks to an embodiment, it is possible to make an aluminum wire that is sized and treated suitably to ensure electrical performance comparable to that of a copper wire. Thanks to an embodiment, it is possible to make an aluminum wire whose performance has been verified through overheating tests pursuant to product standard EN61439-6. Thanks to an embodiment, it is possible to make an aluminum wire that offers comparable performance to that of a copper wire, and that allows the production costs to be reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The features and advantages of the present disclosure will become clearer from the following detailed description of a possible practical embodiment, illustrated as a nonlimiting example in the set of drawings, in which:

- figure 1 shows a flow diagram of the steps of the process according to the present invention,
- figure 2 shows a block diagram of the components

of a plant able to be used to perform the process of figure 1.

[0017] The device illustrated in the attached figures must be considered to be schematically represented, not necessarily to scale and not necessarily with the represented proportions between the various constituent elements.

DETAILED DESCRIPTION

[0018] Even where not explicitly highlighted, the single characteristics described in reference to the specific embodiments should be considered as accessory and/or interchangeable with other characteristics, described in reference to other embodiments.

[0019] The object of the present invention is a process for continuous electrochemical tinning of an aluminum wire 1.

[0020] The process comprises a step of providing an aluminum wire 1, and in particular a first coil 2 of aluminum wire 1 and a second coil 3 configured to rotate and to be operatively coupled with the aluminum wire of the first coil 2. In detail, when the second coil 3 (or winder) rotates, it pulls the aluminum wire 1 making it run from the first coil 2 towards the second coil 3, thus winding the aluminum wire on the second coil 3. In this way, the first coil 2 (or unwinder) rotates through the effect of the traction force exerted on the aluminum wire 1 by the second coil 3 (or winder), thus unwinding the aluminum wire 1 from the first coil 2.

[0021] In other words, the aluminum wire is in traction between the first coil 2 and the second coil 3. The second coil 3 winds the wire that is thus unwound from the first coil 2. Alternatively, both the first coil 2 and the second coil 3 can be set in rotation simultaneously to make the aluminum wire 1 run.

[0022] The process comprises the step of performing a pickling of the aluminum wire 1. In particular, the aluminum wire is made to pass through a pickling tank 4 containing a solution comprising caustic soda and gluconate, and having a temperature comprised between 40°C and 80°C. Preferably, the pickling tank 4 is configured to allow the aluminum wire 1 to run through it, keeping the aluminum wire 1 immersed in the solution of caustic soda and gluconate.

[0023] In accordance with a preferred embodiment of the present invention, the solution of caustic soda and gluconate has a concentration comprised between 25g/l and 35g/l and a temperature comprised between 50°C and 70°C. As specified earlier, the aluminum wire 1 is completely immersed in the solution of caustic soda and gluconate when it runs through the pickling tank 4. It should be specified that the aluminum wire 1 runs through the pickling tank 4 thanks to the synergic movement of the first coil 2 and of the second coil 3. This step allows both the cleaning and the activation of the material of which the aluminum wire 1 consists.

[0024] Preferably, the pickling tank 4 comprises means configured for measuring and regulating the temperature of the pickling solution contained in it. Even more preferably, the means comprise pulleys and guides adapted for keeping the aluminum wire 1 immersed in the solutions contained in each treatment tank, and for allowing the aluminum wire 1 to run through the plurality of tanks.

[0025] In accordance with a preferred solution, the pickling step of the aluminum wire 1 is followed by a washing step, this washing step in turn preferably preceded by a pre-washing step of the aluminum wire 1.

[0026] Advantageously, the pickling step of the aluminum wire 1 makes it possible to remove the oxide layers present on the surface of the wire, so as to make the surface suitable for coating with successive metallic layers (e.g. copper, tin) by electrolytic galvanization.

[0027] The process also comprises a step of carburizing the aluminum wire 1 obtained from the pickling step, carried out by passing the aluminum wire 1 through a carburization tank 5 containing a solution comprising zinc, caustic soda, and preferably additives, and having a temperature comprised between 15°C and 50°C. Preferably, the carburization tank 5 is configured to allow the aluminum wire 1 to run through it, keeping the aluminum wire 1 immersed in the solution of zinc, caustic soda and additives.

[0028] In accordance with a preferred embodiment, the solution of zinc, caustic soda and additives has a concentration comprised between 18% and 22% in volume and a temperature comprised between 20°C and 45°C.

[0029] Preferably, the aluminum wire 1 is completely immersed in the solution of zinc, caustic soda and additives when it runs inside the carburization tank 5.

[0030] In accordance with a preferred solution, the step of carburizing the aluminum wire is followed by a washing step, this washing step in turn preferably preceded by a pre-washing step of the aluminum wire 1.

[0031] Preferably, the carburization tank 5 comprises means configured for measuring and regulating the temperature of the carburization solution contained in it.

[0032] Advantageously, the step of carburizing the aluminum wire 1 allows the surface of the wire itself to be prepared for the application of successive galvanic coating layers. The process comprises a step of performing alkaline copper plating (i.e. by electrolytic galvanization) of the aluminum wire 1 obtained from the carburizing step, by making the aluminum wire 1 pass through an alkaline copper plating tank 6 containing a solution comprising copper and conducting salts, and having a temperature comprised between 50°C and 70°C and an applied voltage value comprised between 2V and 4V. Preferably, the alkaline copper plating tank 6 is configured to allow the aluminum wire 1 to run through it, always keeping the aluminum wire 1 immersed in the solution of copper and conducting salts.

[0033] In accordance with a preferred embodiment, the solution of copper and conducting salts has a temperature comprised between 60°C and 65°C and an applied voltage value comprised between 2.7V and 3.2V, and has a concentration comprised between 14g/l and 17g/l and a pH comprised between 8 and 9.5.

[0034] Preferably, the aluminum wire 1 is completely immersed in said solution of copper and conducting salts when it runs inside the alkaline copper plating tank 6.

[0035] In accordance with a preferred solution, the step of performing alkaline copper plating is followed by a washing step, this washing step in turn preferably preceded by a pre-washing step of the aluminum wire 1.

[0036] Preferably, the alkaline copper plating tank 6 comprises means configured for measuring and regulating the temperature of the alkaline copper plating solution contained in it.

[0037] The process also comprises the step of performing acid copper plating (i.e. by electrolytic galvanization) of the aluminum wire (1) obtained from the alkaline copper plating step, by moving the aluminum wire 1 through an acid copper plating tank 7 containing a solution comprising copper sulfate, sulfuric acid and preferably additives, and having a temperature comprised between 20°C and 40°C and an applied voltage value comprised between 0.8V and 2V. Preferably, the acid copper plating tank 7 is configured to allow the aluminum wire 1 to run through it, always keeping the aluminum wire 1 immersed in the solution of copper sulfate, sulfuric acid and additives.

[0038] In accordance with a preferred embodiment, the solution of copper sulfate, sulfuric acid and additives has a temperature comprised between 25°C and 35°C and an applied voltage value comprised between IV and 1,5V, and has a concentration of copper sulfate comprised between 180g/l and 220g/l, a concentration of sulfuric acid comprised between 60g/l and 70g/l and a concentration of additives comprised between 2cm^3/l and 3cm^3/l.

[0039] Preferably, the aluminum wire 1 is completely immersed in the solution of copper sulfate, sulfuric acid and additives when it runs inside the acid copper plating tank 7. In accordance with a preferred solution, the step of performing acid copper plating of the aluminum wire 1 is followed by a washing step, this washing step in turn preferably preceded by a pre-washing step of the aluminum wire 1.

[0040] Preferably, the acid copper plating tank 7 comprises means configured for measuring and regulating the temperature of the acid copper plating solution contained in it.

[0041] The method also comprises the step of performing tinning (i.e. by electrolytic galvanization) of the aluminum wire 1 obtained from the acid copper plating step, by moving the aluminum wire 1) through a tinning tank 8 containing a solution comprising methanesulfonic acid, methanesulfonic tin and preferably brightener, and having a temperature comprised between 15°C and 35°C and an applied voltage value comprised between 0,5V and 2,7V. Preferably, the tinning tank 8 is configured to allow the aluminum wire 1 to run through it, always keeping the aluminum wire 1 immersed in the solution of methanesulfonic acid, methanesulfonic tin and brightener. In accordance with a preferred embodiment, the solution of methanesulfonic acid, methanesulfonic tin and brightener has a temperature comprised between 20°C and 30°C and an applied voltage value comprised between 1.2V and 1.6V, and has a concentration of methanesulfonic acid comprised between 90g/l and 100g/l and a concentration of methanesulfonic tin comprised between 20g/l and 55g/l and a concentration of brightener comprised between 1cm^3/l and 2cm^3/l.

[0042] Preferably, the aluminum wire 1 is completely immersed in the solution of methanesulfonic acid, methanesulfonic tin and brightener when it runs inside the tinning tank 8.

[0043] In accordance with a preferred solution, the step of tinning the aluminum wire 1 is followed by a washing step, this washing step in turn preferably preceded by a pre-washing step of the aluminum wire 1.

[0044] Preferably, the tinning tank 8 comprises means configured for measuring and regulating the temperature of the tinning solution contained in it.

[0045] In accordance with a preferred embodiment, the aluminum wire 1 is made to move continuously through the series of tanks comprising the pickling tank (4), the carburization tank (5), the alkaline copper plating tank (6), the acid copper plating tank (7) and the tinning tank 8 at a speed comprised between 30m/min and 70m/min. Preferably, after each treatment tank 4-8 there is a washing tank L, and a pre-washing tank (if foreseen) arranged before the washing tank L. Both the washing tank and the pre-washing tank are passed through by the aluminum wire that runs immersed in the respective washing and pre-washing solutions contained in them.

[0046] In accordance with a preferred embodiment, the alkaline copper plating tank 6, the acid copper plating tank 7 and the tinning tank 8 each comprise at least one electrode. Preferably, each electrode is an anode arranged on a basket containing copper or tin depending on the treatment tank. An electric current is passed through the electrodes (e.g. anodes) and the predetermined voltage values are applied for the electrochemical treatment of the respective solutions contained in the treatment tanks.

[0047] Preferably, the process comprises the step of circulating a current of intensity comprised between 120A and 220A in the electrode (e.g. anode).

[0048] Preferably, the intensity of the electrical current in the electrodes (e.g. anodes) is dependent on the advancing speed of the wire. For example, for advancing speeds of the wire of 40m/min, there is an intensity of electric current in the anodes that varies between 130A and 150A, whereas for speed values of the wire of 60m/min, there is an intensity of electric current that varies between 190A and 210A.

[0049] With reference to the example given in figure 1, the process is in the succession of the following steps carried out in the following order: a) providing an aluminum wire 1; b) performing the pickling of the aluminum wire 1; c) performing the carburization of the aluminum wire 1 obtained from step b; d) performing the alkaline copper plating of the aluminum wire 1 obtained from step c; e) performing the acid copper plating of the aluminum wire 1 obtained from step d; f) performing the tinning of the aluminum wire 1 obtained from step e; g) winding the aluminum wire 1 obtained from step f) onto the second coil 3. The wire continuously passes through the plurality of tanks in series in which the steps of the process listed above are performed in sequence. In a preferred embodiment of the invention, each step is followed by at least one washing step that is performed in suitable washing tanks L arranged downstream of each treatment tank (figure 2).

[0050] A plant 9 able to be used to perform the process described above is shown in figure 2.

[0051] The plant 9 comprises a plurality of tanks that are mutually distinct and arranged in series. The plurality of tanks comprises: a pickling tank 4 containing a pickling solution, a carburization tank 5 containing a carburization solution, an alkaline copper plating tank 6 containing an alkaline copper plating solution, an acid copper plating tank 7 containing an acid copper plating solution and a tinning tank 8 containing a tinning solution. The alkaline copper plating tank 6, the acid copper plating tank 7 and the tinning tank 8 comprise at least one electrode each, preferably at least one anode each.

[0052] The plant 9 also comprises a first coil 2 of aluminum wire 1, and a second coil 3 operatively coupled with the first coil 2. The second coil 3 is configured to rotate so as to pull and make the aluminum wire 1 move from the first coil 2 to the second coil 3, so as to unwind the aluminum wire 1 from the first coil 2 to wind it up on the second coil 3. The first coil 2 and the second coil 3 are configured to move the aluminum wire 1 continuously through the plurality of tanks arranged in series. Preferably, the second coil 3 is set in rotation through an electric motor. As an example, the first coil 2 is the coil with which the aluminum wire 1 to be treated with the process of the present invention is supplied, whereas the second coil 3 is the coil onto which the tinned aluminum wire according to the process of the present invention is wound. Preferably, the plurality of tanks comprises means adapted for keeping the aluminum wire 1 always immersed in the respective solutions contained in them. In other words, the plurality of tanks comprises treatment tanks that are mutually separate and arranged in series. Each treatment tank is filled with a predetermined volume of a respective solution, and is configured both to allow the aluminum wire 1 to run inside it, and to keep the aluminum wire 1 immersed in the solution.

[0053] Advantageously, the speed of movement of the aluminum wire 1 can be adjusted during the operation of the plant 9 to determine the exposure time of the aluminum wire 1 to each solution.

[0054] In accordance with a preferred embodiment, the process foresees to perform a washing step of the aluminum wire 1 after each of the steps of the aforementioned process.

[0055] Preferably, the liquids used in the washing steps are treated and purified through a demineralizing apparatus for example made up of a plurality of demineralisers (e.g. for tin, acid copper, alkaline copper, pickling and carburization) arranged near to the single washing tanks L. Preferably, each washing step is preceded by a prewashing step of the aluminum wire 1. Advantageously, the washing step carried out after each treatment makes it possible both to eliminate the deposit of liquids on the aluminum wire 1, and to avoid carrying substances and consequently polluting the solutions contained in the subsequent tanks. Indeed, the washing step of the aluminum wire 1 is a critical aspect for the process, particularly relative to the first two pickling and carburization tanks 4,5. As stated above, a preferred embodiment of the plant 9 foresees the presence of a pre-washing tank arranged in series before each washing tank L, so as to optimize the washing step itself.

[0056] Preferably, the pre-washing water of the first two baths, being particularly critical, are replaced frequently.

[0057] In accordance with an embodiment of the plant 9, the solutions are kept in separate storage tanks from the plurality of tanks of the plant 9. When the plant 9 is started up, the solutions are taken from the storage tanks through a system of pipes and valves, and taken into the respective treatment tanks. In this step, the treatment tanks of the plant 9 are filled so that both the aluminum wire 1 to be treated and the anodes are perfectly immersed in the solutions contained in them.

[0058] Advantageously, the process object of the present invention makes it possible to make an aluminum wire 1 that is tinned uniformly, which has the following characteristics: good adherence of the copper-tin applied layer, adequate thickness of the coating and uniformity of the surface.

[0059] Periodically, the process comprises a step in which the copper-tin applied layer is controlled with metallographic section.

[0060] Preferably, the thickness of the copper layer that coats the aluminum wire 1 is comprised between 1μm and 2μm, whereas the thickness of the tin layer is comprised between 1 μm and 3 μm.

[0061] Advantageously, it is possible to determine the exposure time of the aluminum wire 1 to the solutions contained in the tanks, both by varying the advancement speed of the wire (i.e. through the rotation speed of the coils 2 and 3), and by suitably sizing the treatment tanks. In other words, it is possible to determine the thickness of the copper and tin layer by suitably adjusting the aforementioned parameters.

[0062] It should be noted that the Applicant has carried out adhesion tests through rubbing, in accordance with the standard UNI EN ISO 2819, with a positive outcome on aluminum wires treated with different advancement speeds.

[0063] Accelerated corrosion tests were also carried out through the Machu test, also in this case on aluminum wires coated with copper-tin treated with different advancing speeds, obtaining positive results.

[0064] Furthermore, a corrosion resistance test in a humid chamber was also performed according to the standard UNI EN ISO 6270-1, with a positive outcome.

[0065] Advantageously, the plant 9 operates continuously. Indeed, before the first coil 2 to be treated has completely run out, it is possible to proceed to join the aluminum wire with a sacrificial wire or with an aluminum wire of the next coil through brass joins or through cold welding. In this way, it is possible to stable join the two ends of the two wires, aluminum-sacrificial or aluminum-aluminum. For example, during the passage of the sacrificial, the speed of the wire is reduced. In the case of the plant 9 being switched off for a medium-long time period (e.g. 2-3 days), the aluminum wire can be completely replaced by a sacrificial wire, so as to never lose the continuity of the production process. Advantageously, it is possible to make a process that allows the aluminum wire to be treated continuously, allowing different stationed timed in the various tanks and in the washing steps without ever interrupting the process.

[0066] Advantageously, it is possible to make an aluminum wire 1 that has tinning over the entire surface thereof, which protects the material from oxidation and makes it possible to have a better interface in the electrical contact area.

[0067] Advantageously, it is possible to make an aluminum wire 1 that is suitably sized to ensure comparable electrical performance to that of a copper wire, by performing a sizing of the diameter of the wire and of the thickness of the copper and tin coating layers. Advantageously, it is possible to make an aluminum wire 1 the performance of which has been verified through overheating tests foreseen by the product standard EN61439-6. Thanks to an embodiment, it is possible to make an aluminum wire 1 that offers comparable performance to that of a copper wire, and which makes it possible to reduce the costs both thanks to the lower price per kilo of aluminum with respect to copper, and thanks to the smaller amount of material necessary (for example, roughly half of the material is need for the same length of wire, with increased aluminum wire diameter with respect to that of copper).

Claims

1. Process for continuous electrochemical tinning of an aluminum wire (1), comprising the steps of:

a) - providing an aluminum wire (1),

b) - performing pickling of said aluminum wire (1) by moving said aluminum wire (1) through a pickling tank (4) containing a solution comprising caustic soda and gluconate, and having a temperature comprised between 40°C and 80°C,

c) - performing carburization of said aluminum wire (1) obtained from said step b) by moving said aluminum wire (1) through a carburization tank (5) containing a solution comprising zinc and caustic soda, and having a temperature comprised between 15°C and 50°C,

d) - performing alkaline copper plating of said aluminum wire (1) obtained from said step c) by moving said aluminum wire (1) through an alkaline copper plating tank (6) containing a solution comprising copper and conducting salts, and having a temperature comprised between 50°C and 70°C and an applied voltage value comprised between 2V and 4V,

e) - performing acid copper plating of said aluminum wire (1) obtained from said step d) by moving said aluminum wire (1) through an acid copper plating tank (7) containing a solution comprising copper sulphate and sulfuric acid, and having a temperature comprised between 20°C and 40°C and an applied voltage value comprised between 0,8V and 2V,

f) - performing tinning of said aluminum wire (1) obtained from said step e) by moving said aluminum wire (1) through a tinning tank (8) containing a solution comprising methanesulfonic acid and methanesulfonic tin, and having a temperature comprised between 15°C and 35°C and an applied voltage value comprised between 0,5V and 2,7V.

2. Process according to claim 1, wherein

- said solution of caustic soda and gluconate has a concentration comprised between 25g/l and 35g/l and a temperature comprised between 50°C and 70°C,
- said aluminum wire (1) is completely immersed in said solution of caustic soda and gluconate.

3. Process according to claim 1 or 2, wherein

- said solution of zinc and caustic soda comprises additives,
- said solution of zinc, caustic soda and additives has a concentration comprised between 18% and 22% in volume and a temperature comprised between 20°C and 45°C,
- said aluminum wire (1) is completely immersed in said solution of zinc, caustic soda and additives.

4. Process according to any one of the preceding claims, wherein

- said solution of copper and conducting salts has a temperature comprised between 60°C

and 65°C and an applied voltage value comprised between 2,7V and 3,2V, and has a concentration comprised between 14g/l and 17g/l and a pH comprised between 8 and 9,5,
- said aluminum wire (1) is completely immersed in said solution of copper and conducting salts.

5. Process according to any one of the preceding claims, wherein

- said solution of copper sulphate and sulfuric acid comprises additives,
- said solution of copper sulphate, sulfuric acid and additives has a temperature comprised between 25°C and 35°C and an applied voltage value comprised between 1V and 1,5V, and has a concentration of copper sulphate comprised between 180g/l and 220g/l and a concentration of sulfuric acid comprised between 60g/l and 70g/l and a concentration of additives comprised between 2cc/l and 3cc/l,
- said aluminum wire (1) is completely immersed in said solution of copper sulphate, sulfuric acid and additives.

6. Process according to any one of the preceding claims, wherein

- said solution of methanesulfonic acid and methanesulfonic tin comprises brightener,
- said solution of methanesulfonic acid, methanesulfonic tin and brightener has a temperature comprised between 20°C and 30°C and an applied voltage value comprised between 1,2V and 1,6V, and has a concentration of methanesulfonic acid comprised between 90g/l and 100g/l and a concentration of methanesulfonic tin comprised between 20g/l and 55g/l and a concentration of brightener comprised between 1cc/l and 2cc/l,
- said aluminum wire (1) is completely immersed in said solution of methanesulfonic acid, methanesulfonic tin and brightener.

7. Process according to any one of the preceding claims, wherein each step of said process is followed by at least one washing step of said aluminum wire (1).

8. Process according to any one of the preceding claims, wherein said aluminum wire (1) is made to move continuously through a plurality of tanks arranged in series at a speed comprised between 30m/min and 70m/min, said plurality of tanks comprising said pickling tank (4) and said carburization tank (5) and said alkaline copper plating tank (6) and said acid copper plating tank (7) and said tinning tank (8).

9. Process according to any one of the preceding claims, wherein

- said alkaline copper plating tank (6) and said acid copper plating tank (7) and said tinning tank (8) comprise at least one electrode each,
- said process comprises the step of circulating in said at least one electrode a current of intensity comprised between 120A and 220A.

Patentansprüche

1. Verfahren zur kontinuierlichen elektrochemischen Verzinnung von Aluminiumdrähten (1), umfassend folgende Schritte:

a) - Bereitstellen von einem Aluminiumdraht (1),
b) - Beizen des Aluminiumdrahtes (1) durch Bewegen des Aluminiumdrahtes (1) durch ein Beizbad (4), das eine Lösung aus Natronlauge und Glukonat enthält und eine Temperatur zwischen 40 °C und 80 °C aufweist,
c) - Aufkohlen des aus Schritt b) erhaltenen Aluminiumdrahtes (1) durch Bewegen des Aluminiumdrahtes (1) durch ein Aufkohlungsbad (5), das eine Lösung aus Zink und Natronlauge enthält und eine Temperatur zwischen 15 °C und 50 °C aufweist,
d) alkalisches Verkupfern des aus Schritt c) erhaltenen Aluminiumdrahtes (1) durch Bewegen des Aluminiumdrahtes (1) durch ein alkalisches Verkupferungsbad (6), das eine Lösung aus Kupfer und Leitsalzen enthält und eine Temperatur zwischen 50 °C und 70 °C sowie einen anliegenden Spannungswert zwischen 2 V und 4 V aufweist,
e) saures Verkupfern des aus Schritt d) erhaltenen Aluminiumdraht (1) durch Bewegen des Aluminiumdrahtes (1) durch ein saures Verkupferungsbad (7), das eine Lösung aus Kupfersulfat und Schwefelsäure enthält und eine Temperatur zwischen 20 °C und 40 °C sowie einen anliegenden Spannungswert zwischen 0,8 V und 2 V aufweist,
f) Verzinnen des aus Schritt e) erhaltenen Aluminiumdraht (1) durch Bewegen des Aluminiumdrahtes (1) durch ein Verzinnungsbad (8), das eine Lösung aus Methansulfonsäure und Zinn-Methansulfonat enthält und eine Temperatur zwischen 15 °C und 35 °C sowie einen anliegenden Spannungswert zwischen 0,5 V und 2,7 V aufweist.

2. Verfahren nach Anspruch 1, wobei

- die Lösung aus Natronlauge und Glukonat eine Konzentration zwischen 25 g/l und 35 g/l und

eine Temperatur zwischen 50 °C und 70 °C aufweist,
- der Aluminiumdraht (1) vollkommen in die Lösung aus Natronlauge und Glukonat eingetaucht ist.

3. Verfahren nach Anspruch 1 oder 2, wobei

- die Lösung aus Zink und Natronlauge Additive umfasst,
- die Lösung aus Zink, Natronlauge und Additiven eine Konzentration zwischen 18 Vol.-% und 22 Vol.- % und eine Temperatur zwischen 20 °C und 45 °C aufweist,
- der Aluminiumdraht (1) vollkommen in die Lösung aus Zink, Natronlauge und Additive eingetaucht ist.

4. Verfahren nach einem der vorstehenden Ansprüche, wobei

- die Lösung aus Kupfer und Leitsalzen eine Temperatur zwischen 60 °C und 65 °C und einen anliegenden Spannungswert zwischen 2,7 V und 3,2 V sowie eine Konzentration zwischen 14 g/l und 17 g/l und einen pH-Wert zwischen 8 und 9,5 aufweist,
- der Aluminiumdraht (1) vollkommen in die Lösung aus Kupfer und Leitsalzen eingetaucht ist.

5. Verfahren nach einem der vorstehenden Ansprüche, wobei

- die Lösung aus Kupfersulfat und Schwefelsäure Additive umfasst,
- die Lösung aus Kupfersulfat, Schwefelsäure und Additiven eine Temperatur zwischen 25 °C und 35 °C, einen anliegenden Spannungswert zwischen 1 V und 1,5 V und eine Konzentration an Kupfersulfat zwischen 180 g/l und 220 g/l und eine Konzentration an Schwefelsäure zwischen 60 g/l und 70 g/l und eine Konzentration an Additiven zwischen 2 cc/l und 3 cc/l aufweist,
- der Aluminiumdraht (1) vollkommen in die Lösung aus Kupfersulfat, Schwefelsäure und Additive eingetaucht ist.

6. Verfahren nach einem der vorstehenden Ansprüche, wobei

- die Lösung aus Methansulfonsäure und Zinn-Methansulfonat Aufheller umfasst,
- die Lösung aus Methansulfonsäure, Zinn-Methansulfonat und Aufheller eine Temperatur zwischen 20 °C und 30 °C, und einen anliegenden Spannungswert zwischen 1,2 V und 1,6 V, und eine Konzentration an Methansulfonsäure zwischen 90 g/l und 100 g/l, und eine Konzentration an Zinn-Methansulfonat zwischen 20 g/l und 55 g/l und eine Konzentration an Aufhellern zwischen 1 cc/l und 2 cc/l aufweist,
- der Aluminiumdraht (1) vollkommen in die Lösung aus Methansulfonsäure, Zinn-Methansulfonat und Aufheller eingetaucht ist.

7. Verfahren nach einem der vorstehenden Ansprüche, wobei auf jeden Schritt des Verfahrens wenigstens ein Reinigungsschritt des Aluminiumdrahtes (1) folgt.

8. Verfahren nach einem der vorstehenden Ansprüche, wobei der Aluminiumdraht (1) kontinuierlich mit einer Geschwindigkeit von 30 m/min bis 70 m/min durch eine Mehrzahl von hintereinander angeordneten Bädern bewegt wird, wobei die Mehrzahl von Bädern das Beizbad (4) und das Aufkohlungsbad (5) und das alkalische Verkupferungsbad (6) und das saure Verkupferungsbad (7) und das Verzinnungsbad (8) umfasst.

9. Verfahren nach einem der vorstehenden Ansprüche, wobei

- das alkalische Verkupferungsbad (6) und das saure Verkupferungsbad (7) und das Verzinnungsbad (8) jeweils wenigstens eine Elektrode umfassen,
- das Verfahren den Schritt des Zirkulierens von Strom in einer Stärke zwischen 120 A und 220 A in der wenigstens einen Elektrode umfasst.

Revendications

1. Procédé d'étamage électrochimique continu d'un fil en aluminium (1), comprenant les étapes suivantes :

a) - fourniture d'un fil en aluminium (1),
b) - réalisation du décapage dudit fil en aluminium (1) en déplaçant ledit fil en aluminium (1) à travers un réservoir de décapage (4) contenant une solution contenant de la soude caustique et du gluconate, et ayant une température comprise entre 40°C et 80°C,
c) - réalisation de la carburation dudit fil en aluminium (1) obtenu à partir de ladite étape b) en déplaçant ledit fil en aluminium (1) à travers un réservoir de carburation (5) contenant une solution contenant du zinc et de la soude caustique, et ayant une température comprise entre 15°C et 50°C,
d) - réalisation du cuivrage alcalin dudit fil en aluminium (1) obtenu à l'étape c) en déplaçant ledit fil en aluminium (1) à travers un réservoir de cuivrage alcalin (6) contenant une solution contenant du cuivre et des sels conducteurs, et

ayant une température comprise entre 50°C et 70°C et une valeur de tension appliquée comprise entre 2V et 4V,
e) - réalisation du cuivrage acide dudit fil en aluminium (1) obtenu à l'étape d) en déplaçant ledit fil en aluminium (1) à travers un réservoir de cuivrage acide (7) contenant une solution contenant du sulfate de cuivre et de l'acide sulfurique, et ayant une température comprise entre 20 C et 40°C et une valeur de tension appliquée comprise entre 0,8V et 2V,
f) - réalisation de l'étamage dudit fil en aluminium (1) obtenu à l'étape e) en déplaçant ledit fil en aluminium (1) à travers un réservoir d'étamage (8) contenant une solution contenant de l'acide méthanesulfonique et de l'étain méthanesulfonique, et ayant une température comprise entre 15°C et 35°C et une valeur de tension appliquée comprise entre 0,5V et 2,7V.

2. Procédé selon la revendication 1, dans lequel

- ladite solution de soude caustique et de gluconate a une concentration comprise entre 25 g/l et 35 g/l et une température comprise entre 50°C et 70°C,
- ledit fil en aluminium (1) est complètement immergé dans ladite solution de soude caustique et de gluconate.

3. Procédé selon la revendication 1 ou 2 dans lequel :

- ladite solution de zinc et de soude caustique contient des additifs,
- ladite solution de zinc, de soude caustique et d'additifs a une concentration comprise entre 18% et 22% en volume et une température comprise entre 20°C et 45°C,
- ledit fil en aluminium (1) est complètement immergé dans ladite solution de zinc, de soude caustique et d'additifs.

4. Procédé selon l'une quelconque des revendications précédentes dans lequel

- ladite solution de cuivre et de sels conducteurs a une température comprise entre 60°C et 65°C et une valeur de tension appliquée comprise entre 2,7V et 3,2V, et a une concentration comprise entre 14g/l et 17g/l et un pH compris entre 8 et 9,5,
- ledit fil en aluminium (1) est complètement immergé dans ladite solution de cuivre et de sels conducteurs.

5. Procédé selon l'une quelconque des revendications précédentes dans lequel

- ladite solution de sulfate de cuivre et d'acide sulfurique contient des additifs,
- ladite solution de sulfate de cuivre, d'acide sulfurique et d'additifs a une température comprise entre 25°C et 35°C et une valeur de tension appliquée comprise entre 1V et 1,5V, et a une concentration de sulfate de cuivre comprise entre 180g/l et 220g/l, une concentration d'acide sulfurique comprise entre 60g/l et 70g/l et une concentration d'additifs comprise entre 2cc/l et 3cc/l,
- ledit fil en aluminium (1) est complètement immergé dans ladite solution de sulfate de cuivre, d'acide sulfurique et d'additifs.

6. Procédé selon l'une quelconque des revendications précédentes dans lequel

- ladite solution d'acide méthanesulfonique et d'étain méthanesulfonique contient un azurant,
- ladite solution d'acide méthanesulfonique, d'étain méthanesulfonique et d'azurant a une température comprise entre 20°C et 30°C et une valeur de tension appliquée comprise entre 1,2V et 1,6V, et a une concentration d'acide méthanesulfonique comprise entre 90g/l et 100g/l, une concentration d'étain méthanesulfonique comprise entre 20g/l et 55g/l et une concentration d'azurant comprise entre 1cc/l et 2cc/l,
- ledit fil en aluminium (1) est complètement immergé dans ladite solution d'acide méthanesulfonique, d'étain méthanesulfonique et d'azurant.

7. Procédé selon l'une quelconque des revendications précédentes dans lequel chaque étape dudit procédé est suivie d'au moins une étape de lavage dudit fil en aluminium (1).

8. Procédé selon l'une quelconque des revendications précédentes dans lequel ledit fil en aluminium (1) est fabriqué pour se déplacer en continu à travers une pluralité de réservoirs agencés en série à une vitesse comprise entre 30m/min et 70m/min, ladite pluralité de réservoirs comprenant ledit réservoir de décapage (4), ledit réservoir de carburation (5), ledit réservoir de cuivrage alcalin (6), ledit réservoir de cuivrage acide (7) et ledit réservoir d'étamage (8).

9. Procédé selon l'une quelconque des revendications précédentes dans lequel

- ledit réservoir de cuivrage alcalin (6), ledit réservoir de cuivrage acide (7) et ledit réservoir d'étamage (8) comprennent au moins une électrode chacun,
- ledit procédé comprend l'étape consistant à faire circuler dans ladite au moins une électrode

un courant ayant une intensité comprise entre 120A et 220A.

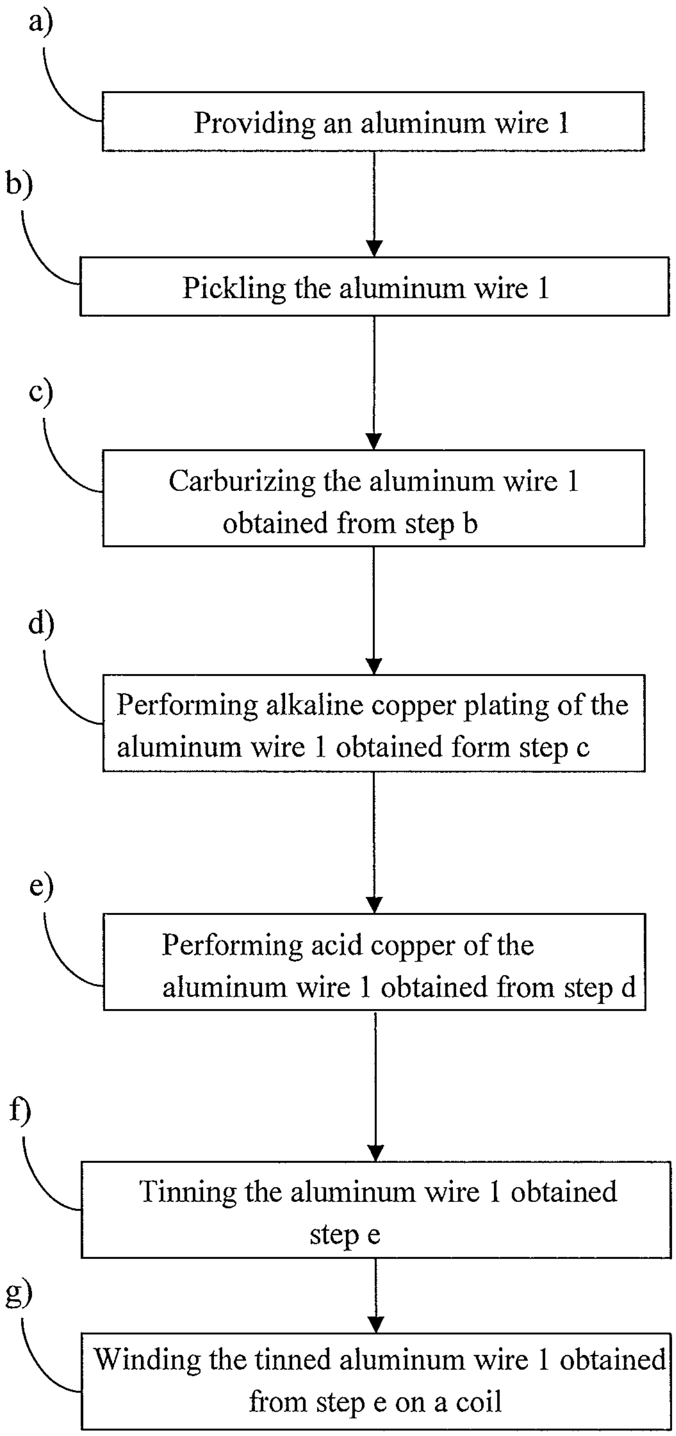
a)
Providing an aluminum wire 1
b)
Pickling the aluminum wire 1
c)
Carburizing the aluminum wire 1 obtained from step b
d)
Performing alkaline copper plating of the aluminum wire 1 obtained form step c
e)
Performing acid copper of the aluminum wire 1 obtained from step d
f)
Tinning the aluminum wire 1 obtained step e
g)
Winding the tinned aluminum wire 1 obtained from step e on a coil

Fig. 1

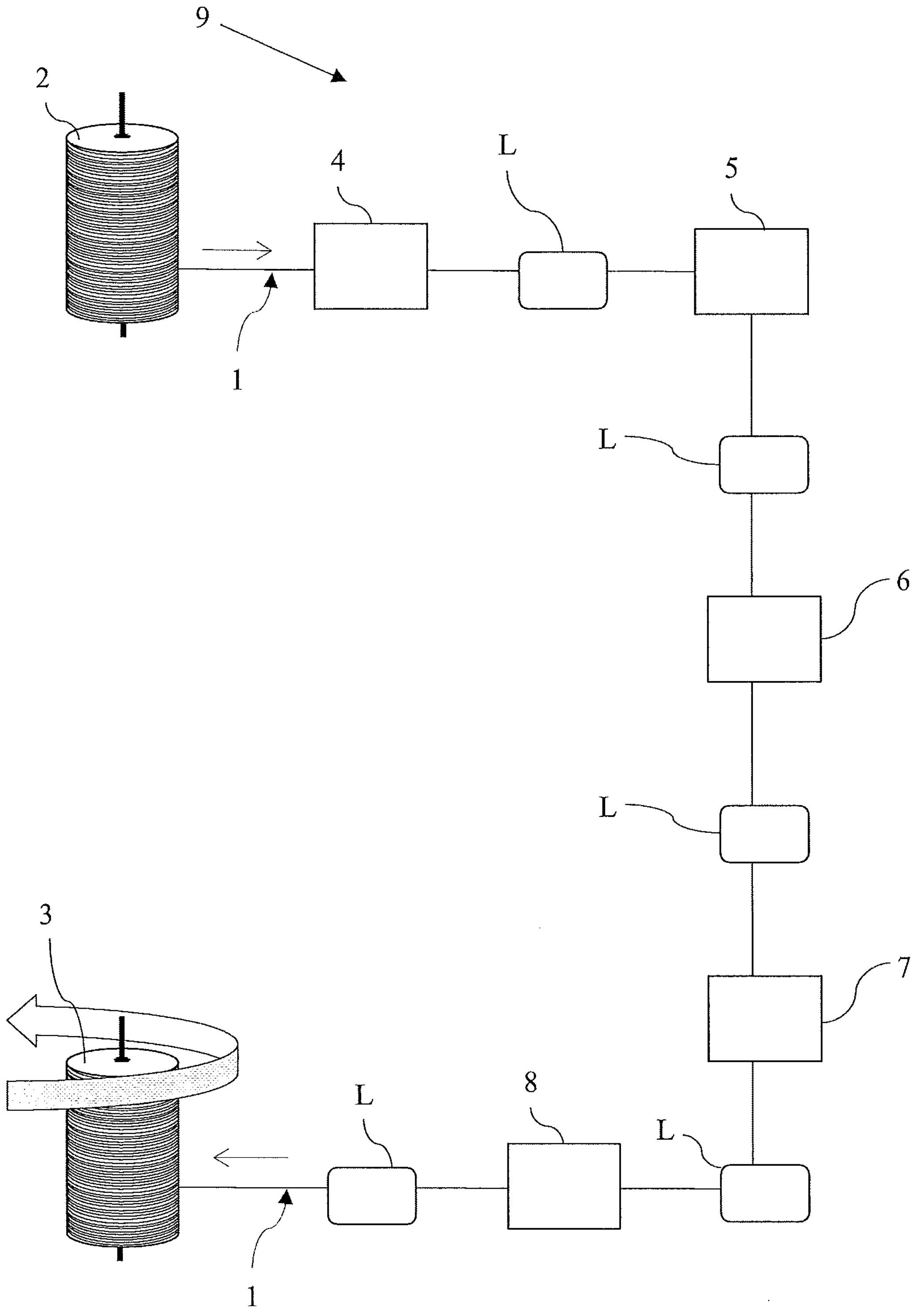

Fig. 2

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- WO 9413866 A **[0009]**
- GB 1464048 A **[0009]**
- US 2509117 A **[0009]**
- US 3622470 A **[0009]**