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Hwang et al.

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(54) **APPARATUS AND METHOD FOR EVALUATING BATTERY PERFORMANCE AND EQUIPMENT FOR TRANSPORTING BATTERY**

(71) Applicant: **SK ON CO., LTD.**, Seoul (KR)

(72) Inventors: **Chang Mook Hwang**, Daejeon (KR); **Na Eun Gil**, Daejeon (KR); **Hyun Ji Kim**, Daejeon (KR); **Jong Hyeok Lee**, Daejeon (KR); **Yoon Ji Jo**, Daejeon (KR)

(73) Assignee: **SK ON CO., LTD.**, Seoul (KR)

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G01R 31/392	(2019.01)
H02J 7/00	(2006.01)

(52) **U.S. Cl.**

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(58) **Field of Classification Search**

None

See application file for complete search history.

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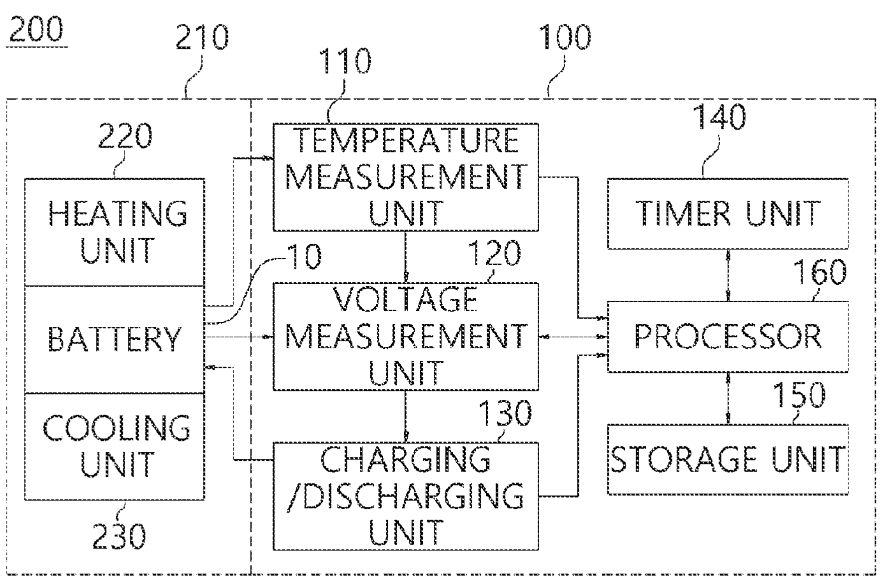
Primary Examiner — Jas A Sanghera
(74) *Attorney, Agent, or Firm* — IP & T GROUP LLP

(57) **ABSTRACT**

The present invention provides an apparatus and a method for evaluating performance of a battery and equipment for transporting the battery. The battery performance evaluation apparatus of the present invention includes: a temperature measurement unit for measuring an aging temperature of the battery; a voltage measurement unit for measuring a first open circuit voltage of the battery at the start of aging and measuring a second open circuit voltage of the battery at the end of aging; and a processor for calculating a delta voltage of a voltage drop using a difference between the first open circuit voltage and the second open circuit voltage measured by the voltage measurement unit, and determining normal or defective of the battery based on the delta voltage calculated using the aging temperature measured by the temperature measurement unit and an aging period between measurement times of the first and second open circuit voltage.

15 Claims, 5 Drawing Sheets



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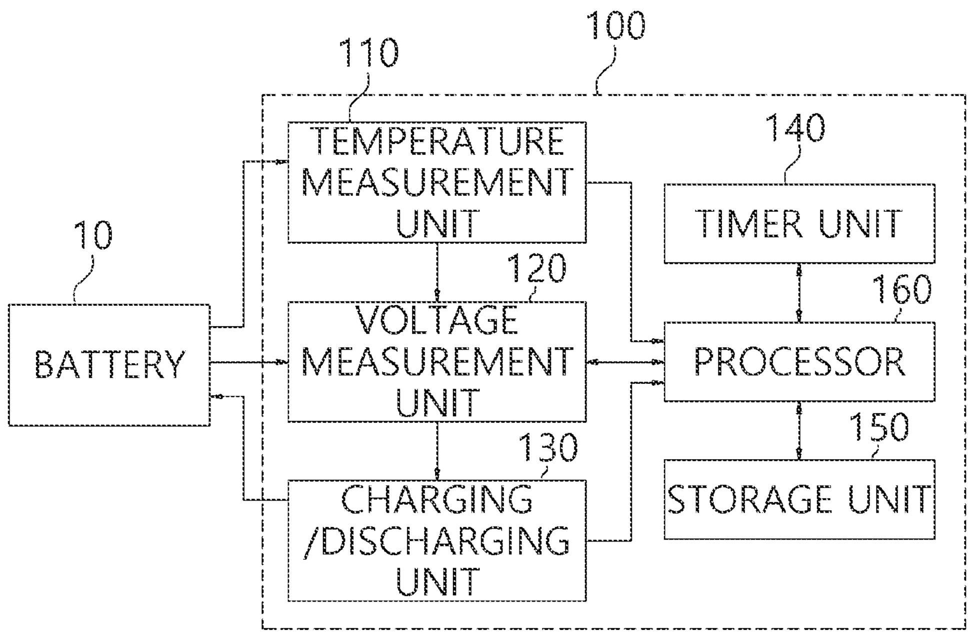
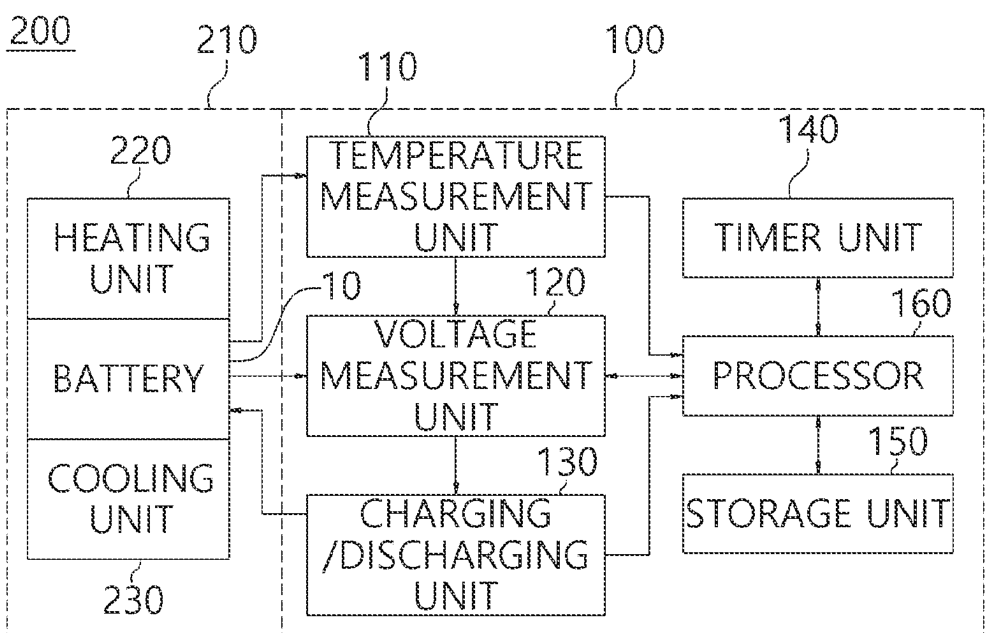
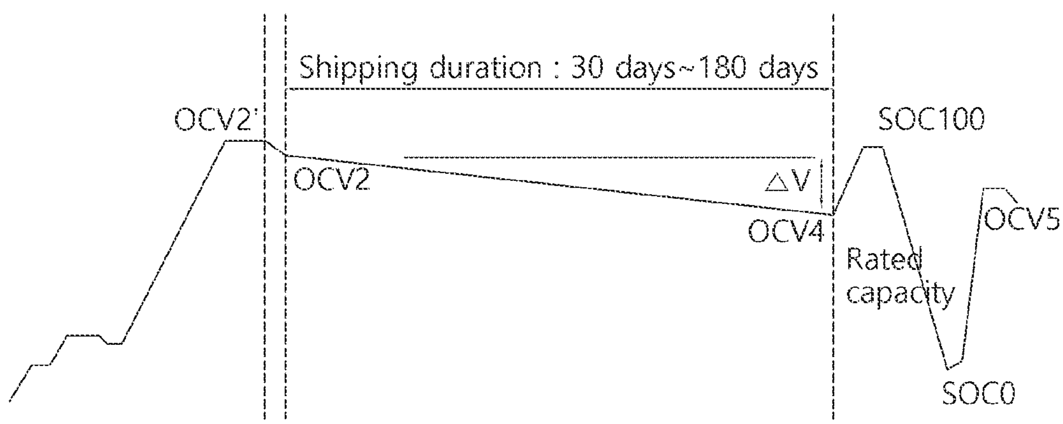
[FIG. 1]


100
110
TEMPERATURE MEASUREMENT UNIT
140
TIMER UNIT
10
120
160
BATTERY
VOLTAGE MEASUREMENT UNIT
PROCESSOR
130
150
CHARGING /DISCHARGING UNIT
STORAGE UNIT

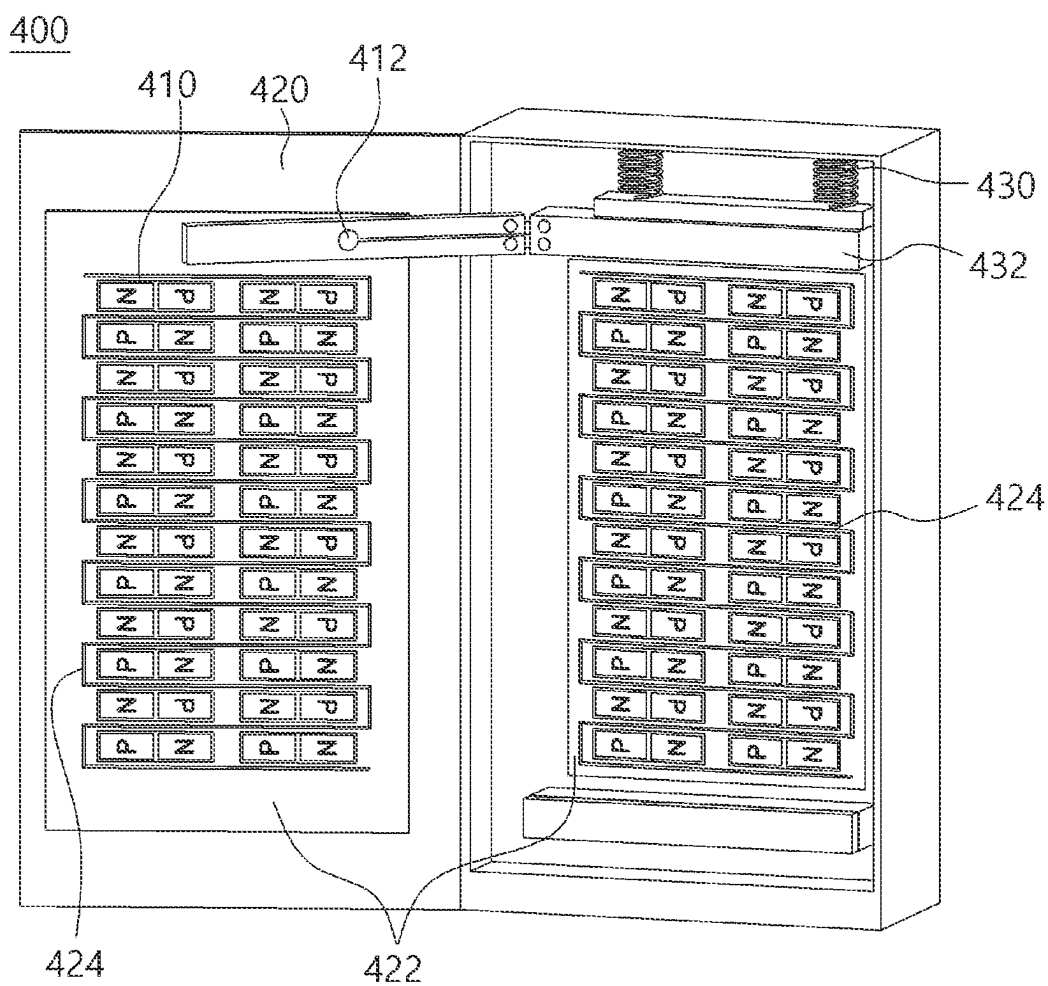
[FIG. 2]


200
210
110
100
220
TEMPERATURE MEASUREMENT UNIT
140
HEATING UNIT
TIMER UNIT
10
120
160
BATTERY
VOLTAGE MEASUREMENT UNIT
PROCESSOR
130
150
COOLING UNIT
CHARGING /DISCHARGING UNIT
STORAGE UNIT
230

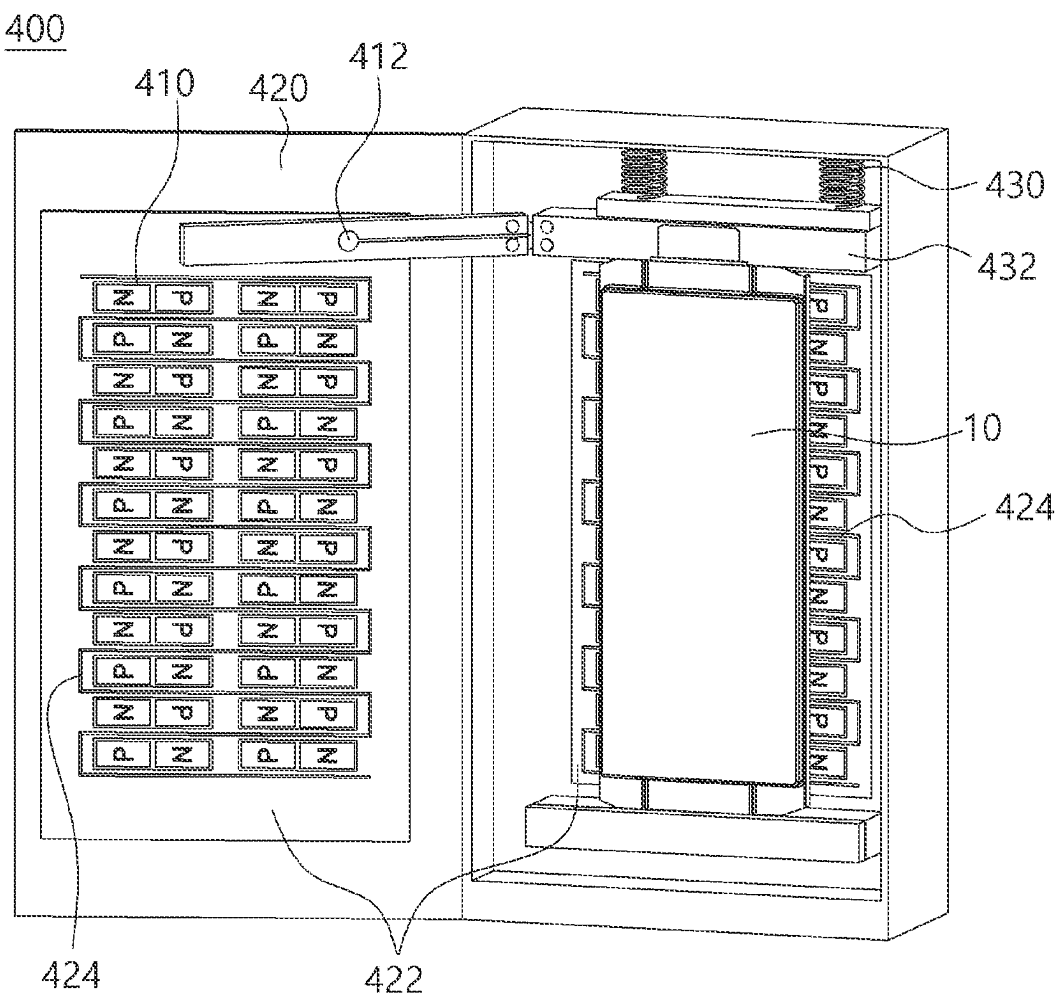
[FIG. 3]


Shipping duration : 30 days~180 days
OCV2'
OCV2
△V
OCV4
SOC100
Rated capacity
OCV5
SOC0

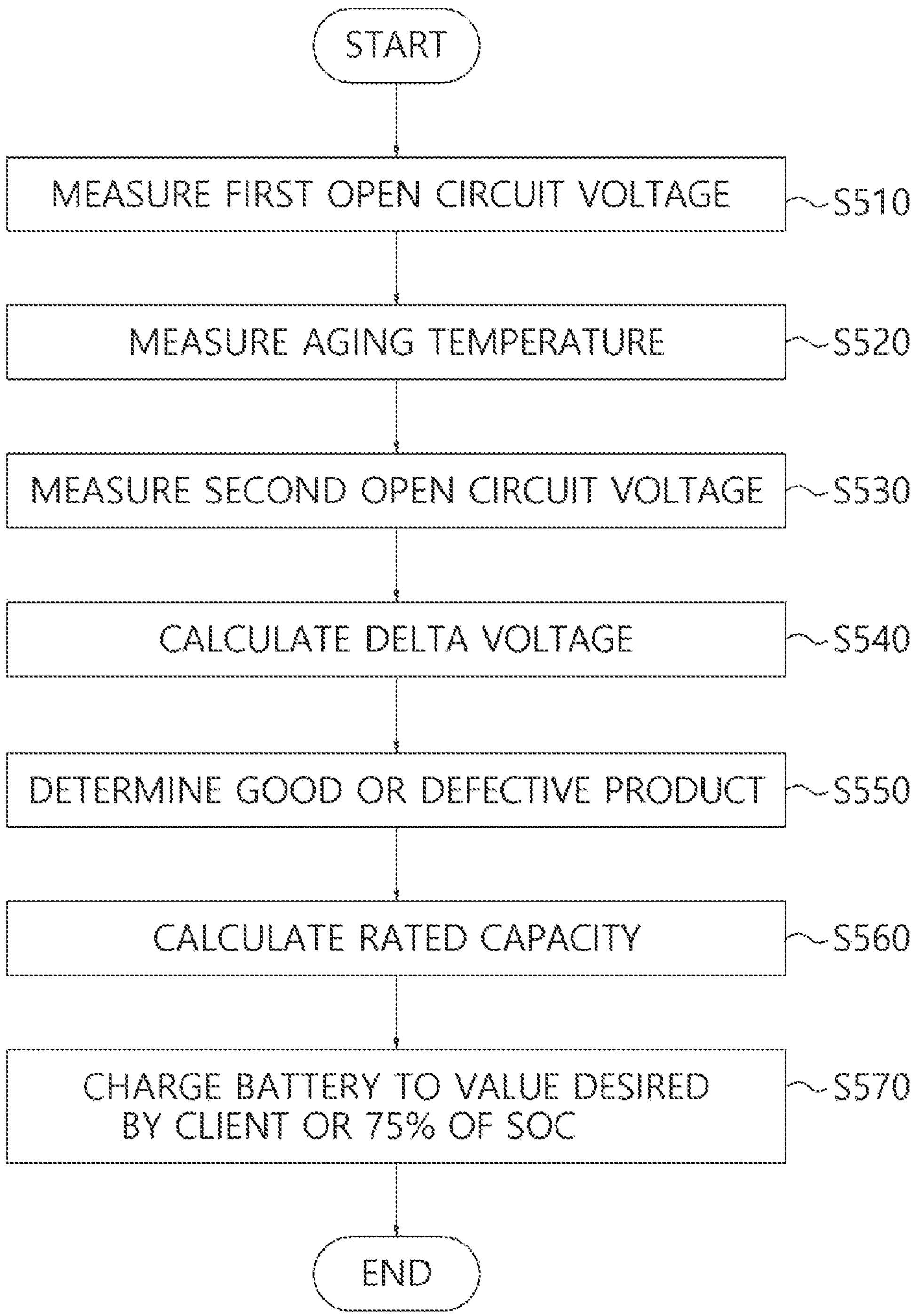
[FIG. 4A]



[FIG. 4B]



[FIG. 5]


START
MEASURE FIRST OPEN CIRCUIT VOLTAGE
S510
MEASURE AGING TEMPERATURE
S520
MEASURE SECOND OPEN CIRCUIT VOLTAGE
S530
CALCULATE DELTA VOLTAGE
S540
DETERMINE GOOD OR DEFECTIVE PRODUCT
S550
CALCULATE RATED CAPACITY
S560
CHARGE BATTERY TO VALUE DESIRED BY CLIENT OR 75% OF SOC
S570
END

APPARATUS AND METHOD FOR EVALUATING BATTERY PERFORMANCE AND EQUIPMENT FOR TRANSPORTING BATTERY

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an apparatus and a method for evaluating performance of a battery and equipment for transporting the battery, and particularly, to an apparatus and a method for evaluating performance of a battery, which may significantly reduce a risk of defective battery while significantly shortening a formation section of a formation process, and equipment for transporting the battery.

2. Description of the Related Art

As currently commercialized secondary batteries, there are a nickel-cadmium battery, a nickel-hydrogen battery, a nickel-zinc battery, a lithium secondary battery and the like. Among them, the lithium secondary battery becomes a mainstream secondary battery due to advantages such as a freer charging/discharging scheme, very lower self-discharge rate, and higher energy density than the nickel-based secondary battery.

However, the lithium secondary battery also require a formation section of the formation process. Although the formation section differs from company to company depending on their owned techniques, the batteries are left in an unloaded state for about 7 to 30 days, then open circuit voltage drops thereof are measured, and normal or defective products are determined based on the magnitude of the measured voltage drops. The temperature of the corresponding formation section varies from room temperature to 45° C. or 60° C., and the reason for increasing the temperature is to shorten the formation section through formation of the battery.

Meanwhile, it is possible to obtain various advantages such as securing a space for production of the battery and enhancing yield by shortening the period of the formation section, but it is not possible to obtain a sufficient delta voltage of the open circuit voltage drop, which is a criterion for screening the defective products, such that problems may occur in screening the defective product. In particular, a battery for an electric vehicle or energy storage system may cause a fire if the defective product is not properly screened.

SUMMARY OF THE INVENTION

One object of the present invention is to provide an apparatus and a method for evaluating performance of a battery, which may significantly reduce a risk of defective battery while significantly shortening a formation section of a formation process, and equipment for transporting the battery.

However, the problem to be solved by the present invention is not limited to the above-described problems, and may be expanded by those skilled in the art in various ways without departing from the technical spirit and scope of the present invention.

To achieve the above object, according to an aspect of the present invention, there is provided an apparatus for evaluating performance of a battery, the apparatus including: a temperature measurement unit configured to measure an aging temperature of the battery; a voltage measurement unit configured to measure a first open circuit voltage of the battery at the start of aging and measure a second open circuit voltage of the battery at the end of aging; and a processor configured to calculate a delta voltage of a voltage drop using a difference between the first open circuit voltage and the second open circuit voltage measured by the voltage measurement unit, and determine whether the battery is a normal or defective product based on the delta voltage calculated using the aging temperature measured by the temperature measurement unit and an aging period between a measurement time of the first open circuit voltage and a measurement time of the second open circuit voltage.

The temperature measurement unit may periodically measure the temperature of the battery at a predetermined time interval during aging of the battery to output the measured temperature values, and the processor may set a voltage range for comparison with the delta voltage in order to determine whether the battery is a normal or defective product in consideration of the temperature values measured at a predetermined time interval by the temperature measurement unit and the aging period.

The processor may set the voltage range for comparison with the delta voltage as a reference voltage and a deviation from the reference voltage.

The processor may set the reference voltage higher as the aging temperature of the battery is increased and the aging period is increased, and may set the deviation greater as the aging temperature is increased.

The apparatus may further include a charging/discharging unit configured to charge and discharge the battery, wherein the processor may calculate a rated capacity of the battery by controlling the charging/discharging unit and the voltage measurement unit.

The processor may control the charging/discharging unit to charge the battery to a value desired by a client or 75% of state of charge after calculating the rated capacity of the battery.

In addition, according to another aspect of the present invention, there is provided equipment for transporting a battery, the equipment including: the above-described apparatus for evaluating performance of a battery; and a tray box in which the battery is loaded, wherein the tray box includes a heating unit configured to increase the temperature of the battery and a cooling unit configured to decrease the temperature of the battery.

The heating unit may include a hot wire configured to heat the battery, and the cooling unit may include a Peltier element configured to cool the battery.

The processor may control the heating unit and the cooling unit to maintain the temperature of the battery in consideration of a shipping duration of the battery in the equipment for transporting a battery.

A first open circuit voltage of the battery loaded in the tray box may be a voltage at a time when the battery is determined to be a normal product in a formation process.

The tray box may further include a spring for close contact of the battery when the battery is loaded in the tray box and a rubber product for protecting electrodes of the battery.

Further, to achieve the above object, according to another aspect of the present invention, there is provided a method for evaluating performance of a battery in an apparatus for evaluating performance of a battery, the method including: measuring a first open circuit voltage of the battery at the start of aging; measuring an aging temperature of the battery; measuring a second open circuit voltage of the battery at the end of aging; calculating a delta voltage of a voltage drop using a difference between the first open circuit voltage measured in the step of measuring the first open circuit voltage and the second open circuit voltage measured in the step of measuring the second open circuit voltage; and determining whether the battery is a normal or defective product based on the delta voltage using the aging temperature measured in the step of measuring the aging temperature and an aging period between a measurement time of the first open circuit voltage and a measurement time of the second open circuit voltage.

According to various embodiments of the present invention, an aging process for inspecting defects of a battery, which is a part of the formation process, may be performed during a delivery or storage process after shipment, such that manufacturing time and costs of the battery can be reduced.

In addition, according to various embodiments of the present invention, the voltage range to be used for determining whether a battery is defective may be set by considering the aging temperature and aging period, such that it is possible to determine whether the battery is defective with high accuracy even if the aging temperature and aging period are variable.

Further, according to various embodiments of the present invention, the rated capacity may be measured and provided at the time of delivering the battery to a client company, such that screening of normal or defective products for capacity can be freed from the storage period and shipping duration.

Furthermore, according to various embodiments of the present invention, since charging or discharging to a desired state of charge (SOC) is performed at the time of delivering the battery to the client company, problems caused by the SOC deviation that may occur in the battery pack for an electric vehicle, an energy storage system, and the like can be resolved.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a block diagram illustrating an apparatus for evaluating performance of a battery according to an embodiment of the present disclosure;

FIG. **2** is a block diagram illustrating equipment for transporting a battery according to another embodiment of the present disclosure;

FIG. **3** is a diagram describing a procedure for determining whether a battery is a normal or defective product and charging to a battery state of charge in the equipment for transporting a battery shown in FIG. **2**;

FIGS. **4**A and **4**B are views illustrating a specific configuration of the equipment for transporting a battery shown in FIG. **2**; and

FIG. **5** is a flowchart illustrating procedures of a method for evaluating performance of a battery according to another embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, embodiments will be described in detail with reference to the accompanying drawings. In denoting reference numerals to components of respective drawings, it should be noted that the same components will be denoted by the same reference numerals although they are illustrated in different drawings. Further, in description of preferred embodiments of the present invention, the publicly known functions and configurations related to the present invention, which are verified to be able to make the purport of the present invention unnecessarily obscure will not be described in detail.

Meanwhile, in respective steps, each of the steps may occur differently from the specified order unless a specific order is clearly described in the context. That is, each of the steps may be performed in the same order as the specified order, may be performed substantially simultaneously, or may be performed in the reverse order.

Further, wordings to be described below are defined in consideration of the functions in the present invention, and may differ depending on the intentions of a user or an operator or custom. Accordingly, such wordings should be defined on the basis of the contents of the overall specification.

It will be understood that, although the terms first, second, etc. may be used herein to describe various components, but these components should not be limited by these terms. These terms are used only to distinguish one component from other components. As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises," "comprising," "includes" and/or "including," when used herein, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

In addition, a division of the configuration units in the present disclosure is intended for ease of description and divided only by the main function set for each configuration unit. That is, two or more of the configuration units to be described below may be combined into a single configuration unit or formed by two or more of divisions by function into more than a single configuration unit. Further, each of the configuration units to be described below may additionally perform a part or all of the functions among functions set for other configuration units other than being responsible for the main function, and a part of the functions among the main functions set for each of the configuration units may be exclusively taken and certainly performed by other configuration units.

FIG. **1** is a block diagram illustrating an apparatus for evaluating performance of a battery according to an embodiment of the present disclosure.

As shown in FIG. **1**, an apparatus for evaluating performance of a battery ('battery performance evaluation apparatus) **100** includes a temperature measurement unit **110**, a voltage measurement unit **120**, a charging/discharging unit **130**, a timer unit **140**, a storage unit **150** and a processor **160**.

The temperature measurement unit **110** is configured to measure a temperature of a battery **10**. The temperature measurement unit **110** particularly measures an aging temperature of the battery **10**, and specifically, may measure the temperature of the battery **10** at a predetermined time interval during aging of the battery **10** to output the measured temperature values.

The voltage measurement unit **120** is configured to measure an open circuit voltage (OCV) of the battery **10** in a no-load state. The voltage measurement unit **120** may measure a first open circuit voltage when the battery **10** is loaded in the battery performance evaluation apparatus **100**, and may finally measure a second open circuit voltage of the battery **10** in the no-load state. That is, the voltage measurement unit **120** may measure the open circuit voltages at the start of aging and at the end of aging. Here, the end of aging may include immediately before and after end of aging. The voltage measurement unit **120** may also measure a voltage of the battery **10** in relation to a rated capacity of the battery **10** and a battery state of charge (SOC).

The charging/discharging unit **130** is configured to charge and discharge the battery **10** under the control of the processor **160**. If it is determined that the battery **10** is a normal product, the processor **160** may measure the rated capacity of the battery **10** while charging and discharging the battery **10** by controlling the charging/discharging unit **130**. For example, the processor **160** may measure the rated capacity of the battery by charging the battery **10** that has been determined to be normal to SOC 100% through the charging/discharging unit **130** and then discharging the battery to SOC 10% again.

le;.4qThe timer unit **140** is a watch configured to inform the time. The storage unit **150** may be configured to store programs or commands for operation of the battery performance evaluation apparatus **100** and store data measured and processed by the battery performance evaluation apparatus **100**. For example, the storage unit **150** may store the temperature of the battery **10** measured by the temperature measurement unit **110**, the first open circuit voltage and second open circuit voltage of the battery measured by the voltage measurement unit **120**, and the measurement time of the first open circuit voltage and the measurement time of the second open circuit voltage, which are read from the timer unit **140**.

The processor **160** is configured to calculate a delta voltage of the voltage drop using a difference between the first open circuit voltage and the second open circuit voltage measured by the voltage measurement unit **120**. The processor **160** is also configured to determine whether the battery **10** is a normal or defective product based on the delta voltage calculated using the aging temperature measured by the temperature measurement unit **110** and an aging period between a measurement time of the first open circuit voltage and a measurement time of the second open circuit voltage.

The processor **160** may also store the temperature values measured by the voltage measurement unit **120** in the storage unit **150** every time set at a predetermined interval, and may differently set a voltage range for comparison with the delta voltage in order to determine whether the battery **10** is a normal or defective product in consideration of the measured temperature values and the aging period between the measurement time of the first open circuit voltage and the measurement time of the second open circuit voltage, which are stored in the storage unit **150**. The processor **160** may set the voltage range as a reference voltage and a deviation from the reference voltage.

Since a degree to which self-discharge occurs varies depending on the aging temperature and the aging period described in Table 1 below, the voltage range for comparison with the delta voltage may be differently set according to these conditions. For the convenience, the SOC of the battery **10** was maintained at 75%.

TABLE 1

No.	Aging temperature (° C.)	Aging period (days)	Delta voltage
1	25	30	25 ± 5 mV
2	25	60	40 ± 5 mV
3	25	90	50 ± 5 mV
4	35	30	30 ± 7 mV
5	35	60	50 ± 7 mV
6	35	90	60 ± 7 mV
7	45	30	38 ± 9 mV
8	45	60	47 ± 9 mV
9	45	90	57 ± 9 mV
10	55	30	45 ± 11 mV
11	55	60	63 ± 11 mV
12	55	90	71 ± 11 mV
13	65	30	50 ± 14 mV
14	65	60	68 ± 14 mV
15	65	90	76 ± 14 mV

In Table 1, if the aging temperature is 25° C. and the aging period is 30 days, the delta voltage of the normal product is within about ±5 mV based on 25 mV, and if the aging temperature is 35° C. and the aging period is 30 days, the delta voltage of the normal product is within about ±7 mV based on 35 mV. Accordingly, the delta voltage of the normal product has a deviation of about ±5 mV to ±14 mV, and this deviation becomes greater when the aging temperature is increased.

As a result, the reference voltage for the delta voltage varies depending on the aging temperature and the aging period. The higher the aging temperature and the longer the aging period, the greater the reference voltage. Meanwhile, in the case of the deviation from the reference voltage, it is preferable to increase the deviation as the aging temperature is increased.

As shown in Table 1, the processor **160** may differently set the reference voltage for comparison with the delta voltage and the deviation using the temperature values measured by the temperature measurement unit **110** and the aging period in order to determine whether the battery **10** is a normal or defective product. In this case, rather than considering all temperature values, an average value of temperature may be obtained for a predetermined period, for example, every day, and the obtained average value may be used.

The processor **160** controls the charging/discharging unit **130** and the voltage measurement unit **120** to calculate the rated capacity of the battery **10**, and may control the charging/discharging unit **130** so as to charge or discharge the battery **10** to a value desired by the client or 75% of the SOC after calculating the rated capacity of the battery **10**.

FIG. **2** is a block diagram illustrating equipment for transporting a battery according to another embodiment of the present disclosure, and FIG. **3** is a diagram describing a procedure for determining whether a battery is a normal or defective product and charging to a battery state of charge in the battery transport equipment shown in FIG. **2**.

As shown in FIG. **2**, equipment for transporting a battery ('battery transport equipment') **200** may include a battery performance evaluation apparatus **100** and a tray box **210**. The battery performance evaluation apparatus **100** may include a temperature measurement unit **110**, a voltage measurement unit **120**, a charging/discharging unit **130**, a timer unit **140**, a storage unit **150** and a processor **160**, and the tray box **210**, in which the battery **10** is loaded, may include a heating unit **220** and a cooling unit **230**. Here, it is necessary to clearly understand that the battery performance evaluation apparatus **100** and the tray box **210** are only classifications for overall description, and that the battery performance evaluation apparatus **100** may be embedded in the tray box **210**.

The temperature measurement unit **110** measures a temperature of the battery **10**. The temperature measurement unit **110** particularly measures an aging temperature of the battery **10**, and specifically, may measure the temperature of the battery at a predetermined time interval during aging of the battery to output the measured temperature values.

The voltage measurement unit **120** measures an open circuit voltage (OCV) of the battery **10** in a no-load state. The voltage measurement unit **120** measures a first open circuit voltage when the battery **10** is loaded in the battery performance evaluation apparatus **100**, and finally measures a second open circuit voltage of the battery **10** in the no-load state. The voltage measurement unit **120** may also measure a voltage of the battery in relation to the rated capacity of the battery **10** and the battery SOC.

The charging/discharging unit **130** charges and discharges the battery **10** under the control of the processor **160**. The timer unit **140** is a watch which informs the time. The storage unit **150** stores the temperature of the battery **10** measured by the temperature measurement unit **110**, the first open circuit voltage and second open circuit voltage of the battery **10** measured by the voltage measurement unit **120**, and the measurement time of the first open circuit voltage and the measurement time of the second open circuit voltage, which are read from the timer unit **140**.

The processor **160** calculates a delta voltage of the voltage drop using a difference between the first open circuit voltage and the second open circuit voltage measured by the voltage measurement unit **120**. The processor **160** also determines whether the battery **10** is a normal or defective product based on the delta voltage calculated using the aging temperature measured by the temperature measurement unit **110** and the aging period between the measurement time of the first open circuit voltage and the measurement time of the second open circuit voltage.

The processor **160** may also store the temperature values measured by the voltage measurement unit **120** in the storage unit **150** every time set at a predetermined interval, and may differently set a voltage range for comparison with the delta voltage and a deviation from the reference voltage in order to determine whether the battery **10** is a normal or defective product in consideration of the measured temperature values and the aging period between the measurement time of the first open circuit voltage and the measurement time of the second open circuit voltage, which are stored in the storage unit **150**.

The processor **160** may calculate the reference voltage for comparison with the delta voltage and the deviation using the temperature values measured by the temperature measurement unit **110** and the aging period in order to determine whether the battery **10** is a normal or defective product. In this case, rather than considering all temperature values, an average value of temperature may be obtained for a predetermined period, for example, every day, and the obtained average value may be used.

As described above, the tray box **210**, in which the battery is loaded, may include the heating unit **220** and the cooling unit **230**.

The heating unit **220** is configured to increase the temperature of the battery **10**. The heating unit **220** may include a hot wire to increase the temperature of the battery **10**. The cooling unit **230** is configured to decrease the temperature of the battery **10**. The cooling unit **230** may include a Peltier element to decrease the temperature of the battery **10**.

Here, referring to Table 1 again, when the aging period of the battery **10**, that is, a shipping duration including shipment of the battery transport equipment **200** is determined, the aging temperature may be adjusted by controlling the heating unit **220** and the cooling unit **230** in order to increase detection reliability according to the shipping duration. Therefore, the processor **160** may control the heating unit **220** and the cooling unit **230** to maintain the temperature of the battery **10** constant in consideration of the shipping duration of the battery **10** in the battery transport equipment **200**.

Meanwhile, a defect detection time and a power consumption amount may vary depending on the maintenance temperature and temperature range described in Table 2 below.

TABLE 2

No.	External temperature (° C.)	Maintenance temperature (° C.)	Detailed condition	Required power (60 days)	Minimum defect detection time (days)
1	23	25	Cooling with Peltier element at 26° C., and heating with hot wire at 24° C.	17.28 kWh	43
2	23	25	Cooling with Peltier element at 28° C., and heating with hot wire at 22° C.	5.76 kWh	46
3	40	25	Cooling with Peltier element at 26° C., and heating with hot wire at 24° C.	51.84 kWh	43
4	40	25	Cooling with Peltier element at 28° C., and heating with hot wire at 22° C.	17.28 kWh	46
5	23	35	Cooling with Peltier element at 36° C., and heating with hot wire at 34° C.	34.56 kWh	33
6	23	35	Cooling with Peltier element at 38° C., and heating with hot wire at 32° C.	11.52 kWh	35
7	23	45	Cooling with Peltier element at 46° C., and heating with hot wire at 44° C.	51.84 kWh	25

TABLE 2-continued

No.	External temperature (° C.)	Maintenance temperature (° C.)	Detailed condition	Required power (60 days)	Minimum defect detection time (days)
8	23	45	Cooling with Peltier element at 48° C., and heating with hot wire at 42° C.	17.28 kWh	26

The batteries **10** in Table 2 were manufactured by inserting metal foreign matters therein, and assuming a problem during manufacturing, an iron (Fe) foreign matter having a central value of 10 μm as a foreign matter was inserted into the battery **10**. In order to verify each effect, the environments, that is, the external temperatures, were prepared for two cases of 23° C. and 40° C., and the inventor looked at how the performance of the battery varies while maintaining the temperatures to 25° C., 35° C. or 45° C., respectively, using the Peltier element and the hot wire under these environments. For the convenience, the SOC of the battery **10** was maintained at 75%, which generally belongs to the high detectability range in shipping SOC.

Further, in Nos. 1, 3, 5 and 7 of the battery **10**, the temperature range of the battery **10** was set and maintained at ±1° C. to maximize the effect, and in Nos. 2, 4, 6 and 8 of the battery **10**, the temperature range of the battery **10** was set and maintained at ±3° C. to confirm whether the power used can be minimized.

Referring to Table 2, Nos. 1 and 2 of the battery **10**, in which the external temperature is set to be 23° C. and the maintenance temperature is set to be 25° C., have a minimum defect detection time of 43 days and 46 days, respectively, and Nos. 3 and 4 of the battery **10**, in which the external temperature is set to be 40° C. and the maintenance temperature is set to be 25° C., also have a minimum defect detection time of 43 days and 46 days, respectively. Thereby, it can be seen that the external temperature of the battery **10** has no effect on the detection of defects, but power consumption is increased as the difference between the external temperature and the maintenance temperature is increased.

Therefore, when supplying the battery **10** abroad, it is preferable for the processor **160** to control the heating unit **220** and the cooling unit **230** to match the maintenance temperature close to the external temperature by minimizing the amount of power used from the viewpoint of deterioration. In addition, when the shipping duration is short, it is preferable to increase the maintenance temperature because it is necessary to detect a defect of the battery **10** in a short period of time. However, in the case of the maintenance temperature, problems may occur if it exceeds 60° C. from the viewpoint of decomposition and deterioration of the electrolyte, such that it is preferable that the temperature does not exceed 50° C.

Meanwhile, procedures for determining whether a battery is a normal or defective product and charging to a battery state of charge in the battery transport equipment shown in FIG. **2** is illustrated in FIG. **3**.

First, an initial open circuit voltage (OCV2') may be measured using a separate open circuit voltage measurement device during a formation section of the formation process. In addition, a first open circuit voltage (OCV2) may be measured by the separate open circuit voltage measurement device, or the like for a predetermined period, for example, in a 20% section of a formation process. A separate processor **160**, or the like may obtain a delta voltage by subtracting the first open circuit voltage from the initial open circuit voltage, and then determine a defect first.

The processor **160** may control the voltage measurement unit **120** to measure the first open circuit voltage (OCV2) of the battery **10** loaded in the tray box **210**. In addition, the processor **160** may control the heating unit **220** and the cooling unit **230** by setting the maintenance temperature inside the tray box **210** according to the shipping duration. The battery **10** loaded in the tray box **210** may be stored for a long period of time at a constant temperature. However, there may be a situation where electricity cannot be supplied from an outside to the battery **10** loaded in the tray box **210**. Therefore, the inventive equipment does not necessarily have to include the heating unit **220** and the cooling unit **230**. However, since maintaining a constant level of the temperature is more effective in screening the defective product, it is preferable to include the heating unit **220** and the cooling unit **230**.

The processor **160** may control the voltage measurement unit **120** to measure a second open circuit voltage (OCV4) at the time of completing the shipment of the battery **10**. The processor **160** may obtain a delta voltage (ΔV) by subtracting the second open circuit voltage from the first open circuit voltage. Here, the delta voltage (ΔV) may be variable according to the maintenance temperature and the aging period.

Meanwhile, the battery transport equipment **200** may charge the battery to a value of SOC (OCV5), which is desired by the client company, in addition to the purpose of screening only the normal or defective product. When requested by the client company, the processor **160** may control the charging/discharging unit **130** to charge the battery **10** that has been determined to the normal product to SOC 100% (SOC100) and then discharge the battery **10** to SOC 0% (SOC0), and may calculate the rated capacity of the battery **10** using the time required to reach SOC 10% capacity. Then, the processor **160** may recharge the battery up to the shipping SOC. In this case, if there is no request from the client company, the SOC may be maintained at 75%.

FIGS. **4**A and **4**B are views illustrating a specific configuration of the battery transport equipment shown in FIG. **2**

As shown in FIGS. **4**A and **4**B, the tray box **210** may include a temperature sensing line **410** for detecting a temperature of the battery, and a voltage detection line **412** for detecting a voltage of the battery. The voltage sensing line **412** may be provided on a tray cover **420** and connected to electrodes of the battery **10** in a hinged manner. The tray cover **420**, which is the front of the tray box **210**, and the rear surface of the tray box **210** are provided with a Peltier module **422** and a hot wire **424**, respectively. The Peltier module **422** may be formed in a plate shape, and may include Peltier elements connected in series therein.

The tray box **210** may further include a spring **430** for close contact of the battery **10** to safely transport and a rubber product **432** for protecting current terminals and the electrodes of the battery **10**.

FIG. **5** is a flowchart illustrating procedures of a method for evaluating performance of a battery according to another embodiment of the present disclosure.

The processor **160** measures a first open circuit voltage of the battery **10** through the voltage measurement unit **120** at the start of aging (S**510**). The processor **160** may store the first open circuit voltage measured by the voltage measurement unit **120** in the storage unit **150**, and may also store the measurement time of the first open circuit voltage of the battery **10** using the timer unit **140** in the storage unit **150**.

The processor **160** measures an aging temperature of the battery **10** through the temperature measurement unit **110** (S**520**). Specifically, the processor **16** may control the temperature measurement unit **110** to measure the temperature of the battery **10** at a predetermined time interval using the timer unit **140** during aging of the battery **10**, and may receive temperature values from the temperature measurement unit **110**. The processor **160** may store the temperature values input from the temperature measurement unit **110** in the storage unit **150**.

The processor **160** measures a second open circuit voltage of the battery **10** through the voltage measurement unit **120** at the end of aging (S**530**). The processor **160** may store the second open circuit voltage measured by the voltage measurement unit **120** in the storage unit **150**, and may also store the measurement time of the second open circuit voltage of the battery **10** using the timer unit **140** in the storage unit **150**.

The processor **160** calculates a delta voltage of the voltage drop using a difference between the first open circuit voltage and the second open circuit voltage measured by the voltage measurement unit **120** (S**540**).

The processor **160** may determine whether the battery **10** is a normal or defective product based on the delta voltage calculated using the aging temperature measured by the temperature measurement unit **110** and the aging period between the measurement time of the first open circuit voltage and the measurement time of the second open circuit voltage (S**550**). The processor **160** may differently set the voltage range for comparison with the delta voltage in order to determine whether the battery **10** is a normal or defective product in consideration of the measured temperature values and the aging period between the measurement time of the first open circuit voltage and the measurement time of the second open circuit voltage, which are stored in the storage unit **150**. The processor **160** may set the voltage range as a reference voltage and a deviation from the reference voltage.

The processor **160** controls the charging/discharging unit **130** and the voltage measurement unit **120** to calculate a rated capacity of the battery **10** (S**560**). If it is determined that the battery **10** is a normal product, the processor **160** may measure the rated capacity of the battery **10** through charging and discharging operations. For example, the processor **160** may measure the rated capacity of the battery by charging the battery **10** that has been determined to be normal to SOC 100% through the charging/discharging unit **130** and then discharging the battery to SOC 10%.

After calculating the rated capacity of the battery **10**, the processor **160** controls the charging/discharging unit **130** and the voltage measurement unit **120** to charge the battery **10** to a value desired by the client or 75% of the SOC (S**570**).

The battery performance evaluation apparatus described in this disclosure may be an apparatus intended to carry out an aging process for inspecting defects of the battery performed during the formation process in the course of delivery or storage after shipment. For example, the battery performance evaluation apparatus may be implemented in the form of a tray box for storing one or more batteries in the course of delivery or storage, or may be implemented as a separate apparatus and mounted in the tray box.

The apparatus described above may be implemented by hardware components, software components, and/or a combination of hardware components and software components. For example, the apparatus and components described in the embodiments may be implemented in one or more general-use computers or special-purpose computers, such as a processor, a controller, an arithmetic logic unit (ALU), a digital signal processor (DSP), a microcomputer, a field programmable array (FPA), a programmable logic unit (PLU), a microprocessor or any device which may execute instructions and respond. A processing unit may implement an operating system (OS) or one or software applications running on the OS. Further, the processing unit may access, store, manipulate, process and generate data in response to execution of software. It will be understood by those skilled in the art that although a single processing unit may be illustrated for the convenience of understanding, the processing unit may include a plurality of processing elements and/or a plurality of types of processing elements. For example, the processing unit may include a plurality of processors or one processor and one controller. Also, the processing unit may have a different processing configuration, such as a parallel processor.

Software may include computer programs, codes, instructions or one or more combinations thereof and configure a processing unit to operate in a desired manner or independently or collectively control the processing unit. Software and/or data may be permanently or temporarily embodied in any type of machine, components, physical equipment, virtual equipment, computer storage media or units or transmitted signal waves so as to be interpreted by the processing unit or to provide instructions or data to the processing unit. Software may be dispersed throughout computer systems connected via networks and be stored or executed in a dispersion manner. Software and data may be recorded in one or more computer-readable storage media.

The method according to the embodiments may be recorded in computer-readable media including program instructions to implement various operations embodied by means of a computer. The computer-readable media may also include, alone or in combination with the program instructions, data files, data structures and the like. The program instructions recorded in the media may be designed and configured specially for the embodiments or be known and available to those skilled in computer software. Examples of computer-readable media include magnetic media such as hard disks, floppy disks, and magnetic tape; optical media such as CD ROMs and DVDs; magneto-optical media such as floptical disks; and hardware devices that are specially configured to store and perform program instructions, such as read-only memory (ROM), random access memory (RAM), flash memory and the like. Examples of program instructions include both machine code, such as produced by a compiler, and files containing higher level code that may be executed by the computer using an interpreter. The hardware devices may be configured to act as one or more software modules to perform the operations of the embodiments, or vice versa.

As described above, although the embodiments have been illustrated and described with reference to the limited embodiments and the accompanying drawings, it will be apparent to those skilled in the art that various modifications and alternations may be possible from the above descriptions. For example, adequate effects may be achieved even if the foregoing processes and methods are carried out in different order than described above, and/or the above-described elements, such as systems, structures, devices, or circuits, are combined or coupled in different forms and modes than as described above or be substituted or switched with other components or equivalents. Therefore, other implements, other embodiments, and equivalents to claims are within the scope of claims to be describe below.

What is claimed is:

1. An apparatus for evaluating performance of a battery, the apparatus comprising:
  a temperature measurement unit configured to measure an aging temperature of the battery;
  a voltage measurement unit configured to measure a first open circuit voltage of the battery at the start of aging and measure a second open circuit voltage of the battery at the end of aging; and
  a processor configured to calculate a delta voltage of a voltage drop using a difference between the first open circuit voltage and the second open circuit voltage measured by the voltage measurement unit, and determine whether the battery is a normal or defective product based on the delta voltage calculated using the aging temperature measured by the temperature measurement unit and an aging period between a measurement time of the first open circuit voltage and a measurement time of the second open circuit voltage,
  wherein the temperature measurement unit periodically measures the temperature of the battery at a predetermined time interval during aging of the battery to output the measured temperature values, and
  the processor sets a voltage range for comparison with the delta voltage in order to determine whether the battery is a normal or defective product in consideration of the temperature values measured at a predetermined time interval by the temperature measurement unit and the aging period.

2. The apparatus according to claim 1, wherein the processor sets the voltage range for comparison with the delta voltage as a reference voltage and a deviation from the reference voltage.

3. The apparatus according to claim 2, wherein the processor sets the reference voltage higher as the aging temperature of the battery is increased and the aging period is increased, and sets the deviation greater as the aging temperature is increased.

4. The apparatus according to claim 1, further comprising a charging/discharging unit configured to charge and discharge the battery,
  wherein the processor calculates a rated capacity of the battery by controlling the charging/discharging unit and the voltage measurement unit.

5. The apparatus according to claim 4, wherein the processor controls the charging/discharging unit to charge the battery to a value desired by a client or 75% of state of charge after calculating the rated capacity of the battery.

6. Equipment for transporting a battery, the equipment comprising:
  the apparatus for evaluating performance of a battery according to claim 1; and
  a tray box in which the battery is loaded,
  wherein the tray box includes a heating unit configured to increase the temperature of the battery and a cooling unit configured to decrease the temperature of the battery.

7. The equipment according to claim 6, wherein the heating unit includes a hot wire configured to heat the battery, and
  the cooling unit comprises a Peltier element configured to cool the battery.

8. The equipment according to claim 6, wherein the processor controls the heating unit and the cooling unit to maintain the temperature of the battery in consideration of a shipping duration of the battery in the equipment for transporting a battery.

9. The equipment according to claim 6, wherein a first open circuit voltage of the battery loaded in the tray box is a voltage at a time when the battery is determined to be a normal product in a formation process.

10. The equipment according to claim 6, wherein the tray box further comprises a spring for close contact of the battery when the battery is loaded in the tray box and a rubber product for protecting electrodes of the battery.

11. A method for evaluating performance of a battery in an apparatus for evaluating performance of a battery, the method comprising:
  measuring a first open circuit voltage of the battery at the start of aging;
  measuring an aging temperature of the battery;
  measuring a second open circuit voltage of the battery at the end of aging;
  calculating a delta voltage of a voltage drop using a difference between the first open circuit voltage measured in the step of measuring the first open circuit voltage and the second open circuit voltage measured in the step of measuring the second open circuit voltage; and
  determining whether the battery is a normal or defective product based on the delta voltage using the aging temperature measured in the step of measuring the aging temperature and an aging period between a measurement time of the first open circuit voltage and a measurement time of the second open circuit voltage,
  wherein the step of measuring the aging temperature comprises periodically measuring the temperature of the battery at a predetermined time interval during aging of the battery to output the measured temperature values; and
  the step of determining whether the battery is a normal or defective product comprises setting a voltage range for comparison with the delta voltage in order to determine whether the battery is a normal or defective product in consideration of the temperature values measured at a predetermined time interval in the step of measuring the aging temperature and the aging period.

12. The method according to claim 11, wherein the step of determining whether the battery is a normal or defective product comprises setting the voltage range for comparison with the delta voltage as a reference voltage and a deviation from the reference voltage.

13. The method according to claim 12, wherein the step of determining whether the product is normal or defective comprises setting the reference voltage higher as the aging temperature of the battery is increased and the aging period is increased, and setting the deviation greater as the aging temperature is increased.

14. The method according to claim **11**, further comprising calculating a rated capacity of the battery through charging and discharging of the battery.

15. The method according to claim **14**, further comprising charging the battery to a value desired by a client or 75% of state of charge after calculating the rated capacity of the battery.

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