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### ACCELERATED FATIGUE EVALUATION DEVICE FOR WELDED PORTION OF BATTERY MODULE FRAME FOR VEHICLE

#### Abstract

An acceleration fatigue evaluation device of a welding part of a module frame includes a module frame for testing having a top plate and an end frame welded to the top and two sides of a U-frame, respectively and an unwelded low surface of the U-frame opened; a center jig connected to support a front and a rear of the module frame for testing; a guide block jig for downwardly supporting an end frame of the module frame for testing; a piston for entering the module frame for testing and applying a repeated load to an inner surface of the top plate; at least one battery cell interposed between the piston and the inner surface of the top plate; and a displacement sensor for measuring a deformation at a center of an outer surface of the top plate.

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## **Background/Summary**

### TECHNICAL FIELD

[0001] The present invention relates to an acceleration fatigue evaluation device of welding part of a battery module frame for a vehicle, in which reliable results on acceleration fatigue failure of the welding part can be obtained by applying a repeated load simulating the swelling behavior of the battery cell to the welding part of the battery module frame for a vehicle.

[0002] This application claims the benefit of priority based on Korean Patent Application No. 10-2022-0180259, filed on Dec. 21, 2022, and the entire contents of the Korean patent application are incorporated herein by reference.

### BACKGROUND ART

[0003] Unlike primary batteries, secondary batteries are rechargeable and have been extensively researched and developed recently due to potential for miniaturization and high-capacity applications. With the increasing technological advancements and demand for mobile devices, as well as the growing prominence of electric vehicles and energy storage systems in response to environmental concerns, the demand for secondary batteries as an energy source are rapidly and significantly increasing.

[0004] When a large capacity of a secondary battery is required, such as in an electric vehicle, a plurality of battery cells is connected in series and/or parallel to form an aggregated structure to fulfill the required capacity requirement. A battery module frame is provided as a case for storing a plurality of secondary batteries, and a plurality of battery cells are stacked in a receiving space formed in a cuboidal shape inside the module frame.

[0005] It is common for a modular frame to be constructed by welding several plates together, and an example of such a module frame is shown in FIG. 1. The module frame is formed by having end frames welded to the left and right sides of an U-frame bent in the form of an U-shape, and a top plate welded to the other side of the U-frame forming the top surface of the module frame.

[0006] A plurality of battery cells stored in the battery module frame are repeatedly charged and discharged, and the electrode assembly in the battery cells is subjected to a swelling phenomenon. As the electrode assembly expands and contracts by repeatedly charging and discharging, the swelling phenomenon causes localized expansion of the battery cells, and the battery module frame is subjected to continuous pressure due to the expansion of the battery cells.

[0007] Since the module frame should maintain its durability over the lifespan of the battery module, it is essential to evaluate the structural stability of the module frame at the initial stage of the battery module design. However, it takes a long time to evaluate the structural stability of the battery module frame by repeatedly charging and discharging actual battery cells, so simulating experiments are conducted to shorten the testing time.

[0008] In the module frame of FIG. 1, the welding part area of the top plate is the most concerning area for fatigue failure. When the stacked battery cells expand, the force due to their deformation applies in the upward and downward directions, and since the bottom surface of the module frame is an integral bending structure, the welding part of the top plate is relatively structurally weak. Therefore, it is expected that a crack may occur in the welding part of the top plate by fatigue failure due to repeated loading and spread along the welding part, causing the top plate to be

damaged, and thus it is evaluated.

[0009] Conventionally, tests have been conducted by applying a constant load to the top plate with a piston hydraulic pressure repeatedly. However, in order to simulate the characteristics of the battery cell, which expands the most in the center, the piston has a convex shape with a gently protruding central area, and it was found that the size and shape of the convex shape caused significant differences in the test results.

[0010] In addition, the hydraulic pressure applied to the piston was based on the loading conditions at the end of life (EOL), which was too harsh from the beginning, making it difficult to obtain reliable results on the actual lifespan of the module frame.

## DISCLOSURE

### Technical Problem

[0011] The present invention is directed to providing an acceleration fatigue evaluation device, which can obtain reliable results on acceleration fatigue failure of welding part by applying repeated loads simulating the swelling behavior of a battery cell accommodated in a battery module frame under conditions similar to actual conditions.

[0012] However, the technical problem to be solved by the present invention is not limited to the above-described problem, and other problems not mentioned can be clearly understood by a person skilled in the art from the description of the invention described below.

### Technical Solution

[0013] The present invention relates to an acceleration fatigue evaluation device of a welding part of a module frame, comprising, in one example, a module frame for testing having: a U-frame, the U-frame having an open, unwelded lower surface; a top plate; and a pair of end frames welded to the top plate and opposite sides of the U-frame; a center jig connected to the module frame for testing to support a front of the module frame for testing and a rear of the module frame for testing; a guide block jig supporting the end frame of the module frame for testing from below; a piston configured to enter the module frame for testing, the piston being configured to apply a repeated load to an inner surface of the top plate; at least one battery cell interposed between the piston and the inner surface of the top plate; and a displacement sensor configured to measure a deformation at a center of an outer surface of the top plate.

[0014] In one embodiment of the present invention, the battery cell may be of a same specification as the battery cell mounted in the module frame.

[0015] For example, the battery cell may be a pouch cell, wherein the pouch cell is preferably interposed between the piston and the inner surface of the top plate in a completely discharged state.

[0016] In addition, the guide block jig may preferably have downwardly supported edges thereof to avoid encroaching on welding parts of the end frame.

[0017] Meanwhile, the repeated load applied by the piston to the top plate via the battery cell may be applied in a profile simulating displacement of swelling expansion and contraction of the battery cell as the battery cell progresses through a charge and discharge cycle.

[0018] For example, the profile is a load-cycle profile that converts the displacement of the swelling expansion and contraction of the battery cell over the progression of the charge and discharge cycle into a load.

[0019] The load-cycle profile may have a pattern wherein a load at charge and a load at discharge increase with the progression of the charge and discharge cycle.

[0020] Further, a difference value between the load at charge and the load at discharge increases with the progression of the charge and discharge cycle.

[0021] Further, the acceleration fatigue evaluation device of a welding part of a module frame may include a controller, and, in a cycle in which the amount of deformation of the top plate measured by the displacement sensor deviates from a linear increasing pattern and suddenly increases sharply, the controller is configured to: determine that the welding part of the top plate has been

destroyed; and stop the application of the repeated load.

#### Advantageous Effects

[0022] The acceleration fatigue evaluation device of a welding part of a module frame of the present invention having the configuration as described above, simulates constraint condition of a module frame mounted on a vehicle by a center jig and a guide block jig, meanwhile, by applying a repeated load of a piston to an inner surface of a top plate, a pressurized condition of a swelling behavior of a battery cell inside a module frame can be simulated, thereby enabling an evaluation of acceleration fatigue of a welding part of a module frame to be reliably performed.

[0023] In addition, the repeated load of the piston acts on the welding part of the top plate through the battery cell interposed between the inner surfaces of the top plate, which makes it possible to more closely approach the conditions under which the battery cell applies force to the top plate in actual conditions and prevents deviations in the evaluation results caused by the form of the piston.

[0024] In addition, by analyzing the swelling behavior of the actual battery cell under charge and discharge cycles and applying it to the cycles of repeated loads applied to the piston, it is possible to derive more realistic and reliable test results, without the overestimation caused by applying end-of-life loading conditions from the beginning of the test.

[0025] However, the technical effects that can be obtained through the present invention is not limited to the above-described effects, and other effects not mentioned can be clearly understood by a person skilled in the art from the description of the invention described below.

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## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

[0026] Because the following drawings attached to the present specification illustrate exemplary embodiments of the present invention and serve to facilitate understanding of the technical idea of the present invention together with the detailed description of the invention described below, the present invention should not be limitedly interpreted on the basis of the drawings.

[0027] FIG. 1 is a drawing illustrating an example of a battery module frame for a vehicle.

[0028] FIG. 2 is a drawing illustrating a structure for installing a center jig and a guide block jig on a module frame for testing.

[0029] FIG. 3 is a drawing illustrating a center jig and a guide block jig installed on a module frame for testing.

[0030] FIG. 4 is a drawing illustrating an acceleration fatigue evaluation device of a welding part of a module frame including the module frame for testing of FIG. 2.

[0031] FIG. 5 is a drawing illustrating an example of the swelling behavior of a battery cell subjected to a charge-discharge cycle.

[0032] FIG. 6 is a drawing illustrating an example conversion of the swelling behavior of FIG. 5 into a load-cycle profile.

[0033] FIG. 7 is a drawing illustrating an exemplary result of a fatigue test using an acceleration fatigue evaluation device of welding part of the module frame of FIG. 4.

### BEST MODE

[0034] The present invention may have various modifications and various embodiments, and thus specific embodiments thereof will be described in detail below.

[0035] However, it should be understood that the present invention is not limited to the specific embodiments, and includes all modifications, equivalents, or alternatives within the spirit and technical scope of the present invention.

[0036] The terms “comprise,” “include,” and “have” used herein designate the presence of characteristics, numbers, steps, actions, components, or members described in the specification or a combination thereof, and it should be understood that the possibility of the presence or addition of

one or more other characteristics, numbers, steps, actions, components, members, or a combination thereof is not excluded in advance.

[0037] In addition, in the present invention, when a part of a layer, film, region, plate, or the like is disposed “on” another part, this includes not only a case in which one part is disposed “directly on” another part, but a case in which still another part is interposed therebetween. In contrast, when a part of a layer, film, region, plate, or the like is disposed “under” another part, this includes not only a case in which one part is disposed “directly under” another part, but a case in which still another part is interposed therebetween. In addition, in the present application, “on” may include not only a case of being disposed on an upper portion but also a case of being disposed on a lower portion.

[0038] The present invention relates to an acceleration fatigue evaluation device of a welding part of a module frame, comprising, in one example, a module frame for testing having a module frame with a top plate and an end frame welded to the top and two sides of a U-frame, respectively and an unwelded low surface of the U-frame opened; and a center jig connected to support a front and a rear of said module frame for testing; and a guide block jig for downwardly supporting an end frame of said module frame for testing; and a piston for entering said module frame for testing and applying a repeated load against an inner surface of the top plate; and at least one battery cell interposed between the piston and the inner surface of the top plate; and a displacement sensor for measuring a deformation at a center of an outer surface of the top plate.

[0039] The acceleration fatigue evaluation device of welding part of a battery module frame of the present invention having the configuration as described above, simulates a constraint condition of a module frame mounted on a vehicle by a center jig and a guide block jig, meanwhile, by applying a repeated load to an inner surface of a top plate by a piston, a pressurization condition of a swelling behavior of a battery cell inside the module frame can be simulated, thereby an evaluation of acceleration fatigue of welding part of the module frame can be reliably performed.

[0040] In addition, the repeated load of the piston acts on the welding part of the top plate through the battery cell interposed between the inner surfaces of the top plate, which more closely approximates the conditions under which the battery cell applies force to the top plate in actual conditions and prevents the form of the piston from causing deviations in the evaluation results.

#### MODE FOR INVENTION

[0041] Hereinafter, specific embodiments of a secondary battery of the present invention will be described in detail with reference to the accompanying drawings. For reference, the directions of front, back, up, down, left, and right used in the following description to designate relative positions are for the purpose of understanding the invention and refer to the directions shown in the drawings unless otherwise specified.

##### First Embodiment

[0042] The acceleration fatigue evaluation device of welding part of module frame **100** (hereinafter referred to as “acceleration fatigue evaluation device of welding part” for short) according to the present invention includes a module frame for testing **100'**, a center jig **200** and a guide block jig **300** for supporting it, a piston **400** operated hydraulically, a battery cell **500**, and a displacement sensor **600**.

[0043] The module frame for testing **100'**, which is provided for fatigue failure of the welding part, is made by processing the module frame **100** of FIG. 1. The module frame **100** is completed by welding an end frame **120** to the left and right sides of the U-frame **110** bent in the form of an U-shape, and a top plate **130** to the other side forming the upper surface of the module frame **100**. Here, it is the area of the welding part of the top plate **130** that is of most concern for fatigue failure in the module frame **100**, so the module frame **100'** is prepared for testing by cutting and leaving open the low side of the unwelded U-frame **110**.

[0044] The module frame for testing **100'** is installed on a test table (not shown) by a center jig **200** and a guide block jig **300**. In particular, the module frame for testing **100'** is preferably installed as

a restraining structure simulating a state in which the actual module frame **100** is mounted on a vehicle.

[0045] Referring to the module frame **100** of FIG. **1**, the end frames **120** on both sides are provided with mounting brackets **122**. Therefore, it is possible to install the module frame for testing upright by utilizing the mounting brackets **122** of the end frames **120**, but in an actual vehicle, the module frame **100** is installed by lying down so that the front and rear faces of the module frame **100** are facing in a straight direction, so that it is not in accordance with the actual situation to install it upright by utilizing the mounting brackets **122**, and if an accelerated fatigue evaluation is performed in which the time taken for one cycle is significantly reduced in order to shorten the test time, there is a high possibility that the test may fail due to the deformation of the mounting brackets **122** and the load of the piston **400** being applied incorrectly.

[0046] Considering these circumstances, the present invention, as illustrated in FIG. **2**, uses a center jig **200** to support the front and rear of the module frame for testing **100'**, meanwhile, a guide block jig **300** is configured to downwardly support the end frame **120** of the module frame for testing **100'**.

[0047] Here, if the center jig **200**, which serves as the four legs supporting the module frame for testing, is directly tied to the front and rear surfaces of the module frame for testing, the force applied to the module frame for testing (the reaction force against the piston load) may be concentrated in a narrow area, causing the U-frame **110** to deform, thereby affecting the rigidity of the welding part of the top plate **130**. This is not intended purely for the purpose of simulating fatigue failure of the welding part due to the swelling behavior of the battery cell **500** as in a real-world situation.

[0048] In consideration of this, the center jig **200** is connected to the front and rear surfaces of the module frame for testing **100'** by means of a reinforced plate **210**. The reinforced plate **210** comprises an area corresponding to approximately 60% or more of the surface area of the front and rear surfaces of the module frame for testing **100'** and is mounted to the front and rear surfaces of the module frame for testing **100'** by a plurality of evenly spaced bolts **240** and nuts **250**, respectively. As shown in FIG. **2**, the reinforced plate **210** and the U-frame **110** are mutually rigidly coupled by the bolts **240** and nuts **250** to a plurality of through holes **220** formed in the front and rear surfaces of the U-frame **110**, respectively.

[0049] Further, the center jig **200** and the reinforced plate **210** are formed with mutually corresponding fastening holes **230**, and a support structure of the center jig **200** is made by fastening the center jig **200** and the reinforced plate **210** with bolts **240** through the fastening holes **230**. In this way, the center jig **200** supports the front and rear surfaces of the U-frame **110** by means of the reinforced plate **210**, so that the top plate **130** is fully subjected to the repeated load of the piston **400**.

[0050] In addition, the end frame **120** of the module frame for testing **100'** is supported downwardly by a guide block jig **300** to properly distribute and burden the forces applied to the center jig **200**. Here, as shown in FIG. **3**, the guide block jig **300** is downwardly supported at its corners so as not to encroach on the welding parts of the end frame **120**. On the top surface of the module frame for testing **100'**, the welding parts of the end frame **120** and the welding parts of the top plate **130** are attached to each other, so that if the guide block jig **300** encroaches on the welding part of the end frame **120**, the guide block jig **300** will consequently support a portion of the welding part of the top plate **130**. This will cause the guide block jig **300** to contribute to fatigue failure of the welding part of the top plate **130** due to the swelling behavior of the battery cell **500**, and to avoid this, the guide block jig **300** is positioned to downwardly support a portion of the edge outside the welding part of the end frame **120**.

[0051] Here, the criteria of the upper surface and the lower surface are based on the module frame **100** of FIG. **1**, and accordingly, the module frame for testing **100'** is installed with the upper and lower surfaces reversed, as shown in FIGS. **2** and **3**, but the side of the top plate **130** on which the

repeated load of the piston **400** is applied is referred to as the upper surface.

[0052] Further, the piston **400**, connected to the hydraulic cylinder **410**, enters through the lower surface of the open module frame for testing **100'** and applies a repeated load to the inner surface of the top plate **130**. Here, in the acceleration fatigue evaluation device of welding part **10** of the present invention, at least one battery cell **500** is interposed between the piston **400** and the inner surface of the top plate **130**.

[0053] By causing the repeated load of the piston **400** to act on the welding part of the top plate **130** through the battery cell **500** interposed between the inner surfaces of the top plate **130**, it is possible to more closely approach the conditions under which a battery cell **500** expanded by the swelling phenomenon would apply force to the top plate **130** in practice. Furthermore, the involvement of the battery cells **500** in the load transfer path of the piston **400** prevents the deviation of the evaluation results from being caused by the shape of the piston **400**.

[0054] In this respect, in one embodiment of the present invention, it may be desirable that the battery cells **500** that enter the module frame for testing **100'** have the same specifications as the battery cells **500** that are actually mounted in the module frame **100**. This is because the accelerated fatigue of the welding part can be evaluated under conditions that more closely approximate the actual situation, and because the size of the actual battery cell **500** accurately loads the module frame for testing **100'**. The number of battery cells **500** used for testing may be selected appropriately and may be as few as slightly less than half the height of the module frame for testing **100'**.

[0055] For example, the battery cell **500** used in the accelerated fatigue test may be a pouch cell, wherein the pouch cell is cased by a pouch made of a flexible laminated sheet, so that the repeated load of the piston **400** acts evenly on the welding parts of the top plate **130**. Preferably, the pouch cell is interposed between the piston **400** and the inner surface of the top plate **130** in a fully discharged state. This is because it is necessary to consider the risk of fire in the event of electrolyte leakage from the pouch cell due to the load application of the piston **400**.

[0056] Further, the acceleration fatigue evaluation device of welding part **10** of the present invention includes a displacement sensor **600** that measures the deformation at the center of the outer surface of the top plate **130**. A sensing part **610** of the displacement sensor **600** is in contact with the center of the outer surface of the top plate **130**, and the displacement of the sensing part **610** measures the amount of deformation of the top plate **130**. Generally, if the displacement sensor **600** has a precision on a level of about 1/100 mm of a millimeter, the amount of deformation of the top plate **130** can be determined with sufficient accuracy.

[0057] The control part **700** controls the hydraulic cylinder **410** so that the repeated load of the piston **400** is applied according to a predetermined strategy, meanwhile, and receives the measurement signal of the displacement sensor **600** to observe and store the amount of deformation of the top plate **130** in real time. The control part **700** may be implemented as a conventional computing device.

## Second Embodiment

[0058] In the first embodiment of the present invention, the hardware configuration of the acceleration fatigue evaluation device of welding part **10** was described in detail, and hereinafter it will be described how it is preferable to set the repeated load applied to the piston **400**.

[0059] The purpose of the present invention is to obtain reliable results on accelerated fatigue failure of welding parts by applying repeated loads simulating the swelling behavior of the battery cells **500** accommodated in the battery module frame **100** under conditions similar to those in practice. Accordingly, the repeated load applied by the piston **400** to the welding part of the top plate **130** preferably simulates the deformation of the battery cell **500** accompanying the swelling behavior of the battery cell **500** in practice.

[0060] FIG. 5 is a drawing illustrating an example of the swelling behavior of the battery cell **500** over a charge-discharge cycle. In the graph of FIG. 5, the top solid line shows the amount of

change (mm) in the overall width of the battery cell module when the battery cell **500** is fully charged (SOC 98.3%) as the charge-discharge cycle progresses, and the bottom dashed line shows the amount of change (mm) in the overall width of the battery cell module when the battery cell **500** is fully discharged (SOC 0%) as the charge-discharge cycle progresses.

[0061] A battery cell module refers to a plurality of battery cells **500** accommodated within a single battery module frame **100**, and the swelling behavior of an individual battery cell **500** can be understood as the amount of change in its overall width when expanded as a module unit. In general, the amount of change in the overall width of a module of battery cells **500** increases as the charge/discharge cycle progresses.

[0062] Therefore, the present invention configures the piston **400** so that the repeated load that it applies to the top plate **130** via the battery cell **500** is applied in a profile that simulates the displacement of the swelling expansion and contraction over the course of the charge and discharge cycles of the battery cell **500**, as shown in FIG. 5, so that more reliable accelerated fatigue testing can be achieved. In other words, the repeated load on the piston **400** will correspond to the change amount in the overall width of the battery cell module of FIG. 5, and will simulate the charge and discharge cycles as closely as possible by repeatedly increasing and decreasing the load by moving between two change curves as the cycles accumulate.

[0063] However, since it is easier to control the load than to control the amount of displacement in an actual fatigue failure test, the repeated load of the piston **400** may be applied as a load-cycle profile that converts the displacement of the swelling expansion and contraction of the battery cell **500** over the course of a charge-discharge cycle into a load. An example of such a load-cycle profile for repeated loading of the piston **400** is shown in FIG. 6.

[0064] Referring to FIG. 6, the load-cycle profile has a shape in which the charge and discharge loads each increase as the charge discharge cycle progresses. The load-cycle profile also shows that the difference between the charging load and the discharging load may also increase with the progression of the cycle. The time taken for a cycle can be selected appropriately by considering the trade-off between shortening the overall test time as an accelerated fatigue test, and the risk that repeating the cycle at shorter intervals may lead to erroneous test results due to a greater deviation from the actual swelling behavior. For example, repeated loads can be applied with a time of 20 seconds per cycle (0.05 Hz).

[0065] FIG. 7 is a graphical drawing illustrating the amount of deformation (mm) of the top plate **130** measured by the displacement sensor **600** during the accelerated fatigue evaluation process described above. The amount of deformation when the charge and discharge loads are applied over the course of the cycle shows a roughly linear increase, but after a certain number of cycles, the linear increase ceases and the amount of deformation increases instantaneously and sharply, like a staircase. At this point, it can be determined that the welding part of the top plate **130** is destroyed and the test can be stopped, and the fatigue failure life of the module frame **100** can be predicted by converting the number of cycles in which the welding part is destroyed as a result of the accelerated fatigue test to the time of the actual charge-discharge cycle.

[0066] In this way, the acceleration fatigue evaluation device of welding part **10** according to the present invention analyzes the swelling behavior of the actual battery cell **500** according to the charge-discharge cycle and applies it to the cycle of repeated load applied to the piston **400**, so that it is possible to derive more realistic and reliable test results, without overestimation due to applying the load condition of the end of lifespan from the beginning of the test.

[0067] As above, the present invention has been described in more detail through the drawings and embodiments. However, since the configuration described in the drawings or embodiments described herein is merely one embodiment of the present invention and do not represent the overall technical spirit of the invention, it should be understood that the invention covers various equivalents, modifications, and substitutions at the time of filing of this application.

DESCRIPTION OF REFERENCE NUMERALS



[0068] **10**: acceleration fatigue evaluation device of welding part [0069] **100**: module frame [0070] **100'**: module frame for testing [0071] **110**: U-frame [0072] **120**: end frame [0073] **122**: mounting bracket [0074] **130**: top plate [0075] **200**: center jig [0076] **210**: reinforced plate [0077] **220**: through hole [0078] **230**: fastening hole [0079] **240**: bolt [0080] **250**: nut [0081] **300**: guide block jig [0082] **400**: piston [0083] **410**: hydraulic cylinder [0084] **500**: battery cell [0085] **600**: displacement sensor [0086] **610**: sensing part [0087] **700**: control part

## Claims

1. An acceleration fatigue evaluation device of a welding part of a module frame, comprising: a module frame for testing having: a U-frame, the U-frame having an open, unwelded lower surface; a top plate; and a pair of end frames welded to the top plate and opposite sides of the U-frame: a center jig connected to the module frame for testing to support a front of the module frame for testing and a rear of the module frame for testing; a guide block jig supporting the end frame of the module frame for testing from below; a piston configured to enter the module frame for testing, the piston being configured to apply a repeated load to an inner surface of the top plate; at least one battery cell interposed between the piston and the inner surface of the top plate; and a displacement sensor configured to measure a deformation at a center of an outer surface of the top plate.
  2. The acceleration fatigue evaluation device of claim 1, wherein the battery cell is of a same specification as the battery cell mounted in the module frame.
  3. The acceleration fatigue evaluation device of claim 2, wherein the battery cell is a pouch cell.
  4. The acceleration fatigue evaluation device of claim 3, wherein the pouch cell is in a completely discharged state.
  5. The acceleration fatigue evaluation device of claim 1, wherein the guide block jig has downwardly supported edges thereof to avoid encroaching on welding parts of the end frame.
  6. The acceleration fatigue evaluation device of claim 1, wherein the repeated load applied by the piston to the top plate via the battery cell is applied in a profile simulating displacement of swelling expansion and contraction of the battery cell as the battery cell progresses through a charge and discharge cycle.
  7. The acceleration fatigue evaluation device of claim 6, wherein the profile is a load-cycle profile that converts the displacement of the swelling expansion and contraction of the battery cell over the progression of the charge and discharge cycle into a load.
  8. The acceleration fatigue evaluation of claim 7, wherein the load-cycle profile has a pattern wherein a load at charge and a load at discharge increase with the progression of the charge and discharge cycle.
  9. The acceleration fatigue evaluation device of claim 8, wherein a difference value between the load at charge and the load at discharge increases with the progression of the charge and discharge cycle.
  10. The acceleration fatigue evaluation device of claim 9, further comprising a controller, wherein the controller is configured to, in a cycle in which the amount of deformation of the top plate measured by the displacement sensor deviates from a linear increasing pattern and suddenly increases sharply; determine that the welding part of the top plate has been destroyed; and stop the application of the repeated load.
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