EX 1008

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(54) [Title of Invention] Vacuum drying device, vacuum drying system, vacuum drying method and manufacturing method of battery electrodes

(57) [Abstract]

[Problem to be Solved] To complete vacuum drying in the optimal state.

[Means for Solving the Problem] The vacuum drying device 1 is equipped with a drying furnace 11, a pressure measurement section 12, a determination section 13, a vacuum drying control section 14, and a judgment section 15, and it performs vacuum drying on battery electrodes arranged inside the drying furnace 11. The pressure measurement section 12 measures the pressure inside the drying furnace 11. The determination section 13 determines whether the pressure measured by the pressure measurement section 12 is below the target pressure. The vacuum drying control section 14 continues the vacuum drying for a first period of time after it has been determined by the determination section 13 that the pressure measured by the pressure measurement section 12 is below the target pressure. The judgment section 15 concludes that the vacuum drying of the battery electrodes is complete when it is determined by the determination section 13 that the pressure measured by the pressure measurement section 12 is below the target pressure after the first period of time has elapsed.

[Selected representative diagram] Fig. 1



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[Scope of Patent Claims]

[Claim 1]

A vacuum drying device that performs vacuum drying on an object to be dried arranged in a drying furnace, comprising: a pressure measurement means for measuring the pressure inside the aforementioned drying furnace;

a determination means for determining whether the pressure measured by the aforementioned pressure measurement means has decreased to below or less than a predetermined target pressure;

a vacuum drying control means that continues vacuum drying for a predetermined first period of time after it has been determined by the aforementioned determination means that the pressure measured by the aforementioned pressure measurement means is below or less than the aforementioned target pressure; and

a judgment means that judges that the vacuum drying of the aforementioned object to be dried is complete when the pressure measured by the aforementioned pressure measurement means is determined by the aforementioned determination means to be below or less than the aforementioned target pressure after the aforementioned first period of time has elapsed. [Claim 2]

A vacuum drying device described in Claim 1, comprising a time-counting means for measuring the time since the start of the vacuum drying of the aforementioned object to be dried, wherein during the period until the time measured by the aforementioned time-counting means exceeds a predetermined second period of time, the determination by the aforementioned determination means is suspended.

[Claim 3]

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A vacuum drying device described in Claim 1 or 2, wherein if the environment in which the aforementioned object to be dried is placed after the completion of vacuum drying is referred to as the predetermined environment, the aforementioned target pressure is set lower than the saturation vapor pressure at the dew point in the aforementioned predetermined environment. [Claim 4]

A vacuum drying device described in Claim 3, wherein if the dew point (in degrees Celsius) in the aforementioned predetermined environment is denoted as t, and predetermined constants are denoted as a and b, the saturation vapor pressure e at the dew point in the aforementioned predetermined environment is determined using the following mathematical formula (1):

[Mathematical formula 1]

$$e = 6.1078 \times 10^{\overline{b+t}} \cdot \cdot \cdot (1)$$

[Claim 5]

A vacuum drying device described in Claim 3 or 4, wherein how much lower than the saturation vapor pressure at the dew point in the aforementioned predetermined environment the aforementioned target pressure is set is determined according to the material of the aforementioned object to be dried.

[Claim 6]

A vacuum drying device described in any one of Claims 1 to 5, wherein the aforesaid determination means performs abnormality detection of the aforementioned vacuum drying device based on the pressure measured by the aforementioned pressure measurement means, and if an abnormality is detected, outputs an indication of the abnormality. [Claim 7]

A vacuum drying device described in any one of Claims 1 to 6, wherein the objects to be dried are battery electrodes. [Claim 8]

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A vacuum drying system comprising a vacuum drying device according to any one of Claims 1 to 7, and a dry room where the aforementioned object to be dried is placed after the completion of vacuum drying by the aforementioned vacuum drying device, wherein after the vacuum drying of the aforementioned object to be dried is determined to be complete by the aforementioned judgment means, the object to be dried is transferred from the aforementioned drying furnace to the aforementioned dry room.

[Claim 9]

A vacuum drying method for performing vacuum drying on an object to be dried arranged in a drying furnace, comprising: a first step of measuring the pressure inside the aforementioned drying furnace;

a second step of determining whether the pressure measured in the aforementioned first step has decreased to below or less than a predetermined target pressure;

a third step of continuing vacuum drying for a predetermined first period of time after it is determined in the aforementioned second step that the pressure measured in the aforementioned first step is below or less than the aforementioned target pressure;

a fourth step of measuring the pressure inside the aforementioned drying furnace after the aforementioned first period of time has elapsed;

a fifth step of determining whether the pressure measured in the aforementioned fourth step has decreased to below or less than the aforementioned target pressure;

a sixth step of determining that the vacuum drying of the aforementioned object to be dried is complete when the pressure measured in the aforementioned fourth step is determined in the aforementioned fifth step to be below or less than the aforementioned target pressure; and

a seventh step of transferring the object to be dried, which is judged to have completed vacuum drying in the aforementioned sixth step, from the aforementioned drying furnace to an area adjusted to a predetermined environment. [Claim 10]

The vacuum drying method described in Claim 9, further comprising an eighth step of measuring the time since the start of vacuum drying of the aforementioned object to be dried, wherein during the period until the time measured in the aforementioned eighth step exceeds a predetermined second period of time, the determination in the aforementioned second step is suspended.

[Claim 11]

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The vacuum drying method described in Claim 9 or 10, wherein the aforementioned target pressure is set lower than the saturation vapor pressure at the dew point in the aforementioned predetermined environment.

[Claim 12]

The vacuum drying method described in Claim 11, wherein if the dew point (in degrees Celsius) in the aforementioned predetermined environment is denoted as t, and predetermined constants are denoted as a and b, the saturation vapor pressure e at the dew point in the aforementioned predetermined environment is determined using the following mathematical formula (2):

[Mathematical formula 2]

$$e = 6.1078 \times 10^{\overline{b+t}} \cdot \cdot \cdot (2)$$

[Claim 13]

A vacuum drying method described in Claim 11 or 12, wherein how much lower than the saturation vapor pressure at the dew point in the aforementioned predetermined environment the aforementioned target pressure is set is determined according to the material of the aforementioned object to be dried.

[Claim 14]

A vacuum drying method described in Claim 9 to 13, wherein in the second step, the abnormality detection of the vacuum drying device that is used to perform vacuum drying on the aforementioned object to be dried is performed based on the pressure measured in the aforementioned first step.

[Claim 15]

A vacuum drying method described in any one of Claims 9 to 14, wherein the object to be dried are battery electrodes. [Claim 16]

A manufacturing method of battery electrodes for performing vacuum drying on battery electrodes arranged in a drying furnace, comprising:

a first step of measuring the pressure inside the aforementioned drying furnace;

a second step of determining whether the pressure measured in the aforementioned first step has decreased to below or less than a predetermined target pressure;

a third step of continuing vacuum drying for a predetermined first period of time after it is determined in the aforementioned second step that the pressure measured in the aforementioned first step is below or less than the aforementioned target pressure;

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a fourth step of measuring the pressure inside the aforementioned drying furnace after the aforementioned first period of time has elapsed;

a fifth step of determining whether the pressure measured in the aforementioned fourth step has decreased to below or less than the aforementioned target pressure;

a sixth step of determining that the vacuum drying of the aforementioned battery electrodes is complete when the pressure measured in the aforementioned fourth step is determined in the aforementioned fifth step to be below or less than the aforementioned target pressure; and

a seventh step of transferring the battery electrodes, which are judged to have completed vacuum drying in the aforementioned sixth step, from the aforementioned drying furnace to an area adjusted to a predetermined environment.

[Detailed Explanation of the Invention]

[Technical Field] [0001]

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This invention relates to a vacuum drying device, a vacuum drying system, a vacuum drying method, and a manufacturing method for battery electrodes.

[Background Technology]

[0002]

Conventional techniques have been proposed for performing vacuum drying on objects to be dried (for example, refer to Patent Document 1).

[Existing Technology Document]

[Patent Document]

[0003]

[Patent Document 1] Japanese Unexamined Patent Application Publication Official Gazette No. 2005-140536.

[Overview of the Invention]

[Problems to be Solved by the Invention]

[0004]

The methods described in Patent Document 1, as well as those shown in the literature referenced therein, aim to accurately determine the completion of vacuum drying, thereby suppressing occurrences of excessive drying and insufficient drying. Although this challenge of optimally completing vacuum drying has existed historically, various improvements continue to be made, and no satisfactory technology for determining the completion of vacuum drying has emerged so far. In particular, when

drying electrodes for secondary batteries such as lithium-ion batteries, if the electrodes are not sufficiently dried, there is a risk that the batteries produced using those electrodes will fail to demonstrate the desired performance. [0005]

Therefore, this invention has been developed in light of the aforementioned issues, with the aim of completing vacuum drying under optimal conditions.

[Means for Solving the Problems]

[0006]

This invention proposes the following measures to solve the aforementioned problems. Moreover, to facilitate understanding, reference numerals corresponding to embodiments of this invention are provided, but the invention is not limited to these embodiments. [0007]

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(1) This invention is a vacuum drying device (for example, corresponding to the vacuum drying device 1 in Fig. 1) for performing vacuum drying on an object to be dried (for example, corresponding to the battery electrodes mentioned later) arranged in a drying furnace (for example, corresponding to the drying furnace 11 in Fig. 1). It comprises: a pressure measurement means (for example, corresponding to the pressure measurement section 12 in Fig. 1) for measuring the pressure inside the aforementioned drying furnace; a determination means (for example, corresponding to the determination section 13 in Fig. 1) for determining whether the pressure measured by the aforementioned pressure measurement means has decreased to below or less than a predetermined target pressure; a vacuum drying for a predetermined first period after it is determined by the aforementioned pressure measurement means is below or less than the aforementioned target pressure; and a judgment means (for example, corresponding to the judgment

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