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(54) CONTINUOUS KILN AND THERMAL TREATMENT OR THERMAL CHEMICAL PROCESSING METHOD

(57) A continuous kiln and a thermal treatment or thermal chemical processing method, relating to the field of lithium-ion battery material processing. The continuous kiln comprises a kiln, an airflow supply and exhaust device, and an airflow control device. The airflow supply and exhaust device and the airflow control device work in conjunction to control an atmosphere in a furnace chamber of the kiln. Since air supply nozzles and air exhaust nozzles in the airflow supply and exhaust device are arranged opposite to each other, transverse airflow perpendicular to the length direction of the kiln may be formed, and the internal atmosphere may be kept stable.

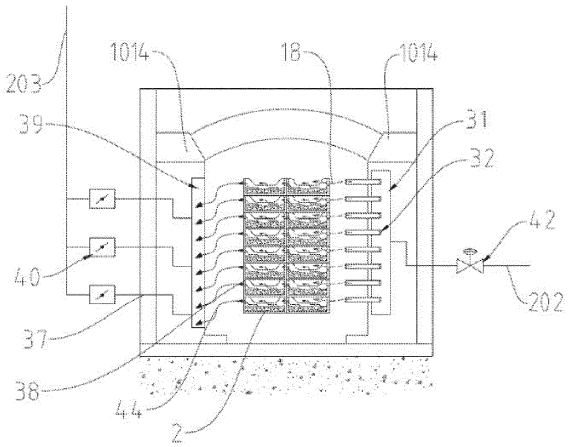

FIG. 2

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Description

CROSS-REFERENCE TO RELEVANT APPLICATIONS

[0001] The present disclosure claims the priority of the Chinese patent application filed with the China National Intellectual Property Administration on December 1st, 2020 with the application number of 2020113884985, entitled "CONTINUOUS KILN AND THERMAL TREATMENT OR THERMAL CHEMICAL PROCESSING METHOD", and the priority of the Chinese patent application filed with the China National Intellectual Property Administration on December 1st, 2020 with the application number of 2020228595682, entitled "CONTINUOUS KILN", which are incorporated herein in their entireties by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to the field of lithium-ion battery material processing, and more particularly, relates to a continuous kiln and thermal treatment or thermal chemical processing method.

BACKGROUND ART

[0003] A continuous kiln is one of the important pieces of equipment to produce cathode materials for lithium-ion batteries. The continuous kiln is a kind of kiln mainly made of refractory materials, thermal insulation materials, and building materials, and is usually built into a tunnel structure with openings at both ends.

[0004] In the production process of cathode materials for lithium-ion batteries, it is usually necessary to introduce a specific gas (such as dry air, oxygen, or nitrogen, etc.) into the continuous kiln to form the process atmosphere required for the thermal treatment or thermal chemical treatment of cathode materials, and this particular gas is called the process gas. Meanwhile, when the cathode materials are subjected to thermal treatment or thermal chemical treatment in the kiln, some gaseous by-products (which may be called exhaust gas) generated during the reaction process will be released, such as water vapor and carbon dioxide. In addition, the exhaust gas often contains some residual corrosive gas. These exhaust gas needs to be exhausted from the kiln as soon as possible, otherwise, the atmosphere control in the kiln will be seriously affected, resulting in the deterioration of the performance of the calcined cathode materials.

SUMMARY

[0005] In order to improve the problem of control of existing atmosphere in the kiln, the purpose of the present disclosure is to propose a continuous kiln and a thermal treatment or thermal chemical processing method.

[0006] The present disclosure is implemented as follows:

[0007] The present disclosure provides a continuous kiln, including a kiln, an airflow supplying and exhausting device, and an airflow control device.

[0008] In the above, the kiln is provided with a furnace chamber extending along a first direction from a furnace head to a furnace tail. The airflow supplying and exhausting device is configured for forming a directional airflow in the furnace chamber, wherein the directional airflow is capable of flowing along a second direction from a furnace wall on one side to a furnace wall on the other side of the kiln, the airflow supplying and exhausting device is provided with a supplying and exhausting set, wherein the supplying and exhausting set is provided with air-supply nozzles and air-exhaust nozzles, wherein the air-supply nozzles and the air-exhaust nozzles are connected to the furnace walls and are matched and arranged opposite to each other, and the air-supply nozzles and the air-exhaust nozzles are arranged along a third direction from a furnace top to a furnace bottom of the kiln. The airflow control device is matched and connected to the airflow supplying and exhausting device, so as to control the air-supply nozzles and the air-exhaust nozzles.

[0009] Optionally, the furnace wall is provided with a gas distributor at a position where the air-supply nozzles are connected, and the air-supply nozzles communicate with an air chamber of the gas distributor.

[0010] In some possible implementations of the present disclosure, the furnace wall is provided with a suction port at a position where the air-exhaust nozzles are connected, the suction port is arranged along the third direction, and the air-exhaust nozzles communicate with the suction port.

[0011] Optionally, the suction port is long-narrow shaped.

[0012] Optionally, a cross section of the suction port is rectangular-shaped or elliptical-shaped. Optionally, the continuous kiln includes saggars configured for containing materials, wherein side walls of the saggars are formed with gaps, the gaps constitute channels for directional air to pass through the saggars, and the gaps face the suction port and the air-supply nozzles, respectively.

[0013] Optionally, openings of the air-supply nozzles are close to the gaps.

[0014] Optionally, the continuous kiln includes a detecting device, wherein the detecting device includes a furnace-pressure sensor and/or a gas-concentration sensor configured for detecting the kiln.

[0015] Optionally, the detecting device includes a pressure sensor and/or a flow sensor, wherein one or both of the air-exhaust nozzles and the air-supply nozzles are matched and provided with the pressure sensor and/or the flow sensor.

[0016] Optionally, the detecting device includes a temperature sensor. Optionally, the airflow control device includes an air-supply valve and air-exhaust valves, wherein the air-supply valve is matched and connected to the

air-supply nozzles, the air-exhaust valves are connected to the air-exhaust nozzles, and the air-supply valve and the air-exhaust valves are configured to be controlled in response to the detecting device.

[0017] Optionally, the airflow control device is configured to be capable of controlling the air-supply nozzles and the air-exhaust nozzles in linkage, so as to control an air-intake volume and an air-exhaust volume in the kiln in linkage.

[0018] Optionally, both the air-supply valves and the air-exhaust valves are proportional solenoid valves.

[0019] Optionally, all the air-exhaust nozzles in a plurality of the supplying and exhausting sets are located at the furnace wall on one side, and all the air-supply nozzles in a plurality of the supplying and exhausting sets are located at the furnace wall on the other side; or

the furnace wall on one side and the furnace wall on the other side are both provided with the air-exhaust nozzles and the air-supply nozzles; and in the third direction, the air-exhaust nozzles and the air-supply nozzles at the furnace wall on the same side are alternately arranged at intervals; or

a plurality of the airflow supplying and exhausting devices are arranged in the first direction, the air-supply nozzles of the same airflow supplying and exhausting device are located at one of the furnace walls, and the air-exhaust nozzles are located at the other furnace wall, wherein in the first direction, the air-exhaust nozzles and the air-supply nozzles of two adjacent airflow supplying and exhausting devices are alternately arranged at intervals. Optionally, the continuous kiln includes heaters, and the heaters are connected to the kiln.

[0020] Optionally, the heaters are arranged along the third direction and are connected to the furnace walls of the kiln.

[0021] Optionally, the air-supply nozzle or the air-exhaust nozzle is arranged between the two adjacent heaters.

[0022] Optionally, the furnace walls on two sides of the kiln are both connected with the heaters, and the number of the heaters connected to the furnace wall on one side is equal to that of the heaters connected to the furnace wall on the other side.

[0023] The present disclosure provides a thermal treatment or a thermal chemical processing method by the aforementioned continuous kiln. Herein, the thermal treatment or the thermal chemical treatment method includes: heating the furnace chamber of the kiln to a temperature required for the thermal treatment or the thermal chemical processing method; and conveying an object to be thermal-treated or to be thermal-chemical-processed to the furnace chamber along the first direction by a loading tool, wherein during the conveying process, process gas is supplied to the furnace chamber by the airflow supplying and exhausting device under control of the airflow control device, and the gas is exhausted from the furnace chamber by the airflow control device synchronously, so as to maintain the process atmosphere of the thermal treatment or the thermal chemical processing in the furnace chamber.

BRIEF DESCRIPTION OF DRAWINGS

[0024] In order to more clearly explain the technical solution in the embodiments of the present disclosure, the following content will be used to briefly introduce the drawings illustrated in the embodiments. It should be understood that the following drawings only illustrate some embodiments of the present disclosure and should not be regarded as a limitation of the scope, and for ordinary people skilled in this filed, they may also obtain other relevant drawings according to these drawings without paying for any creative work.

FIG. 1 is a structural diagram of a kiln body of a continuous kiln;

FIG. 2 is a structural diagram of the continuous kiln from a first perspective provided by the present disclosure;

FIG. 3 is a structural diagram of the continuous kiln from a second perspective provided by the present disclosure;

FIG. 4 is a structural diagram of a saggar used in the continuous kiln provided by the present disclosure;

FIG. 5 is a structural diagram of air-supply nozzles with incisions provided by the present disclosure;

FIG. 6 is a flow chart of a thermal treatment or thermal chemical processing method provided by the present disclosure; and

FIG. 7 is a schematic diagram of positions of various detecting devices arranged in the continuous kiln provided by the present disclosure.

[0025] Reference numerals: 101-kiln; 1011-furnace head; 1012-furnace tail; 1013-furnace chamber; 1014-furnace wall; 1015-furnace top; 1016-furnace bottom; 11-heater; 32-air-supply nozzle; 202-gas-injection device; 203-gas-exhausting device; 31-gas distributor; 2-saggar; 38-gap; 39-suction port; 40-air-exhaust valve; 42-air-supply valve; 18-process gas; 37-air-exhaust nozzle; 44-exhaust gas; 55-temperature sensor; 65-pressure sensor; 66-flow sensor; 88-furnace-pressure sensor; 89-air-concentration sensor.

DETAILED DESCRIPTION OF EMBODIMENTS

[0026] As one of the core materials of lithium-ion batteries, the cathode active materials (hereinafter referred to as the cathode materials) play a crucial role in the safety, comprehensive performance, and cost of the battery.

[0027] In the production process, a thermal treatment, or a thermal chemical processing, especially the high-

temperature calcination treatment for the cathode materials is the core step that determines the performance of the material. Moreover, during the calcination process, many cathode materials are required to introduce a specific process gas into the calcined kiln to maintain a special atmosphere, and the special atmosphere is also required to be strictly controlled. For example, oxygen needs to be introduced for ternary cathode materials such as high nickel ternary materials; and nitrogen needs to be introduced for cathode materials such as lithium iron phosphate. For this type of cathode materials that are required a special atmosphere during calcination, the atmosphere control during calcination is very important, because it will affect the performance of the cathode materials after calcination, therefore, the cathode material manufacturers and related researchers have been striving to improve the atmosphere control ability that the kiln should be provided with when the cathode materials are calcined.

[0028] At present, the calcination of cathode materials is generally implemented by kilns in a continuous mode (also referred to as continuous kilns), such as pusher-type tunnel kilns (referred to as pusher kilns) and roller tunnel kilns (referred to as roller kilns), and both are implementation modes of the continuous kilns. The so-called tunnel kiln is a kiln having a tunnel structure with openings at both ends, and is made of refractory materials, thermal insulation materials, and building materials. Depending on the temperatures and functions, the tunnel kiln is generally divided into zones to form a rising-temperature zone, an constant-temperature zone, and a cooling zone. In the tunnel kiln, the kiln body is heated by an electric heater or by means of injecting fuels for burning, such as natural gas, heavy oil, etc. The material to be thermal-treated or thermal-chemical-processed or a carrier (such as a saggar) that carries the material is carried by the conveying tool, and enters the tunnel kiln from one end (kiln head) of the tunnel, and moves through the rising-temperature zone, the constant-temperature zone, and the cooling zone successively, then leaves the kiln from the other end (kiln tail) of the tunnel kiln, thus completing the thermal treatment.

[0029] However, through practice, the inventors of the present disclosure have found that there are defects in the existing kilns to different extents, thereby resulting in the calcination of the cathode materials cannot meet the requirements.

[0030] After analysis, the inventor believes that the above problems are mainly caused by the following reasons:

[0031] During the calcination process, the cathode materials and the process gas participate in the reaction, and two key conditions are required to promote the reaction: (1) the process gas is in full contact with the calcined material; (2) a large volume of process gas flows over the surface of the material, so that the gaseous by-products produced by the reaction are taken away as soon as possible. However, the existing continuous kilns used for calcining cathode materials cannot meet at least one of these two key conditions. For example, the air intake and exhaust systems of pusher kilns or roller kilns cannot fully meet the above conditions.

[0032] For ease of understanding, taking the cathode materials of lithium-ion battery as an example, the cathode materials of lithium-ion battery generally exist in the form of powder before calcination, and when the powder material is calcined in a kiln, it is usually necessary to put the powder materials to be calcined into a carrying tool such as saggars. In order to improve the production capacity of the kiln, the saggars that carry the materials usually need to be placed on the conveying tool in a stacked manner, which will seriously affect the supplying and exhausting of the airflow, so that the process gas cannot fully contact with the powder materials in the stacking saggars, and a large volume of the process gas cannot flow over the surface of the powder materials in the stacking saggars. For ease of understanding, the detailed explanations are as follows:

[0033] Taking the existing typical technology of supplying air from the bottom and side walls of the kiln, and exhausting air from the top of the kiln as an example, the process gas entering from the air-supplying port of the kiln side wall will flow upwards under the suction of the negative pressure of the air-exhausting port at the top of the kiln, and is exhausted from the kiln by the exhaust port on the top of the kiln.

[0034] Due to the process gas entering from the air-supplying port at bottom is blocked by the bottom of the lower saggars, most of the process gas may only flow along the periphery of the saggars and merge into the main airflow that flows upward, and a small part of the process gas passes through gaps between the saggars and flows upward and enters the air-exhausting port.

[0035] The materials in the upper saggars are in relatively full contact with the process gas because there is no obstruction on the top of the saggars, and the exhaust gas released by the materials in the upper saggars may also be relatively smoothly exhausted from the top air-exhausting port along with the main airflow.

[0036] However, since the lower saggars are blocked by the upper saggars, the process gas cannot enter smoothly, and the exhaust gas released by the calcination of the materials cannot be smoothly taken away by the upward-flowing airflow. The gas exchange inside and outside the lower saggars is mainly completed by diffusion, that is, a small part of the process gas around the lower saggars enters the saggars through the gaps at the edges of the lower saggars through diffusion. Similarly, the exhaust gas released from the calcination of the material in the lower saggars also escapes from the saggars through the gaps on the edge of the saggars by diffusion, and merges to the top of the kiln with the airflow around the saggars, then is exhausted from the air-exhausting port.

[0037] As mentioned above, in the existing typical technology, the fact that the air is supplied from the bottom

and side walls of the kiln and is exhausted from the top of the kiln cannot solve the problems such as the obstruction of the air-exhausting of the lower saggar materials and the insufficient contact with the fresh process gas. Similarly, in the typical technology, the fact that the air is supplied from the top of the kiln and is exhausted from the bottom cannot solve the problems such as the obstruction of the air-exhausting of the lower saggar materials and the insufficient contact with the fresh process gas.

[0038] In short, in the case of stacking saggars, since the upper saggars block the lower saggars, whether the process gas enters the lower saggars or the exhaust gas escapes from the lower saggars, it mainly depends on the diffusion effect. Therefore, the gas exchange efficiency inside and outside the lower saggars is very low. Moreover, the diffusion directions of the two gases are opposite, which weakens the gas exchange, so that the concentration of the process gas in the lower saggars is much lower than that of the upper saggars, and the accumulation of the exhaust gas in the lower saggars is much higher than that of the upper saggars.

[0039] The above phenomenon makes a huge difference in the atmosphere in contact with the materials in the upper and lower saggars, which further makes a huge difference in the performance of the cathode materials in the upper and lower saggars after calcination, resulting in poor consistency of products. Even worse, in order to reduce costs, manufacturers of cathode materials usually stack more saggars in the kiln, and as the number of stacks of the saggars increases, the aforementioned problems become more severe.

[0040] In addition, since the air pressure at the air-supplying port of the kiln is not high, after the process gas enters the larger space in the kiln body from the air-supplying port, the airflow speed will be greatly slowed down, which makes obstruction to the exhausting of the exhaust gas and the uniform distribution of the process gas. However, if the air-supplying pressure is too high, it may cause excessive disturbance to the cathode material powder and makes the cathode material powder fly, which is inconvenience for normal conveying.

[0041] In view of the above situation, the inventors propose to form an orderly and highly directional airflow in the kiln, so that the cathode active material may be fully contacted with the process gas to fully react, at the same time, the generated exhaust gas by the reaction may be timely exhausted, so as to suppress the adverse effect of the exhaust gas on the reaction.

[0042] In order to achieve the above effects, the inventors propose a continuous kiln in the present disclosure. In some implementation modes, the continuous kiln mainly includes three major components: the kiln, the airflow supplying and exhausting device, and the airflow control device, which will be described in detail below, respectively.

(1). Kiln

[0043] The structure of the kiln 101 is shown in FIG. 1, which is provided with a furnace wall 1014, a furnace bottom 1016, and a furnace top 1015. In particular, in order to facilitate the controlling of process gas 18 therein and reducing the ineffective consumption of the process gas 18, the internal cross section of the kiln 101 may be designed to be thin and tall, and the free space (the space without saggars 2) of the furnace top 1015 inside the kiln 101 (the arc-shaped structure at the top in FIG. 2) occupies a small proportion (the area of the furnace chamber at the arc-shaped top region is smaller than that of the furnace chamber at the furnace wall region).

[0044] The flow direction of the process gas 18 in the continuous kiln of the present disclosure is shown in FIG. 2 and FIG. 3. For the convenience of explanation and understanding, the kiln 101 is defined in three directions, namely a first direction, a second direction, and a third direction respectively. In particular, the direction from a furnace head 1011 to a furnace tail 1012 is defined as the first direction, as shown in the direction B in FIG. 1 (or called a length direction); the direction from a furnace wall 1014 at one side to the furnace wall 1014 at the other side is defined as the second direction, as shown in the direction C in FIG. 1 (or called the width direction); and the direction from the furnace top 1015 to the furnace bottom 1016 is defined as the third direction, as shown in the direction A in FIG. 1 (or called the height direction).

[0045] The kiln 101 constitutes the main structure of the continuous kiln, and operations such as thermal treatment or thermal chemical processing are also mainly performed in the kiln 101. The kiln 101, as a place for providing thermal treatment or thermal chemical processing, is provided with a furnace chamber 1013 bounded by furnace walls 1014. In the practical using process, the thermal treatment or thermal chemical processing material enters from the furnace head 1011 of the kiln 101, and enters different zones (for example, rising-temperature zone, constant-temperature zone, and cooling zone that are sequentially distributed) of the furnace chamber 1013 in sequence, and finally leaves from a furnace tail 1012 thereof. It should be noted that, the kiln 101, as a place for providing thermal treatment or thermal chemical processing, is usually required to maintain a certain degree of airtightness and sealing, therefore, its furnace head 1011 and the furnace tail 1012 are usually required to be provided with a gate that is selectively opened and closed, and so forth. At the same time, the kiln 101 may also be constructed with airtightness through the outer housing, which is not illustrated by figures in the present disclosure. People skilled in the art may understand that the above-mentioned equipment such as gate and housing may be provided by the existing technology, which are briefly described in the present disclosure in order to avoid unnecessary repetition.

[0046] In order to perform the heating operation, the kiln 101 is usually required to be configured with heating

equipment. As previously mentioned, the heating equipment may directly heat selected locations within the kiln 101 by injecting fuels. However, the considering the possible introduction of foreign objects and their influence on the calcination reaction, the heater 11 is generally selected to be used, and the heater 11 may be an electric heater, for example, an electric heater such as a heating rod is used for electric heating, and the heater 11 may also using a heat radiation pipe to perform combustion heating. The heater may be a specific product such as a resistance heater, etc., which is not limited herein.

[0047] In the present disclosure, the continuous kiln is provided with the heater 11, and the heater 11 is connected to the kiln 101. Optionally, the heater 11 may be inserted into the furnace chamber 1013 from the furnace top 1015, or the heater 11 may be inserted into the furnace chamber 1013 through the furnace bottom 1016 or the furnace wall 1014. Considering that the heater 11 may block the material to be calcined conveyed in the furnace chamber 1013, in the present disclosure, the heater 11 is inserted and fixed close to the furnace wall 1014, and it is inserted along the direction A from the furnace top 1015 to the furnace bottom 1016, please refer to FIG. 1 and FIG. 3.

[0048] In the contents disclosed in FIG. 3, the heaters 11 are provided on the furnace walls 1014 on both sides of the kiln 101. The number of heaters 11 on the furnace wall 1014 on one side is equal to that of the heaters 11 on the furnace wall 1014 on the other side, and they are opposite in a direction C one to one. In the furnace wall 1014 on the same side, two adjacent heaters 11 are spaced apart from each other by an appropriate distance. Certainly, there are other options for the installation position and manner of the heater 11, which are not specifically limited in the present disclosure.

[0049] In addition, according to different demands, the kiln 101 may also be selectively configured with various appropriate devices and equipment such as detection devices, which may be flexibly set according to the practical situation.

[0050] For example, in different usage manners, when other atmospheres need to be provided in the furnace chamber 1013 of the kiln 101, other air supply pipeline equipment may also be selected to be provided.

[0051] For another example, in order to monitor the temperature in the furnace chamber 1013 of the kiln 101 so as to adjust the temperature in time, a temperature detection device such as a temperature sensor 55 may also be provided in the kiln 101, for example, it may particularly be an infrared temperature detector, etc.

[0052] Since the process gas 18 needs to be provided for material calcination in the furnace chamber 1013, corresponding to this, a detection device may also be provided in the kiln 101. The detection device herein may be an air pressure detector, and it may also be a concentration detector, or both. The gas pressure detector herein may be a furnace-pressure sensor 88 for detecting the kiln 101; and the concentration detector herein may be a gas-concentration sensor 89 for detecting the concentration of the process gas 18 (e.g., oxygen) in the kiln 101.

[0053] In addition, the continuous kiln may also be configured with equipment for containing and conveying calcined materials (such as cathode materials), such as a saggar 2, as shown in FIG. 4. In order to facilitate the airflow through the saggar 2, the side wall of the saggar 2 is formed with a gap 38. Therefore, when a plurality of saggars 2 are stacked, the gaps 38 of different saggars 2 may constitute passages for directional airflow passing through the saggars 2. The gaps 38 formed at the saggar 2 facilitate the flowing of the airflow, so that the exhaust gas may be more easily taken away by the airflow, and the turbulent flow of the airflow is reduced.

(2) Airflow supplying and exhausting device

[0054] In the present disclosure, the airflow supplying and exhausting device mainly includes an airflow-supplying part and an airflow-exhausting part. Moreover, the two parts cooperate with each other and may form a continuous and directional airflow in the kiln 101. The "orientation" herein refers to the direction C that intersects (e.g., crossing vertically and horizontally) with the direction B of the kiln 101, that is, the direction from the furnace wall 1014 on one side to the furnace wall 1014 on other side of the kiln 101. In other words, during the longitudinal conveying process of the calcined material from the kiln head to the kiln tail in the furnace chamber 1013, a transverse airflow may be formed by the airflow supplying and exhausting device.

[0055] In the above, the airflow-supplying part is configured to supply the process gas 18 into the furnace chamber 1013 of the kiln 101 for the reaction needs in the calcination process. The airflow-exhausting part herein is configured to exhaust the exhaust gas 44 in the furnace chamber 1013 of the kiln 101 out of the kiln 101.

[0056] By using the airflow supplying and exhausting device, the renewal of the atmosphere in the furnace chamber 1013 of the kiln 101 may be realized, for example, fresh process gas 18 may be added, and the exhausting gas 44 may be exhausted at the same time. In addition, by controlling the conveying state of the airflow such as flow rate, flow volume, etc., the temperature in the furnace chamber 1013 may also be controlled to a certain extent. Since some of the heat may be carried away by the exhaust gas 44, some of the heat may be absorbed by the freshly supplied process gas 18.

[0057] The airflow supplying and exhausting device is provided with a supplying and exhausting set. The supplying and exhausting set includes any number of air-supply nozzles 32 and air-exhaust nozzles 37. In addition, the air-supply nozzles 32 and the air-exhaust nozzles 37 are separated at intervals and opposite to each other, and the air-supply nozzles 32 and the air-exhaust nozzles 37 are both connected on the furnace wall 1014. Therefore, the interval area between the two is the chan-

nel for conveying calcined materials in the furnace chamber 1013.

[0058] The air-supply nozzles 32 and the air-exhaust nozzles 37 in the supplying and exhausting set are arranged along the third direction from the furnace top 1015 to the furnace bottom 1016 of the kiln 101. That is, the air-supply nozzles 32 and the air-exhaust nozzles 37 are arranged along the height direction of the kiln. Therefore, when a calcined object with a relatively larger height is placed in the furnace chamber 1013 of the kiln 101, the arrangement of the air-supply nozzles 32 and the air-exhaust nozzles 37 along the third direction may effectively cover the calcined object, so that the calcined object is uniformly subjected to the action and influence of the directional airflow. As an improved solution, the gaps 38 of the saggars 2 for containing the calcined material face toward the air-supply nozzles 32. Furthermore, openings (gas outlet) of the air-supply nozzles 32 are close to the gaps 38 (to the extent that the normal transportation of the saggars is not blocked), so that it is easier to accurately convey the gas to the saggars 2.

[0059] FIG. 2 is a schematic cross-sectional structural diagram of the continuous kiln, wherein a supplying and exhausting set is shown, which includes eight air-supply nozzles 32 and three air-exhaust nozzles 37. Optionally, the number of the air-supply nozzles 32 and the air-exhaust nozzles 37 in one supplying and exhausting set may also be equal, or the number of the air-supply nozzles 32 is smaller than the number of the air-exhaust nozzles 37. In other words, the air-supply nozzles 32 and the air-exhaust nozzles 37 may be in a one-to-one arrangement, or a one-to-many or many-to-one arrangement, which is not limited herein.

[0060] The continuous kiln provided with only one air supplying and exhausting device is taken as an example to illustrate as mentioned above. Certainly, the continuous kilns may also be provided with a plurality of airflow supplying and exhausting devices. Optionally, when the continuous kiln is provided with a plurality of the airflow supplying and exhausting devices, a plurality of airflow supplying and exhausting sets are provided correspondingly. Thus, in the case of a plurality of the airflow supplying and exhausting sets are provided, all airflow supplying and exhausting sets may be arranged along the length direction of the kiln 101, as shown in FIG. 3.

[0061] The above-mentioned FIG. 2 and FIG. 3 only disclose one arrangement of the supplying and exhausting sets in the present disclosure. Optionally, the supplying and exhausting sets may also have other arrangements. Two cases are used as examples to describe in detail as follows:

[0062] Case one: in the direction A of the kiln 101, in a supplying and exhausting set, all the air-supply nozzles 32 are arranged in one furnace walls 1014, and all the air-exhaust nozzles 37 are arranged in the other furnace wall 1014.

[0063] Case two: in the direction A of the kiln 101, in a supplying and exhausting set, part of the air-supply nozzles 32 are arranged in one furnace walls 1014, and the remaining part of the air-supply nozzles 32 are located in the other furnace wall 1014. Correspondingly, in the supplying and exhausting set, part of the air-exhaust nozzles 37 are arranged in one furnace walls 1014, and the remaining air-exhaust nozzles 37 are arranged in the other furnace wall 1014.

[0064] For the continuous kiln with only one gas supplying and exhausting device (one supplying and exhausting set is provided correspondingly), the air-supply nozzles 32 and the air-exhaust nozzle 37 therein may be arbitrarily selected to be configured in the manner of the above-mentioned case one or case two.

[0065] For the continuous kiln with a plurality of (e.g., two or more) airflow supplying and exhausting devices (a plurality of supplying and exhausting sets are provided correspondingly), all supplying and exhausting sets are arranged along the direction B of the kiln 101. Moreover, the air-supply nozzles 32 and the air-exhaust nozzles 37 in each supplying and exhausting set may all be arranged in the manner of case one, or all be arranged in the manner of case two, or all the supplying and exhausting sets may be arranged in a combined manner of case one and case two.

[0066] In the schematic scheme of the present disclosure, a plurality of the supplying and exhausting sets are provided, and the air-supply nozzles 32 and air-exhaust nozzles 37 are arranged in the combined manner of case one and case two as above-mentioned. In particular, two adjacent supplying and exhausting sets on the furnace wall 1014 on the same side are arranged in an alternate way with the air-supply nozzles 32 and air-exhaust nozzles 37. In this manner, when more than one column of saggars 2 (two columns are shown in FIG. 3) stacked on the conveying tool for the calcined materials in the kiln 101 pass through the kiln, saggars 2 on each side have an equal chance of facing gas-injection device 202 or gas-exhaust device 203, that is, for the conveying tool, the chance of facing the gas-injection device 32 and the gas-exhausting device 37 is equal. This improves the consistency of material calcination in different columns of saggar 2, so that each saggar 2 has airflow alternately passing through the two sides. For better consistency, the saggars 2 in the present disclosure are stacked in two columns, as shown in FIG. 3.

[0067] The different structural modes of the air supplying and exhausting device may meet the different realization forms of the continuous kiln, and may also achieve different degrees of renewal of atmosphere and temperature adjustment effect in the furnace chamber.

[0068] When considering the arrangement of the air-supply nozzles 32 and the air-exhaust nozzles 37, the position and structure of the heater 11 in the kiln may also be adjusted in a targeted manner. For example, the air-supply nozzles 32 or air-exhaust nozzles 37 are provided between two adjacent heaters 11. That is, for a plurality of supplying and exhausting sets, the air-supply nozzles 32 and the air-exhaust nozzles 37 of two adjacent

supplying and exhausting sets are alternately arranged, therefore, the heater 11 can be provided between the air-supply nozzle 32 and the air-exhaust nozzle 37. Correspondingly, the air-supply nozzle 32 and the air-exhaust nozzle 37 are alternately "clamped" between the two heaters 11. The alternation mode may be an interval manner of one heater 11, one air-supply nozzle 32, one heater 11, and one air-supply nozzle 32; or two heaters 11, two air-supply nozzles 32, two heaters 11, and two air-supply nozzles 32, and so on. Through the above arrangement, when the process gas 18 is sprayed, the gas may be prevented from being directly sprayed onto the adjacent heaters 11 to affect the heating power of the heaters 11, and the process gas 18 may be sufficiently preheated again.

[0069] The arrangement of the supplying and exhausting sets is described above, and the specific structures of the air-supply nozzle and the air-exhaust nozzle therein are described in detail below.

[0070] Optionally, the air-supply nozzle 32 is constructed as a cylindrical hollow pipe, one end thereof is inserted into the furnace wall 1014, and the other end is extended into the furnace chamber 1013. The air-supply nozzle 32 may be configured as an airflow channel through the pipeline buried in the furnace wall 1014, so as to convey the process gas 18 through the blower; herein, the above-mentioned pipeline may be hollow refractory bricks spliced together, a ceramic pipe, or a high-temperature resistant metal pipe lined with ceramic, which is not limited herein. Optionally, the air-supply nozzle 32 may also be placed outside the kiln 101, and the injection pipe connected to the air-supply nozzle 32 may be inserted into the furnace through a hole on the furnace wall 1014; or, the furnace chamber 1013 is not provided with the injection pipe inserted into the furnace, instead, the air is injected through the holes on the furnace wall 1014 from the air-supply nozzle 32 outside the furnace. Or, the kiln is formed by stacking hollow bricks, and then the hollow bricks are provided with air holes communicating with the furnace chamber 1013, and the gas is injected through the air holes.

[0071] When the number of air-supply nozzles 32 is large, arranging an independent pipeline for each of the air-supply nozzles 32 will make the process and the structure complicated. Therefore, a chamber is selected to be reserved in the furnace wall 1014, and it may be directly supplied with pipelines. The air-supply nozzles 32 may also communicate with the chamber. Functionally, the chamber essentially constitutes a gas distributor 31. In other words, the furnace wall 1014 is provided with the gas distributor 31 at a position where the air-supply nozzles 32 is connected, and the air-supply nozzles 32 communicate with the air chamber of the gas distributor 31. A heating plate may also be provided in the gas distributor 31 for heating the process gas 18 entering therein, so as to prevent the cold process gas 18 from directly entering the furnace chamber 1013. Certainly, the process gas 18 may also be preheated outside the continuous kiln, then introduced into the gas distributor 31, and injected into the furnace chamber 1013 through the gas-supplying nozzles 32. The gas distributor 31 may achieve the effect of simplifying the gas conveying structure, and at the same time, it may also reduce the control difficulty of the airflow control device.

[0072] In addition, as an improved solution, the structure of the air-supply nozzle 32 in the form of a hollow pipe may also be improved and matched with the gas distributor 31. For example, optionally, one end of the air-supply nozzle 32 extending into the gas distributor 31 is formed with a gap, thereby forming an "L" end structure. In addition, the incident direction of the process gas 18 entering the gas distributor 31 is away from the gap of the air-supply nozzle 32 and is opposite to each other, as shown in FIG. 5. Therefore, the time for the process gas 18 in the gas distributor 31 to enter the nozzle may be delayed, so that the process gas 18 may obtain a longer heating time in the distributor, thus improving the heating effect.

[0073] Similarly, the air-exhaust nozzle 37 may also be constructed with respect to hollow pipe. The air-exhaust nozzle 37 may also be provided with a groove structure in the furnace wall 1014 for the air-supplying pipeline to exhaust the exhaust gas 44 from the furnace chamber 1013. In the present disclosure, the furnace wall 1014 is formed with a suction port 39 at the air-exhaust nozzle 37, and obviously, the air-exhaust nozzle 37 connects with the suction port 39. And the suction port 39 is formed along the third direction (i.e., the depth direction of the furnace chamber 1013). Optionally, the suction port 39 is in a long-narrow shape, for example, the suction port 39 may be a structure with a rectangular cross-section or an elliptical cross-section. The long-narrow suction port 39 may provide a larger suction area for the gas, and correspond to more air-exhaust nozzles 37, thereby further improving the uniformity of suction and exhaust at various positions. When the furnace wall 1014 is formed with the suction port 39, one end of the air-exhaust nozzle 37 may be inserted into the suction port 39, and the other end thereof may be extended out of the kiln 101.

[0074] In addition, as a power source for supplying gas to the air-supply nozzles 32 and the air-exhaust nozzles 37, the airflow supplying and exhausting device may also be matched and configured with one or more of the equipment such as a suction fan, a blower, an exhaust fan, and air pump. In the present disclosure, corresponding to the air-supply nozzles 32, the continuous kiln is configured with a gas-injection device 202; corresponding to the air air-exhaust nozzles 37, the continuous kiln is configured with a gas-exhaust device 203.

(3) airflow control device

[0075] The airflow control device is a device that works in conjunction with the airflow supplying and exhausting device, and it is capable of controlling the air-supply noz-

zles 32 and the air-exhaust nozzles 37, and making the air-supply nozzles 32 and the air-exhaust nozzles 37 work in a match manner together. That is, the working state of air-supply nozzles 32 is related to the working state of air-exhaust nozzles 37. When adjusting the working state of air-supply nozzles 32, the state of air-exhaust nozzles 37 may be adjusted accordingly. Through the adjustment of the airflow control device, the air-intake volume of air-supply nozzles 32 may be matched with the air-exhaust volume of air-exhaust nozzles 37, for example, the air-intake volume is equal to the air-exhaust volume.

[0076] In other words, optionally, the airflow control device may control the airflow-supplying nozzles 32 and the air-exhaust nozzles 37 in linkage. Certainly, optionally, the airflow control device may also control the airflow-supplying nozzles and the airflow-exhausting nozzles independently. For example, when an automatic control in the linkage mechanism fails, or the automatic control adjustment range cannot meet the actual needs, or in some special cases, it needs to be changed into manual operation, the system related to the airflow control device may be programmed to switch the automatic control into manual mode, wherein relying on field instruments (such as flow meter, differential pressure gauge and pressure transmitter), the intake-control valve is manually adjusted and the exhaust-control valve is manually adjust based on the detection values of the field instruments, so as to achieve the gas balance in the furnace. In practical application, whether the gas is balanced is determined by the display of the oxygen partial pressure value.

[0077] By controlling the air-intake volume and the air-exhaust volume, the air-intake volume and the air-exhaust volume may be matched, which may make the formed directional airflow more stable. In addition, it may not only effectively avoid the problem that excessive exhaust gas may take away a large amount of heat from the kiln 101 and cause excessive energy loss due to relatively large air-exhaust volume, but also may effectively avoid the problem that the residual amount of the exhaust gas 44 in the kiln 101 is too large due to relatively small air-exhaust volume.

[0078] Optionally, the airflow control device includes an air-supply valve 42 (which may be an automatic-control valve and may be provided with a handle with manual adjustment) and air-exhaust valves 40 (which may be automatic-control corrosion-resistant high-temperature valves and may be provided with handles with manual adjustment).

[0079] In the above, the air-supply valve 42 is matched and connected to the air-supply nozzles 32, and the air-exhaust valves 40 are connected to the air-exhaust nozzles 37. The control of the conveying state of the process gas 18 and the conveying state of the exhaust gas 44 may be realized by adjusting the opening degrees of the two valves. The valves may adopt various valves such as butterfly valves, ball valves, regulating valves, throttle valves, etc., which will not be limited herein. In order to improve the accuracy of control and the convenience of operation, the air-exhaust valves 40 and the air-supply valve 42 may selectively adopt proportional solenoid valves.

[0080] Further, the continuous kiln may also be provided with a detection device, so that the air-supply valve 42 and the air-exhaust valves 40 are configured to be controlled in response to the detection device. In other words, according to the work condition of the continuous kiln detected by the detection device, the air-supply valve 42 and the air-exhaust valves 40 are adjusted accordingly, so as to realize the operation of the air-supply nozzles 32 and the air-exhaust nozzles 37.

[0081] In the above, the detection device may include a pressure sensor 65 and/or a flow sensor 66. Optionally, the pressure sensor 65 and the flow sensor 66 may be connected in the air-supply pipe system, and located upstream of the air-supply nozzles 32. Or, the pressure sensor 65 and the flow sensor 66 may also be connected in the air-exhaust pipe system, and located downstream of the air-exhaust nozzles 37.

[0082] In addition, corresponding to the kiln 101, the furnace-pressure sensor 88 and the gas-concentration sensor 89 of the process gas 18 provided may also be configured as components of the detection device. The furnace-pressure sensor 88 and the gas-concentration sensor 89 may reflect the pressure and atmosphere concentration in the furnace chamber of the kiln, respectively, so as to facilitate the user to detect the atmosphere in the furnace chamber. The pressure sensor 65 and the flow sensor 66 may reflect the work conditions of the air-supply nozzles 32 and the air-exhaust nozzles 37, as well as the airflow transported into the furnace chamber 1013 and the airflow exhausted out of the furnace chamber 1013, so as to control the atmosphere in the furnace chamber 1013 more effective and efficient. Therefore, various states of the injected gas, the exhaust gas, and the gas in the furnace chamber 1013 of the kiln 101 may be truly reflected by the detection device, so that the operation of the airflow control device may be more accurate.

[0083] Based on the requirements to improve the automation of control, the controller may be selected to be used to control the air-supply valve 42 and the air-exhaust valves 40, and the detection device and the controller are matched and connected, so that the collection and processing of the control information and the sending of the detection information cooperate with each other. Herein, the controller may be various electronic components or combination thereof that are capable of storing and processing data to a certain extent. For example, a Central Processing Unit (CPU), a Micro Control Unit (MCU), a Programmable Logic Controller (PLC), a Programmable Automation Controller (PAC), an Industrial Programming Computer (IPC), a Field-Programmable Gate Array (FPGA), an Application Specific Integrated Circuit chip (ASIC chip) and so on. Through such struc-

tural design, the continuous kiln is capable of realizing the closed-loop operation of gas injection and exhaust.

[0084] For ease of understanding, the working principle of the controller is summarized as an example as follows:

First, the partial pressure data of the process gas 18 in the furnace chamber 1013 is collected by the furnace-pressure sensor 88 and the gas-concentration sensor 89. Based on the collected data, the gas exchange efficiency in the furnace is determined by the controller, and a target air-intake volume is set for the intake flow volume of the air-supply valve 42 of the air-supply nozzles 32, and the actual air-intake volume is adjusted according to the target air-intake volume. At the same time, the flow data of the air-supply valve 42 is also taken as a parameter by the controller, to calculate the target opening degree of the air-exhaust valve 40 of the air-exhaust system. The air-exhaust volume of the air-exhaust system is adjusted according to the target opening degree, so as to realize the linkage control of the air-exhaust volume and the air-intake volume.

[0085] When the partial pressure of the process gas 18 is lower than a certain percentage of the set value, the opening degree of the air-supply valve 42 is increased, and the opening degree of the air-exhaust control valve is increased; when the partial pressure of the process gas 18 is higher than a certain percentage of the set value, the intake flow volume control valve is turned down, and the opening degree of the air-exhaust control valve becomes smaller; when the partial pressure of the process gas 18 is maintained within a certain percentage of the set value, the intake flow volume control valve and the air-exhaust control valve remain unchanged. In addition, in order to make the feedback system operate smoothly without the unstable situation in which the action is too large or too slow, the furnace pressure in the furnace chamber 1013 of the kiln 101 may be taken as an intermediate equilibrium constant, and any adjustment is required to maintain the furnace pressure within the set fluctuation range.

[0086] In conclusion, the continuous kiln proposed in the present disclosure may achieve a better using effect, and make the concentration of the process gas 19 in the kiln evenly distributed, so that the calcined materials may be in uniform and consistent contact with the process gas 18, and thus improving the consistency of product performance after calcination.

[0087] As an application, the present disclosure further provides a thermal treatment or a thermal chemical processing method, and as referred to the flow chart of a thermal treatment or a thermal chemical processing method shown in FIG. 6, it mainly includes step S100 and step S200 as follows:

Step 100: providing a temperature for the thermal treatment or the thermal chemical processing in the furnace chamber of the kiln.

[0088] Herein, the temperature for the thermal treatment or the thermal chemical processing method may be provided by the heater 11 provided in the kiln 101 of the continuous kiln. For different temperature zones of the kiln 101 (rising-temperature zone, constant-temperature zone, and cooling zone, etc.,), the number and positions of the heaters 11 may be adjusted adaptively.

[0089] Step 200: conveying an object to be thermal-treated or to be thermal-chemical-processed in the furnace chamber along the first direction by a loading tool, wherein during the conveying process, process gas is supplied to the furnace chamber by the airflow supplying and exhausting device under control of the airflow control device, and the gas is exhausted from the furnace chamber by the airflow control device synchronously, so as to maintain the process atmosphere required by the thermal treatment or the thermal chemical processing in the furnace chamber.

[0090] Herein, the loading tool such as saggars 2 performs conveying by transporting tools such as rollers, pushers, or kiln carts. In order to increase production while considering the utilization of the process gas 18, the saggars on the transporting tools are arranged in two columns, with eight layers for each column. The kiln carts convey saggars 2 from the kiln head, and successively pass through the rising-temperature zone, the constant-temperature zone, and the cooling zone. During this process, the process gas 18 may be continuously injected and the exhaust gas may also be exhausted continuously, until the saggars 2 leave the kiln from the kiln tail and the calcination process is completed.

[0091] By using the continuous kiln proposed by the present disclosure, when performing the thermal treatment or the thermal chemical processing under the condition of high staking layers of the saggars 2, the concentration of the process gas 18 contacting with the calcinated materials in the lower saggars 2 can be increased, and the accumulation of the exhaust gas 44 in the lower saggars 2 can be reduced, so as to ensure the atmosphere consistency in the upper and lower saggars 2, and improve the consistency of product performance after calcination. In addition, through optional linkage control of the air-intake volume and the air-exhaust volume, stability of directional airflow is enhanced; and through staggered arrangement of the gas-injection device 202 and the gas-exhaust device 203 on the kiln wall on each side, it ensures that when a plurality of saggars 2 are stacked, the outermost saggar may face the gas-injection device 202 and the gas-exhaust device 203 with equal probability, and improves the consistency of the atmosphere of the saggars on two sides.

[0092] It should be noted that, although in the present disclosure, the continuous kiln is proposed for producing cathode materials of lithium-ion batteries by calcination, however, this does not mean that the present disclosure is intended to limit its use to this purpose only. Optionally, the continuous kiln may also be used to burn other ceramic materials or other alloy materials and so on.

[0093] The above descriptions are only examples of the present disclosure, and are not intended to limit the

present disclosure. For those skilled in the art, the present disclosure may have various modifications and changes. Any modification, equivalent replacement, improvement, etc. made within the spirit and principle of the present disclosure shall be included within the protection scope of the present disclosure.

INDUSTRIAL APPLICABILITY

[0094] The continuous kiln and thermal treatment or the thermal chemical processing method in the present disclosure may make the concentration of the process gas in the continuous kiln evenly distributed, so that the calcined materials may contact the process gas uniformly and consistently, so as to improve the consistency of product performance after calcination.

Claims

1. A continuous kiln, **characterized in that** it comprises:

   a kiln, provided with a furnace chamber extending along a first direction from a furnace head to a furnace tail;
   an airflow supplying and exhausting device, configured for forming a directional airflow in the furnace chamber, wherein the directional airflow is capable of flowing along a second direction from a furnace wall on one side to a furnace wall on the other side of the kiln, the airflow supplying and exhausting device is provided with a supplying and exhausting set, wherein the supplying and exhausting set is provided with air-supply nozzles and air-exhaust nozzles, wherein the air-supply nozzles and the air-exhaust nozzles are connected to the furnace walls and are matched and arranged opposite to each other, and the air-supply nozzles and the air-exhaust nozzles are arranged along a third direction from a furnace top to a furnace bottom of the kiln; and
   an airflow control device, which is matched and connected to the airflow supplying and exhausting device, so as to be able to control the air-supply nozzles and the air-exhaust nozzles.

2. The continuous kiln according to claim 1, wherein the furnace wall is provided with a gas distributor at a position where the air-supply nozzles are connected, and the air-supply nozzles connect with an air chamber of the gas distributor.

3. The continuous kiln according to claim 1 or 2, wherein the furnace wall is provided with a suction port at a position where the air-exhaust nozzle are connected, the suction port is arranged along the third direction, and the air-exhaust nozzles connect with the suction port.

4. The continuous kiln according to claim 3, wherein the suction port is in a long-narrow shape.

5. The continuous kiln according to claim 4, wherein a cross section of the suction port is in a rectangular shape or an elliptical shape.

6. The continuous kiln according to any one of claims 3-5, wherein the continuous kiln comprises saggars configured for containing materials, wherein side walls of the saggars are formed with gaps, the gaps constitute channels for directional air to pass through the saggars, and the gaps face the suction port and the air-supply nozzles, respectively.

7. The continuous kiln according to claim 6, wherein openings of the air-supply nozzles are close to the gaps.

8. The continuous kiln according to claim 1, wherein the continuous kiln comprises a detecting device, and the detecting device comprises a furnace-pressure sensor and/or a gas-concentration sensor configured for detecting the kiln.

9. The continuous kiln according to claim 8, wherein the detecting device comprises a pressure sensor and/or a flow sensor, wherein one or both of the air-exhaust nozzles and the air-supply nozzles are matched and provided with the pressure sensor and/or the flow sensor.

10. The continuous kiln according to claim 9, wherein the detecting device further comprises a temperature sensor.

11. The continuous kiln according to any one of claims 8 to 10, wherein the airflow control device comprises an air-supply valve and air-exhaust valves, wherein the air-supply valve is matched and connected with the air-supply nozzles, the air-exhaust valves are connected to the air-exhaust nozzles, and the air-supply valve and the air-exhaust valves are configured to be controlled in response to the detecting device.

12. The continuous kiln according to claim 11, wherein the airflow control device is configured to be capable of controlling the air-supply nozzles and the air-exhaust nozzles in linkage, so as to control an air-intake volume and an air-exhaust volume in the kiln in linkage.

13. The continuous kiln according to claim 11 or 12, wherein both the air-supply valves and the air-exhaust valves are proportional solenoid valves.

14. The continuous kiln according to any one of claims 1 to 13, wherein all the air-exhaust nozzles in the supplying and exhausting set are located at the furnace wall on one side, and all the air-supply nozzles in the supplying and exhausting set are located at the furnace wall on the other side; or

the furnace wall on one side and the furnace wall on the other side are both provided with the air-exhaust nozzles and the air-supply nozzles; and in the third direction, the air-exhaust nozzles and the air-supply nozzles at the furnace wall on the same side are alternately arranged at intervals; or

a plurality of the airflow supplying and exhausting devices are arranged in the first direction, the air-supply nozzles of the same airflow supplying and exhausting device are located at one of the furnace walls, and the air-exhaust nozzles are located at the other furnace wall, wherein in the first direction, the air-exhaust nozzles and the air-supply nozzles of two adjacent airflow supplying and exhausting devices are alternately arranged at intervals.

15. The continuous kiln according to any one of claims 1 to 14, wherein the continuous kiln comprises heaters, and the heaters are connected to the kiln.

16. The continuous kiln according to claim 15, wherein the heaters are arranged along the third direction and are connected to the furnace walls of the kiln.

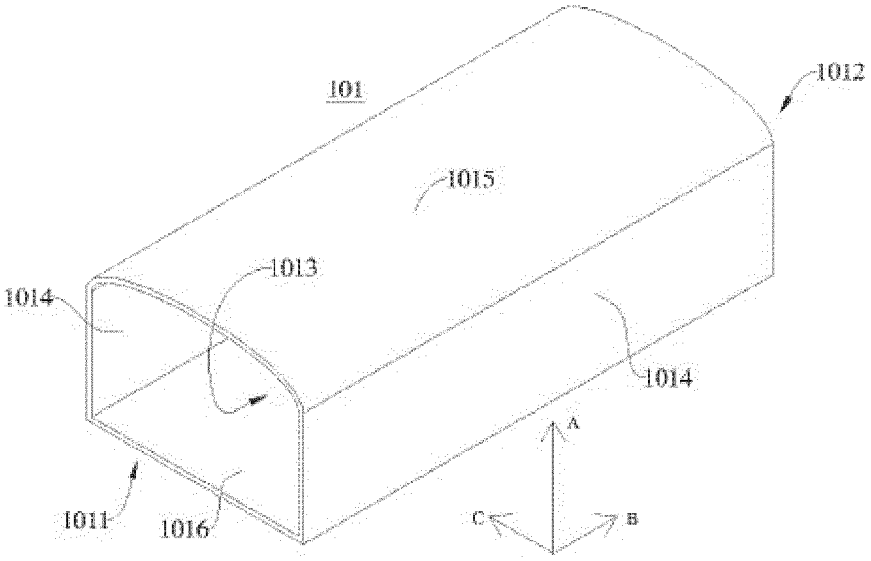
17. The continuous kiln according to claim 16, wherein the air-supply nozzle or the air-exhaust nozzle is provided between the two adjacent heaters.

18. The continuous kiln according to claim 16 or 17, wherein the furnace walls on two sides of the kiln are both connected with the heaters, and the heaters connected to the furnace wall on one side is in a number which is equal to that of the heaters connected to the furnace wall on the other side.

19. A thermal treatment or a thermal chemical processing method, **characterized in that** it is implemented by the continuous kiln according to any one of claims 1 to 18, wherein, the thermal treatment or the thermal chemical treatment method comprises:

heating the furnace chamber of the kiln to a temperature required for the thermal treatment or the thermal chemical processing method; and

conveying an object to be thermal-treated or to be thermal-chemical-processed in the furnace chamber along the first direction by a loading tool, wherein during the conveying process, process gas is supplied to the furnace chamber by the airflow supplying and exhausting device under control of the airflow control device, and the gas is exhausted from the furnace chamber by the airflow control device synchronously, so as to maintain a process atmosphere of the thermal treatment or the thermal chemical processing in the furnace chamber.


101
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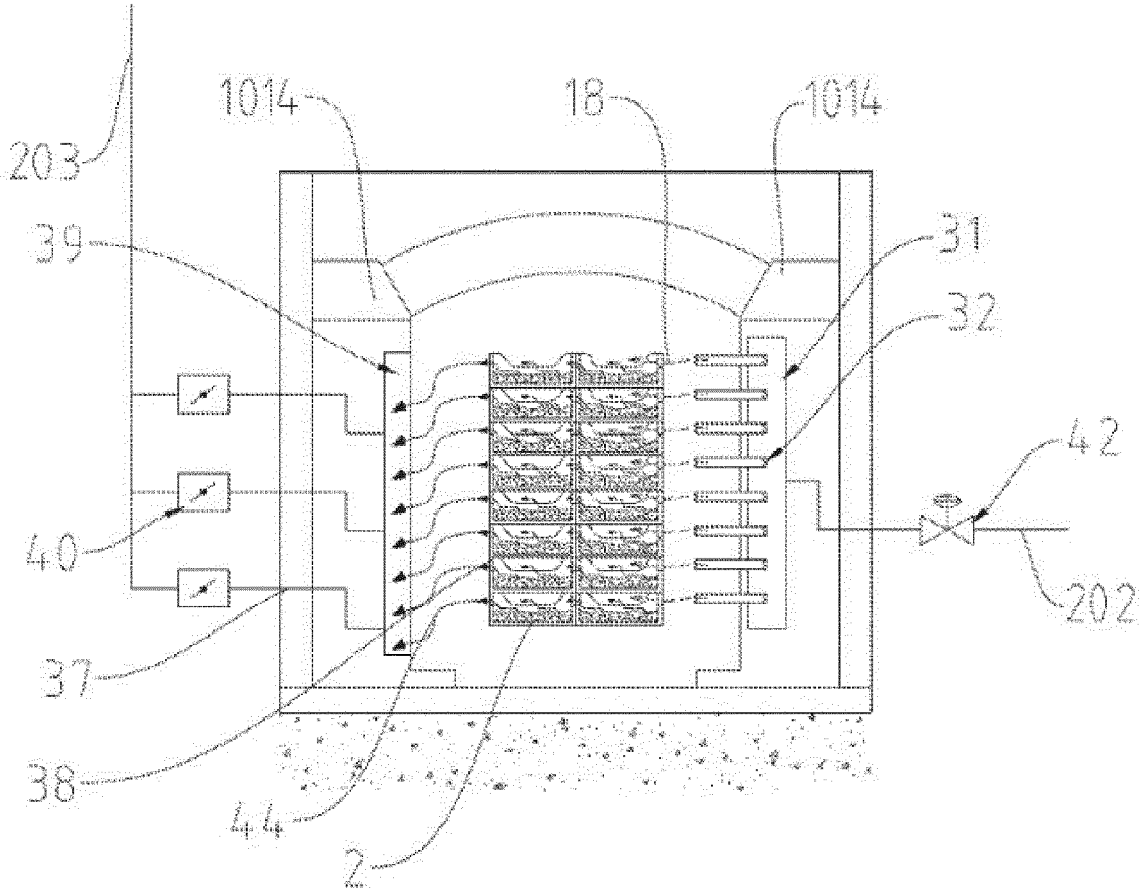
1015
1013
1014
1014
A
C
B
1011
1016

FIG. 1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202
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44
2

FIG. 2

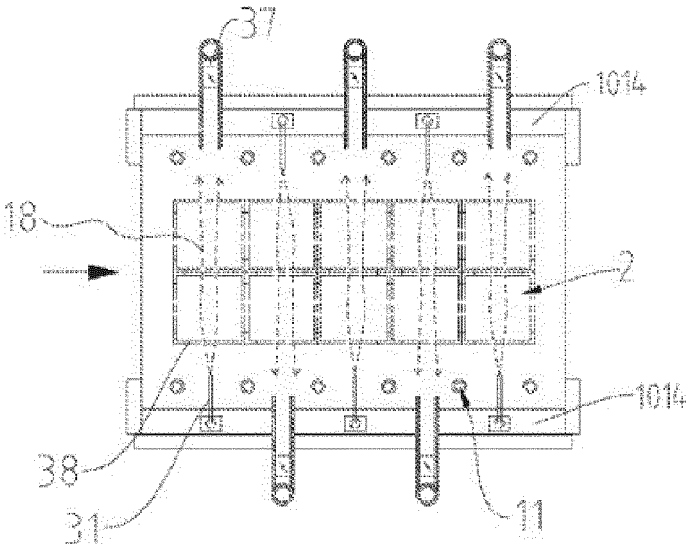

FIG. 3

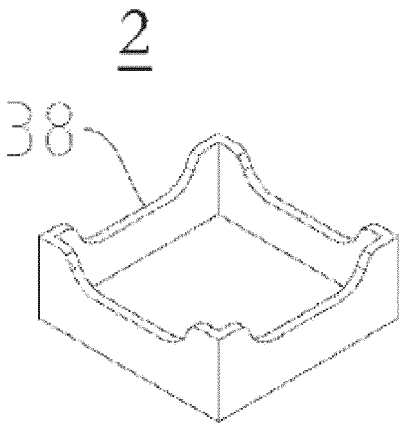

FIG. 4

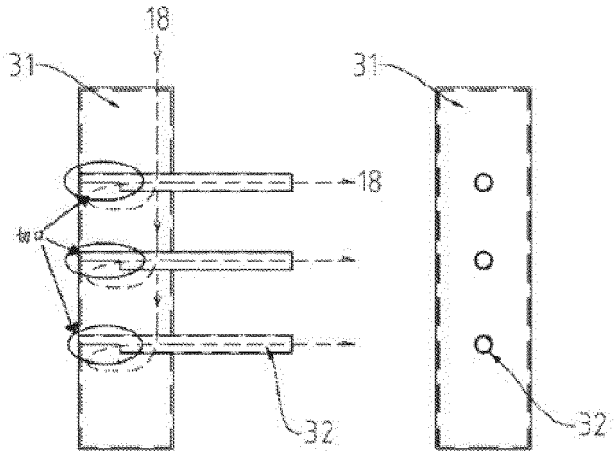

FIG. 5

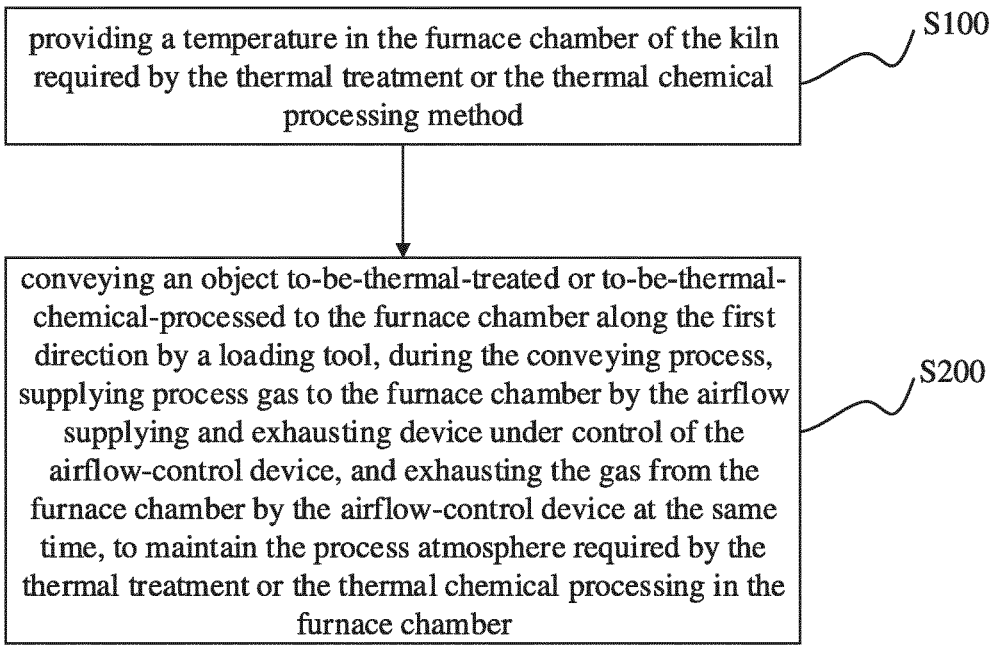
providing a temperature in the furnace chamber of the kiln required by the thermal treatment or the thermal chemical processing method
S100
conveying an object to-be-thermal-treated or to-be-thermal-chemical-processed to the furnace chamber along the first direction by a loading tool, during the conveying process, supplying process gas to the furnace chamber by the airflow supplying and exhausting device under control of the airflow-control device, and exhausting the gas from the furnace chamber by the airflow-control device at the same time, to maintain the process atmosphere required by the thermal treatment or the thermal chemical processing in the furnace chamber
S200

FIG. 6

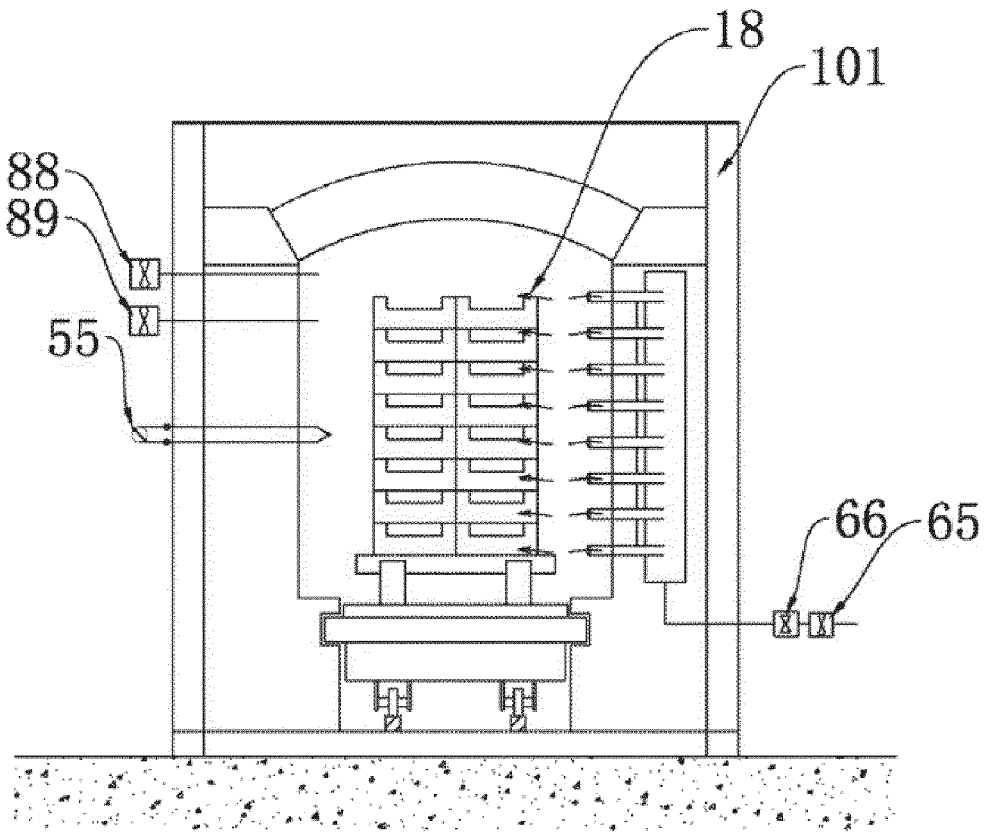
18
101
88
89
55
66
65

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2021/106417

A. CLASSIFICATION OF SUBJECT MATTER

F27B 9/04(2006.01)i; F27B 9/26(2006.01)i; F27B 9/30(2006.01)i; F27B 9/36(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)

F27B

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)

DWPI; SIPOABS; CNABS; CNTXT; USTXT; ISI WEB of Science; 中国期刊网全文数据库: 信诺先端热工科技（苏州）有限公司, 王霞, 吴桢, 连续窑, 辊道窑, 推板窑, 隧道窑, 窑炉, 窑, 炉墙, 炉腔, 炉体, 侧壁, 侧面, 进气, 入气, 送气, 吸气, 排气, 抽气, 出气, 对置, 相对, 气流, 稳定, 定向, 温度, 压力, 浓度, 流量, 传感器, 匣钵, continuous kiln, chamber, push board kiln, pushed-bat kiln, kiln, tunnel kiln, roller kiln, wall, body, side wall, air intake, inlet, outlet, inflow, suction, exhaust, vent, correspond+ arranged, opposite, airflow, airstream, direction+, temperature, pressure, concentration, sensor, saggar, sagger

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 112414112 A (WANG, Xia et al.) 26 February 2021 (2021-02-26) entire document	1-19
A	CN 209166115 U (NGK TECHNOCERA SUZHOU CO., LTD.) 26 July 2019 (2019-07-26) description, paragraphs 25-38, figures 1-2	1-19
A	CN 209926846 U (SUZHOU YUNXIGU INTELLIGENT SYSTEM EQUIPMENT CO., LTD.) 10 January 2020 (2020-01-10) entire document	1-19
A	CN 211626062 U (HUNAN GOLD FURNACE SCIENCE & TECHNOLOGY CO., LTD.) 02 October 2020 (2020-10-02) entire document	1-19
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☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
26 September 2021	**12 October 2021**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China**	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2021/106417

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 105783507 A (GEM (WUXI) ENERGY MATERIAL CO., LTD.) 20 July 2016 (2016-07-20) entire document	1-19
A	CN 111578697 A (GUANGDONG ZHONGPENG XINNENG TECHNOLOGY CO., LTD.) 25 August 2020 (2020-08-25) entire document	1-19
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INTERNATIONAL SEARCH REPORT
Information on patent family members

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Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 112414112 A	26 February 2021	None	
CN 209166115 U	26 July 2019	None	
CN 209926846 U	10 January 2020	None	
CN 211626062 U	02 October 2020	None	
CN 207365694 U	15 May 2018	None	
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CN 111578697 A	25 August 2020	None	
US 4291471 A	29 September 1981	None	

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REFERENCES CITED IN THE DESCRIPTION

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