

US Patent & Trademark Office

Patent Public Search | Text View

United States Patent Application Publication

20250266515

Kind Code

A1

Publication Date

August 21, 2025

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BATTERY SAFETY EVALUATION DEVICE

Abstract

Battery safety evaluation devices are provided. The battery safety evaluation devices may comprise: a mounting plate, the mounting plate comprising an upper surface for affixing a battery thereto; a chamber unit, the chamber unit comprising a battery accommodation space for accommodating the mounting plate; a plurality of temperature sensor units in the battery accommodation space; and a temperature analysis unit for receiving temperature measurement signals periodically from the plurality of temperature sensor units, wherein the plurality of temperature sensor units are spaced apart from each other within the battery accommodation space.

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Family ID: 1000008617931

Appl. No.: 18/842016

Filed (or PCT Filed): October 17, 2023

PCT No.: PCT/KR2023/015994

Foreign Application Priority Data

KR 10-2022-0148296

Nov. 09, 2022

Publication Classification

Int. Cl.: H01M10/42 (20060101); G01K1/02 (20210101); G01K1/14 (20210101); H01M10/48 (20060101)

U.S. Cl.:

CPC **H01M10/4285** (20130101); **G01K1/026** (20130101); **G01K1/14** (20130101);
H01M10/486 (20130101);

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a National Phase entry pursuant to 35 U.S.C. § 371 of International Application No. PCT/KR2023/015994 filed on Oct. 17, 2023, which claims priority to and the benefit of Korean Patent Application No. KR 10-2022-0148296, filed on Nov. 9, 2022. The contents of the above-identified applications are herein incorporated by reference in their entireties.

TECHNICAL FIELD

[0002] The present disclosure relates to battery safety evaluation apparatuses, and to battery safety evaluation apparatuses capable of quantitatively analyzing location and temperature of gas and flame emitted from a battery over time.

BACKGROUND

[0003] A sealed chamber is used to ensure the safety of researchers during battery experiments that have the risk of ignition and explosion, as well as to collect and analyze gases generated from the battery. At this time, the composition and amount of gas generated from the battery vary in real time depending on the kinetic characteristics (SOC, battery temperature, evaluation atmospheric environmental conditions, etc.). In addition, as the composition and amount of the gas change, the physical properties of the gas, such as temperature and density, also change.

[0004] Identifying the location and temperature distribution of gas and flame emitted outside the battery when excessive gas is generated inside the battery or when the battery ignites is very important in designing the battery itself and a device containing the battery.

[0005] Conventionally, a thermal imaging camera was used to measure the temperature distribution of the gas and flame generated and emitted from a battery.

[0006] When installing a thermal imaging camera inside a chamber for battery analysis, the thermal imaging camera may be damaged by harsh conditions within the chamber, and it was difficult to operate a cooling device for the thermal imaging camera inside the chamber.

[0007] When the thermal imaging camera is installed outside the chamber for battery analysis, a window made of a material capable of transmitting infrared rays is required by the chamber, and chambers designed in consideration of explosion-proof, and the like, have limitations in the size of the window, so there was also a limit to the scale of measurement.

[0008] Therefore, an effective technology is required to analyze real-time temperature distribution due to gas and flame emitted from the battery located inside the chamber.

[0009] The background description provided herein is for the purpose of generally presenting context of the disclosure. Unless otherwise indicated herein, the materials described in this section are not prior art to the claims in this application and are not admitted to be prior art, or suggestions of the prior art, by inclusion in this section.

SUMMARY

[0010] The present disclosure relates to battery safety evaluation apparatuses, and provides battery safety evaluation apparatuses capable of quantitatively analyzing location and temperature of gas and flame emitted from a battery over time.

[0011] Technical objects to be achieved by the present disclosure are not limited to the technical objects mentioned above, and other technical objects that are not mentioned will be clearly understood by those skilled in the art from the description below.

[0012] A battery safety evaluation apparatus of the present disclosure may include: a mounting plate, the mounting plate comprising an upper surface; a chamber unit, the chamber unit comprising a battery accommodation space for accommodating the mounting plate; a plurality of temperature sensor units in the battery accommodation space; and a temperature analysis unit for receiving temperature measurement signals periodically from the plurality of temperature sensor units, wherein the plurality of temperature sensor units are spaced apart from each other within the battery accommodation space.

[0013] A battery safety evaluation apparatus of the present disclosure may further include a mounting plate that is plate shaped, has a width in a first direction, and extends in a second direction, wherein the second direction is perpendicular to the first direction and the first direction and the second direction are perpendicular to a vertical direction.

[0014] A battery safety evaluation apparatus of the present disclosure may further include: a battery affixed to the upper surface of the mounting plate; a temperature sensor of the plurality of temperature sensor units arranged on a first virtual line extending in the second direction; and a temperature sensor of the plurality of temperature sensor units arranged on a second virtual line extending in the second direction, wherein the battery is between the first virtual line and the second virtual line.

[0015] A battery safety evaluation apparatus of the present disclosure may further include: a temperature sensor of the plurality of temperature sensor units located at an intersection of the first virtual line and a third virtual line extending in the first direction; a temperature sensor of the plurality of temperature sensor units located at an intersection of the first virtual line and a fourth virtual line extending in the first direction; a temperature sensor of the plurality of temperature sensor units located at an intersection of the second virtual line and the third virtual line; and a temperature sensor of the plurality of temperature sensor units located at an intersection of the second virtual line and the fourth virtual line, wherein the battery is between the third virtual line and the fourth virtual line.

[0016] A battery safety evaluation apparatus of the present disclosure may further include: a temperature sensor of the plurality of temperature sensor units located at an intersection of the first virtual line and a fifth virtual line extending in the first direction; and a temperature sensor of the plurality of temperature sensor units located at an intersection of the second virtual line and the fifth virtual line, wherein the fifth virtual line is between a first end of the battery and a second end of the battery.

[0017] A battery safety evaluation apparatus of the present disclosure may further include: a temperature sensor of the plurality of temperature sensor units located at an intersection of the first virtual line and a sixth virtual line extending in the first direction; and a temperature sensor of the plurality of temperature sensor units located at an intersection of the second virtual line and the sixth virtual line, wherein the sixth virtual line is between a first end of the battery and a second end of the battery.

[0018] A battery safety evaluation apparatus of the present disclosure may further include: a temperature sensor unit of the plurality of temperature sensor units that is rod shaped and extends in the vertical direction.

[0019] A battery safety evaluation apparatus of the present disclosure may further include: a temperature sensor unit that comprises a first measurement point and a second measurement point, and wherein the first measurement point is above the mounting plate, and the second measurement point is below the mounting plate.

[0020] A battery safety evaluation apparatus of the present disclosure may further include: a temperature sensor unit that further comprises a third measurement point, wherein the third measurement point is between the first measurement point and the second measurement point, and the third measurement point is above the mounting plate.

[0021] A battery safety evaluation apparatus of the present disclosure may further include a

chamber unit that comprises: a body unit having an opening; and a door unit coupled to the body unit and configured to cover the opening, wherein a first end of the mounting plate in the second direction is coupled to a surface of the door unit facing the opening, and a second end of the mounting plate in the second direction is in the battery accommodation space.

[0022] A battery safety evaluation apparatus of the present disclosure may further include: an upper end of a temperature sensor unit of the plurality of temperature sensor units that is fixed to a ceiling surface of the chamber unit, and a spacing between the first virtual line and the second virtual line that is longer than a length of the mounting plate in the first direction.

[0023] A battery safety evaluation apparatus of the present disclosure may further include a temperature sensor unit of the plurality of temperature sensor units that penetrates the mounting plate, and a spacing between the first virtual line and the second virtual line that is shorter than a length of the mounting plate in the first direction and longer than a length of the battery in the first direction.

[0024] A battery safety evaluation apparatus of the present disclosure may further include a door unit that includes a feed-through for connecting the plurality of temperature sensor units to the temperature analysis unit by wire.

[0025] A battery safety evaluation apparatus of the present disclosure may further include: a battery affixed to the upper surface of the mounting plate; a lower jig with a bottom surface fixed on the upper surface of the mounting plate; a first insulating layer between the battery and the lower jig; an upper jig for pressurizing an upper surface of the battery; a second insulating layer between the upper jig and the upper surface of the battery; a bottom surface temperature measurement sensor between the first insulating layer and the battery; and an upper surface temperature measurement sensor between the second insulating layer and the battery.

[0026] A battery safety evaluation apparatus of the present disclosure may further include: a first fixing means for fixing the upper jig to the lower jig; and a second fixing means for fixing the lower jig to the mounting plate.

[0027] A battery safety evaluation apparatus of the present disclosure may be capable of effectively analyzing real-time temperature distribution due to gas and flame emitted from a battery located inside a chamber.

[0028] A battery safety evaluation apparatus of the present disclosure may be capable of quantifying location and temperature of the gas and flame emitted from the inside of the battery to the outside over time.

[0029] A battery safety evaluation apparatus of the present disclosure may maximize the reproducibility of analysis by minimizing parts consumed for repeated measurements.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0030] The accompanying drawings illustrate various embodiments of the present disclosure and together with the foregoing disclosure, serve to provide further understanding of the technical features of the present disclosure, and thus, the present disclosure is not construed as being limited to the drawings.

[0031] FIG. 1 is a cross-sectional view illustrating a battery safety evaluation apparatus of the present disclosure.

[0032] FIG. 2 is a plan view illustrating a positional relationship between a temperature sensor unit and a battery.

[0033] FIG. 3 is a cross-sectional view illustrating a chamber unit.

[0034] FIG. 4 is a perspective view illustrating an embodiment in which a temperature sensor unit is coupled to a mounting plate.

[0035] FIG. 5 is a perspective view illustrating an embodiment in which a battery is fixed to a mounting plate.

DETAILED DESCRIPTION

[0036] A battery safety evaluation apparatus of the present disclosure may include: [0037] a mounting plate, a battery being fixed on an upper surface of the mounting plate; [0038] a chamber unit in which a battery accommodation space to accommodate the mounting plate is formed inside; [0039] a temperature sensor unit provided in the battery accommodation space; and [0040] a temperature analysis unit that receives temperature measurement signals as input at a predetermined time period from the temperature sensor unit, [0041] wherein a plurality of the temperature sensor units may be provided, and [0042] the plurality of temperature sensor units may be provided to be spaced a predetermined distance apart from each other within the battery accommodation space.

[0043] The mounting plate of the battery safety evaluation apparatus of the present disclosure may be provided in a plate shape having a constant width in a first direction perpendicular to a vertical direction and extending in a second direction perpendicular to the vertical direction and the first direction.

[0044] In the battery safety evaluation apparatus of the present disclosure, when a pair of virtual straight lines extending in the second direction with the battery in between are referred to as a first virtual line and a second virtual line, at least one or more of the plurality of temperature sensor units may be arranged on each of the first virtual line and the second virtual line.

[0045] In the battery safety evaluation apparatus of the present disclosure, when a pair of virtual straight lines extending in the first direction with the battery in between are referred to as a third virtual line and a fourth virtual line, the plurality of temperature sensor units may be disposed at an intersection point of the third virtual line and the first virtual line, an intersection point of the third virtual line and the second virtual line, an intersection point of the fourth virtual line and the first virtual line, and an intersection point of the fourth virtual line and the second virtual line.

[0046] In the battery safety evaluation apparatus of the present disclosure, when a pair of virtual straight lines located between one end and the other end of the battery and extending in the first direction are referred to as a fifth virtual line, the plurality of temperature sensor units may be further disposed at an intersection point of the fifth virtual line and the first virtual line, and an intersection point of the fifth virtual line and the second virtual line.

[0047] In the battery safety evaluation apparatus of the present disclosure, a plurality of the fifth virtual lines may be provided.

[0048] In the battery safety evaluation apparatus of the present disclosure, the temperature sensor unit may be provided in a rod shape extending in the vertical direction.

[0049] In the battery safety evaluation apparatus of the present disclosure, the temperature sensor unit may include a first measurement point and a second measurement point, wherein the first measurement point may be located at a higher position than the mounting plate, and the second measurement point may be located at a lower position than the mounting plate.

[0050] In the battery safety evaluation apparatus of the present disclosure, the temperature sensor unit may further include a third measurement point located between the first measurement point and the second measurement point, and the third measurement point may be located at a higher position than the mounting plate.

[0051] In the battery safety evaluation apparatus of the present disclosure, the chamber unit may include a body unit in which one end in the second direction is opened to form an opening and the battery accommodation space is formed inside, and a door unit coupled to the body unit and configured to cover the opening, wherein one end of the mounting plate in the second direction may be coupled to a surface of the door unit facing the opening, and the other end of the mounting plate in the second direction may be inserted into the battery accommodation space through the opening.

[0052] In the battery safety evaluation apparatus of the present disclosure, upper ends of the plurality of temperature sensor units may be fixed to a ceiling surface of the chamber unit, and an interval between the first virtual line and the second virtual line may be longer than a length of the mounting plate in the first direction.

[0053] In the battery safety evaluation apparatus of the present disclosure, the plurality of temperature sensor units may be fixed to the mounting plate in a state of penetrating the mounting plate, and an interval between the first virtual line and the second virtual line may be shorter than a length of the mounting plate in the first direction and longer than a length of the battery in the first direction.

[0054] In the battery safety evaluation apparatus of the present disclosure, the door unit may be provided with a feed-through for connecting the plurality of temperature sensor units and the temperature analysis unit by wire.

[0055] The battery safety evaluation apparatus of the present disclosure may further include a lower jig with a bottom surface fixed on the upper surface of the mounting plate; a first insulating layer stacked between the battery and the lower jig; a second insulating layer stacked on an upper surface of the battery; an upper jig for pressurizing the upper surface of the battery with the second insulating layer in between; a bottom surface temperature measurement sensor inserted between the first insulating layer and the battery; and an upper surface temperature measurement sensor inserted between the second insulating layer and the battery.

[0056] The battery safety evaluation apparatus of the present disclosure may further include a first fixing means for fixing the upper jig to the lower jig; and a second fixing means for fixing the lower jig to the mounting plate.

[0057] Hereinafter, embodiments according to the present disclosure will be described in detail with reference to the attached drawings. In this process, the size or shape of components shown in the drawings may be exaggerated for clarity and convenience of explanation.

[0058] In the description of the present disclosure, it should be noted that an orientation or positional relationship indicated by the terms such as “center”, “upper”, “lower”, “left”, “right”, “vertical”, “horizontal”, “inner side”, “outer side”, “one side”, and “other side” is based on an orientation or positional relationship shown in a drawing or an orientation or positional relationship that is placed when using the product of the present disclosure on a daily basis, and is merely for explanation and brief description of the present disclosure, and it does not suggest or imply that the displayed device or element must necessarily be configured or operated in a specified orientation and should not be construed as limiting the present disclosure.

[0059] FIG. 1 is a cross-sectional view illustrating a battery safety evaluation apparatus of the present disclosure. FIG. 2 is a plan view illustrating a positional relationship between a temperature sensor unit **100** and a battery **11**. FIG. 3 is a cross-sectional view illustrating a chamber unit **300**. FIG. 4 is a perspective view illustrating an embodiment in which the temperature sensor unit **100** is coupled to a mounting plate **200**. FIG. 5 is a perspective view illustrating an embodiment in which the battery **11** is fixed to the mounting plate **200**.

[0060] Hereinafter, with reference to FIGS. 1 to 5, battery safety evaluation apparatuses of the present disclosure will be described in detail. In FIGS. 1 to 5, the y-axis direction may be a first direction, the x-axis direction may be a second direction, and the z-axis direction may be a vertical direction. The vertical direction, which is the z-axis direction, may be the direction of gravity. For example, gravity may act to bring a bottom surface of the battery **11** into close contact with an upper surface of the mounting plate **200**.

[0061] As shown in FIG. 1, a battery safety evaluation apparatus of the present disclosure may include: [0062] the mounting plate **200**, the battery **11** being fixed on an upper surface of the mounting plate **200**; [0063] the chamber unit **300** in which a battery accommodation space **311** to accommodate the mounting plate **200** is formed inside; [0064] the temperature sensor unit **100** provided in the battery accommodation space **311**; and [0065] a temperature analysis unit **400** that

receives temperature measurement signals as input at a predetermined time period from the temperature sensor unit **100**, [0066] wherein a plurality of the temperature sensor units **100** may be provided, and [0067] the plurality of temperature sensor units **100** may be provided to be spaced a predetermined distance apart from each other within the battery accommodation space **311**. [0068] The battery safety evaluation apparatus of the present disclosure may dispose the plurality of temperature sensor units **100** around the battery **11** within the sealed chamber unit **300**, collect temperature measurement values at a predetermined time period from the plurality of temperature sensor units **100** disposed, and calculate thermal mapping data as time series data indicating situations in which the battery **11** is damaged in situations such as explosion or leakage of the battery **11**.

[0069] In other words, it may be possible to analyze safety of a local position of the battery **11** by analyzing emission and movement of heat for each position of the battery **11**.

[0070] The temperature analysis unit **400** may receive the temperature measurement values output from the temperature sensor units **100**. The temperature analysis unit **400** may store position information and identification codes for each of the plurality of temperature sensor units **100**. The temperature measurement value received from the plurality of temperature sensor units **100** may be stored by matching the identification code corresponding to each of the plurality of temperature sensor units **100**.

[0071] The temperature analysis unit **400** may receive temperature measurement values from the temperature sensor units **100** at a predetermined time period and calculate temperature analysis data as time series data.

[0072] The temperature analysis unit **400** may be a computing device. The temperature analysis unit **400** may be connected to a display device and may output temperature analysis data to the display device.

[0073] The temperature analysis unit **400** may be located outside the chamber unit **300**, and a feed-through **321** may be provided on a wall of the chamber unit **300** for electrical connection with the temperature sensor unit **100**, a charge/discharge cable **410**, a heater inside the chamber unit **300**, or the like. The temperature analysis unit **400** may forcibly impose conditions such as explosion or damage on the battery **11** by controlling a charge/discharge module, a heater, or the like.

[0074] The mounting plate **200** may be provided in a plate shape having a constant width in a first direction perpendicular to a vertical direction and extending in a second direction perpendicular to the vertical direction and the first direction. The battery **11** may be mounted on the upper surface of the mounting plate **200**. The battery **11** may be fixed by directly contacting the mounting plate **200**, or may be fixed to the mounting plate **200** through an upper jig **220** and a lower jig **210**, which will be described later.

[0075] In the battery safety evaluation apparatus of the present disclosure, the battery **11** to be analyzed may be, for example, a pouch-type battery **11**. Specifically, it may be the battery **11** including flat shape electrodes (anode, cathode) perpendicular to the vertical direction. More specifically, the electrode may be provided in a rectangular shape with a side length in the second direction longer than that in the first direction.

[0076] As shown in FIG. 2, when a pair of virtual straight lines extending in the second direction with the battery **11** in between are referred to as a first virtual line **l1** and a second virtual line **l2**, at least one of the plurality of temperature sensor units **100** may be arranged on each of the first virtual line **l1** and the second virtual line **l2**. On each of the first virtual line **l1** and the second virtual line **l2**, 2 to 10 temperature sensor units **100** may be arranged. For example, 3 or 7 temperature sensor units **100** may be arranged on each of the first virtual line **l1** and the second virtual line **l2** of the temperature sensor unit **100**. The number of temperature sensor units **100** arranged on each of the first virtual line **l1** and the second virtual line **l2** may be determined by considering conditions such as the standard, material, and structure of the battery **11**, or insulation and explosion-proof of the structure to which the battery **11** is applied and installed.

[0077] A spacing between the first virtual line **l1** and the second virtual line **l2** may be 110% to 150% of a length of the battery **11** in the first direction. For example, the interval between the first virtual line **l1** and the second virtual line **l2** may be 240 mm to 360 mm. The interval between the first virtual line **l1** and the second virtual line **l2** may be about 300 mm.

[0078] The battery safety evaluation method of the present disclosure may be to determine the temperature around the battery **11** in real time and analyze thermal behavior in a situation where the battery **11** explodes or ignites. In other words, the chamber unit **300** may be formed to have an explosion-proof structure that may withstand high pressure, high heat, explosion, and the like, during analysis. For example, the chamber unit **300** may be provided in a cylindrical shape extending in the second direction for the explosion-proof structure.

[0079] At this time, if the first virtual line **l1** and the second virtual line **l2** becomes excessively far apart, the volume of the battery accommodation space **311** of the chamber unit **300** may become excessively large because the temperature sensor unit **100** may also be provided in a rod shape extending in the vertical direction. In this case, a space in which a battery-generated gas generated inside the battery **11** diffuses becomes larger, which may make it difficult to analyze the battery-generated gas. In addition, if the temperature sensor unit **100** is located too close to the battery **11**, when the battery **11** explodes or ignites, the temperature sensor unit **100** may be damaged, or the temperature sensor unit **100** itself may affect the airflow around the battery **11**. Accordingly, the interval between the first virtual line **l1** and the second virtual line **l2** may be 110% to 150% of the length of the battery **11** in the first direction.

[0080] As shown in FIG. 2, when a pair of virtual straight lines extending in the first direction with the battery **11** in between are referred to as a third virtual line **l3** and a fourth virtual line **l4**, the plurality of temperature sensor units **100** may be disposed at an intersection point **P1** of the third virtual line **l3** and the first virtual line **l1**, an intersection point **P2** of the third virtual line **l3** and the second virtual line **l2**, an intersection point **P3** of the fourth virtual line **l4** and the first virtual line **l1**, and an intersection point **P4** of the fourth virtual line **l4** and the second virtual line **l2**. An interval between the third virtual line **l3** and the fourth virtual line **l4** may be 110% to 150% of a length of the battery **11** in the second direction. For example, the interval between the third virtual line **l3** and the fourth virtual line **l4** may be 640 mm to 960 mm. For example, the interval between the third virtual line **l3** and the fourth virtual line **l4** may be about 800 mm.

[0081] When a pair of virtual straight lines located between one end and the other end of the battery **11** and extending in the first direction are referred to as a fifth virtual line **l5**, the plurality of temperature sensor units **100** may be further disposed at an intersection point **P5** of the fifth virtual line **l5** and the first virtual line **l1**, and an intersection point **P6** of the fifth virtual line **l5** and the second virtual line **l2**.

[0082] At the center of the first virtual line **l1** and the second virtual line **l2**, a sixth virtual line (not shown), which is a straight line extending in the second direction, may be located, and the temperature sensor unit **100** may be located at each of the intersection point between the sixth virtual line and the third virtual line **l3**, and the intersection point between the sixth virtual line and the fourth virtual line **l4**.

[0083] When the battery **11** is formed to be very long along the major axis (second direction), a plurality of the fifth virtual lines **l5** may be provided. For example, there may be five fifth virtual lines **l5**, and a total of 16 temperature sensor units **100** may be provided. In the battery safety evaluation apparatus of the present disclosure, one temperature sensor unit **100** may have 3 measurement points, as will be described later. Therefore, in the battery accommodation space **311** of the battery safety evaluation apparatus of the present disclosure, temperature may be measured at 48 points, and the temperature measurement value may be provided as time series data (temperature-time graph) for each of the 48 points.

[0084] As shown in FIGS. 1 and 3, the temperature sensor unit **100** may be provided in a rod shape extending in the vertical direction. The temperature sensor unit **100** may be a thermocouple (TC)

with high heat resistance. One temperature sensor unit **100** may include a plurality of temperature measurement points.

[0085] Specifically, the temperature sensor unit **100** may include a first measurement point (t) and a second measurement point (c), wherein the first measurement point (t) may be located at a higher position than the mounting plate **200**, and the second measurement point (c) may be located at a lower position than the mounting plate **200**. More specifically, the first measurement point (t) may be located at a higher position than an upper surface of the battery **11**, and the second measurement point (c) may be located at a lower position than the bottom surface of the battery **11**.

[0086] The temperature sensor unit **100** may further include a third measurement point (m) located between the first measurement point (t) and the second measurement point (c), wherein the third measurement point (m) may be located at a higher position than the mounting plate **200**. More specifically, the third measurement point (m) may be formed at a position facing the side surface of the battery **11**.

[0087] Therefore, each of the plurality of temperature sensor units **100** may have three temperature measurement points, and for example, when six temperature sensor units **100** are provided, the temperature analysis unit **400** may output temperature measurement data for a total of 18 points. For example, 18 graphs of temperature over time may be output from the temperature analysis unit **400**.

[0088] As shown in FIGS. **1** and **3**, the chamber unit **300** may include a body unit **310** in which one end in the second direction is opened to form an opening **312** and the battery accommodation space **311** is formed inside, and a door unit **320** coupled to the body unit **310** and configured to cover the opening **312**, wherein one end of the mounting plate **200** in the second direction may be coupled to a surface of the door unit **320** facing the opening **312**, and the other end of the mounting plate **200** in the second direction may be inserted into the battery accommodation space **311** through the opening **312**.

[0089] The door unit **320** may be coupled to or separated from the body unit **310** while sliding in the second direction and moving linearly.

[0090] When the door unit **320** is slid to approach the body unit **310**, the mounting plate **200** may move together with the door unit **320** and be inserted into the battery accommodation space **311** through the opening **312**. When the door unit **320** is slid to be separated from the body unit **310**, the mounting plate **200** may move together with the door unit **320** and be discharged from the battery accommodation space **311**.

[0091] The body unit **310** may be an explosion-proof chamber. The body unit **310** may be provided in a cylindrical shape with an opening **312** formed at one end in the second direction and extending in the second direction. The body unit **310** may be connected to a relief valve **313** to relieve a high pressure of the battery accommodation space **311**, and a gas delivery pipe **315** for delivering the gas diffused in the battery accommodation space **311** to an external gas collection pipe or gas analysis device.

[0092] In an embodiment, as shown in FIGS. **1** and **3**, upper ends of the plurality of temperature sensor units **100** may be fixed to a ceiling surface of the chamber unit **300**, and an interval between the first virtual line **l1** and the second virtual line **l2** may be longer than a length of the mounting plate **200** in the first direction. In other words, the plurality of temperature sensor units **100** may be arranged side by side in two rows (first virtual line **l1** and second virtual line **l2**) and fixed to the body unit **310**, and the mounting plate **200**, when inserted into the battery accommodation space **311**, may be inserted between the two rows of the first virtual line **l1** and the second virtual line **l2**.

[0093] The door unit **320** may be provided in a hemisphere or disk shape. To a side surface of the door unit **320** (a surface facing the opening **312** of the body unit **310**), the mounting plate **200** may be fixed. A plurality of the feed-throughs **321** may be provided in the door unit **320**.

[0094] As another embodiment, as shown in FIG. **4**, the plurality of temperature sensor units **100** may be fixed to the mounting plate **200** in a state of penetrating the mounting plate **200**, and the

interval between the first virtual line **l1** and the second virtual line **l2** may be shorter than the length of the mounting plate **200** in the first direction and longer than the length of the battery **11** in the first direction. In other words, the plurality of temperature sensor units **100** may move together with the door unit **320**. At this time, the door unit **320** may be provided with the feed-through **321** for connecting the plurality of temperature sensor units **100** and the temperature analysis unit **400** by wire.

[0095] In the mounting plate **200**, a ventilation hole **250** for air flow in the vertical direction may be formed. For example, the ventilation hole **250** may be provided in the shape of a long hole extending in the second direction.

[0096] As shown in FIG. 5, the battery safety evaluation apparatus of the present disclosure may further include: [0097] the lower jig **210** with a bottom surface fixed on the upper surface of the mounting plate **200**; [0098] a first insulating layer **230** stacked between the battery **11** and the lower jig **210**; [0099] a second insulating layer **240** stacked on the upper surface of the battery **11**; [0100] the upper jig **220** for pressurizing the upper surface of the battery **11** with the second insulating layer **240** in between; [0101] a bottom surface temperature measurement sensor **110** inserted between the first insulating layer **230** and the battery **11**; and [0102] an upper surface temperature measurement sensor **120** inserted between the second insulating layer **240** and the battery **11**.

[0103] The upper jig **220** and lower jig **210** may prevent the battery **11** from leaving its original position, and the temperature of the battery **11** itself may be measured by attaching the upper surface temperature measurement sensor **120** and the bottom surface temperature measurement sensor **110** to the battery **11**.

[0104] The upper jig **220** and lower jig **210** may be Al plates.

[0105] The upper surface temperature measurement sensor **120** and the bottom surface temperature measurement sensor **110** may be rod-shaped thermocouples.

[0106] A temperature measurement sensor insertion groove may be formed on an upper surface of the first insulating layer **230** and a bottom surface of the second insulating layer **240**, so that the first insulating layer **230** and the second insulating layer **240** may be prevented from lifting from the surface of the battery **11** by the upper surface temperature measurement sensor **120** and the bottom surface temperature measurement sensor **110**.

[0107] The battery safety evaluation apparatus of the present disclosure may further include a first fixing means for fixing the upper jig **220** to the lower jig **210**; and a second fixing means for fixing the lower jig **210** to the mounting plate **200**. The first fixing means and the second fixing means may be bolts, nuts, or the like, for screw connection.

[0108] Although embodiments according to the present disclosure have been described above, they are merely illustrative, and those skilled in the art will understand that various modifications and embodiments of an equivalent scope are possible therefrom. Therefore, the true technical protection scope of the present disclosure should be determined by the appended claims. [0109] <Explanation of Symbols> **11** . . . Battery, **100** . . . Temperature sensor unit, **110** . . . Bottom surface temperature measurement sensor, **120** . . . Upper surface temperature measurement sensor, **200** . . . Mounting plate, **210** . . . Lower jig, **220** . . . Upper jig, **230** . . . First insulating layer, **240** . . . Second Insulating layer, **250** . . . Ventilation hole, **300** . . . Chamber unit, **310** . . . Body unit, **311** . . . Battery accommodation space, **312** . . . Opening, **313** . . . Relief valve, **315** . . . Gas delivery pipe, **320** . . . Door unit, **321** . . . Feed-through, **400** . . . Temperature analysis unit, **410** . . . Charge/discharge cable, **l1** . . . First virtual line, **l2** . . . Second virtual line, **l3** . . . Third virtual line, **l4** . . . Fourth virtual line, **l5** . . . Fifth virtual line, **t** . . . First measurement point, **c** . . . Second measurement point, **m** . . . Third measurement point

[0110] A battery safety evaluation apparatus of the present disclosure may be capable of effectively analyzing real-time temperature distribution due to gas and flame emitted from a battery located inside a chamber.

[0111] A battery safety evaluation apparatus of the present disclosure may be capable of quantifying location and temperature of the gas and flame emitted from the inside of the battery to the outside over time.

[0112] A battery safety evaluation apparatus of the present disclosure may maximize the reproducibility of analysis by minimizing the parts consumed for repeated measurements.

Claims

1. A battery safety evaluation apparatus comprising: a mounting plate, the mounting plate comprising an upper surface; a chamber unit, the chamber unit comprising a battery accommodation space for accommodating the mounting plate; a plurality of temperature sensor units in the battery accommodation space; and a temperature analysis unit for receiving temperature measurement signals periodically from the plurality of temperature sensor units, wherein the plurality of temperature sensor units are spaced apart from each other within the battery accommodation space.
2. The battery safety evaluation apparatus of claim 1, wherein the mounting plate is plate shaped, has a width in a first direction, and extends in a second direction, wherein the second direction is perpendicular to the first direction and the first direction and the second direction are perpendicular to a vertical direction.
3. The battery safety evaluation apparatus of claim 2, further comprising a battery affixed to the upper surface of the mounting plate, wherein: a temperature sensor of the plurality of temperature sensor units is arranged on a first virtual line extending in the second direction; and a temperature sensor of the plurality of temperature sensor units is arranged on a second virtual line extending in the second direction, wherein the battery is between the first virtual line and the second virtual line.
4. The battery safety evaluation apparatus of claim 3, wherein: a temperature sensor of the plurality of temperature sensor units is located at an intersection of the first virtual line and a third virtual line extending in the first direction; a temperature sensor of the plurality of temperature sensor units is located at an intersection of the first virtual line and a fourth virtual line extending in the first direction; a temperature sensor of the plurality of temperature sensor units is located at an intersection of the second virtual line and the third virtual line; and a temperature sensor of the plurality of temperature sensor units is located at an intersection of the second virtual line and the fourth virtual line, wherein the battery is between the third virtual line and the fourth virtual line.
5. The battery safety evaluation apparatus of claim 4, wherein: a temperature sensor of the plurality of temperature sensor units is located at an intersection of the first virtual line and a fifth virtual line extending in the first direction; and a temperature sensor of the plurality of temperature sensor units is located at an intersection of the second virtual line and the fifth virtual line, wherein the fifth virtual line is between a first end of the battery and a second end of the battery.
6. The battery safety evaluation apparatus of claim 5, wherein: a temperature sensor of the plurality of temperature sensor units is located at an intersection of the first virtual line and a sixth virtual line extending in the first direction; and a temperature sensor of the plurality of temperature sensor units is located at an intersection of the second virtual line and the sixth virtual line, wherein the sixth virtual line is between the first end of the battery and the second end of the battery.
7. The battery safety evaluation apparatus of claim 3, wherein a temperature sensor unit of the plurality of temperature sensor units is rod shaped and extends in the vertical direction.
8. The battery safety evaluation apparatus of claim 7, wherein the temperature sensor unit comprises a first measurement point and a second measurement point, and wherein the first measurement point is above the mounting plate, and the second measurement point is below the mounting plate.
9. The battery safety evaluation apparatus of claim 8, wherein the temperature sensor unit further comprises a third measurement point, wherein the third measurement point is between the first

measurement point and the second measurement point, and the third measurement point is above the mounting plate.

10. The battery safety evaluation apparatus of claim 7, wherein the chamber unit comprises: a body unit having an opening; and a door unit coupled to the body unit and configured to cover the opening, wherein a first end of the mounting plate in the second direction is coupled to a surface of the door unit facing the opening, and a second end of the mounting plate in the second direction is in the battery accommodation space.

11. The battery safety evaluation apparatus of claim 10, wherein: an upper end of a temperature sensor unit of the plurality of temperature sensor units is fixed to a ceiling surface of the chamber unit; and a spacing between the first virtual line and the second virtual line is longer than a length of the mounting plate in the first direction.

12. The battery safety evaluation apparatus of claim 10, wherein: a temperature sensor unit of the plurality of temperature sensor units penetrates the mounting plate; and a spacing between the first virtual line and the second virtual line is shorter than a length of the mounting plate in the first direction and longer than a length of the battery in the first direction.

13. The battery safety evaluation apparatus of claim 12, wherein the door unit includes a feed-through for connecting the plurality of temperature sensor units to the temperature analysis unit by wire.

14. The battery safety evaluation apparatus of claim 1, further comprising: a battery affixed to the upper surface of the mounting plate; a lower jig having a bottom surface fixed on the upper surface of the mounting plate; a first insulating layer between the battery and the lower jig; an upper jig for pressurizing an upper surface of the battery; a second insulating layer between the upper jig and the upper surface of the battery; a bottom surface temperature measurement sensor between the first insulating layer and the battery; and an upper surface temperature measurement sensor between the second insulating layer and the battery.

15. The battery safety evaluation apparatus of claim 14, further comprising: a first fixing means for fixing the upper jig to the lower jig; and a second fixing means for fixing the lower jig to the mounting plate.
