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Rotary Kiln

Abstract

A rotary kiln for sintering raw material powder includes a sintering device provided with a tube assembly configured to mix the raw material powder and a heating assembly configured to heat the raw material powder that is mixed by the tube assembly. Moreover, the rotary kiln includes a supply device provided with a supply assembly inserted into one end of the tube assembly to supply the raw material powder into the tube assembly and a collecting assembly provided on one end of the tube assembly to collect a gas and vapor, which are generated while heating the raw material powder. Additionally, the rotary kiln includes a condensing device configured to condense the vapor collected in the collecting assembly to liquefy the vapor into a liquid state. As a result, the vapor generated in the tube assembly may be smoothly removed.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] The present application is a national phase entry under 35 U.S. C. § 371 of International Application No. PCT/KR2023/006103 filed on May 4, 2023, which claims priority to Korean Patent Application No. 10-2022-0057238, filed on May 10, 2022, which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD
[0002] The present disclosure relates to a rotary kiln capable of collecting vapor generated during heating of raw material powder to condense the vapor into a liquid state so as to remove the condensate.
BACKGROUND
[0003] In general, unlike primary batteries, which are not chargeable, secondary batteries refer to batteries which are chargeable and dischargeable. Secondary batteries are widely used in high-tech electronic devices such as mobile phones, notebook computers, and camcorders.
[0004] Particularly, as the technological development of, and demand for, mobile devices increase, the demand for secondary batteries as energy sources is also rapidly increasing. Among these secondary batteries, lithium secondary batteries having high energy density and voltage, long cycle life, and low self-discharge rate has been commercialized and widely used.
[0005] In lithium secondary batteries, lithium transition metal oxide is used as a positive electrode active material. That is, lithium cobalt oxide having a high operating voltage and excellent capacity characteristics, lithium nickel oxide having a high reversible capacity of about 200 mAh/g and which is easy to implement in large-capacity batteries, lithium nickel cobalt oxide in which a portion of nickel is substituted with cobalt, lithium nickel cobalt metal oxide in which a portion of nickel is substituted with manganese, cobalt or aluminum, low-cost lithium manganese oxide having excellent thermal stability, lithium iron phosphate having excellent stability, and the like are being used as the positive electrode active material.
[0006] The positive electrode active material is prepared by mixing a precursor for producing the positive electrode active material with the lithium raw material and then putting the mixture into a heating device to perform sintering at a high temperature.
[0007] Here, a rotary kiln may be applied as the heating device. The rotary kiln includes a rotating tube accommodating a precursor for producing a positive electrode active material and a lithium raw material (hereinafter, referred to as a raw material powder) which rotates the above-described materials in a horizontal direction to mix the materials, a heating body provided outside the rotating tube which applies heat to the rotating tube to heat the raw material powder so that the raw material powder reacts, a supply member which supplies the raw material powder to the rotating tube, and a collecting member which collects the raw material powder discharged from the rotating tube.
[0008] The raw material powder contains moisture. That is, when the raw material powder is heated, moisture is evaporated to generate vapor. Here, it is necessary to smoothly discharge and remove the vapor generated inside the rotating tube to smoothly mix and dry the raw material powder.
Technical Problem
[0009] An object of the present disclosure is to provide a rotary kiln capable of collecting vapor

generated during heating of raw material powder outside a rotating tube to condense the vapor into a liquid state so as to remove the condensate.

Technical Solution

[0010] A rotary kiln for sintering raw material powder according to the present disclosure includes: a sintering device provided with a tube assembly configured to mix the raw material powder while rotating in a state of being disposed in a horizontal direction and a heating assembly configured to heat the raw material powder that is mixed by the tube assembly; a supply device provided with a supply assembly inserted into one end of the tube assembly to supply the raw material powder into the tube assembly and a collecting assembly provided on one end of the tube assembly to collect a gas and vapor, which are generated while heating the raw material powder supplied into the tube assembly; and a condensing device configured to condense the vapor collected in the collecting assembly to liquefy the vapor into a liquid state.

[0011] The collecting assembly may include a chamber connected to one end of the tube assembly to collect the gas and vapor which are discharged from the tube assembly. The condensing device may include a condensing tube provided inside the chamber to condense the vapor collected into the chamber via a refrigerant so as to liquefy the vapor into the liquid state, a supply part configured to supply the refrigerant into the condensing tube, and a collecting part configured to collect the refrigerant passing through the condensing tube.

[0012] The condensing device may further include: a fixing plate, on which the condensing tube is installed; and one or more condensing plates connected to the condensing tube to diffuse cold air transferred from the condensing tube so that the vapor is condensed, wherein the condensing plate may be provided to be elongated in a vertical direction that is perpendicular to a longitudinal direction of the tube assembly.

[0013] The fixing plate may be made of the same material as the condensing plate.

[0014] The supply assembly may include: an input tube which is inserted into one end of the tube assembly and into which the raw material powder is put; and a transfer screw provided in the input tube and configured to move the raw material powder toward the tube assembly while rotating so as to supply the raw material powder to the tube assembly, wherein the condensing device may be installed close to the input tube.

[0015] The condensing device may further include a blocking plate provided in the input tube disposed at one end of the tube assembly to block an inflow of the condensed liquid into the tube assembly.

[0016] The blocking plate may have a disk shape surrounding an outer circumferential surface of the input tube.

[0017] The blocking plate may be provided to be position-adjustable in a longitudinal direction of the input tube.

[0018] The condensing device may further include a hopper provided in a bottom surface of the chamber, configured to collect a liquid dropping from the condensing device and a liquid dropping from the blocking plate so as to discharge the liquids to the outside.

[0019] The collecting assembly may further include a protection member configured to seal a gap between an end of the tube assembly and the chamber, wherein the protection member may include: a fixed tube fixed to the chamber; a support tube supported on an outer circumferential surface of the tube assembly; and a connection tube provided in the form of a corrugated tube to connect the fixed tube to the support tube.

[0020] The rotary kiln may further include a collecting member configured to collect the raw material powder discharged from the tube assembly.

[0021] The condensing tube may be provided in a ‘U’ shape, and the supply part and the collecting part may be connected to both ends of the condensing tube provided in the ‘U’ shape to protrude to the outside of the chamber, respectively.

Advantageous Effects

[0022] The rotary kiln of the present disclosure may include the sintering device, the supply device, and the condensing device to collect the vapor generated during the heating of the raw material powder and condense the vapor into the liquid state so as to remove the condensate. Particularly, defective operation of the supply device due to the vapor may be prevented.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] FIG. **1** is a front elevation view illustrating a rotary kiln according to a first embodiment of the present invention.

[0024] FIG. **2** is an enlarged view of a portion 'A' illustrated in FIG. **1**.

[0025] FIG. **3** is a cross-sectional view taken along line B-B of FIG. **1**.

[0026] FIG. **4** is an enlarged view of a portion 'C' illustrated in FIG. **1**.

[0027] FIG. **5** is an enlarged view of a portion 'D' illustrated in FIG. **1**.

[0028] FIG. **6** is an enlarged view illustrating a protection member of a collecting device according to the present disclosure.

[0029] FIG. **7** is a cross-sectional view of a rotary kiln according to a second embodiment of the present invention.

DETAILED DESCRIPTION

[0030] Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings in such a manner that the technical idea of the present disclosure may easily be carried out by a person with ordinary skill in the art to which the disclosure pertains. The present disclosure may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. In the drawings, anything unnecessary for describing the present disclosure will be omitted for clarity, and also like reference numerals in the drawings denote like elements.

Rotary Kiln According to First Embodiment of the Present Invention

[0031] A rotary kiln according to a first embodiment of the present invention has a structure capable of collecting vapor generated when raw material powder is heated and then condensing the collected vapor into a liquid state to remove the condensate. Thus, the vapor generated inside the rotary kiln may be smoothly removed, and as a result, the raw material powder may be stably mixed and dried.

[0032] Hereinafter, the rotary kiln according to the first embodiment of the present invention will be described in detail with reference to the accompanying drawings.

[0033] FIG. **1** is a front elevation view illustrating a rotary kiln according to a first embodiment of the present invention, FIG. **2** is an enlarged view of a portion 'A' illustrated in FIG. **1**, and FIG. **3** is a cross-sectional view taken along line B-B of FIG. **1**.

[0034] The rotary kiln according to the first embodiment of the present invention is configured to sinter raw material powder and includes a sintering device **100**, a supply device **200**, a condensing device **300**, and a collecting device **400**.

Sintering Device

[0035] The sintering device **100** includes a tube assembly **110** that mixes the raw material powder while rotating in a state of being disposed in a horizontal direction and a heating assembly **120** that heats the raw material powder mixed by the tube assembly **110**.

[0036] The tube assembly **110** has a structure extending in the horizontal direction and has a double structure including an outer tube **111** and an inner tube **112** provided inside the outer tube **111**. In addition, the tube assembly **110** is made of a metal material having excellent thermal conductivity. For example, the tube assembly **110** may be made of a nickel material.

[0037] The tube assembly **110** having such a structure may smoothly mix the input raw material

powder while rotating in the horizontal direction.
[0038] The heating assembly **120** is configured to heat the raw material powder put into the tube assembly **110**.
[0039] For example, the heating assembly **120** may be disposed in a shape surrounding an outer circumferential surface of the tube assembly **110** and may heat the raw material powder put into the tube assembly **110** as the outside of the tube assembly **110** is heated.
[0040] That is, the heating assembly **120** includes a heating body **121** provided in a shape surrounding an outer surface of the tube assembly **110** and a heating medium **122** provided in the heating body **121** corresponding to the tube assembly **110** to heat the tube assembly **110**.
[0041] Here, the heating medium may be any one of an electric heat generation element, SIC, Mo—Si, and a gas burner.
[0042] The outer surface of the heating body **121** is made of a heat-resistant material so that the heat source of the heating medium **122** is not discharged to the outside.
[0043] The heating assembly **120** having such a structure may smoothly heat the raw material powder mixed by the tube assembly **110**.
[0044] The sintering device **100** includes a support member **130** configured to support the tube assembly **110** to rotate in the horizontal direction.
[0045] The support member includes a rotary gear **131** provided in a shape surrounding the outer circumferential surface of the tube assembly **110** and a support **132** provided with a support gear **132***a* that is engaged with each of both sides of a bottom surface of the rotary gear **131** to support the rotary gear **131** and be rotated by the rotary gear **131**.
[0046] That is, in the support member **130**, when the tube assembly **110** rotates, the rotary gear **131** rotates by being interlocked with the tube assembly **110**, and the support gear **132***a* rotates by the rotary gear **131**. Here, since the support gear **132***a* supports both sides of a lower portion of the rotary gear **131**, the tube assembly **110** rotating in the horizontal direction may be stably supported.
[0047] The sintering device **100** includes a rotating member **140** configured to rotate the tube assembly **110** in the horizontal direction. The rotating member **140** includes a driving gear **141** coupled to surround the outer circumferential surface of the tube assembly **110** and a driving motor **142** engaged with the driving gear **141** to rotate the tube assembly **110** in the horizontal direction through the driving gear **141**.
Supply Device
[0048] The supply device **200** is configured to supply the raw material powder to the tube assembly and includes a supply assembly **210** and a collecting assembly **220**.
[0049] The supply assembly **210** has a structure for supplying the raw material powder into the tube assembly **110** while being inserted into one end (a left end of the tube assembly when viewed in FIG. **1**) of the tube assembly **110**.
[0050] That is, the supply assembly **210** includes an input tube **211** which is inserted into one end of the tube assembly **110** and into which the raw material powder is put. Furthermore, the supply assembly **210** includes a transfer screw **212** provided inside the input tube **211** to move the raw material powder to the tube, in the direction of the tube assembly **110**, during the rotation so as to supply the raw material powder to the tube assembly **110**.
[0051] Here, the input tube **211** may be provided with an inlet, through which the raw material powder is input, at one end thereof and an outlet, through which the raw material powder is discharged through the tube assembly **110**, at the other end thereof.
[0052] The collecting assembly **220** is provided at one end of the tube assembly **110** and has a structure for collecting a gas and vapor generated when heating the raw material powder supplied to the inside of the tube assembly **110**. That is, the collecting assembly **220** has a structure for collecting a gas and vapor discharged from one end of the tube assembly **110**.
[0053] For example, the collecting assembly **220** includes a chamber **221** provided in a shape surrounding one end of the tube assembly **110** which collects the gas and vapor discharged from the

tube assembly **110** and a protection member **222** that seals a gap between one end of the tube assembly **110** and the chamber **221**.

[0054] FIG. **4** is an enlarged view of a portion C illustrated in FIG. **1**.

[0055] Here, the protection member **222** includes a fixed tube **222***a* fixed to the chamber **221**, a support tube **222***b* supported on the outer circumferential surface of the tube assembly **110**, and a connection tube **222***c* having a shape of a corrugated tube to connect the fixed tube **222***a* to the support tube **222***b*. Thus, the protection member may protect the gap between the tube assembly **110** and the chamber **221** from the outside.

Condensing Device

[0056] The condensing device **300** is configured to condense the vapor collected in the chamber **221** of the collecting assembly **220** to liquefy the vapor into a liquid state.

[0057] That is, the condensing device **300** includes a condensing tube **310** provided inside the chamber **221** to condense the vapor collected in the chamber **221** through a supplied refrigerant so as to liquefy the condensed vapor, a supply part **320** supplying the refrigerant to the condensing tube **310**, and a collecting part **330** collecting the refrigerant passing through the condensing tube **310**.

[0058] In the condensing device **300** having such a structure, when the refrigerant is supplied to the condensing tube **310** through the supply part **320**, cold air may be diffused into the chamber **221** through the condensing tube **310** to condense the vapor collected in the chamber **221**, and thus, the vapor may be liquefied into the liquid state, and as a result, the vapor may be effectively removed. The refrigerant passing through the condensing tube **310** is collected through the collecting part **330**.

[0059] Here, the condensing tube **310** is made of a metal material, and preferably, the condensing tube **310** may be made of a copper material.

[0060] The condensing tube **310** may be provided in a zigzag-bent form. This may increase the residence time of the refrigerant passing through the condensing tube **310**, and as a result, the vapor may be condensed more effectively. For example, the condensing tube **310** may be provided in a 'U' or 'L' shape.

[0061] When the condensing tube **310** has the 'U' shape, the supply part **320** and the collecting part **330** are connected to both ends of the 'U'-shaped condensing tube **310**, respectively. Particularly, the supply part **320** and the collecting part **330** may be provided to protrude out of the chamber **221**, and thus, a refrigerant generator (not shown), the supply part **320**, and the collecting part **330** may be easily connected or separated to improve work efficiency.

[0062] When the vapor is condensed in the input tube **211** of the supply assembly **210**, conduction of heat applied to the transfer screw **212** is blocked, and as a result, smooth operation of the transfer screw **212** may be difficult. To prevent this problem, the condensing tube **310** of the condensing device **300** may be installed close to the input tube **211**. Thus, the condensing tube **310** may condense the vapor before condensing the vapor in the input tube **211**, and as a result, the smooth operation of the transfer screw **212** may be maintained.

[0063] The condensing tube **310** may be spaced a set distance from the input tube **211**. That is, when the condensing tube **310** is in close contact with the inlet tube **211**, frictional noise may occur, and the liquid condensed in the condensing tube **310** may flow into the outer circumferential surface of the inlet tube **211**.

[0064] The condensing device **300** may include a fixing plate **340** on which the condensing tube **310** is installed. The fixing plate **340** has a rectangular plate shape and is fixed inside the chamber **221** using a fixing means, and the condensing tube **310** is fixed to one surface of the fixing plate **340** by welding or clipping.

[0065] The condensing device **300** may include one or more condensing plates **350** that improve condensing power of the vapor. The condensing plate **350** is connected to the condensing tube **310** to diffuse the cold air transferred from the condensing tube **310** into the chamber **221**, thereby

effectively condensing the vapor collected in the chamber **221**. Particularly, referring to FIG. **2**, the condensing plate **350** may be provided to be elongated in a vertical direction that is perpendicular to the longitudinal direction of the tube assembly **110**. Particularly, the condensing plate **350** may be provided in at least two or more, preferably four or more. Thus, the liquid condensed on the condensing plate **350** may smoothly drop to be removed.

[0066] The fixing plate **340** may be made of the same material as the condensing plate **350**. In other words, the condensing tube **310**, the fixing plate **340**, and the condensing plate **350** may be made of the same material, and thus, the vapor may be condensed through the fixing plate **340**, and as a result, the vapor may be condensed more quickly to be removed.

[0067] The condensing device **300** further includes a blocking plate **360** provided to the input tube **211** disposed at one end of the tube assembly **110**.

[0068] That is, the blocking plate **360** may block the condensed liquid from flowing into the tube assembly **110** along the input tube **211** thereby preventing the liquid from being mixed with the raw material powder supplied to the tube assembly **110**.

[0069] Particularly, the blocking plate **360** may be provided in a shape surrounding an outer circumferential surface of the input tube **211**. For example, the blocking plate **360** may have a disk shape as illustrated in FIG. **3**. Thus, the entire outer circumferential surface of the input tube **211** may be stably covered. Referring to FIG. **7**, a rubber pad **361** may be further provided between the input tube **211** and the blocking plate **360** to increase in sealing power.

[0070] Here, one blocking plate **360** may be provided on the outer circumferential surface of the input tube **211**, but two or more blocking plates **360** may be provided in the input tube **211** to stably block the penetration of the liquid. Particularly, when the two or more blocking plates **360** are provided in the input tube **211**, one blocking plate **360** corresponding to the tube assembly **110** may be made of a heat-resistant material to prevent the blocking plate from being damaged by the heat of the tube assembly **110**.

[0071] The condensing device **300** may include the refrigerant generator (not shown) that supplies the refrigerant to the supply part **320** and collects the refrigerant passing through the collecting part **330**. The refrigerant generator may be applied to any device that normally generates the refrigerant.

[0072] The condensing device **300** may include a hopper **370** that discharges the liquid condensed inside the chamber **221** to the outside. The hopper **370** is provided on the bottom surface of the chamber **221**, and after collecting the liquid falling from the condensing device **300** and the liquid falling from the blocking plate **360**, the liquid is discharged to the outside through the connection tube which maybe elongated.

[0073] Here, the hopper **370** may be provided at a lower portion of the condensing device **300** and below the blocking plate **360** and may be provided to cover the entire lower portion of the condensing device **300** and the entire lower side of the blocking plate **360**.

[0074] The condensing device **300** having such a structure may quickly and smoothly condense the vapor collected inside the chamber **221** to liquefy the vapor into a liquid state. Moreover, the condensing device **300** may smoothly discharge the condensed liquid to the outside to remove the liquid. Particularly, the condensing device **300** may prevent the condensation of the vapor in the supply assembly **210** which thereby prevents malfunctions from occurring in advance.

Collecting Device

[0075] FIG. **5** is an enlarged view of a portion D illustrated in FIG. **1**.

[0076] The collecting device **400** has a structure that collects the raw material powder discharged from the tube assembly **110**.

[0077] That is, the collecting device **400** includes a collecting member **410** into which the other end of the tube assembly **110** (a right end of the tube assembly **110** when viewed in FIG. **1**) is freely rotatably inserted. The collecting member **410** collects the raw material powder discharged from the tube assembly **110** to move the raw material powder to a set place so as to store the raw material powder.

[0078] Here, the collecting member **410** may be provided to be separable from the other end of the tube assembly **110**, and thus, the other end of the tube assembly **110** and the collecting member **410** may be more easily maintained.
[0079] The collecting member **410** and the other end of the tube assembly **110** may be maintained to be spaced a set interval from each other. Thus, a heat source of the tube assembly **110** may be prevented from being directly conducted to the collecting member **410**.
[0080] The collecting device **400** may include a gas discharge member **420** that discharges a gas inside the tube assembly **110**, and the gas discharge member **420** may be provided on an upper end of the collecting member **410**. That is, the gas discharge member **420** filters the gas collected in the collecting member **410** from the tube assembly **110** and then discharges only air without impurities to the outside.
[0081] FIG. **6** is an enlarged view illustrating a protection member of the collecting device according to the present disclosure.
[0082] The collecting device **400** may include a protection member **430** that connects the collecting member **410** to the tube assembly **110** to form a seal. The protection member **430** includes a fixed tube **431** fixed to the collecting member **410**, a support tube **432** supported at the other end of the tube assembly **110**, and a connection tube **433** that is provided in the form of a corrugated tube to connect the fixed tube to the support tube.
[0083] Therefore, the rotary kiln according to the first embodiment of the present invention includes the sintering device **100**, the supply device **200**, and the condensing device **300** to smoothly collect the vapor generated in the tube assembly **110** and then smoothly condense the collected vapor, thereby removing the condensed vapor.
[0084] Hereinafter, an operation of the rotary kiln according to the first embodiment of the present invention will be described.

Operation Method of Rotary Kiln According to First Embodiment of the Present Invention

[0085] First, a tube assembly **110** of a sintering device **100** rotates in a horizontal direction. Then, the tube assembly **110** is heated to a set temperature using a heating assembly **120** and then is maintained at the set temperature.
[0086] When the tube assembly **110** is maintained at the set temperature, raw material powder is supplied to one end of the tube assembly **110** through a supply assembly **210** of a supply device **200**. Then, the raw material powder is mixed and heated at the same time by the heated tube assembly **110**. Particularly, the raw material powder moves a little in a direction of the other end of the tube assembly **110**.
[0087] Here, a gas and vapor are generated when the raw material powder is heated, and the gas and vapor are collected in a chamber **221** of a collecting assembly **220** through one end of the tube assembly **110**.
[0088] Here, the condensing device **300** is provided inside the chamber **221**, and the condensing device **300** may condense the vapor collected in the chamber **221** via a supplied refrigerant to liquefy the vapor into a liquid state. As a result, the vapor collected in the chamber **221** may be quickly and smoothly removed. Particularly, the condensing device **300** is provided with a condensing tube **310**, a fixing plate **340**, and a condensing plate **350** to more smoothly condense the vapor.
[0089] The liquid condensed by the condensing device **300** may be introduced into a hopper **370**, and the liquid introduced into the hopper **370** may be removed while being discharged to the outside through a discharge tube connected to the hopper **370**.
[0090] Hereinafter, in descriptions of another embodiment of the present invention, constituents having the same function as the above-mentioned embodiment have been given the same reference numerals in the drawings, and thus, duplicated descriptions will be omitted.

Rotary Kiln According to Second Embodiment of the Present Invention

[0091] FIG. **7** is a cross-sectional view of a rotary kiln according to a second embodiment of the

present invention.
[0092] A rotary kiln according to a second embodiment of the present invention corresponds to another embodiment of the blocking plate **360** of the configuration of the rotary kiln according to the forgoing first embodiment of the present invention.
[0093] That is, a blocking plate **360** of the rotary kiln according to the second embodiment of the present invention may be provided to be adjustable in position in a longitudinal direction of an input tube **211**.
[0094] That is, the blocking plate **360** may move in the longitudinal direction of the input tube **211**, and thus, be disposed close to one end of the tube assembly **110** or be disposed spaced a set distance from one end of the tube assembly **110**.
[0095] For example, the blocking plate **360** may include a blocking part **362** provided in a shape surrounding an outer circumferential surface of the input tube **211**, a fixing part **363** provided to be integrated with one surface of the blocking part **362**, and a fixing bolt **364** passing through the fixing part so as to be press-fitted into the input tube **211**. That is, the blocking plate **360** may be fixed to the input tube **211** by tightening the fixing bolt **364**, and the blocking plate **360** may move in the longitudinal direction of the input tube **211** by loosening the fixing bolt **364**.
[0096] Therefore, the rotary kiln according to the second embodiment of the present invention may be provided with the blocking plate **360**, which is adjustable in position in the longitudinal direction of the input tube **211**, to improve efficiency of use.
[0097] Accordingly, the scope of the present disclosure is defined by the appended claims more than the foregoing description and the exemplary embodiments described therein. Various modifications made within the meaning of an equivalent of the claims and within the claims are to be regarded as being within the scope of the present disclosure.
DESCRIPTION OF THE SYMBOLS
[0098] **100**: Sintering device [0099] **110**: Tube assembly [0100] **111**: Outer tube [0101] **112**: Inner tube [0102] **120**: Heating assembly [0103] **121**: Heating body [0104] **122**: Heating medium [0105] **130**: Support member [0106] **131**: Rotary gear [0107] **132**: Support [0108] **132***a*: Support gear [0109] **140**: Rotating member [0110] **141**: Driving gear [0111] **142**: Driving motor [0112] **200**: Supply device [0113] **210**: Supply assembly [0114] **211**: Input tube [0115] **212**: Transfer screw [0116] **220**: Collecting assembly [0117] **221**: Chamber [0118] **222**: Protection member [0119] **222***a*: Fixed tube [0120] **222***b*: Support tube [0121] **222***c*: Connection tube [0122] **300**: Condensing device [0123] **310**: Condensing tube [0124] **320**: Supply part [0125] **330**: Collecting part [0126] **340**: Fixing plate [0127] **350**: Condensing plate [0128] **360**: Blocking plate [0129] **361**: Rubber pad [0130] **362**: Blocking part [0131] **363**: Fixing part [0132] **364**: Fixing bolt [0133] **370**: Hopper [0134] **400**: Collecting device [0135] **410**: Collecting member [0136] **420**: Gas discharge member [0137] **430**: Protection member

Claims

1. A rotary kiln for sintering raw material powder, the rotary kiln comprising: a sintering device provided with a tube assembly configured to mix the raw material powder while rotating in a state of being disposed in a horizontal direction and a heating assembly configured to heat the raw material powder that is mixed by the tube assembly; a supply device provided with a supply assembly inserted into one end of the tube assembly to supply the raw material powder into the tube assembly and a collecting assembly provided on the one end of the tube assembly to collect a gas and vapor, which are generated while heating the raw material powder supplied into the tube assembly; and a condensing device configured to condense the vapor collected in the collecting assembly to liquefy the vapor into a liquid state.
2. The rotary kiln of claim 1, wherein the collecting assembly comprises a chamber connected to the one end of the tube assembly to collect the gas and vapor, which are discharged from the tube

assembly, and the condensing device comprises a condensing tube provided inside the chamber to condense the vapor collected into the chamber via a refrigerant so as to liquefy the vapor into the liquid state, a supply part configured to supply the refrigerant into the condensing tube, and a collecting part configured to collect the refrigerant passing through the condensing tube.

3. The rotary kiln of claim 2, wherein the condensing device further comprises: a fixing plate, on which the condensing tube is installed; and one or more condensing plates connected to the condensing tube to diffuse cold air transferred from the condensing tube so that the vapor is condensed, wherein the one or more condensing plates are provided to be elongated in a vertical direction that is perpendicular to a longitudinal direction of the tube assembly.

4. The rotary kiln of claim 3, wherein the fixing plate is made of the same material as the condensing plate.

5. The rotary kiln of claim 2, wherein the supply assembly comprises: an input tube which is inserted into the one end of the tube assembly and into which the raw material powder is put; and a transfer screw provided in the input tube and configured to move the raw material powder toward the tube assembly while rotating so as to supply the raw material powder to the tube assembly, wherein the condensing device is installed close to the input tube.

6. The rotary kiln of claim 5, wherein the condensing device further comprises a blocking plate provided in the input tube disposed at the one end of the tube assembly to block an inflow of the condensed liquid into the tube assembly.

7. The rotary kiln of claim 6, wherein the blocking plate has a disk shape surrounding an outer circumferential surface of the input tube.

8. The rotary kiln of claim 6, wherein the blocking plate is provided to be position-adjustable in a longitudinal direction of the input tube.

9. The rotary kiln of claim 6, wherein the condensing device further comprises a hopper provided in a bottom surface of the chamber, configured to collect a liquid dropping from the condensing device and a liquid dropping from the blocking plate so as to discharge the liquids to the outside.

10. The rotary kiln of claim 2, wherein the collecting assembly further comprises a protection member configured to seal a gap between the one end of the tube assembly and the chamber, wherein the protection member includes: a fixed tube fixed to the chamber; a support tube supported on an outer circumferential surface of the tube assembly; and a connection tube provided in the form of a corrugated tube to connect the fixed tube to the support tube.

11. The rotary kiln of claim 1, further comprising a collecting member configured to collect the raw material powder discharged from the tube assembly.

12. The rotary kiln of claim 2, wherein the condensing tube is provided in a zigzag shape, and the supply part and the collecting part are connected to both ends of the condensing tube provided in the zigzag shape to protrude to the outside of the chamber, respectively.