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

(11) EP 4 092 148 A1

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

(43) Date of publication:
23.11.2022 Bulletin 2022/47

(21) Application number: **20914305.6**

(22) Date of filing: **28.05.2020**

(51) International Patent Classification (IPC):
C22C 22/00 (2006.01) ***C22C 1/02*** (2006.01)

(86) International application number:
PCT/CN2020/092953

(87) International publication number:
WO 2021/143013 (22.07.2021 Gazette 2021/29)

(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
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **16.01.2020 CN 202010047967**

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(54) MANGANESE ALUMINUM ALLOY AND PREPARATION METHOD THEREFOR

(57) Disclosed are a manganese-aluminum alloy and its preparation method. The manganese-aluminum alloy comprises, by weight, 5% to 90% of manganese and the balance of aluminum. The method comprises: adding metal aluminum or molten aluminum to a container, the temperature of the molten aluminum being between 700 °C and 800 °C; adding a metal manganese raw material to the molten aluminum, closing a furnace cover, measuring the pressure, and introducing argon to ensure that the interior of a magnetic induction furnace is in a positive-pressure state, and stirring the mixture with a graphite stirring head; powering on and heating the metal aluminum or the molten aluminum to 1000 °C or above, melting, and holding the temperature between 1000 °C and 1500 °C; and after alloying is completed, cooling to 850 °C or below, opening the furnace cover, and taking a manganese-aluminum alloy out. In comparison to existing products, the manganese and aluminum in the manganese-aluminum alloy obtained by the present invention are fully alloyed, thus improving the absorption rate and absorption speed of manganese as an alloy additive element in molten aluminum in an aluminum machining and smelting process, and reducing the environment pollution of the preparation process.

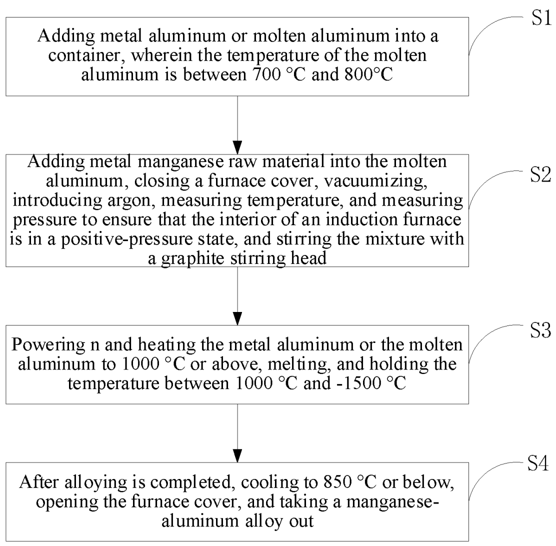

FIG. 8

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Description

Field of the Invention

[0001] The present invention relates to the technical field of manganese-aluminum alloys and preparation thereof, in particular to a manganese-aluminum alloy and its preparation method.

Background of the Invention

[0002] During the production and processing of aluminum alloy materials (such as aluminum plates for aviation, aluminum plates for cans, and aluminum plates for PS plate bases, etc.), it is usually required to add manganese element to a molten aluminum melt (having a temperature generally controlled between 740 °C and 750 °C), so that the metal manganese and aluminum form intermetallic compounds (i.e., aluminum-manganese alloys) with a densely linked network structure, so as to significantly improve the strength of the aluminum material. However, since the melting point of metal manganese is 1246 °C, and the melting temperature of an aluminum melt is generally controlled between 740 °C and 750 °C, in order to rapidly melt and blend metal manganese into the aluminum melt and make the metal manganese and aluminum form intermetallic compounds (aluminum-manganese intermetallic compounds), at present, there are mainly the following methods available.

[0003] A first method is to add a calculated amount of a manganese additive to an aluminum melt. This manganese additive is made by thoroughly mixing, by a physical method, mechanically broken manganese powder and mechanically broken potassium fluoroaluminate ($KAlF_4$, commonly known as PAF) together and pressing the mixture into cakes by virtue of a mechanical pressure (oil pressure, air pressure, etc.). Because the specific gravity of the cakes is higher than that of molten aluminum, after these cakes are put into the molten metal, under the fluxing action of PAF, the metal manganese can be rapidly melted and bend into molten aluminum and form intermetallic compounds (alloys) with aluminum. However, since the main component of PAF contains fluorine (F), it causes environmental pollution due to the volatilization and cleaning (refining) of fluorine (F) in the production process.

[0004] A second method is to replace a flux $KAlF_4$ with aluminum powder. Since the aluminum powder will burn at 740 °C to produce aluminium oxide and generate a large amount of heat simultaneously, the heat generated by the burning of the aluminum powder can promote the rapid melting and blending of the manganese powder into the aluminum melt and causing the metal manganese in the aluminum melt and aluminum to form alloys (intermetallic compounds). However, since the aluminum powder is completely oxidized to aluminium oxide after the burning and heat release in the whole process, the aluminium oxide will partially enter the molten aluminum, which has a negative effect on the purification of the aluminum melt. Moreover, due to the high cost of aluminum powder, the aluminium oxide produced after complete burning can only be get rid of as slag in the smelting process, which increases the production cost.

[0005] In order to solve these technical problems, at present, in the processing of aluminum alloy materials (various types, various types of plates, various types of bars, etc.), a calculated amount of a manganese element additive (commonly known as a manganese agent) is usually added to the molten aluminum with a temperature between 740 °C and 750 °C, to increase the strength of aluminum produced. The common specifications of manganese agents currently used are 70 manganese agents (Mn: 70wt%), 75 manganese agents (Mn: 75wt%), 80 manganese agents (Mn: 80wt%), 85 manganese agents (Mn: 85wt%), and the like. At present, the following two methods are usually used to produce manganese agents.

1. Manganese flakes are broken into manganese powder of certain meshes. The manganese powder and PAF powder of certain meshes are thoroughly mixed and then pressed into cakes by mechanical means through combination of a pressure and a mold. The specific gravity of the cakes should be higher than that of aluminum melt to ensure that the cakes can sink into the aluminum melt during the addition process and avoid being oxidized by air as much as possible.

2. Aluminum powder of certain meshes and manganese powder of certain meshes are mixed thoroughly and then pressed into cakes by mechanical means through combination of a pressure and a mold. The specific gravity of the cakes should be higher than that of aluminum melt to ensure that the cakes can sink into the aluminum melt during the addition process and avoid being oxidized by air as much as possible. In the cakes, by weight, the manganese powder accounts for 70%, 75%, 80%, 85%, or the like, and the aluminum powder accounts for 30%, 25%, 20%, or 15%. The manganese agents may also be commonly known as 70 manganese agent, 75 manganese agent, 80 manganese agent, 85 manganese agent and so on in business.

[0006] According to the production methods of these two manganese agents, the products obtained are physical mixtures of manganese and aluminum or manganese and PAF. When the physical mixtures are added to molten aluminum as manganese additives, to achieve the improvement of the strength of the produced aluminum material, intermetallic compounds (aluminum-manganese alloys) can only be completely formed after two steps. The first step is the dissolution process of elemental manganese in molten aluminum; the second step is the alloying (forming intermetallic compounds) process of metal manganese dissolved in the molten aluminum and aluminum. The implementation of these two processes has the following defects:

1. During the process, elemental manganese may be oxidized by oxygen in the air to form manganese oxide and float on the surface of molten aluminum, which affects the absorption rate of metal manganese in the smelting process.

2. The process of causing the metal manganese successfully dissolved into molten aluminum and aluminum to form intermetallic compounds and weaving into dense network-like reinforcement phases. The completeness of this process will affect the strength and quality of the aluminum material due to improper or insufficient time control in the smelting process.

Summary of the Invention

[0007] The main objective of the present invention is to provide a manganese-aluminum alloy and its preparation method, in order to achieve a solution where manganese and aluminum alloy in a manganese-aluminum alloy are first alloyed fully and the alloyed product is then used as a manganese additive to replace a current popular manganese agent and added to molten aluminum as a manganese additive during the smelting process. Compared with the current popular manganese additives, this product has better absolute absorption rate and absorption speed of elemental manganese, and can eliminate the pollution caused by fluorine to the environment and is beneficial to the purification of an aluminum melt.

[0008] In order to achieve the above objective, the present invention provides a manganese-aluminum alloy. The manganese-aluminum alloy is composed of metal manganese and aluminum and includes, by weight, 55% to 90% of manganese and the balance of aluminum.

[0009] The manganese-aluminum alloy is an intermetallic compound formed by metal manganese and metal aluminum at a high temperature.

[0010] The manganese-aluminum alloy can be amorphous blocks, flakes or powder. Regardless of blocks, flakes or powder, their specifications can be restricted by formulating corresponding standards.

[0011] In order to achieve the above objective, the present invention further provides a preparation method of a manganese-aluminum alloy. The method includes the following steps:

step S1, adding metal aluminum or molten aluminum into a container, wherein the temperature of the molten aluminum is between 700 °C and 800°C;

step S2, adding metal manganese raw material (manganese flakes or manganese powder or a mixture of manganese flakes and manganese powder) into the molten aluminum, closing a furnace cover, vacuumizing, introducing argon, measuring temperature, and measuring pressure to ensure that the interior of a magnetic induction furnace is in a positive-pressure state, and stirring the mixture with a graphite stirring head;

step S3, powering on and heating the metal aluminum or the molten aluminum to 1000 °C or above, melting, and holding the temperature between 1000 °C and 1500 °C, wherein the metal aluminum and manganese form an intermetallic compound in this process and the time of the alloying process is between 30 min and 2 h; and

step S4, after alloying is completed, cooling to 850 °C or below, opening the furnace cover, and taking a manganese-aluminum alloy out.

[0012] As a further technical solution of the present invention, the container is a crucible placed in a vacuum magnetic furnace, or a crucible placed in a vacuum resistance furnace, or a non-vacuum container with a protective flux.

[0013] As a further technical solution of the present invention, a frequency of the induction furnace ranges from 800 Hz to 1200 Hz.

[0014] As a further technical solution of the present invention, the metal manganese raw material is manganese powder, or manganese flakes, or a mixture of manganese powder and manganese flakes.

[0015] As a further technical solution of the present invention, the manganese powder is a powder of 30 meshes to 300 meshes.

[0016] As a further technical solution of the present invention, in step S3, the time of stirring with the graphite stirring head is within a range of 30 min to 2 h.

[0017] As a further technical scheme of the present invention, the production method of the manganese-aluminum alloy includes but is not limited to a production process using a vacuum magnetic induction furnace, a production process using crucibles lined with different materials in a vacuum resistance furnace, and other heating production processes where in a non-vacuum way, a suitable protective flux is selected to isolate the air.

[0018] As a further technical solution of the present invention, subsequent to step S4, the method further includes:

casting the manganese-aluminum alloy into various types of blocks, flakes, or powders with different diameters as required, and adding the manganese-aluminum alloy as a manganese element additive to a smelting and preparation process of an aluminum alloy material to increase the strength of the aluminum material produced.

[0019] The beneficial effects of the manganese-aluminum alloy of the present invention and its preparation method are as follows.

[0020] Compared with the existing products, the manganese-aluminum alloy prepared by the present invention contains manganese and aluminum which are fully and completely alloyed. Comparison with existing manganese additives used in the production of aluminum to increase its strength, this fully alloyed manganese-aluminum alloy is no longer a physical mixture of aluminum powder and manganese powder, nor is it a physical mixture of manganese powder and potassium fluoroaluminate (commonly known as PAF). This manganese-aluminum alloy is used as an element additive for metal manganese in the aluminum production process to replace the currently popular manganese additives (one type is a cake-like substance formed by pressing, by virtue of a pressure, metal manganese powder and PAF powder which are thoroughly mixed in a certain proportion in a physical manner; the other type is a cake-like substance formed by pressing, by virtue of a pressure, metal manganese powder and metal aluminum powder which are mixed in a physical manner.) Compared with the currently popular manganese additives, this manganese-aluminum alloy has the following four major advantages.

1. The present invention solves the problem of environmental pollution (fluorine pollution) caused after a smelting and dissolution process where using PAF as a flux, metal manganese enters into an aluminum melt to form an intermetallic compound with metal aluminum.

2. The present invention solves the problem of pollution (alumina inclusions) to an aluminum alloy melt after a melting and dissolution process where using aluminum powder as a heat generating agent (the high heat generated by the oxidation process of aluminum powder takes a fluxing effect in the alloying of manganese), metal manganese enters into an aluminum melt to form an intermetallic compound with metal aluminum.

3. The manganese-aluminum alloy which is a basically formed intermetallic compound serves as a manganese element additive. When added to the aluminum melt, the manganese-aluminum alloy functions in the aluminum melt to diffuse and form a dense network-like alloyed intermetallic compound, instead of first forming an intermetallic compound and then diffusing into a network. Therefore, In the same time of smelting with addition of manganese agents, the strength and quality of an aluminum material produced by use of the manganese-aluminum alloy as a manganese element additive and the purity of the aluminum material are much higher than the quality of aluminum materials produced by use of the above-mentioned first and second types of manganese additives.

4. Compared with manganese additives (pressure-processed physical mixtures of manganese powder and PAF and of manganese powder and aluminum powder), the manganese-aluminum alloy has better absolute absorption rate and absorption speed of metal manganese in the addition process of aluminum smelting.

Brief Description of the Drawings

[0021]

FIG. 1 is a diffraction pattern of AlMn55;

FIG. 2 is a diffraction pattern of AlMn60;

FIG. 3 is a diffraction pattern of AlMn65;

FIG. 4 is a diffraction pattern of AlMn70;

FIG. 5 is a diffraction pattern of AlMn75;

FIG. 6 is a diffraction pattern of AlMn80;

FIG. 7 is a diffraction pattern of AlMn85;

FIG. 8 is a schematic flow chart of a preferred embodiment of the preparation method of a manganese-aluminum alloy according to the present invention; and

FIG. 9 is a schematic structural diagram of a magnetic induction furnace.

Detailed Description of the Invention

[0022] It should be understood that the preferred embodiments described here are only for explaining the present invention rather than limiting it.

[0023] In order to achieve full alloying of manganese and aluminum in manganese-aluminum alloys, improve the manganese absorption rate and absorption speed of manganese-aluminum alloy additives in the processing of manganese-aluminum alloy profiles, and reduce environmental pollution, the present invention provides a manganese-aluminum alloy. The manganese-aluminum alloy is composed of metal aluminum and manganese and includes, by weight, 55% to 90% of manganese and the balance of aluminum.

[0024] The weight percentage of the manganese can be, for example, 55%, 60%, 65%, 70%, 75%, 80%, 85%, and 90%, and the corresponding manganese-aluminum alloy can be expressed as AlMn55, AlMn60, AlMn65, AlMn70, AlMn75, AlMn80, AlMn85, and AlMn90.

[0025] It can be understood that the manganese-aluminum alloy of the present invention is mainly used as an additive of elemental manganese in the production process of aluminum alloy profiles. It should be specially pointed out that the impurities of this manganese-aluminum alloy product should be limited, for example, the content of iron and silicon should not be greater than 0.5%, and the combined content of alumina and manganese oxide should not be greater than 0.5%.

[0026] The manganese-aluminum alloy is an intermetallic compound formed by metal manganese and metal aluminum at a high temperature.

[0027] The manganese-aluminum alloy can be amorphous blocks, flakes or powder. Regardless of blocks, flakes or powder, their specifications can be restricted by formulating corresponding standards.

[0028] In this embodiment, when metal manganese and metal aluminum are melted at a high temperature, an intermetallic compound Al8Mn5 and Mn are formed. For the phase diagrams of manganese and aluminum, reference can be made to FIGS. 1 to 7.

[0029] FIG. 1 is the diffraction pattern of AlMn55, where the main phases are Al_8Mn_5 and elemental manganese.

[0030] FIG. 2 is the diffraction pattern of AlMn60, wherein the main phases are $Al_{77}Mn_{23}$, Al_8Mn_5, and elemental manganese.

[0031] FIG. 3 is the diffraction pattern of AlMn65, where the main phases are Al_8Mn_5 and elemental manganese.

[0032] FIG. 4 is the diffraction pattern of AlMn70, where the main phases are Al_8Mn_5 and elemental manganese.

[0033] FIG. 5 is the diffraction pattern of AlMn75, where the main phases are Al_2Mn_3 and elemental manganese.

[0034] FIG. 6 is the diffraction pattern of AlMn80, where the main phases are $Al_{0.43}Mn_{0.47}$ and elemental manganese.

[0035] FIG. 7 is the diffraction pattern of AlMn85, where the main phases are $Al_{0.43}Mn_{0.47}$ and elemental manganese.

[0036] Compared with the currently popular manganese element additives, the manganese-aluminum alloy of the present invention has better absolute absorption rate and absorption speed of manganese in the process of aluminum alloy smelting and processing, especially AlMn80 which has the most outstanding absorption speed and absorption rate.

[0037] In order to achieve the above objective, the present invention further provides a preparation method of the manganese-aluminum alloy as described above.

[0038] Reference is made to FIG. 8. FIG. 8 is a schematic flow chart of a preferred embodiment of the preparation method of a manganese-aluminum alloy according to the present invention.

[0039] As shown in FIG. 8, in this embodiment, the preparation method of a manganese-aluminum alloy includes the following steps.

[0040] In step S1, metal aluminum or molten aluminum is added into a container, wherein the temperature of the molten aluminum is between 700 °C and 800°C.

[0041] The container can be the crucible 3 placed in the magnetic induction furnace as shown in FIG. 9. The magnetic induction electric furnace includes a furnace cover 1, a magnetic induction furnace shell 2, a vacuumizing opening 5, a pressure measuring opening 6, an argon inlet 7, and a temperature measuring opening 8. The magnetic induction furnace shell 2 is made of an aluminum material. The outer periphery of the crucible 3 placed in the magnetic induction furnace is provided with a copper magnetic induction coil 4 (hollow, with cooling water inside). The crucible 3 can be a silicon carbide crucible, a graphite crucible, a clay crucible or a crucible for an induction furnace, made from other refractory materials formed by hammering ramming materials (such as quartz sand, magnesia, alumina, and the like) to hold the molten metal.

[0042] The frequency of the magnetic induction furnace can be selected from 800 to 1200 Hz.

[0043] In other embodiments, the container can also be crucibles lined with different materials in a vacuum resistance furnace, or use other heating production processes where in a non-vacuum way, a suitable protective flux is selected to isolate the air.

[0044] In step S2, metal manganese raw material is added into 700 °C molten aluminum, the furnace cover is closed, and then the operations of vacuuming, argon introduction, temperature measuring, and pressure measuring are carried out to ensure that the interior of the magnetic induction furnace is in a positive-pressure state, and the mixture is then stirred with a graphite stirring head.

[0045] In step S3, the furnace is powered on for heating the metal aluminum or the molten aluminum to 1000 °C or above, the metal aluminum or the molten aluminum are molten and the temperature is held between 1000 °C and 1500 °C, for example, 1000 °C, 1250 °C or 1500 °C, wherein the metal aluminum and manganese form an intermetallic compound, i.e., the manganese-aluminum alloy, in this process and the time of the alloying process is between 30 min and 2 h.

[0046] The metal manganese raw material herein can be manganese powder, or manganese flakes, or a mixture of manganese powder and manganese flakes.

[0047] The manganese powder herein can be a powder of 30 meshes to 300 meshes.

[0048] In this embodiment, the time of stirring with the graphite stirring head may be set within a range of 30 min to 2 h according to actual needs, for example, 0.5 h, 1.25 h, or 2 h.

[0049] It can be understood that the time required for the entire alloying process is generally controlled within the range of 30 min to 2 h, which can ensure that metal manganese and aluminum form an intermetallic compound as much as possible, thus obtaining a qualified fully alloyed manganese-aluminum alloy and avoiding the generation of a small amount of metal oxides (manganese oxide or aluminum oxide).

[0050] In step S4, after alloying is completed, the alloyed product is cooled to 850 °C or below, the furnace cover is then opened, and the manganese-aluminum alloy is taken out.

[0051] In addition, as an implementation manner, subsequent to step S4, the method may further include: Casting the manganese-aluminum alloy into amorphous blocks or flakes or mechanically breaking the manganese-aluminum alloy into a powder; and then accurately adding a calculated amount of the manganese-aluminum alloy as a manganese element additive to the smelting and preparation process of the aluminum alloy material. The manganese-aluminum alloy can be amorphous blocks, flakes or powder. Regardless of blocks, flakes or powder, their specifications can be restricted by formulating corresponding standards.

[0052] The aluminum alloy profile is, for example, a 3003 aluminum alloy plate, a 3A21 aluminum alloy pipe, a YX65-430 aluminum-magnesium-manganese metal roof panel, or the like.

[0053] The beneficial effects of the manganese-aluminum alloy of the present invention and its preparation method are as follows. Compared with the existing products, the manganese-aluminum alloy prepared by the present invention contains manganese and aluminum which are fully and completely alloyed. Comparison with existing manganese additives used in the production of aluminum to increase its strength, this fully alloyed manganese-aluminum alloy is no longer a physical mixture of aluminum powder and manganese powder, nor is it a physical mixture of manganese powder and potassium fluoroaluminate (commonly known as PAF). This manganese-aluminum alloy is used as an element additive for metal manganese in the aluminum production process to replace the currently popular manganese additives (one type is a cake-like substance formed by pressing, by virtue of a pressure, metal manganese powder and PAF powder which are thoroughly mixed in a certain proportion in a physical manner; the other type is a cake-like substance formed by pressing, by virtue of a pressure, metal manganese powder and metal aluminum powder which are mixed in a physical manner. Compared with the currently popular manganese additives, this manganese-aluminum alloy has the following four major advantages.

1. The present invention solves the problem of environmental pollution (fluorine pollution) caused after a smelting and dissolution process where using PAF as a flux, metal manganese enters into an aluminum melt to form an intermetallic compound with metal aluminum.

2. The present invention solves the problem of pollution (alumina inclusions) to an aluminum alloy melt after a melting and dissolution process where using aluminum powder as a heat generating agent (the high heat generated by the oxidation process of aluminum powder takes a fluxing effect in the alloying of manganese), metal manganese enters into an aluminum melt to form an intermetallic compound with metal aluminum.

3. The manganese-aluminum alloy which is a basically formed intermetallic compound serves as a manganese element additive. When added to the aluminum melt, the manganese-aluminum alloy functions in the aluminum melt to diffuse and form a dense network-like alloyed intermetallic compound, instead of first forming an intermetallic compound and then diffusing into a network. Therefore, In the same time of smelting with addition of manganese agents, the strength and quality of an aluminum material produced by use of the manganese-aluminum alloy as a manganese element additive and the purity of the aluminum material are much higher than the quality of aluminum materials produced by use of the above-mentioned first and second types of manganese additives.

4. Compared with manganese additives (pressure-processed physical mixtures of manganese powder and PAF and of manganese powder and aluminum powder), the manganese-aluminum alloy has better absolute absorption rate and absorption speed of metal manganese in the addition process of aluminum smelting.

[0054] The above description is set forth only as preferred embodiments of the present invention and is not intended to limit the scope of the present invention. Any equivalent structure or equivalent process transformation, made on the basis of the contents of the description of the present invention and the accompanying drawings and directly or indirectly used in other related technical fields, is likewise included within the scope of the patent protection of the present invention.

Claims

1. A manganese-aluminum alloy, being composed of metal aluminum and manganese and comprising, by weight, 55% to 90% of the manganese and a balance of the metal aluminum.

2. A preparation method of the manganese-aluminum alloy according to claim 1, comprising the following steps:

step S1, adding metal aluminum or molten aluminum into a container, wherein a temperature of the molten aluminum is between 700 °C and 800°C;

step S2, adding metal manganese raw material into the molten aluminum, closing a furnace cover, vacuumizing, introducing argon, measuring temperature, and measuring pressure to ensure that a interior of a magnetic induction furnace is in a positive-pressure state, and stirring the mixture with a graphite stirring head;

step S3, powering on and heating the metal aluminum or the molten aluminum to 1000 °C or above, melting, and holding the temperature between 1000 °C and 1500 °C, wherein the metal aluminum and the manganese form an intermetallic compound in this process and a time required for the alloying process is between 30 min and 2 h; and
step S4, after alloying is completed, cooling to 850 °C or below, opening the furnace cover, and taking a manganese-aluminum alloy out.

3. The preparation method of the manganese-aluminum alloy according to claim 2, wherein the container is a crucible placed in magnetic induction furnace, or a crucible placed in a vacuum resistance furnace, or a non-vacuum container with a protective flux.

4. The preparation method of the manganese-aluminum alloy according to claim 3, wherein a frequency of the magnetic induction furnace ranges from 800 Hz to 1200 Hz.

5. The preparation method of the manganese-aluminum alloy according to claim 2, wherein the metal manganese raw material is manganese powder, manganese flakes, or a mixture of the manganese powder and the manganese flakes.

6. The preparation method according to claim 5, wherein the manganese powder is a powder of 30 meshes to 300 meshes.

7. The preparation method according to claim 2, wherein in step S3, a time of stirring with the graphite stirring head is within a range of 30 min to 2 h.

8. The preparation method according to any of claims 1 to 7, subsequent to step S4, further comprising: casting the manganese-aluminum alloy into various types of blocks, flakes, or powders with different diameters as required, and adding the manganese-aluminum alloy as a manganese element additive to a smelting preparation process of an aluminum alloy material to increase the strength of the aluminum material produced.

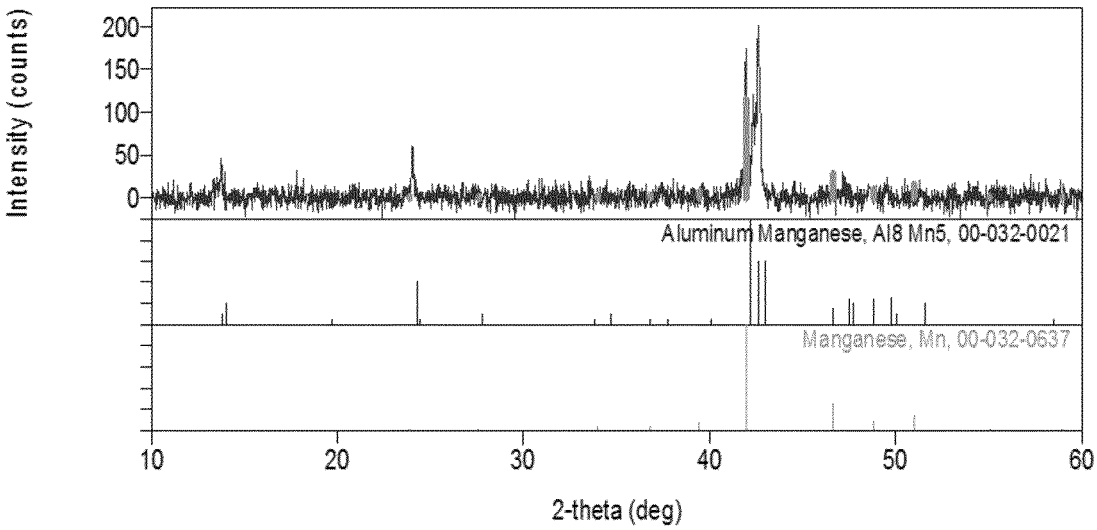
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FIG. 1

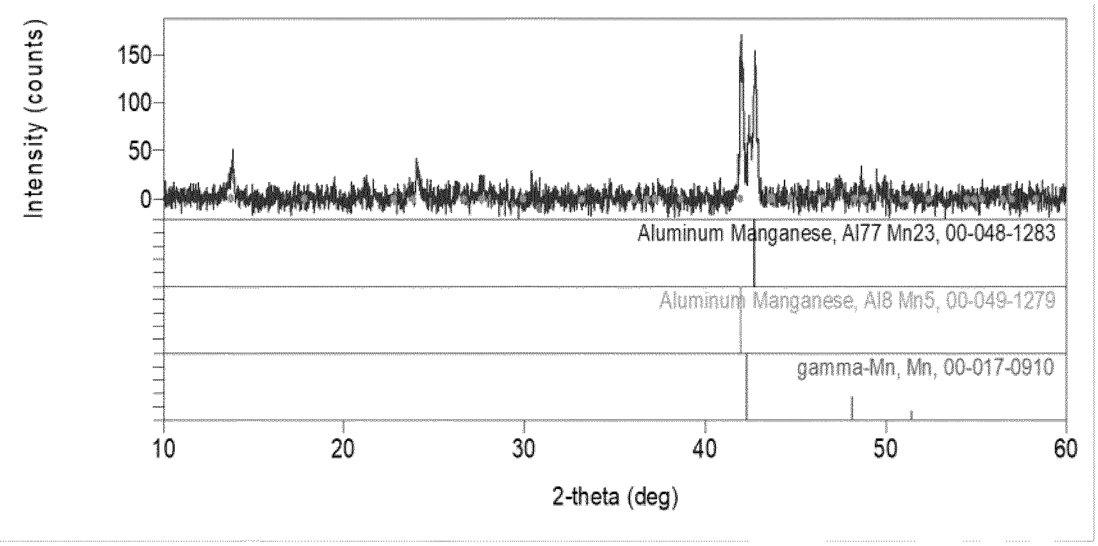
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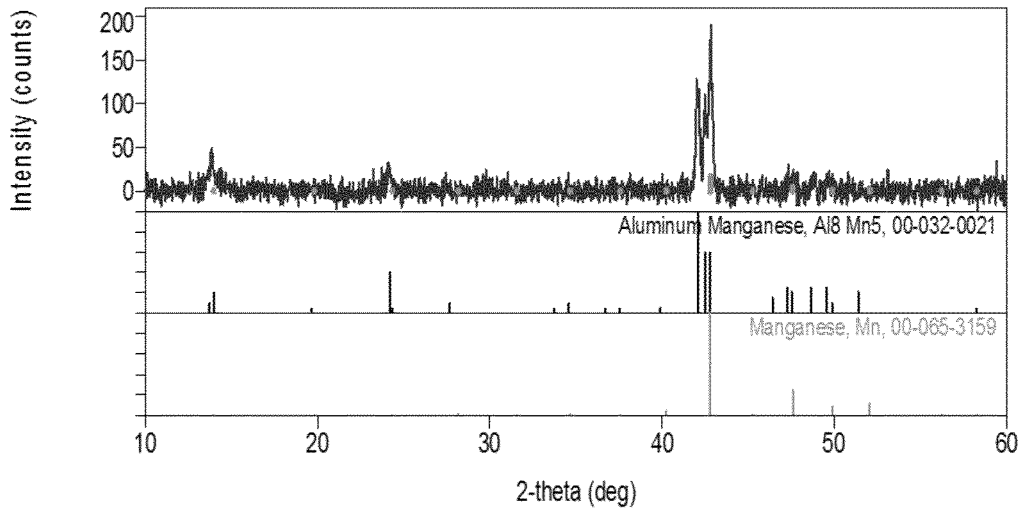
FIG. 2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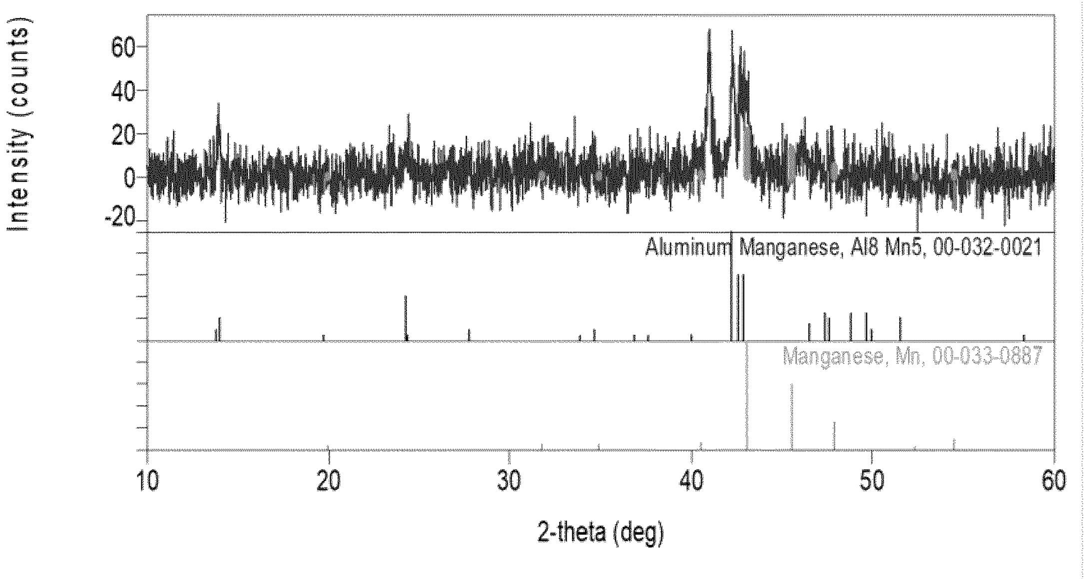
2-theta (deg)

FIG. 3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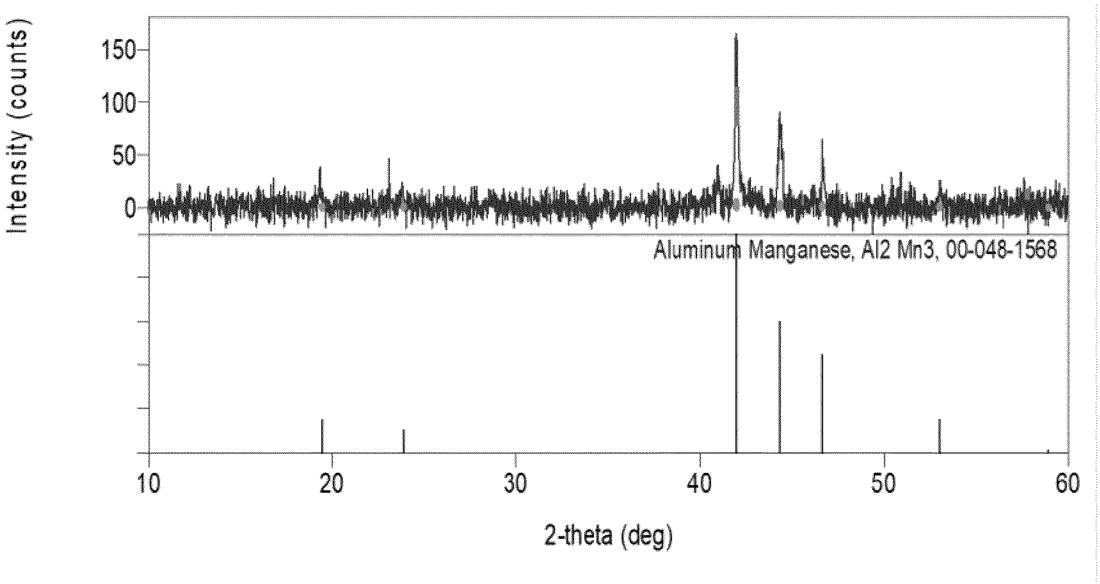
60
2-theta (deg)

FIG. 4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50
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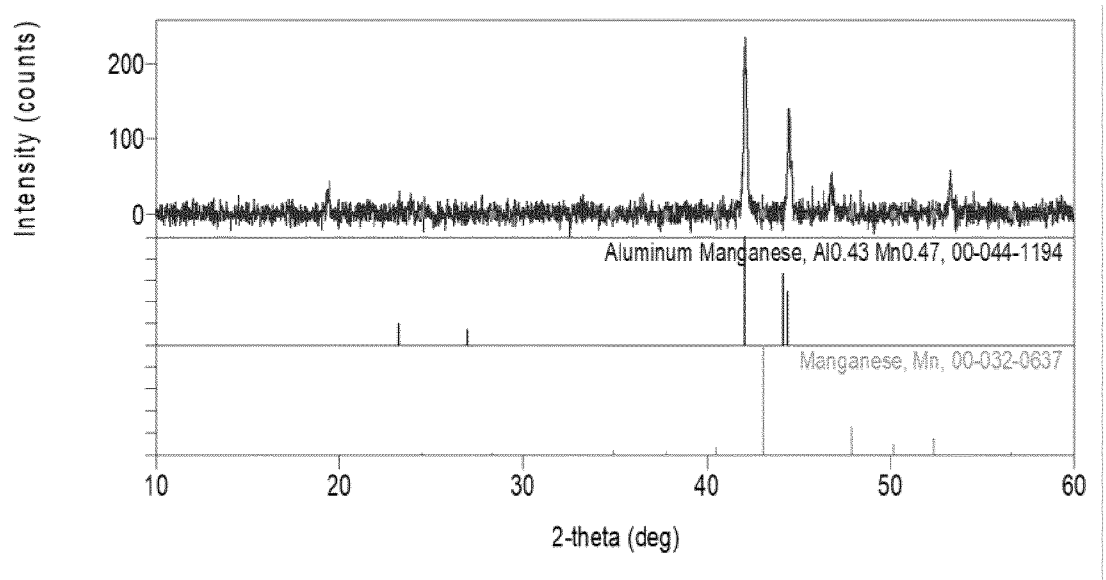
2-theta (deg)

FIG. 5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2-theta (deg)

FIG. 6

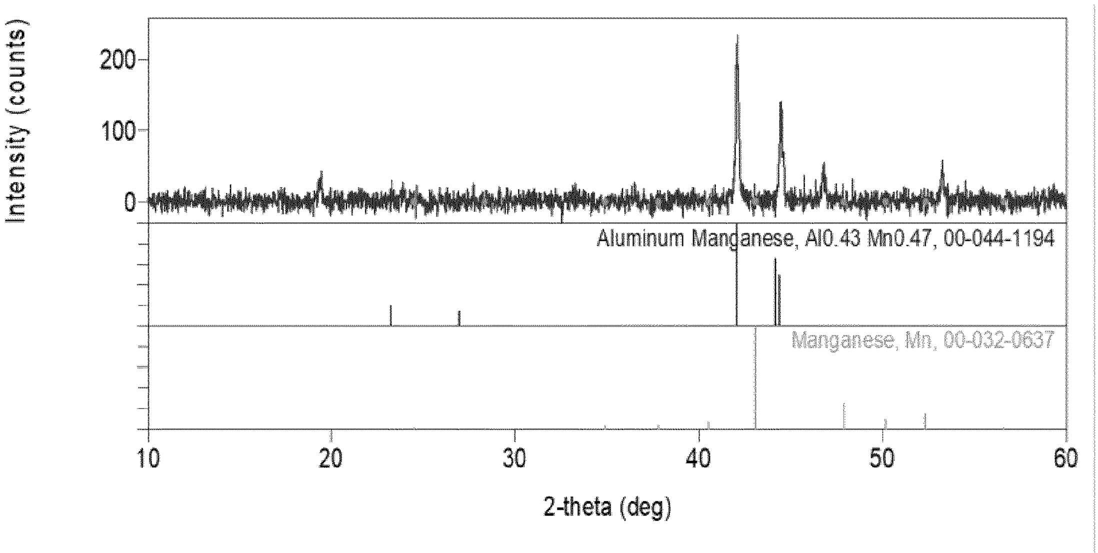
Intensity (counts)
200
100
0
Aluminum Manganese, Al0.43 Mn0.47, 00-044-1194
Manganese, Mn, 00-032-0637
10
20
30
40
50
60
2-theta (deg)

FIG. 7

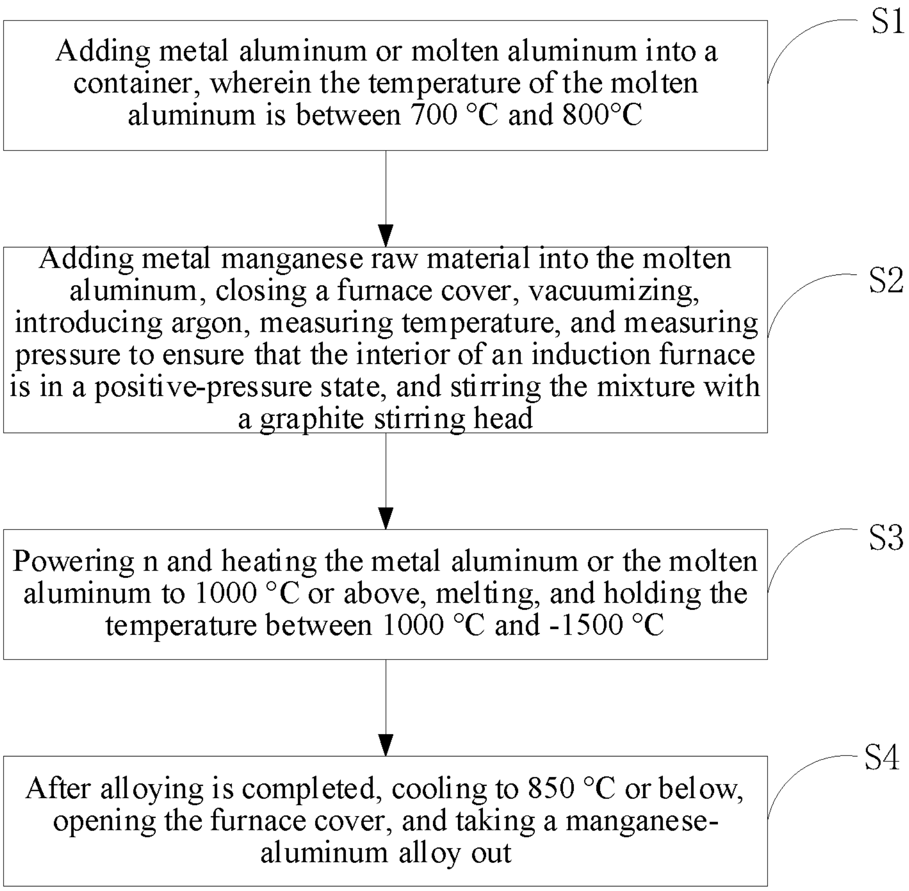
Adding metal aluminum or molten aluminum into a container, wherein the temperature of the molten aluminum is between 700 °C and 800°C
S1
Adding metal manganese raw material into the molten aluminum, closing a furnace cover, vacuumizing, introducing argon, measuring temperature, and measuring pressure to ensure that the interior of an induction furnace is in a positive-pressure state, and stirring the mixture with a graphite stirring head
S2
Powering n and heating the metal aluminum or the molten aluminum to 1000 °C or above, melting, and holding the temperature between 1000 °C and -1500 °C
S3
After alloying is completed, cooling to 850 °C or below, opening the furnace cover, and taking a manganese-aluminum alloy out
S4

FIG. 8

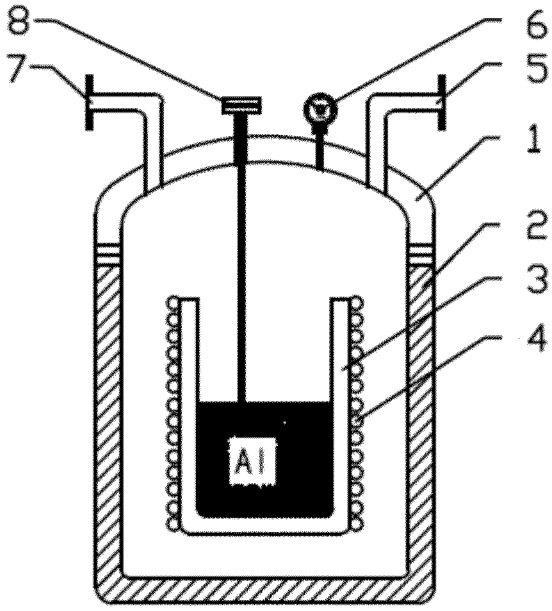

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2020/092953

A. CLASSIFICATION OF SUBJECT MATTER

C22C 22/00(2006.01)i; C22C 1/02(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

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

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

CNKI, DWPI, VEN, CNABS: 锰, 铝, 合金, 搅拌, 化合物, 金属间, 铝液, Mn, manganese, Al, aluminum, alloy, stir, mix, compound, intermetallic, fluid

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 101481766 A (TSINGHUA UNIVERSITY) 15 July 2009 (2009-07-15) claim 1	1
Y	CN 101481766 A (TSINGHUA UNIVERSITY) 15 July 2009 (2009-07-15) claim 1	2-8
Y	CN 101509087 A (BI, Xiangyu) 19 August 2009 (2009-08-19) claims 1-3	2-8
X	CN 103409669 A (GUILIN UNIVERSITY OF ELECTRONIC TECHNOLOGY) 27 November 2013 (2013-11-27) claim 1	1
A	US 4342608 A (BELL TELEPHONE LABOR INC.) 03 August 1982 (1982-08-03) entire document	1-8

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

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

Date of the actual completion of the international search	Date of mailing of the international search report
23 September 2020	**28 September 2020**

Name and mailing address of the ISA/CN	Authorized officer
China National Intellectual Property Administration (ISA/CN) **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088** **China**	
Facsimile No. **(86-10)62019451**	Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2020/092953

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	101481766	A	15 July 2009	CN	101481766	B	18 January 2012
CN	101509087	A	19 August 2009		None		
CN	103409669	A	27 November 2013	CN	103409669	B	29 July 2015
US	4342608	A	03 August 1982		None		

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