

DESCRIPTION

Title of Invention: HEAT TREATMENT METHOD FOR LITHIUM-ION
SECONDARY BATTERY

Technical Field

[0001]

The present invention relates to a heat treatment method used for a pretreatment to recover valuable materials from lithium-ion secondary battery.

Background Art

[0002]

Lithium-ion secondary batteries are lighter and have a higher capacity and a higher electromotive force than conventionally used secondary batteries, and therefore are being widely used in electronic devices such as personal computers and mobile phones, automotive batteries for cars, and the like.

[0003]

A positive electrode active material of a lithium-ion secondary battery has generally been formed of a composite oxide of lithium and a transition metal. Above all, lithium cobalt oxide (LiCoO_2), which is a composite oxide containing Co as a component, has been widely used. In addition,

recently, the use of lithium nickel oxide (LiNiO_2), lithium manganese oxide (LiMn_2O_4), or a ternary system ($\text{LiNi}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3}\text{O}_2$ or the like), or a composite type thereof has also been increasing. As an electrolytic solution of a lithium-ion secondary battery, one obtained by dissolving a lithium salt such as an electrolyte LiPF_6 or LiBF_4 in a mixed solvent of a cyclic carbonate ester such as PC (propylene carbonate) or EC (ethylene carbonate) and a chain ester such as DMC (dimethyl carbonate), EMC (ethyl methyl carbonate), or DEC (diethyl carbonate) is mainly used. However, these organic solvents are flammable and may pose a risk of ignition depending on how they are handled.

[0004]

In recent years, due to the rapid expansion in the use of the lithium-ion secondary battery, there has been a demand for separating and recovering valuable metals, such as nickel and cobalt used in a positive electrode active material, and aluminum and copper used in a current collector of an electrode, from used and discarded lithium-ion secondary batteries or scraps of defective products generated in a process for producing the batteries.

[0005]

At that time, lithium-ion secondary batteries used in, for example, portable electronic devices and the like are becoming smaller and thinner, and it is practically

impossible to treat independent lithium-ion secondary batteries separately when considering cost factors and the like. Therefore, conventionally, a large number of lithium-ion secondary batteries are housed in a metallic housing unit, and the lithium-ion secondary batteries are stored or transported in a stacked state, or are subjected to a separation and recovery treatment.

[0006]

Discarded lithium-ion secondary batteries contain a flammable organic solvent therein. In addition, it may be difficult to completely discharge and deactivate all batteries at the sources of discharge of waste lithium-ion secondary batteries, and lithium-ion secondary batteries that remain in a charged state may be discarded. As described above, lithium-ion secondary batteries are becoming smaller and thinner, and when a large number of lithium-ion secondary batteries are stacked, the batteries are easily deformed by a force from the outside, and therefore it is known that there is a risk that a short circuit occurs inside the batteries and the batteries themselves may ignite during storage of waste lithium-ion secondary batteries or during a separation and recovery treatment.

[0007]

In the separation and recovery treatment, an organic

solvent remaining in a lithium-ion secondary battery is burned by a heat treatment as a pretreatment. However, at that time, the organic solvent may undergo explosive and abnormal combustion, and thermal runaway may occur within a housing unit. This thermal runaway also occurs due to a reaction in which the positive electrode active material of a lithium-ion secondary battery thermally decomposes to release oxygen and accelerate its own combustion. Therefore, even if the atmosphere (oxygen concentration) during the heat treatment is regulated, thermal runaway cannot sometimes be prevented. When abnormal combustion occurs, the temperature of the exhaust gas increases sharply, which may damage the furnace wall and flue of the heating furnace. Further, rapid combustion may cause an oxygen-deficient state in the furnace, resulting in an increase in the CO concentration in the exhaust gas. Therefore, a method for controlling the combustion rate of lithium-ion secondary batteries in a housing unit has been demanded.

[0008]

As a method for controlling the combustion rate of a lithium-ion secondary battery, for example, PTL 1 discloses a technique in which a lithium-ion secondary battery is housed in an oxygen-shielding container and the oxygen partial pressure in the shielding container is regulated from 0% to 5% to roast the lithium-ion secondary battery.

The use of an oxygen-shielding container reduces the combustion rate of a lithium-ion secondary battery, but when a plurality of lithium-ion secondary batteries are treated, there has been a problem that due to the combustion heat from one lithium-ion secondary battery, other lithium-ion secondary batteries are heated, and thermal runaway may be caused mainly by decomposition of the positive electrode active material and generation of oxygen. Further, a step of reducing the oxygen partial pressure in the oxygen-shielding container is required, and there has been a problem that the treatment cost increases.

[0009]

PTL 2 discloses a heat treatment method for battery waste, in which an atmospheric gas containing at least one selected from the group consisting of oxygen, nitrogen, carbon dioxide, and water vapor is allowed to flow into a heat treatment furnace in which lithium-ion secondary battery waste is placed to adjust the oxygen partial pressure inside the furnace, and the oxygen partial pressure in the heat treatment furnace is preferably in a range of 5×10^{-4} atm to 4×10^{-2} atm. However, also in the case of the method disclosed in PTL 2, when a plurality of lithium-ion secondary batteries are treated, there has been a problem that due to the combustion heat from one lithium-ion secondary battery, other lithium-ion secondary batteries

are heated, and thermal runaway may be caused mainly by decomposition of the positive electrode active material and generation of oxygen. Further, it is necessary to reduce the oxygen partial pressure in the heat treatment furnace, and there has been a problem that the treatment cost increases.

[0010]

PTL 3 discloses a technique in which lithium-ion secondary batteries are housed in a metallic housing unit, and when the housing unit is heated from the outside with a direct flame burner, a flame blocking unit is provided between the direct flame burner and the housing unit to decrease the temperature increase rate of the housing unit where the lithium-ion secondary batteries are housed. The technique disclosed in PTL 3 can control the combustion rate of the metallic housing unit, but has a disadvantage that when a plurality of metallic housing units are heated to a high temperature using the technique, in a case where thermal runaway occurs in one housing unit, it is not possible to prevent the effect from spreading to other housing units.

Citation List

Patent Literature

[0011]

PTL 1: JP2016-219402A

PTL 2: JP2021-163645A

PTL 3: JP2022-048614A

Summary of Invention

Technical Problem

[0012]

In view of the above problems, an object of the invention is to provide a method for preventing thermal runaway due to ignition of a lithium-ion secondary battery at low cost without controlling the heating atmosphere in a heat treatment used in a pretreatment to recover valuable materials from lithium-ion secondary battery. In this description, thermal runaway refers to a combustion state in which a rapid temperature increase behavior is observed even in a temperature range in which the heating furnace outlet temperature is 1000°C or higher. The heating furnace outlet temperature is a gas temperature at the outlet for a gas in a furnace to flow out into an exhaust path.

Solution to Problem

[0013]

In order to achieve the above object, the present description discloses the following invention.

[1] A heat treatment method for a lithium-ion

secondary battery, including placing lithium-ion secondary batteries in a plurality of metallic housing units, and heating the plurality of housing units where the lithium-ion secondary batteries are housed by a heating unit disposed outside the plurality of metallic housing units in an air atmosphere, in which a temperature increase rate of the housing units where the lithium-ion secondary batteries are housed is regulated by retaining water together with the lithium-ion secondary batteries in some or all of the plurality of metallic housing units, and performing heating.

[2] The heat treatment method for a lithium-ion secondary battery according to the above [1], in which when the plurality of housing units where the lithium-ion secondary batteries are housed are heated by the heating unit, the housing unit where lithium-ion secondary batteries and water are retained and the housing unit where only lithium-ion secondary batteries are placed are arranged.

[3] The heat treatment method for a lithium-ion secondary battery according to the above [1] or [2], in which the housing units are formed of iron or stainless steel.

[4] The heat treatment method for a lithium-ion secondary battery according to any one of the above [1] to [3], in which the housing unit where water is retained has a lid member provided with a plurality of openings at an

upper part thereof.

Advantageous Effects of Invention

[0014]

When the heat treatment method of the invention is used, atmospheric control is not required during the heat treatment, and the pretreatment to recover valuable materials from lithium-ion secondary batteries can be performed safely at low cost. Therefore, the invention can contribute to reducing the cost of the process for recovering valuable metals from discarded lithium-ion secondary batteries.

Brief Description of Drawings

[0015]

[FIG. 1] FIG. 1 is a graph showing examples of time courses of the heating furnace outlet temperature and the oxygen concentration in a chimney when only lithium-ion secondary batteries were housed and heated externally.

[FIG. 2] FIG. 2 is a horizontal cross-sectional view of a heating furnace schematically showing the arrangement of DMs and other objects to be heated in Example 1.

[FIG. 3] FIG. 3 is a graph showing time courses of the heating furnace outlet temperature and the temperatures in the vicinity of mobile phone DMs and mix DMs when a heat

treatment was performed in Example 1.

[FIG. 4] FIG. 4 is a horizontal cross-sectional view of a heating furnace schematically showing the arrangement of mix DMs and automotive LIB housing units in Example 2.

[FIG. 5] FIG. 5 is a graph showing a time course of the heating furnace outlet temperature when a heat treatment was performed in Example 2.

[FIG. 6] FIG. 6 is a vertical cross-sectional view of the heating furnace schematically showing the A-A cross section in FIG. 2.

[FIG. 7] FIG. 7 is a horizontal cross-sectional view of a heating furnace schematically showing the arrangement of an automotive LIB housing unit and mix LIB housing DMs in Example 3.

[FIG. 8] FIG. 8 is a graph showing a time course of the heating furnace outlet temperature when a heat treatment was performed in Example 3.

Description of Embodiments

[0016]

[Lithium-Ion Secondary Battery]

Discarded lithium-ion secondary batteries targeted by the heat treatment method of the invention are not limited to small lithium-ion secondary batteries such as button batteries used in mobile phones or other electronic devices

and the like, but may be any type of lithium-ion secondary batteries such as large lithium-ion secondary batteries for automotive use. In addition, not only used and discarded lithium-ion secondary batteries, but also scraps and the like discarded in a process for producing lithium-ion secondary batteries due to poor performance or other reasons are included.

[0017]

[Housing Unit]

When discarded lithium-ion secondary batteries are stacked and stored in a housing unit, the batteries may be deformed by the weight of the batteries themselves or by a force from the outside, which may cause the batteries to ignite. In addition, in the heat treatment method for a lithium-ion secondary battery of the invention, a housing unit where batteries are housed is heated from the outside, and therefore the housing unit is required to have heat resistance and impact resistance. Therefore, as the housing unit that houses the lithium-ion secondary batteries, one made of a metal, preferably made of iron or a stainless steel plate is used. Specifically, from the viewpoint of availability and price, a drum specified in JIS Z1600 or the like can be used. Here, the drum is one in which a bottom plate is provided at the bottom of one end of a cylindrical body plate.

[0018]

The housing unit that houses the lithium-ion secondary batteries may have a lid member provided with a plurality of openings at an upper part thereof. In that case, the opening diameters of the plurality of openings are set to be slightly smaller than the diameters or lengths of the batteries to be subjected to a heat treatment. As the lid member, a punched plate, a mesh-like or grid-like metallic member, a woven metallic fabric, or the like can be used. The lid member is configured to be detachable in order to house discarded lithium-ion secondary batteries in the housing unit. The reason why the lid member having a plurality of openings is provided for the housing unit is as follows.

[0019]

The most significant technical feature of the heat treatment method for a lithium-ion secondary battery of the invention is, as described later, to regulate the temperature increase rate of the housing unit by retaining water in the housing unit where lithium-ion secondary batteries are housed, and performing heating. At that time, it is necessary to regulate the amount of water to be retained in the housing unit.

[0020]

In a case where lithium-ion secondary batteries are

stacked and stored in the housing unit, in order to prevent spontaneous ignition of the batteries, it is generally practiced to retain water in the housing unit where the lithium-ion secondary batteries are housed and perform the storage. In that case, as a simple method for regulating the amount of water, the housing unit where the lithium-ion secondary batteries and water are housed is inverted by a known mechanical unit to discharge water through the lid member.

[0021]

[Heating Unit]

In the heat treatment method for a lithium-ion secondary battery of the invention, a plurality of housing units where discarded lithium-ion secondary batteries are housed are heated in an air atmosphere using a heating unit disposed outside the plurality of metallic housing units. In the case of atmospheric heating, no equipment for controlling the heating atmosphere is required, and the treatment cost can be reduced. In the heat treatment method of the invention, as a heat treatment furnace for external heating, heating with a direct flame burner, a batch type muffle furnace, a continuous type roller hearth kiln, a mesh belt kiln, an electric heating furnace, or the like can be used, and from the viewpoint of energy efficiency, heating with a direct flame burner is preferred. When a plurality

of direct flame burners are used for external heating, it becomes possible to heat an arbitrary housing unit among the plurality of metallic housing units.

[0022]

[Heat Treatment]

As described above, in the heat treatment method for a lithium-ion secondary battery of the invention, a plurality of housing units where lithium-ion secondary batteries are housed are heated from the outside in an air atmosphere, and at that time, a temperature increase rate of the housing units where the lithium-ion secondary batteries are housed is regulated by retaining water together with the lithium-ion secondary batteries in some or all of the plurality of metallic housing units, and performing heating, which is the most significant technical feature. When the temperature increase rate of the housing units can be regulated, even if thermal runaway occurs due to ignition of batteries in one housing unit, the effect can be prevented from spreading to other housing units.

[0023]

FIG. 1 shows examples of time courses of the heating furnace outlet temperature and the oxygen concentration in a chimney in a case where thermal runaway occurred in the heating furnace when only lithium-ion secondary batteries were housed in all housing units and heated externally

(Comparative Example 1 described below). When thermal runaway occurs, rapid combustion of the lithium-ion secondary batteries occurs, and oxygen in the heating furnace is rapidly consumed to cause incomplete combustion, and therefore a sharp increase in the heating furnace outlet temperature and a decrease in the oxygen concentration in the chimney are observed.

[0024]

In a first embodiment of the invention, water is retained in all of the plurality of housing units where the lithium-ion secondary batteries are housed, and heating is performed. In the case of the present embodiment, the amount of water to be retained in each housing unit may be the same, but preferably differs for each housing unit. In the case where the amount differs for each housing unit, the time until all water retained in the housing units evaporates when external heating is performed varies depending on the housing units, and therefore even if thermal runaway occurs in one housing unit, a housing unit having water retained therein without evaporation of all water exists in a surrounding area. Even if the amount of water retained in the housing units is the same, the evaporation amount of water in each housing unit varies depending on the distance from a heat source (for example, a direct flame burner) in the furnace, and therefore, it is

possible to prevent thermal runaway from occurring simultaneously in the respective housing units.

[0025]

In a case where no water has been placed in the housing units when waste lithium-ion secondary batteries are stored, the amount of water to be retained in the housing units is regulated by regulating the amount of water to be fed to the housing units where the waste lithium-ion secondary batteries are housed. In a case where waste lithium-ion secondary batteries have been stored with water placed in the housing units, the amount of water to be retained is regulated by inverting the housing units where the waste lithium-ion secondary batteries are housed and regulating the time for discharging water.

[0026]

In a second embodiment of the invention, water is retained in some of the plurality of housing units where the lithium-ion secondary batteries are housed, and heating is performed. With respect to the housing units where water is retained, water may be retained in an amount sufficient to fill the housing units. In a case where waste lithium-ion secondary batteries have been stored with water placed in a housing unit, by completely discharging water in the housing unit where the waste lithium-ion secondary batteries are housed, it is possible to be a housing unit in a state

in which only waste lithium-ion secondary batteries are housed and water is not retained.

[0027]

In the second embodiment of the invention, external heating is performed in a state in which a housing unit where water is not retained and a housing unit where water is retained are arranged in a heating furnace. In the present embodiment, in consideration of the capacity of the waste lithium-ion secondary batteries to be treated and the heating unit from the outside, the housing units where water is retained may be appropriately arranged between the housing units where water is not retained. From the viewpoint of preventing thermal runaway, it is preferred to set the ratio of the number of housing units where water is retained to the total number of housing units where lithium-ion secondary batteries are housed to 30% or more.

[0028]

In the second embodiment of the invention, the process for individually adjusting the amount of water to be retained in the housing units can be omitted, and therefore, use of this embodiment is preferred from the viewpoint of omitting the step and reducing the treatment cost.

Examples

[0029]

[Example 1]

Four iron open drums (hereinafter referred to as DMs) with a capacity of 200 L were prepared as housing units for lithium-ion secondary batteries (hereinafter referred to as LIBs) to be subjected to a heat treatment. To two of the DMs, LIBs for mobile phones were fed until the DMs were almost full. The mass of the LIBs for mobile phones fed was 200 kg in each DM. The remaining two DMs were fed with a mixture of small LIBs used in household appliances until the DMs were almost full. The mass of the mixture of LIBs fed was 150 kg in each DM.

[0030]

Tap water was injected into one of the DMs fed with the LIBs for mobile phones (hereinafter referred to as "mobile phone DM") and one of the DMs fed with the mixture of LIBs (hereinafter referred to as "mix DM") among the DMs fed with the LIBs, until the LIBs in the DMs were completely immersed. The four DMs were loaded on a carriage together with 750 kg of other objects to be heated, which was then loaded into a heating furnace equipped with eight direct flame burners.

[0031]

FIG. 2 shows the arrangement of the DMs and other objects to be heated. In the drawing, the contents of the DMs where water was retained are marked with water. "Mix

LIB" in the drawing means a mixture of LIBs. The loading direction of the carriage into the heating furnace is such that the DMs are on the back side and the other objects to be heated are on the door side. A thermocouple was installed in each DM to measure the temperature in the vicinity of the LIBs during the heat treatment.

FIG. 6 schematically shows an A-A cross-sectional view of the furnace shown in FIG. 2. In FIG. 6, a state where the door is slightly opened is shown, and the description of the objects to be heated is omitted.

FIG. 3 shows time courses of the heating furnace outlet temperature, and the temperatures in the vicinity of the mobile phone DMs and the mix DMs when the heat treatment was performed in Example 1.

[0032]

In this example, first, the burners No. 4 and No. 8 were ignited, and the heating furnace outlet temperature was increased to about 300°C to promote the combustion of the LIBs in the DMs where water was not retained. About 60 minutes after the ignition, the LIBs in the DMs where water was not retained started to burn, and therefore the burners were extinguished and the LIBs were allowed to undergo spontaneous combustion. The temperature in the vicinity of the LIBs increased due to the spontaneous combustion of the LIBs, but thermal runaway did not occur. The spontaneous

combustion continued for about 60 minutes (until about 120 minutes from the initial ignition) and was completed.

[0033]

From that time point, the other objects to be heated were heated using the burners No. 1 and No. 5. Therefore, due to the combustion heat from the other objects to be heated, the evaporation of water in the DMs where water was retained proceeded, and 180 to 210 minutes after the initial ignition, the start of combustion of the LIBs in the DMs where water was retained was observed with a camera in the furnace. Even after the combustion of the LIBs in the DMs where water was retained was almost completed, the heating furnace outlet temperature was maintained at 750°C or higher, but no sharp increase in the heating furnace outlet temperature was observed.

[0034]

[Comparative Example 1]

The heat treatment of this example was performed by repeating the same operation as in Example 1, except that tap water was not injected into any of the DMs. The results are shown in FIG 1. About 30 minutes after ignition, the heating furnace outlet temperature increased sharply, and temperature control became difficult. Thereafter, the heating furnace outlet temperature increased to 1200°C or higher and an oxygen-deficient state occurred inside the

furnace such that the oxygen concentration fell to 5% or less.

[0035]

[Example 2]

The LIBs to be subjected to a heat treatment in this Example are mix LIB (a mixture of small LIBs) used in household appliances and an automotive LIB pack. The sample preparation method for the mix LIB used in household appliances was the same as that for the mix DM where water was retained described in Example 1, except that the amount of water retained (height in the DM) was set to about half of the DM. As the automotive LIB pack, a 500 kg LIB pack was housed without dismantling in a dedicated iron housing unit (an iron container with a width of 2350 mm and a depth of 1650 mm) without retaining water.

[0036]

Two housing units where the automotive LIB pack was housed were loaded apart on a carriage, and two mix DMs were placed between them. FIG. 4 shows the arrangement of the mix DMs and the automotive LIB housing units. In this case, the left side of the drawing is the back side of the heating furnace, and the right side is the door side.

FIG. 5 shows a time course of the heating furnace outlet temperature when a heat treatment was performed in Example 2.

[0037]

In this example, first, the burners No. 4 and No. 8 were ignited, and 75 minutes later when the heating furnace outlet temperature reached about 300°C, the automotive LIB pack started to burn, and therefore the burners were extinguished and the automotive LIB pack was allowed to undergo spontaneous combustion. The spontaneous combustion continued for the next 60 minutes (until 135 minutes from the initial ignition) and was completed. From that time point, the burners No. 1 and No. 5 were ignited to heat the automotive LIB pack on the heating furnace door side. Immediately thereafter, the automotive LIB pack started to burn, and therefore the burners were extinguished and the automotive LIB pack was allowed to undergo spontaneous combustion. Subsequently, the burners No. 2 and No. 6 were ignited to promote the evaporation of water in the mix DMS and combustion of LIBs, combustion of LIBs in the mix DMS was started at 225 minutes from the initial ignition, and therefore the burners were extinguished and the LIBs were allowed to undergo spontaneous combustion. After the combustion of all the LIBs was completed, the heating furnace temperature was maintained at 750°C for 1 hour, but thermal runaway did not occur.

[0038]

From the above results, it was found that use of the

heat treatment method of the invention can prevent thermal runaway due to abnormal combustion of lithium-ion secondary batteries during a heat treatment as a pretreatment to recover valuable materials from lithium-ion secondary batteries.

[0039]

[Example 3]

As the objects to be subjected to a heat treatment, an automotive LIB pack and mix LIB (a mixture of small LIBs used in mobile phones or household appliances) were prepared. A 500 kg automotive LIB pack was fed without dismantling to a dedicated iron housing unit (an iron container) without retaining water. Further, the mix LIB was fed to eight DMs (open iron drums) with a capacity of 200 L until each was almost full. The mass of the mix LIB housed in each DM was about 200 kg. Water was placed in three DMs among these eight DMs up to 50% of the DM height in a state where the mix LIB was housed, and water was placed in the remaining five DMs up to 80% of the DM height in a state where the mix LIB was housed.

[0040]

The one iron container where the automotive LIB pack was housed and the eight DMs where the mix LIB was housed were placed on a carriage which was loaded into a heating furnace in the same manner as in Example 1.

FIG. 7 schematically shows the arrangement of the automotive LIB housing unit and the mix LIB housing DMs. In FIG. 7, a DM marked with the symbol (A) is one in which water was placed up to 50% of its height, and a DM marked with the symbol (B) is one in which water was placed up to 80% of its height.

FIG. 8 shows a time course of the heating furnace outlet temperature when a heat treatment was performed in Example 3.

[0041]

In this example, first, the burners No. 4 and No. 8 were ignited, and the heating furnace outlet temperature was increased to about 300°C to promote combustion of the automotive LIB pack. The automotive LIB pack started to burn at 45 minutes after the ignition, and therefore the burners were extinguished and the automotive LIB pack was allowed to undergo spontaneous combustion. The spontaneous combustion was completed 75 minutes later (about 120 minutes after ignition). Subsequently, the burners No. 1 and No. 6, with which direct flame was applied to the DMs with water 50%, were ignited to promote combustion of the mix LIB in the DMs with water 50%, and combustion in the DMs with water 50% started at 210 minutes after the initial ignition. Subsequently, the burners No. 2 and No. 5 were ignited to promote the evaporation of water and combustion of the mix

LIB in the DMS with water 80%. As a result, all water was evaporated in 270 minutes after the initial ignition, and combustion of the remaining mix LIB started. Thereafter, introduction of flames of the burners No. 1, No. 6, No. 2, and No. 5 was continued, and the temperature was increased to nearly 1000°C, but the temperature decreased due to completion of the combustion of the mix LIB. Thereafter, the temperature was kept at 750°C or higher for 1 hour or more, and then all burners were extinguished.

[0042]

As shown in this example, by setting the amount of water to be placed in containers serving as housing units in multiple stages, it becomes easier to control the division (shifting) of combustion timing of lithium-ion secondary batteries placed in a furnace so as to prevent unpredictable sudden combustion and enable safer operation.

CLAIMS

[Claim 1]

A heat treatment method for a lithium-ion secondary battery, comprising placing lithium-ion secondary batteries in a plurality of metallic housing units, and heating the plurality of housing units where the lithium-ion secondary batteries are housed by a heating unit disposed outside the plurality of metallic housing units in an air atmosphere, wherein a temperature increase rate of the housing units where the lithium-ion secondary batteries are housed is regulated by retaining water together with the lithium-ion secondary batteries in some or all of the plurality of metallic housing units, and performing heating.

[Claim 2]

The heat treatment method for a lithium-ion secondary battery according to claim 1, wherein when the plurality of housing units where the lithium-ion secondary batteries are housed are heated by the heating unit, the housing unit where lithium-ion secondary batteries and water are retained and the housing unit where only lithium-ion secondary batteries are placed are arranged.

[Claim 3]

The heat treatment method for a lithium-ion secondary battery according to claim 1, wherein the housing units are formed of iron or stainless steel.

[Claim 4]

The heat treatment method for a lithium-ion secondary battery according to claim 1, wherein the housing unit where water is retained has a lid member provided with a plurality of openings at an upper part thereof.