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(54) **METHOD FOR AUTONOMOUSLY PRODUCING ALUMINUM-BASED COMPOSITE MATERIAL IN SITU WITH MELT CONTROL UNDER ELECTROMAGNETIC STIRRING**

(57) The invention provides a method of in-situ self-generating aluminum-based composite material by melt control with electromagnetic stirring, including the following steps: providing a vacuum tank having an immersion tube and an air extraction port, wherein the immersion tube is configured to be immersed in an aluminum melt in an aluminum melting furnace; a graphite rotator for argon rotary blowing; an electromagnetic stirring device disposed below the aluminum melting furnace; after melting the pure aluminum or aluminum alloy matrix in the aluminum melting furnace, adding reaction salt and reaction promoters to react; immersing the immersion tube of the vacuum tank into the aluminum melt and vacuuming the vacuum chamber; dropping down the graphite rotator and the rotating rod passing through the vacuum chamber of the vacuum tank via the sealing bearing at the top of the vacuum tank and inserting the spray head into the bottom of the aluminum melt for argon rotary blowing; starting the electromagnetic stirring device for electromagnetic stirring of the aluminum melt.

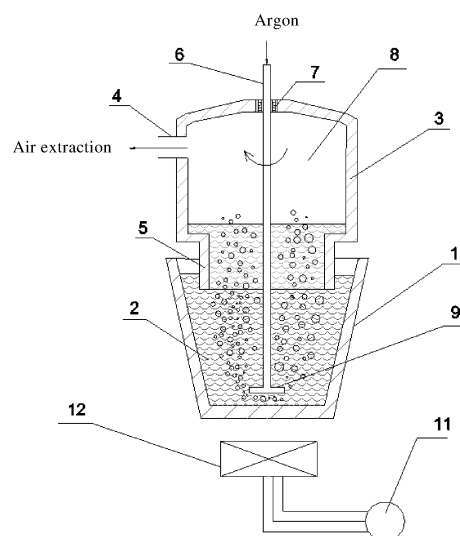


FIG. 2

Description

Technical Field

[0001] This invention relates to aluminum-based composite material, in particular to the preparation of aluminum-based composite material involving in-situ self-generation.

Background of the Invention

[0002] In the in-situ self-generation of aluminum-based composite material, chemical reactions takes place between different elements or chemicals under certain conditions, and one or more types of ceramic phase particles are generated in the aluminum matrix, so as to achieve the purpose of improving the performance of a single metal alloy. The composite material prepared through in-situ self-generation has enhancement particles with no contamination on their surface, and the compatibility of the matrix and enhancement particles is better. By selecting the reaction type and controlling the reaction parameters, in-situ enhancement particles of varied types and quantity can be obtained.

[0003] However, the in-situ self-generated aluminum-based composite material has higher requirements for conditions including degassing and impurity removal in the preparation process. Otherwise, the size and distribution of the reinforced phase particles in the prepared composite material will be less uniform, the mass fraction will be less. The mechanical property of the material will be reduced: the metal texture is deteriorated, the casting performance becomes poor.

[0004] In the prior art, an inert gas rotary blowing technology is used to perform an aluminum melt degassing process. The core component is a hollow rotating rod with a rotary spray head at one end, i.e. the rotator. When in operation, the rotator is inserted into the aluminum melt, and the inert gas is blown in through the middle channel of the rotating rod and is sprayed out by the rotary spray head. The formed bubbles are scattered into a large number of small bubbles due to high-speed rotation of the spray head. Hydrogen in the aluminum melt will attach to these small bubbles and separate into hydrogen gas. In this case, the impurities in the aluminum melt will be absorbed by these bubbles and float to the liquid surface, achieving the purpose of degassing and impurity removal.

[0005] In the prior art, aluminum melt degassing rotator is mostly made of graphite. The graphite material has excellent thermal shock resistance, and is machinable. In addition, the molten aluminum does not infiltrate the graphite material. However, the defect of the graphite material is that it does not resist high temperature oxidation and a graphite rotator needs to be replaced only for 14 -20 days.

[0006] Therefore, how to further improve the uniform distribution of enhanced phase particles is also a problem

to be solved by a person skilled in the art.

Summary of the Invention

[0007] In order to achieve the above objects, the present invention provides, in a first aspect, a system of in-situ self-generating aluminum-based composite material by melt control with electromagnetic stirring, which includes an aluminum melting furnace containing aluminum melt; a vacuum tank having an immersion tube and an air extraction port, wherein the immersion tube is configured to be immersed in an aluminum melt in an aluminum melting furnace and the air extraction port is configured to vacuum the vacuum tank; a graphite rotator for argon rotary blowing having a rotating rod and a spray head, wherein the graphite rotator is configured to be inserted into the bottom of the aluminum melt passing through a vacuum chamber of the vacuum tank via a sealing bearing provided at the top of the vacuum tank; an electromagnetic stirring device disposed below the aluminum melting furnace.

[0008] Further, the electromagnetic stirring device includes an inductor and a frequency converter connected to the inductor.

[0009] In a second aspect, the present invention provides a method for in-situ self-generating aluminum-based composite material by melt control with electromagnetic stirring, comprising the following steps:

- (1) providing a vacuum tank having an immersion tube and an air extraction port, wherein the immersion tube is configured to be immersed in an aluminum melt in an aluminum melting furnace; a graphite rotator for argon rotary blowing having a rotating rod and a spray head, wherein the graphite rotator is configured to be inserted into the bottom of the aluminum melt passing through a vacuum chamber of the vacuum tank via a sealing bearing provided at the top of the vacuum tank; an electromagnetic stirring device disposed below the aluminum melting furnace;
- (2) after melting the pure aluminum or aluminum alloy matrix in the aluminum melting furnace, adding reaction salt and reaction promoters to react;
- (3) immersing the immersion tube of the vacuum tank into the aluminum melt and vacuumizing the vacuum chamber through the air extraction port;
- (4) dropping down the graphite rotator, making the rotating rod pass through the vacuum chamber of the vacuum tank via the sealing bearing at the top of the vacuum tank and insert the spray head into the bottom of the aluminum melt for argon rotary blowing;
- (5) starting the electromagnetic stirring device for electromagnetic stirring of the aluminum melt.

[0010] Preferably, the argon flow rate of argon blowing is 7-12L / min, and the stirring speed is 270-320r / min.

[0011] Preferably, the reaction promoters include Na_3AlF_6 , LiF_3 , and LiCl_3 in a mass ratio of 2.2:1:1-3.8:1:1.

[0012] Preferably, the reaction salt includes NaBF_4 and Na_2TiF_6 with a mass ratio of 1.2:1-1.8:1. Preferably, the amount of the reaction promoters is 8-12 wt% of the reaction salt.

[0013] Preferably, a pulsed magnetic field with an intensity of 2-4T is applied in the reaction process.

[0014] Preferably, a high-energy ultrasonic field with an intensity of 200-1800 W/m² is applied in the reaction process.

[0015] Preferably, the reaction time is 10 min-30 min.

[0016] According to the present invention, a vacuum environment in a vacuum tank and an immersion tube which is sealed by aluminum melt is generated by air extraction. The vacuum environment reduces oxygen, hydrogen partial pressure, and improves degassing conditions. Meanwhile, the graphite rotating rod enters the aluminum melting furnace through the vacuum chamber without contacting oxygen in the whole process, prevents the oxidation of the graphite rotator and greatly prolongs its service life.

[0017] According to the present invention, by simultaneously performing electromagnetic stirring and argon blowing, the stirring motion of the aluminum melt is enhanced, which is advantageous in that the distribution of the reinforcing phase particles is more uniform, and the reaction conditions of degassing and impurity removal are further improved.

[0018] In the present invention, an appropriate amount of magnesium is added to the composite material. The particles generated will first adsorb magnesium in the molten aluminum to reduce their surface energy. Thus the particles can attain a better combination with aluminum. In this case, magnesium is served as a means for reducing particle surface energy and preventing agglomeration and the particle sedimentation is effectively reduced. Due to the addition of magnesium, the viscosity of the molten aluminum is increased. According to the Stock formula, if the viscosity of the composite material is increased, the moving speed of the particles will be reduced. Therefore, agglomeration will not be caused by mutual contact until a long time, and the composite material will be more easily captured by the crystal grains of the $\alpha\text{-Al}$ in the solidification process to form a uniform and stable reinforced matrix.

[0019] In general, the in-situ generated TiB_2 particles have a diameter of about 1 micron, and the particles of this size do not sink in the molten aluminum. However, due to the fact that the particles are often generated on a certain local area (the interface between molten salt and molten aluminum), agglomeration occurs frequently due to high local concentration. Once agglomeration appears, it is very difficult to be separated and refined, and segregation takes place during sedimentation and solidification. By applying the pulsed magnetic field with an intensity of 2-4T and the high-energy ultrasonic field with an intensity of 200 -1800 W/m², the protection effect of

the reaction molten salt is leveraged. On one hand, the contact opportunity of the molten salt and the molten aluminum is increased, and the reaction is accelerated and the TiB_2 particles generated in situ are uniform and fine. On the other hand, the diffusion of the particles from the high-concentration region of the reaction to the low-concentration region is promoted and the TiB_2 particles are uniform and dispersed, and the sedimentation of the composite material is also relieved to a certain extent.

[0020] Referencing to the figures, conceptions, specific structures and technical effect, the present invention will be further described to provide a thorough understanding of the purpose, features, and effects of the invention.

Brief Description of the Drawings

[0021]

FIG. 1 provides a schematic diagram of a system of in-situ self-generating aluminum-based composite material by melt control with a vacuum tank in a preferred embodiment of the present invention.

FIG. 2 provides a schematic diagram of a system of in-situ self-generating aluminum-based composite material by melt control with electromagnetic stirring in a preferred embodiment of the present invention.

FIG. 3 provides a schematic diagram of a system of in-situ self-generating aluminum-based composite material by melt control with continuous treatments in a preferred embodiment of the present invention.

FIG. 4 provides a schematic diagram of a system of in-situ self-generating aluminum-based composite material by melt control with continuous treatment in a preferred embodiment of the present invention.

FIG. 5 is a schematic diagram of the graphite rotator in FIG. 4;

FIG. 6 provides a schematic diagram of a system of in-situ self-generating aluminum-based composite material by melt control with permanent magnetic stirring in a preferred embodiment of the present invention;

FIG. 7 is a schematic diagram of the graphite rotator in FIG. 6.

Detailed Description of the Preferred Embodiments

[0022] A plurality of preferred embodiments of the present invention are described below with reference to the drawings, which makes its technical content more clear and convenient to understand. The present invention may be embodied in many different forms of embodiments, and the scope of protection of the present invention is not limited to the embodiments set forth herein.

Embodiment 1

[0023] As shown in FIG. 1, the pure aluminum or alu-

minum alloy matrix is melted at 700 -760°C. The aluminum melting furnace 1 containing the aluminum melt 2 is placed on the hydraulic lifting platform 10. The reaction salt and the reaction promoters are added for reaction. The hydraulic lifting platform 10 is lifted so that the immersion tube 5 of the vacuum tank 3 disposed above the aluminum melting furnace 1 is immersed in the aluminum melt 2. The vacuum chamber 8 of the vacuum tank 3 is vacuumized through the air extraction port 4, and then the aluminum melt 2 enters the vacuum tank 3 under the action of atmospheric pressure.

[0024] Thereafter, argon rotatory blowing is applied on the aluminum melt. The graphite rotator is dropped down and the rotating rod 6 of the graphite rotator passes through the vacuum chamber 8 through the sealing bearing 7 arranged at the top of the vacuum tank 3 and nozzle 9 is inserted into the bottom of the aluminum melt 2. Then argon is blown in through the middle channel of the rotating rod 6, and is ejected by the rotating spray head 9. The formed bubbles are scattered into a large number of small bubbles due to the high-speed rotation of the spray head 9. Hydrogen in the aluminum melt will attach to these small bubbles and separate into hydrogen gas, while adsorbing impurity particles in the aluminum melt to float together to the liquid surface. Most of the bubbles enter the vacuum chamber 8 and are then discharged through the air extraction port 4. A vacuum environment in the vacuum tank and the immersion tube which is sealed by aluminum melt is generated by air extraction. The vacuum environment reduces oxygen, hydrogen partial pressure, and improves degassing conditions. Meanwhile, the graphite rotating rod enters the aluminum melting furnace through the vacuum chamber without contacting oxygen in the whole process, thus prevents the oxidation of the graphite rotator and greatly prolongs its service life.

[0025] In a preferred embodiment according to the invention, the argon flow rate of argon blowing is 7-12L / min, and the stirring speed is 270-320r / min.

[0026] In a preferred embodiment according to the invention, the reaction promoters include Na_3AlF_6 , LiF_3 , and LiCl_3 in a mass ratio of 2.2:1:1-3.8:1:1.

[0027] In a preferred embodiment according to the invention, the reaction salt includes NaBF_4 and Na_2TiF_6 with a mass ratio of 1.2:1-1.8:1.

[0028] In a preferred embodiment according to the invention, the amount of the reaction promoters is 8-12 wt% of the reaction salt.

[0029] In a preferred embodiment according to the invention, a pulsed magnetic field with an intensity of 2-4T is applied in the reaction process.

[0030] In a preferred embodiment according to the invention, the reaction time is 10 min-30 min.

Embodiment 2

[0031] As shown in FIG. 2, the pure aluminum or aluminum alloy matrix is melted at 700 -760°C. The alumi-

num melting furnace 1 containing the aluminum melt 2 is placed on the hydraulic lifting platform 10. The reaction salt and the reaction promoters are added for reaction. The hydraulic lifting platform 10 is lifted so that the immersion tube 5 of the vacuum tank 3 disposed above the aluminum melting furnace 1 is immersed in the aluminum melt 2. The vacuum chamber 8 of the vacuum tank 3 is vacuumized through the air extraction port 4, and then the aluminum melt 2 enters the vacuum tank 3 under the action of atmospheric pressure.

[0032] Thereafter, argon rotatory blowing is applied on the aluminum melt. The graphite rotator is dropped down and rotating rod 6 of the graphite rotator passes through the vacuum chamber 8 through the sealing bearing 7 arranged at the top of the vacuum tank 3 and nozzle 9 is inserted into the bottom of the aluminum melt 2. Then argon is blown in through the middle channel of the rotating rod 6, and is ejected by the rotating spray head 9. The formed bubbles are scattered into a large number of small bubbles due to the high-speed rotation of the spray head 9. Hydrogen in the aluminum melt will attach to these small bubbles and separate into hydrogen gas, while adsorbing impurity particles in the aluminum melt to float together to the liquid surface. Most of the bubbles enter the vacuum chamber 8 and are then discharged through the air extraction port 4. A vacuum environment in the vacuum tank and the immersion tube which is sealed by aluminum melt is generated by air extraction. The vacuum environment reduces oxygen, hydrogen partial pressure, and improves degassing conditions. Meanwhile, the graphite rotating rod enters the aluminum melting furnace through the vacuum chamber without contacting oxygen in the whole process, thus prevents the oxidation of the graphite rotator and greatly prolongs its service life.

[0033] An electromagnetic stirring device is arranged below the aluminum melting furnace including an inductor 12 and a frequency converter 11, which are used for enabling the aluminum melt to generate stirring motion under the action of electromagnetic force.

[0034] In a preferred embodiment according to the invention, the argon flow rate of argon blowing is 7-12L / min, and the stirring speed is 270-320r / min.

[0035] In a preferred embodiment according to the invention, the reaction promoters include Na_3AlF_6 , LiF_3 , and LiCl_3 in a mass ratio of 2.2:1:1-3.8:1:1.

[0036] In a preferred embodiment according to the invention, the reaction salt includes NaBF_4 and Na_2TiF_6 with a mass ratio of 1.2:1-1.8:1.

[0037] In a preferred embodiment according to the invention, the amount of the reaction promoters is 8-12 wt% of the reaction salt.

[0038] In a preferred embodiment according to the invention, a pulsed magnetic field with an intensity of 2-4T is applied in the reaction process.

[0039] In a preferred embodiment according to the invention, the reaction time is 10 min-30 min.

Embodiment 3

[0040] As shown in FIG. 3, the pure aluminum or aluminum alloy matrix is melted at 700 -760°C. The aluminum melting furnace 1 containing the aluminum melt 2 is placed on the hydraulic lifting platform 10. The reaction salt and the reaction promoters are added for reaction. The hydraulic lifting platform 10 is lifted so that the immersion tube 5 of the vacuum tank 3 disposed above the aluminum melting furnace 1 is immersed in the aluminum melt 2. The vacuum chamber 8 of the vacuum tank 3 is vacuumized through the air extraction port 4, and then the aluminum melt 2 enters the vacuum tank 3 under the action of atmospheric pressure.

[0041] Thereafter, argon rotatory blowing is applied on the aluminum melt. The graphite rotator is dropped down and the rotating rod 6 of the graphite rotator passes through the vacuum chamber 8 through the sealing bearing 7 arranged at the top of the vacuum tank 3 and nozzle 9 is inserted into the bottom of the aluminum melt 2. Then argon is blown in through the middle channel of the rotating rod 6, and is ejected by the rotating spray head 9. The formed bubbles are scattered into a large number of small bubbles due to the high-speed rotation of the spray head 9. Hydrogen in the aluminum melt will attach to these small bubbles and separate into hydrogen gas, while adsorbing impurity particles in the aluminum melt to float together to the liquid surface. Most of the bubbles enter the vacuum chamber 8 and are then discharged through the air extraction port 4. A vacuum environment in the vacuum tank and the immersion tube which is sealed by aluminum melt is generated by air extraction. The vacuum environment reduces oxygen, hydrogen partial pressure, and improves degassing conditions. Meanwhile, the graphite rotating rod enters the aluminum melting furnace through the vacuum chamber without contacting oxygen in the whole process, thus prevents the oxidation of the graphite rotator and greatly prolongs its service life.

[0042] An electromagnetic stirring device is arranged below the aluminum melting furnace including an inductor 12 and a frequency converter 11, which are used for enabling the aluminum melt to generate stirring motion under the action of electromagnetic force.

[0043] An outlet flow channel 13 is provided on an upper portion of the wall of the aluminum melting furnace 1. The outlet flow channel 13 is provided with a shut-off sliding plate 131. An inlet flow channel 14 is provided at the bottom of the wall of the aluminum melting furnace 1. The inlet flow channel 14 is provided with a shut-off sliding plate 141. After a complete treatment for a furnace of aluminum melt is done, the shut-off sliding plates 131, 141 on the aluminum melt outlet flow channel 13 and the inlet flow channel 14 are opened. The untreated aluminum melt is introduced from the inlet flow channel 14 at the bottom of the furnace, meanwhile the processed aluminum melt in the aluminum melting furnace flows out from the outlet flow channel 13. When a set volume of

the untreated aluminum melt has flown into the aluminum melting furnace 1, the flow shut-off sliding plates 131, 141 are closed, and the above treatments are performed again. Therefore, continuous treatments of the aluminum melt under a vacuum condition can be realized with no need to repeat vacuum pumping for a next furnace of aluminum melt, thereby greatly saving the process preparation time and energy consumption.

[0044] In a preferred embodiment according to the invention, the argon flow rate of argon blowing is 7-12L / min, and the stirring speed is 270-320r / min.

[0045] In a preferred embodiment according to the invention, the reaction promoters include Na_3AlF_6 , LiF_3 , and LiCl_3 in a mass ratio of 2.2:1:1-3.8:1:1.

[0046] In a preferred embodiment according to the invention, the reaction salt includes NaBF_4 and Na_2TlF_6 with a mass ratio of 1.2:1-1.8:1.

[0047] In a preferred embodiment according to the invention, the amount of the reaction promoters is 8-12 wt% of the reaction salt.

[0048] In a preferred embodiment according to the invention, a pulsed magnetic field with an intensity of 2-4T is applied in the reaction process.

[0049] In a preferred embodiment according to the invention, the reaction time is 10 min-30 min.

Embodiment 4

[0050] As shown in FIG. 4, the pure aluminum or aluminum alloy matrix is melted at 700 -760°C. The aluminum melting furnace 1 containing the aluminum melt 2 is placed on the hydraulic lifting platform 10. The reaction salt and the reaction promoters are added for reaction. The hydraulic lifting platform 10 is lifted so that the immersion tube 5 of the vacuum tank 3 disposed above the aluminum melting furnace 1 is immersed in the aluminum melt 2. The vacuum chamber 8 of the vacuum tank 3 is vacuumized through the air extraction port 4, and then the aluminum melt 2 enters the vacuum tank 3 under the action of atmospheric pressure.

[0051] Thereafter, argon rotatory blowing is applied on the aluminum melt. The graphite rotator is dropped down and the rotating rod 6 of the graphite rotator passes through the vacuum chamber 8 through the sealing bearing 7 arranged at the top of the vacuum tank 3 and nozzle 9 is inserted into the bottom of the aluminum melt 2. Then argon is blown in through the middle channel of the rotating rod 6, and is ejected by the rotating spray head 9. The formed bubbles are scattered into a large number of small bubbles due to the high-speed rotation of the spray head 9. Hydrogen in the aluminum melt will attach to these small bubbles and separate into hydrogen gas, while adsorbing impurity particles in the aluminum melt to float together to the liquid surface. Most of the bubbles enter the vacuum chamber 8 and are then discharged through the air extraction port 4. A vacuum environment in the vacuum tank and the immersion tube which is sealed by aluminum melt is generated by air extraction.

The vacuum environment reduces oxygen, hydrogen partial pressure, and improves degassing conditions. Meanwhile, the graphite rotating rod enters the aluminum melting furnace through the vacuum chamber without contacting oxygen in the whole process, thus prevents the oxidation of the graphite rotator and greatly prolongs its service life.

[0052] As shown in FIG. 5, the graphite rotating rod 6 includes an inner pipe 65 and an outer pipe 63. An argon blowing passage 64 is provided between the inner pipe 65 and the outer pipe 63. The outer pipe 63 is connected to the argon blowing pipe 631 through a rotating joint 62. The inner pipe 65 is connected to the powder conveying cabin 61. The powder conveying bin 61 is connected to the powder conveying pipe 611. The inner pipe 65 provides a powder delivery passage 66.

[0053] Argon blows in through the argon blowing pipe 631 and the outer pipe 63. The alloy powder 9 in the powder conveying bin 61 is blown into the aluminum melt 2 through the powder conveying pipe 611 and the inner pipe 65.

[0054] Preferably, the outer tube 63 is made of graphite, while the inner tube 63 is made of a metal material such as copper or steel to improve the wear resistance of the inner tube 63 to deal with high pressure gas and powder erosion.

[0055] Preferably, the powder conveying pipe 611 and the argon blowing pipe 631 share the same argon gas source.

[0056] In a preferred embodiment according to the invention, the argon flow rate of argon blowing is 7-12L / min, and the stirring speed is 270-320r / min.

[0057] In a preferred embodiment according to the invention, the reaction promoters include Na_3AlF_6 , LiF_3 , and LiCl_3 in a mass ratio of 2.2:1:1-3.8:1:1.

[0058] In a preferred embodiment according to the invention, the reaction salt includes NaBF_4 and Na_2TiF_6 with a mass ratio of 1.2:1-1.8:1.

[0059] In a preferred embodiment according to the invention, the amount of the reaction promoters is 8-12 wt% of the reaction salt.

[0060] In a preferred embodiment according to the invention, a pulsed magnetic field with an intensity of 2-4T is applied in the reaction process.

[0061] In a preferred embodiment according to the invention, the reaction time is 10 min-30 min.

Embodiment 5

[0062] As shown in FIG. 4, the pure aluminum or aluminum alloy matrix is melted at 700 -760°C. The aluminum melting furnace 1 containing the aluminum melt 2 is placed on the hydraulic lifting platform 10. The reaction salt and the reaction promoters are added for reaction. The hydraulic lifting platform 10 is lifted so that the immersion tube 5 of the vacuum tank 3 disposed above the aluminum melting furnace 1 is immersed in the aluminum melt 2. The vacuum chamber 8 of the vacuum tank 3 is

vacuumized through the air extraction port 4, and then the aluminum melt 2 enters the vacuum tank 3 under the action of atmospheric pressure.

[0063] Thereafter, argon rotatory blowing is applied on the aluminum melt. The graphite rotator is dropped down and the rotating rod 6 of the graphite rotator passes through the vacuum chamber 8 through the sealing bearing 7 arranged at the top of the vacuum tank 3 and nozzle 9 is inserted into the bottom of the aluminum melt 2. Then argon is blown in through the middle channel of the rotating rod 6, and is ejected by the rotating spray head 9. The formed bubbles are scattered into a large number of small bubbles due to the high-speed rotation of the spray head 9. Hydrogen in the aluminum melt will attach to these small bubbles and separate into hydrogen gas, while adsorbing impurity particles in the aluminum melt to float together to the liquid surface. Most of the bubbles enter the vacuum chamber 8 and are then discharged through the air extraction port 4. A vacuum environment in the vacuum tank and the immersion tube which is sealed by aluminum melt is generated by air extraction. The vacuum environment reduces oxygen, hydrogen partial pressure, and improves degassing conditions. Meanwhile, the graphite rotating rod enters the aluminum melting furnace through the vacuum chamber without contacting oxygen in the whole process, thus prevents the oxidation of the graphite rotator and greatly prolongs its service life.

[0064] As shown in FIG. 7, the graphite rotating rod 6 includes an inner pipe 65 and an outer pipe 63. An argon blowing passage 64 is provided between the inner pipe 65 and the outer pipe 63. The outer pipe 63 is connected to the argon blowing pipe 631 through a rotating joint 62. The inner pipe 65 is connected to the powder conveying cabin 61. The powder conveying bin 61 is connected to the powder conveying pipe 611. The inner pipe 65 provides a powder delivery passage 66.

[0065] Argon blows in through the argon blowing pipe 631 and the outer pipe 63. The alloy powder 9 in the powder conveying bin 61 is blown into the aluminum melt 2 through the powder conveying pipe 611 and the inner pipe 65.

[0066] Preferably, the outer tube 63 is made of graphite, while the inner tube 63 is made of a metal material such as copper or steel to improve the wear resistance of the inner tube 63 to deal with high pressure gas and powder erosion.

[0067] Preferably, the powder conveying pipe 611 and the argon blowing pipe 631 share the same argon gas source.

[0068] As shown in FIG. 6, a track 17 of the permanent magnet stirring device is disposed below the aluminum melting furnace 1. A motor 18, a transmission belt 19 and a permanent magnet device 15 are provided on the carrier 16 which can move on the track 17. When the permanent magnet stirring device operates, the carrier 16 moves below the aluminum melting furnace 1 in advance. Then the motor 18 drives the permanent magnet device

15 to rotate through the transmission belt. In this case, the magnetic field of the permanent magnet device 15 interacts with the aluminum melt 2 to generate a magnetic force to push the aluminum melt 2 to undergo a stirring motion.

[0069] In a preferred embodiment according to the invention, the argon flow rate of argon blowing is 7-12L / min, and the stirring speed is 270-320r / min.

[0070] In a preferred embodiment according to the invention, the reaction promoters include Na_3AlF_6 , LiF_3 , and LiCl_3 in a mass ratio of 2.2:1:1-3.8:1:1.

[0071] In a preferred embodiment according to the invention, the reaction salt includes NaBF_4 and Na_2TiF_6 with a mass ratio of 1.2:1-1.8:1.

[0072] In a preferred embodiment according to the invention, the amount of the reaction promoters is 8-12 wt% of the reaction salt.

[0073] In a preferred embodiment according to the invention, a pulsed magnetic field with an intensity of 2-4T is applied in the reaction process.

[0074] In a preferred embodiment according to the invention, the reaction time is 10 min-30 min.

[0075] In other embodiments, the aluminum melting furnace may also be disposed on a lifting platform. The lifting platform is provided with a rotatory platform. The rotatory platform can rotate relative to the lifting platform under the driving of the motor. The aluminum melting furnace is fixedly disposed on the rotatory platform. When argon blowing is performed on the molten aluminum in the aluminum melting furnace, the aluminum melting furnace rotates along with the rotating platform. The rotation of the aluminum melting furnace will drive the molten aluminum in the aluminum melting furnace, especially the portion of the molten aluminum adjacent to the furnace wall, to rotate as well, so as to overcome the defect that this portion of molten aluminum is less subjected to the rotatory effect by argon blowing.

[0076] The foregoing detailed description describes preferred embodiments of the invention. It should be understood that many modifications and variations can be made in accordance with the concepts of the present invention without creative efforts by those of ordinary skill in the art. Accordingly, all the modifications and alterations of the device and method made by those skilled in the art without departing from the spirit shall be deemed as still within the scope of the invention as defined by the appended claims.

Claims

1. A method of in-situ self-generating aluminum-based composite material by melt control with electromagnetic stirring is **characterized by** comprising the following steps:

(1) providing a vacuum tank having an immersion tube and an air extraction port, wherein the

immersion tube is configured to be immersed in an aluminum melt in an aluminum melting furnace; a graphite rotator for argon rotary blowing having a rotating rod and a spray head, wherein the graphite rotator is configured to be inserted into the bottom of the aluminum melt passing through a vacuum chamber of the vacuum tank via a sealing bearing provided at the top of the vacuum tank; an electromagnetic stirring device disposed below the aluminum melting furnace; (2) melting the pure aluminum or aluminum alloy matrix in the aluminum melting furnace, then adding reaction salt and reaction promoters to react;

(3) immersing the immersion tube of the vacuum tank into the aluminum melt and vacuuming the vacuum chamber through the air extraction port; (4) dropping down the graphite rotator to make the rotating rod pass through the vacuum chamber of the vacuum tank via the sealing bearing at the top of the vacuum tank and insert the spray head into the bottom of the aluminum melt for argon rotary blowing;

(5) starting the electromagnetic stirring device for electromagnetic stirring of the aluminum melt.

2. A method of in-situ self-generating aluminum-based composite material by melt control with electromagnetic stirring according to claim 1, wherein the argon flow rate of argon blowing is 7-12L / min, and the stirring speed is 270-320r / min.

3. A method of in-situ self-generating aluminum-based composite material by melt control with electromagnetic stirring according to claim 2, wherein the reaction promoters include Na_3AlF_6 , LiF_3 , and LiCl_3 in a mass ratio of 2.2:1:1-3.8:1:1.

4. A method of in-situ self-generating aluminum-based composite material by melt control with electromagnetic stirring according to claim 3, wherein the reaction salt includes NaBF_4 and Na_2TiF_6 with a mass ratio of 1.2:1-1.8:1.

5. A method of in-situ self-generating aluminum-based composite material by melt control with electromagnetic stirring according to claim 4, wherein the amount of the reaction promoters is 8-12 wt% of the reaction salt.

6. A method of in-situ self-generating aluminum-based composite material by melt control with electromagnetic stirring according to claim 5, wherein a pulsed magnetic field with an intensity of 2-4T is applied in the reaction process.

7. A method of in-situ self-generating aluminum-based

composite material by melt control with electromagnetic stirring according to claim 6, wherein a high-energy ultrasonic field with an intensity of 200-1800 W/m² is applied in the reaction process.

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8. A method of in-situ self-generating aluminum-based composite material by melt control with electromagnetic stirring according to claim 7, wherein the reaction time is 10 min-30 min.

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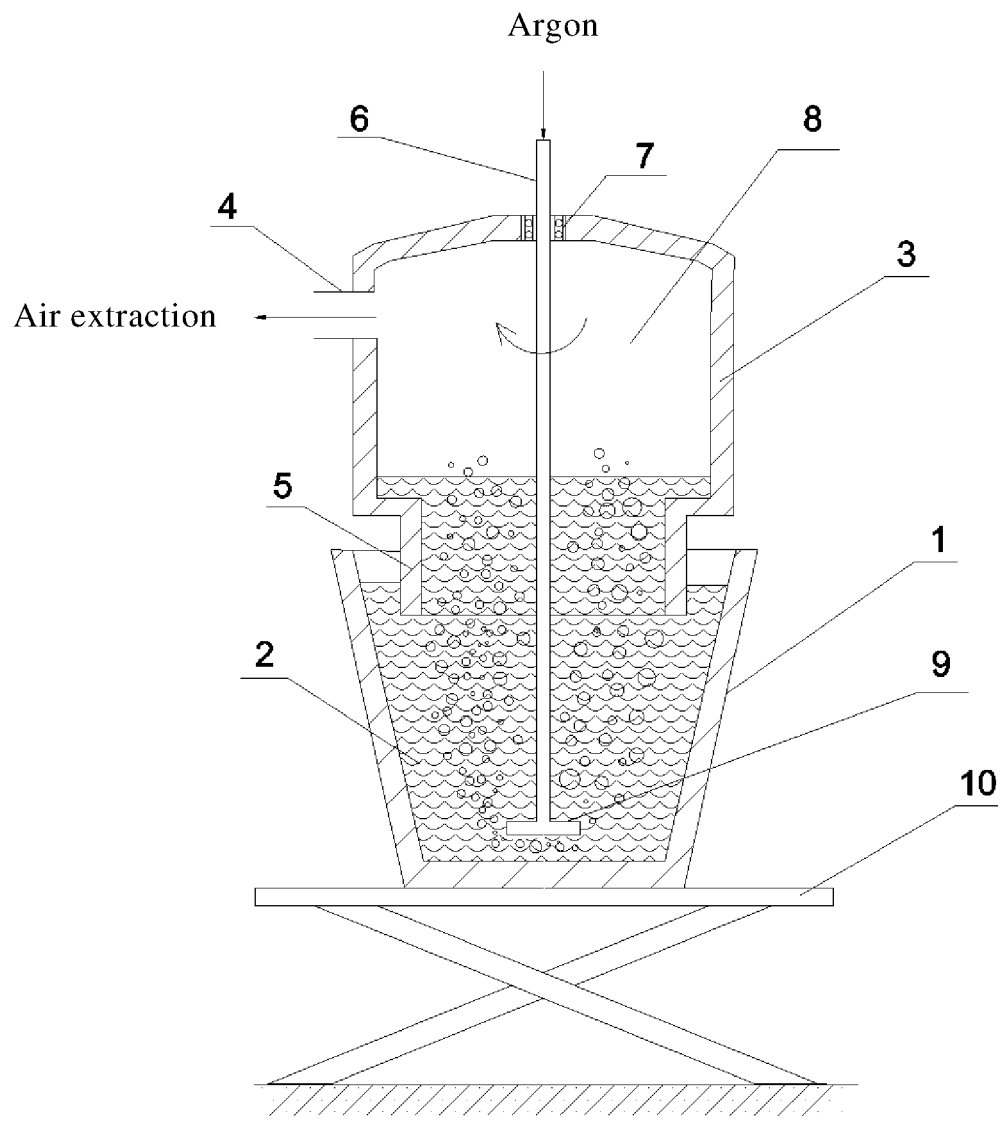


FIG. 1

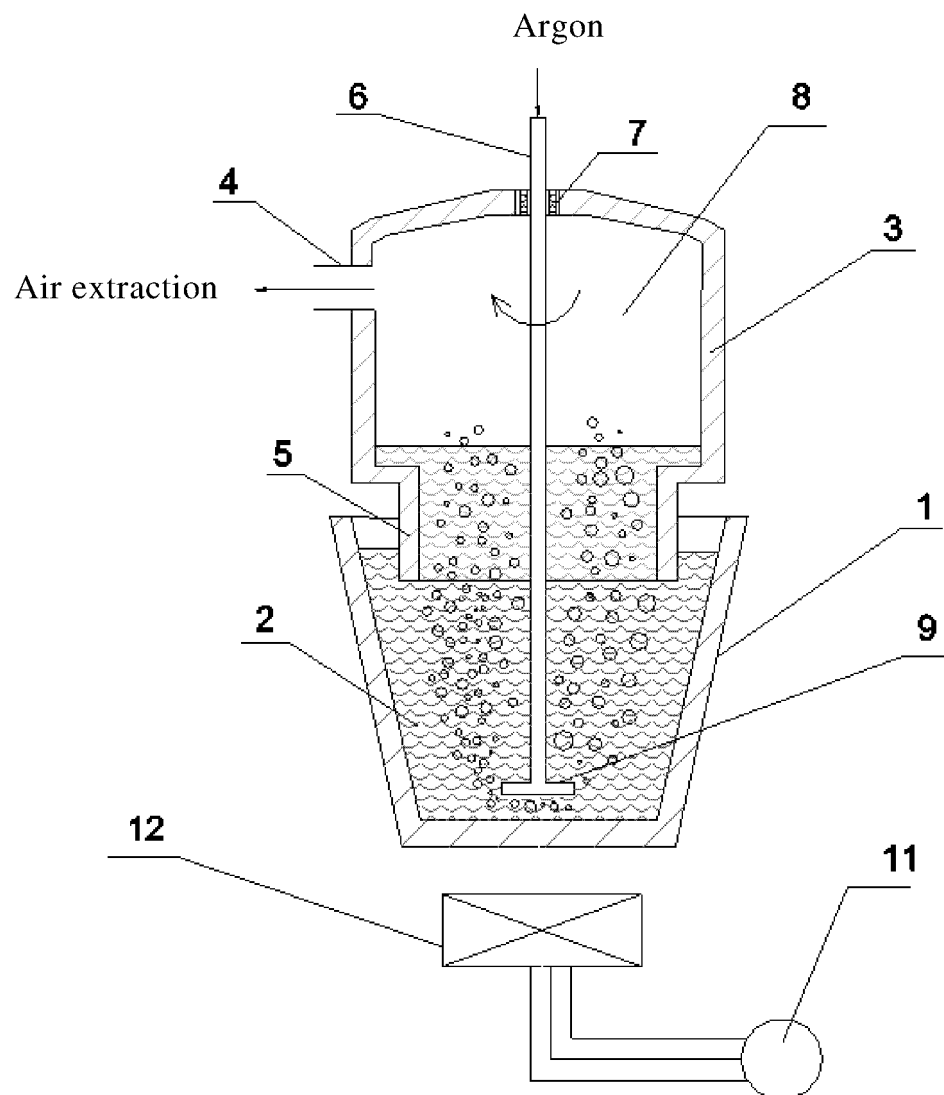


FIG. 2

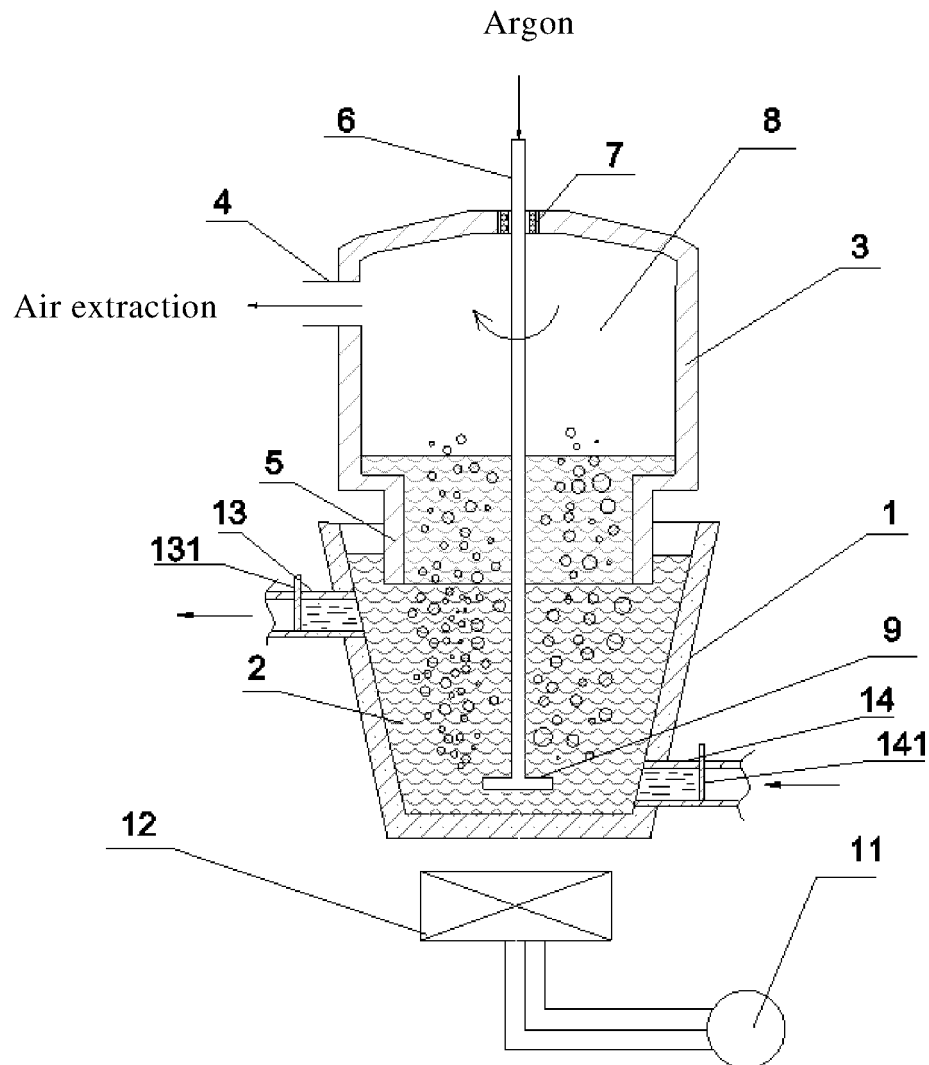


FIG. 3

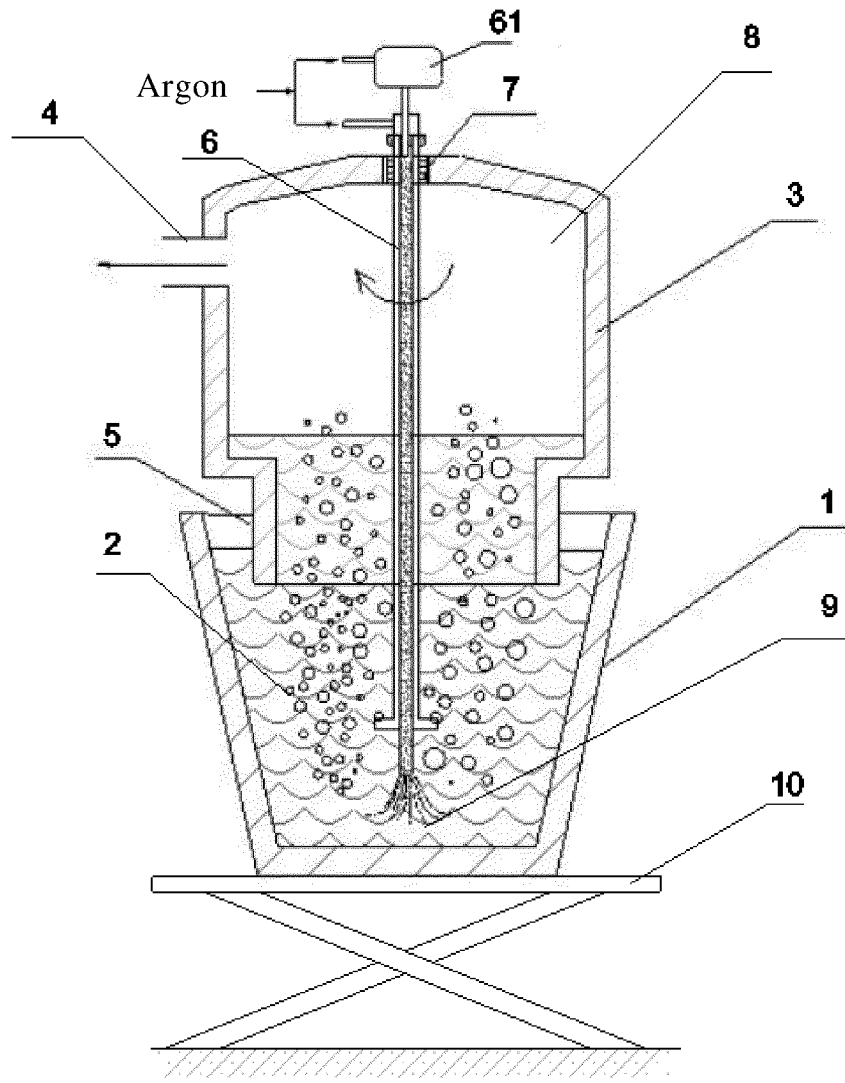


FIG. 4

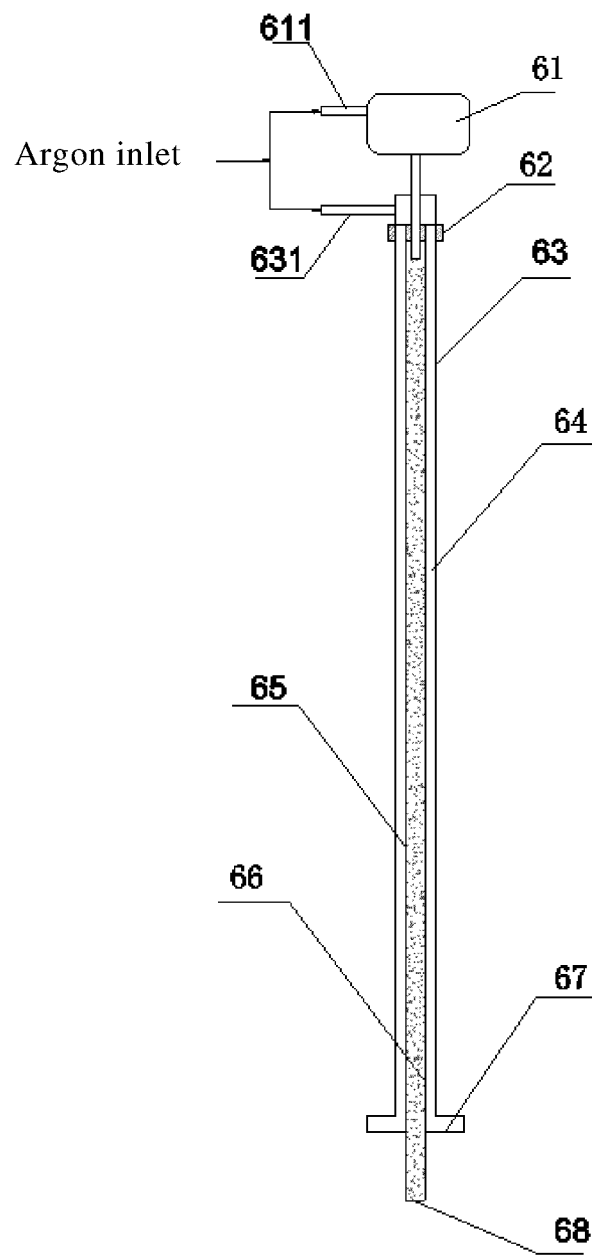


FIG. 5

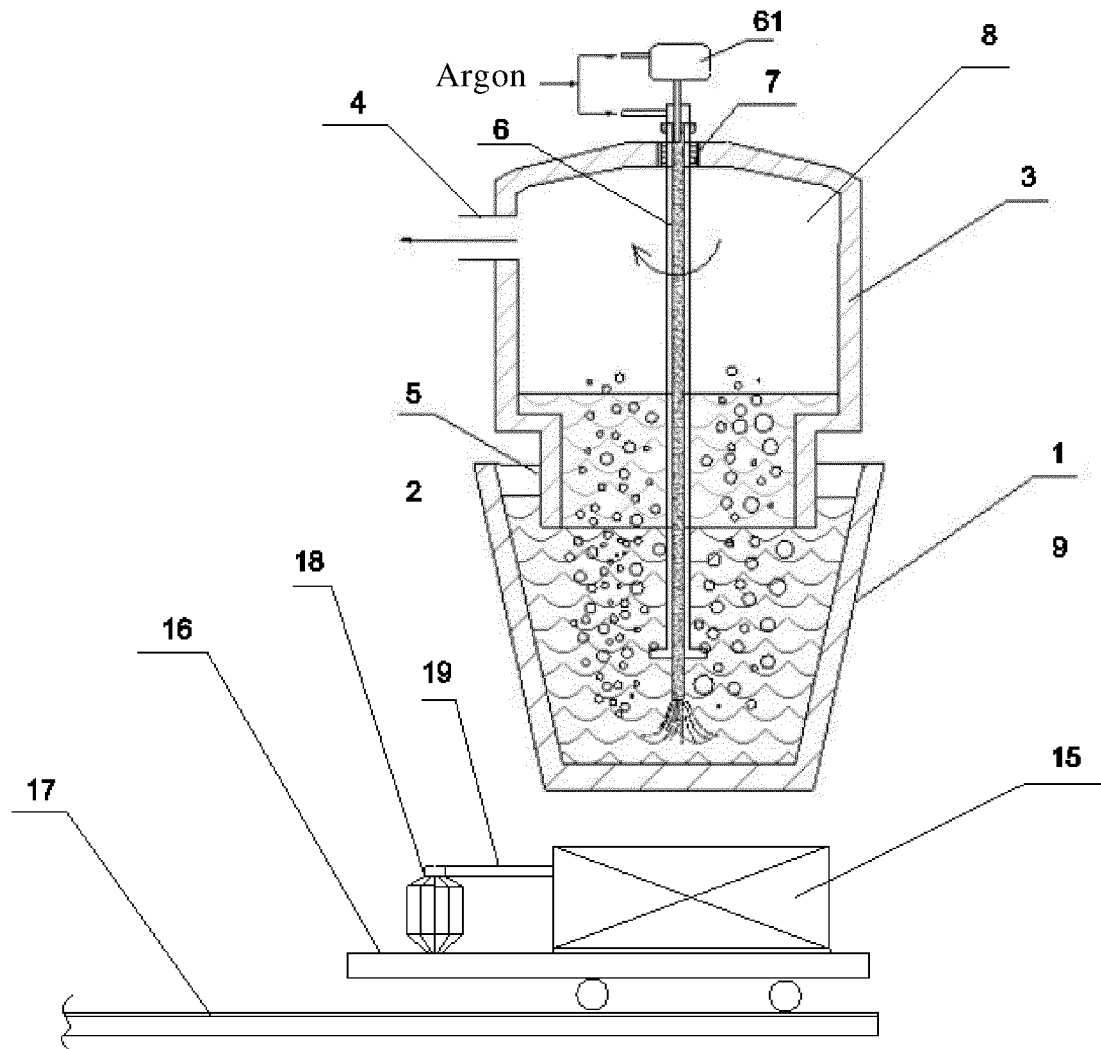


FIG. 6

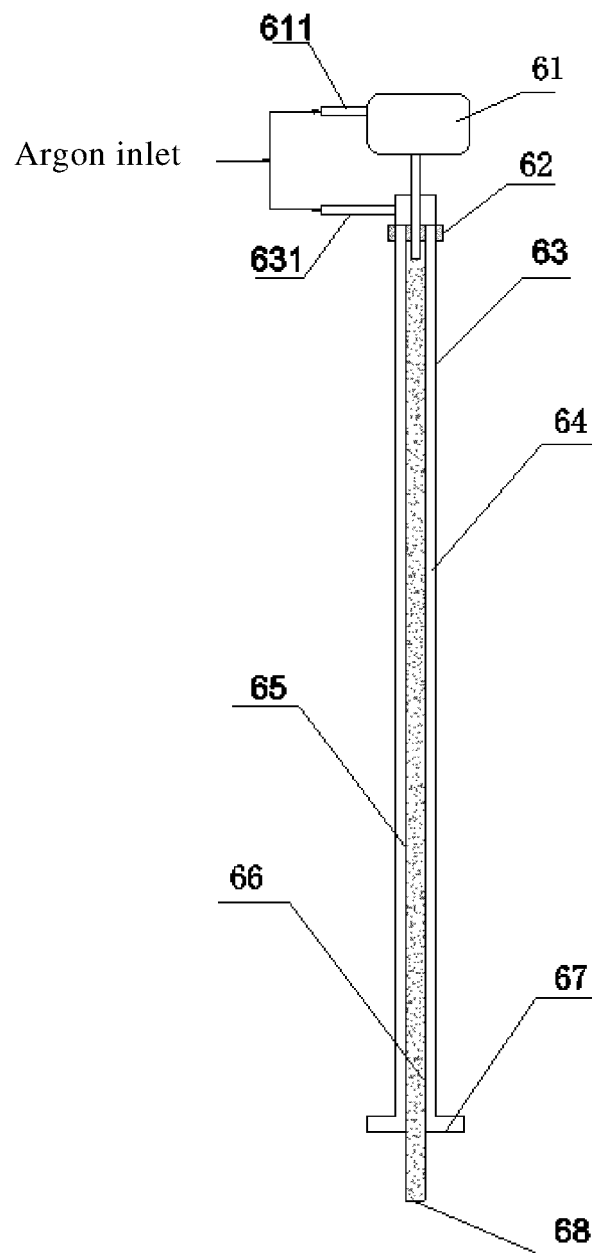


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2021/111633

A. CLASSIFICATION OF SUBJECT MATTER

C22C 1/06(2006.01)i; C22C 1/10(2006.01)i; C22C 21/00(2006.01)i; C22C 32/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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)

CNABS; VEN; CNKI; CNTXT; USTXT; WOTXT; EPTXT; ISI Web of Knowledge: 上海交通大学, 安徽相邦复合材料有限公司, 电磁, 搅拌, 熔体, 铝基, 真空, 氩气, 旋转, 喷吹, 石墨, 转子, aluminum, melt, electromagnetic, stirring, vacuum, argon, rotating, spray, graphite, rotor

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 112779435 A (ANHUI (HUAIBEI) CERAMIC AND ALUMINUM NEW MATERIALS RESEARCH INSTITUTE, SHANGHAI JIAOTONG UNIVERSITY et al.) 11 May 2021 (2021-05-11) claims 1-8	1-8
PX	CN 112808991 A (ANHUI (HUAIBEI) CERAMIC AND ALUMINUM NEW MATERIALS RESEARCH INSTITUTE, SHANGHAI JIAOTONG UNIVERSITY et al.) 18 May 2021 (2021-05-18) description, paragraphs 4-33	1-8
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PX	CN 112779433 A (ANHUI (HUAIBEI) CERAMIC AND ALUMINUM NEW MATERIALS RESEARCH INSTITUTE, SHANGHAI JIAOTONG UNIVERSITY et al.) 11 May 2021 (2021-05-11) description, paragraphs 21-91	1-8

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

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“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

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“&” document member of the same patent family

Date of the actual completion of the international search

10 September 2021

Date of mailing of the international search report

27 October 2021

Name and mailing address of the ISA/CN

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Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2021/111633

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
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PX	CN 112795805 A (ANHUI (HUAIBEI) CERAMIC AND ALUMINUM NEW MATERIALS RESEARCH INSTITUTE, SHANGHAI JIAOTONG UNIVERSITY et al.) 14 May 2021 (2021-05-14) description paragraphs 28-98	1-8
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PX	CN 112795804 A (ANHUI (HUAIBEI) CERAMIC AND ALUMINUM NEW MATERIALS RESEARCH INSTITUTE, SHANGHAI JIAOTONG UNIVERSITY et al.) 14 May 2021 (2021-05-14) description paragraphs 30-100	1-8
PX	CN 112760518 A (ANHUI (HUAIBEI) CERAMIC AND ALUMINUM NEW MATERIALS RESEARCH INSTITUTE, SHANGHAI JIAOTONG UNIVERSITY et al.) 07 May 2021 (2021-05-07) description paragraphs 26-96	1-8
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2021/111633

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CN	112779433	A	11 May 2021		None				
CN	112795803	A	14 May 2021		None				
CN	112813279	A	18 May 2021		DE	202021100530	U1	22 July 2021	
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CN	112760518	A	07 May 2021		None				
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Form PCT/ISA/210 (patent family annex) (January 2015)