CELL SAFETY PREDICTION METHOD, APPARATUS, DEVICE, AND MEDIUM

TECHNICAL FIELD

[0001] The present application relates to the technology of battery test, and more particularly relates to a cell safety prediction method, apparatus, device and medium.

BACKGROUND

[0002] Batteries and energy storage system products need to be subjected to overcharging test to verify the safety performance thereof. By reasonably designing the batteries and battery packs, thermal runaway that may be caused by the overcharging of batteries can be avoided, thus reducing the occurrence of fire or explosion that seriously affects the safety.

[0003] Whether the thermal runaway occurs when the battery pack is overcharged is related to the overcharging performance of a single cell and the structural design of the battery pack. Before the actual test on the overcharging of the battery pack, the overcharging performance of the battery pack can be estimated, and if a estimation result shows that the battery pack has high risk of thermal runaway, the design can be adjusted in time, which can reduce the material cost and time cost of trial and error using actual materials, and is beneficial for improving the research and development efficiency.

[0004] However, the current estimation solution requires to accurately obtain material compositions and reaction situation for modeling, and a corresponding system structure is complex, resulting in low estimation efficiency. Therefore, a cell safety prediction method is needed to simplify the cell safety prediction system and improve the efficiency in the prediction of the cell safety.

SUMMARY

[0005] The present application provides a cell safety prediction method, apparatus, device and medium, which are used to solve the problem that the existing cell safety estimation solution needs to accurately obtain material compositions and reaction situation for modeling, and a

corresponding system structure is complex, resulting in low estimation efficiency.

[0006] In a first aspect, the present application provides a cell safety prediction method, including:

determining a first environmental parameter of a target area, performing a first thermal runaway operation on a target cell according to the first environmental parameter until a thermal runaway phenomenon occurs in the target cell, and obtaining a first state parameter of the target cell during the first thermal runaway operation;

determining a target heat production model corresponding to each target cell according to the first state parameter, where the target heat production model is used to indicate a quantity of heat production of each target cell under a preset working parameter;

establishing a structural model of a target battery pack, performing a second thermal runaway operation on the structural model, and determining a second state parameter of each target cell according to each target heat production model during the second thermal runaway operation; and

determining safety of the target battery pack according to the second state parameter, where the second state parameter is used to indicate a thermal runaway condition of each target cell.

[0007] As an optional implementation, the first environmental parameter includes a thermal insulation parameter, and the thermal insulation parameter is used to indicate an environmental parameter for a situation in which a thermal insulation condition is maintained in the target area;

before the determining the first environmental parameter of the target area, and performing the first thermal runaway operation on the target cell according to the first environmental parameter until the thermal runaway phenomenon occurs in the target cell, the method further includes:

charging the target cell until each target cell is in a fully-charged state;

determining a plurality of first measurement points associated with the target cell; and

where the first measurement point is used to obtain a temperature parameter of each target cell; and

the determining the first environmental parameter of the target area, and performing the first thermal runaway operation on the target cell according to the first environmental

parameter until the thermal runaway phenomenon occurs in the target cell includes:

determining the first environmental parameter of the target area, and performing the first thermal runaway operation on the target cell according to the first environmental parameter;

determining whether the thermal runaway phenomenon occurs in the target cell according to the temperature parameter corresponding to each first measurement point; and

if the thermal runaway phenomenon does not occur in the target cell, adjusting the first environmental parameter according to a preset environmental parameter change gradient until the thermal runaway phenomenon occurs in the target cell.

[0008] As an optional implementation, the first state parameter includes one or more of the following: a cell surface temperature, a charging current and a cell voltage, the target heat production model includes a target overcharging model, and the determining the target heat production model corresponding to each target cell according to the first state parameter includes:

establishing a single cell overcharging model corresponding to each target cell according to the first state parameter, and determining a third state parameter in each single cell overcharging model;

where the single cell overcharging model includes an electrochemical reaction heat production model and a decomposition reaction heat production model; and

optimizing each third state parameter to obtain a target state parameter, and determining the target overcharging model corresponding to each target cell according to the target state parameter and each single cell overcharging model.

[0009] As an optional implementation, the optimizing each third state parameter to obtain the target state parameter includes:

determining a target boundary and a target order of magnitude of each third state parameter;

determining a state parameter change gradient corresponding to each third state parameter according to the target order of magnitude of each third state parameter;

adjusting each third state parameter in the target boundary according to the state parameter change gradient corresponding to each third state parameter;

under different values of each third state parameter, determining a measured value of

a cell surface temperature corresponding to each target cell, and a calculated value of the cell surface temperature corresponding to each target cell calculated according to the single cell overcharging model;

determining a first thermal runaway initial temperature according to the measured value, determining a second thermal runaway initial temperature according to the calculated value, determining a thermal runaway initial temperature difference according to the first thermal runaway initial temperature and the second thermal runaway initial temperature, and determining a sum of squares of the difference according to the measured value and the calculated value; and

determining candidate parameter values of the third state parameter under a condition that the sum of squares of the difference is less than a preset threshold of the sum of squares, and/or the thermal runaway initial temperature difference is less than a preset difference threshold, and determining the target state parameter from the candidate parameter values.

[0010] As an optional implementation, the establishing the structural model of the target battery pack, and performing the second thermal runaway operation on the structural model includes:

determining an electrical component structure and a mechanical component structure of the target battery pack, and establishing the structural model of the target battery pack according to the electrical component structure and the mechanical component structure;

where the electrical component structure includes a cell structure and a connection bank structure;

establishing a first heat production model corresponding to the cell structure according to the target overcharging model of each target cell; determining a quantity of ohmic heat production corresponding to the connection bank structure, and establishing a second heat production model; and determining a convective heat transfer coefficient and a radiation emissivity corresponding to the mechanical component structure, and establishing a third heat production model; and

performing simulative overcharging on the structural model according to a target charging time and a target charging current to perform the second thermal runaway operation, and determining a thermal runaway condition;

where the thermal runaway condition is associated with the first heat production

model, the second heat production model and the third heat production model and used to indicate a corresponding thermal physical condition under which the safety of the target battery pack meets a preset safety requirement.

[0011] In a second aspect, the present application provides a cell safety prediction apparatus, including:

a determination module, configured to determine a first environmental parameter of a target area;

a processing module, configured to perform a first thermal runaway operation on a target cell according to the first environmental parameter until a thermal runaway phenomenon occurs in the target cell, and obtain a first state parameter of the target cell during the first thermal runaway operation;

where the processing module is further configured to determine a target heat production model corresponding to each target cell according to the first state parameter, where the target heat production model is used to indicate a quantity of heat production of each target cell under a preset working parameter;

the processing module is further configured to establish a structural model of a target battery pack, perform a second thermal runaway operation on the structural model, and determine a second state parameter of each target cell according to each target heat production model during the second thermal runaway operation; and

the processing module is further configured to determine safety of the target battery pack according to the second state parameter, where the second state parameter is used to indicate a thermal runaway condition of each target cell.

[0012] As an optional implementation, the first environmental parameter includes a thermal insulation parameter, and the thermal insulation parameter is used to indicate an environmental parameter for a situation in which a thermal insulation condition is maintained in the target area;

before the determination module determines the first environmental parameter of the target area, the processing module is further configured to:

charge the target cell until each target cell is in a fully-charged state;

determine a plurality of first measurement points associated with the target cell; and

where the first measurement point is used to obtain a temperature parameter of each

target cell; and

a specific way in which the processing module performs the first thermal runaway operation on the target cell according to the first environmental parameter until the thermal runaway phenomenon occurs in the target cell after the determination module determines the first environmental parameter of the target area includes:

determining the first environmental parameter of the target area, and performing the first thermal runaway operation on the target cell according to the first environmental parameter;

determining whether the thermal runaway phenomenon occurs in the target cell according to the temperature parameter corresponding to each first measurement point; and

if the thermal runaway phenomenon does not occur in the target cell, adjusting the first environmental parameter according to a preset environmental parameter change gradient until the thermal runaway phenomenon occurs in the target cell.

[0013] As an optional implementation, the first state parameter includes one or more of the following: a cell surface temperature, a charging current and a cell voltage, the target heat production model includes a target overcharging model, and a specific way in which the processing module determines the target heat production model corresponding to each target cell according to the first state parameter includes:

establishing a single cell overcharging model corresponding to each target cell according to the first state parameter, and determining a third state parameter in each single cell overcharging model;

where the single cell overcharging model includes an electrochemical reaction heat production model and a decomposition reaction heat production model; and

optimizing each third state parameter to obtain a target state parameter, and determining the target overcharging model corresponding to each target cell according to the target state parameter and each single cell overcharging model.

[0014] As an optional implementation, a specific way in which the processing module optimizes each third state parameter to obtain the target state parameter includes:

determining a target boundary and a target order of magnitude of each third state parameter;

determining a state parameter change gradient corresponding to each third state

parameter according to the target order of magnitude of each third state parameter;

adjusting each third state parameter in the target boundary according to the state parameter change gradient corresponding to each third state parameter;

under different values of each third state parameter, determining a measured value of a cell surface temperature corresponding to each target cell, and a calculated value of the cell surface temperature corresponding to each target cell calculated according to the single cell overcharging model;

determining a first thermal runaway initial temperature according to the measured value, determining a second thermal runaway initial temperature according to the calculated value, determining a thermal runaway initial temperature difference according to the first thermal runaway initial temperature and the second thermal runaway initial temperature, and determining a sum of squares of the difference according to the measured value and the calculated value; and

determining candidate parameter values of the third state parameter under a condition that the sum of squares of the difference is less than a preset threshold of the sum of squares, and/or the thermal runaway initial temperature difference is less than a preset difference threshold, and determining the target state parameter from the candidate parameter values.

[0015] As an optional implementation, a specific way in which the processing module establishes the structural model of the target battery pack, and performs the second thermal runaway operation on the structural model includes:

determining an electrical component structure and a mechanical component structure of the target battery pack, and establishing the structural model of the target battery pack according to the electrical component structure and the mechanical component structure;

where the electrical component structure includes a cell structure and a connection bank structure;

establishing a first heat production model corresponding to the cell structure according to the target overcharging model of each target cell; determining a quantity of ohmic heat production corresponding to the connection bank structure, and establishing a second heat production model; and determining a convective heat transfer coefficient and a radiation emissivity corresponding to the mechanical component structure, and establishing a third heat production model; and

performing simulative overcharging on the structural model according to a target charging time and a target charging current to perform the second thermal runaway operation, and determining a thermal runaway condition;

where the thermal runaway condition is associated with the first heat production model, the second heat production model and the third heat production model and used to indicate a corresponding thermal physical condition under which the safety of the target battery pack meets a preset safety requirement.

[0016] In a third aspect, the present application further provides an electronic device, including:

at least one processor; and

a memory communicatively connected with the at least one processor, where

the memory stores instructions capable of being executed by the at least one processor, and the instructions, when being executed by the at least one processor, enable the at least one processor to execute the method as described in the first aspect.

[0017] In a fourth aspect, the present application further provides a computer readable storage medium, where the computer readable storage medium stores computer execution instructions, and the computer execution instructions, when being executed by a processor, are used to implement the method as described in the first aspect.

[0018] The present application provides a cell safety prediction method, apparatus, device and medium determines a first environmental parameter, and performs a first thermal runaway operation on a target cell according to the first environmental parameter until thermal runaway occurs in the target cell; obtains a first state parameter of the target cell during the process to determine a target heat production model according to the first state parameter, performs three-dimensional modeling on a battery structure, and performs a second thermal runaway operation according to the three-dimensional model, and obtains a the second state parameter during the second thermal runaway operation according to the determined target heat production model, so that safety of a target battery pack can be judged according to the second state parameter. Therefore, through an actual thermal runaway operation, the target heat production model is determined, and through a simulated thermal runaway operation, the safety of the target battery pack is determined according to the target heat production model, which saves the test

cost and simplifies a cell safety prediction system; and at the same time, the method reduces requirements of mechanism modeling for basic data, and generally improves the efficiency and accuracy in the prediction of the cell safety.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The drawings described herein are incorporated into the specification and constitute a part of the specification. The drawings illustrate embodiments in conformity with the present application and are used to explain the principle of the present application together with the specification.

[0020] FIG. 1 is a flowchart of a cell safety prediction method provided by an embodiment of the present application.

[0021] FIG. 2 is a structural schematic diagram of a cell safety prediction apparatus provided by an embodiment of the present application.

[0022] FIG. 3 is a structural schematic diagram of a cell safety prediction electronic device provided by an embodiment of the present application.

[0023] Definite embodiments of the present application are shown by the above accompanying drawings, which are described in more details hereinafter. These accompanying drawings and textual descriptions are not intended to limit the scope of the present application in any way, but rather to illustrate the concept of the present application for those skilled in the art with reference to specific embodiments.

DESCRIPTION OF EMBODIMENTS

[0024] Exemplary embodiments are described in detail herein, and examples are shown in the accompanying drawings. When the following description involves in the accompanying drawings, the same numerals in different accompanying drawings indicate the same or similar elements, unless otherwise indicated. The implementations described in the following exemplary embodiments do not represent all implementations consistent with the present application. On the contrary, the implementations are only examples of apparatuses and methods consistent with some aspects of the present application as claimed in claims.

[0025] Batteries and energy storage system products need to be subjected to overcharging test to verify the safety performance thereof. By reasonably designing the batteries and battery packs, thermal runaway that may be caused by the overcharging of batteries can be avoided, thus reducing the occurrence of fire or explosion that seriously affects the safety.

[0026] Whether the thermal runaway occurs when the battery pack is overcharged is related to the overcharging performance of a single cell and the structural design of the battery pack. Before the actual test on the overcharging of the battery pack, the overcharging performance of the battery pack can be estimated, and if a estimation result shows that the battery pack has high risk of thermal runaway, the design can be adjusted in time, which can reduce the material cost and time cost of trial and error using actual materials, and is beneficial for improving the research and development efficiency.

[0027] However, the current estimation solution requires to accurately obtain material compositions and reaction situation for modeling, and a corresponding system structure is complex, resulting in low estimation efficiency. Therefore, a cell safety prediction method is needed to simplify the cell safety prediction system and improve the efficiency in the prediction of the cell safety.

[0028] A technical concept of the present application is to determine a first environmental parameter, and perform a first thermal runaway operation on a target cell according to the first environmental parameter until thermal runaway occurs in the target cell; obtain a first state parameter of the target cell during the process to determine a target heat production model according to the first state parameter, perform three-dimensional modeling on a battery structure, and perform a second thermal runaway operation according to the three-dimensional model, and obtain a the second state parameter during the second thermal runaway operation according to the determined target heat production model, so that safety of a target battery pack can be judged according to the second state parameter. Therefore, through an actual thermal runaway operation, the target heat production model is determined, and through a simulated thermal runaway operation, the safety of the target battery pack is determined according to the target heat production model, which saves the test cost and simplifies a cell safety prediction system; and at the same time, the method reduces requirements of mechanism modeling for basic data, and generally improves the efficiency and accuracy in the prediction of the cell safety.

[0029] Embodiment I

[0030] Referring to FIG. 1, FIG. 1 is a flowchart of a cell safety prediction method provided by an embodiment of the present application. As shown in FIG. 1, the method includes the following steps.

[0031] S101: determining a first environmental parameter of a target area, performing a first thermal runaway operation on a target cell according to the first environmental parameter until a thermal runaway phenomenon occurs in the target cell, and obtaining a first state parameter of the target cell during the first thermal runaway operation.

[0032] The target cell structurally includes a plurality of target cells and corresponding mechanical and electrical connection devices, and a corresponding structural model needs to be established according to an actual structure of the target cell in the subsequent modeling process of the structural model. In the present application, the thermal runaway of the target cell may be determined according to the thermal runaway diffusion phenomenon of a plurality of target cells.

[0033] During the first thermal runaway operation, it is necessary to ensure that the thermal runaway phenomenon occurs in the target cell, so that the first state parameter corresponding to the target cell in a process from charging to the thermal runaway can be recorded. If the thermal runaway phenomenon does not occur in the target cell under the current environmental condition, the first environmental parameter needs to be adjusted to ensure the occurrence of the thermal runaway in the target cell, which can specifically refer to relevant descriptions of other implementations.

[0034] S102: determining a target heat production model corresponding to each target cell according to the first state parameter, where the target heat production model is used to indicate a quantity of heat production of each target cell under a preset working parameter.

[0035] The target heat production model can include an electrochemical reaction heat production model and a decomposition reaction heat production model, which is described in detail in other implementations; and it shall be noted that in a case where a definite convective heat transfer coefficient and radiation emissivity of the single cell are known, the method provided by the present application can be carried out not strictly in a thermal insulation environment, but can be carried out in a constant-temperature or variable-temperature environment at any temperature. The target heat production model then needs to consider the

actual thermophysical phenomena, and the complexity of the model may increase.

[0036] S103: establishing a structural model of a target battery pack, performing a second thermal runaway operation on the structural model, and determining a second state parameter of each target cell according to each target heat production model during the second thermal runaway operation.

[0037] The structure model, i.e. a three-dimensional model result obtained in modeling software according to the plurality of target cells and the corresponding mechanical and electrical connection devices is used to simulate the actual target battery pack structure, the second thermal runaway operation is performed on the structural model, and the corresponding state parameter is obtained according to the target heat production model in the process, thus saving the cost for testing the cell safety, and simplifying the system structure.

[0038] S104: determining safety of the target battery pack according to the second state parameter, where the second state parameter is used to indicate a thermal runaway condition of each target cell.

[0039] The second state parameter can include one or more of the following: a temperature distribution of each target cell, a preset cell temperature change rate of at least one cell surface on each target cell and an overall temperature distribution and temperature change rate of the target battery pack, which can determine the thermal runaway condition of the target cell, thereby realizing the test on the overall safety of each target cell and the target battery pack.

[0040] As an optional implementation, the first environmental parameter includes a thermal insulation parameter, and the thermal insulation parameter is used to indicate an environmental parameter for a situation in which a thermal insulation condition is maintained in the target area;

before the determining the first environmental parameter of the target area, and performing the first thermal runaway operation on the target cell according to the first environmental parameter until the thermal runaway phenomenon occurs in the target cell, the method further includes:

charging the target cell until each target cell is in a fully-charged state;

determining a plurality of first measurement points associated with the target cell; and

where the first measurement point is used to obtain a temperature parameter of each target cell; and

the determining the first environmental parameter of the target area, and performing the first thermal runaway operation on the target cell according to the first environmental parameter until the thermal runaway phenomenon occurs in the target cell includes:

determining the first environmental parameter of the target area, and performing the first thermal runaway operation on the target cell according to the first environmental parameter;

determining whether the thermal runaway phenomenon occurs in the target cell according to the temperature parameter corresponding to each first measurement point; and

if the thermal runaway phenomenon does not occur in the target cell, adjusting the first environmental parameter according to a preset environmental parameter change gradient until the thermal runaway phenomenon occurs in the target cell.

[0041] Thus can be seen that in the implementation, the preliminary preparation of the first thermal runaway operation is completed by pre-charging the target cell until the target cell is fully charged before the first thermal runaway operation and determining the plurality of first measurement points for obtaining the temperature parameter; at the same time, the thermal insulation environment is created for the first thermal runaway operation according to the determined first environmental parameter, the first thermal runaway operation is performed on the target cell in the thermal insulation environment, and according to an actual state of the target cell in the first thermal runaway operation, the first environmental parameter is adjusted until the thermal runaway phenomenon actually occurs in the target cell.

[0042] Consequently, the effectiveness and practicability of the first thermal runaway operation process can be ensured, and moreover, during the first thermal runaway operation, the parameter related to the overcharged thermal runaway phenomenon of the target cell can be successfully obtained, which can provide effective basic data for the target heat production model. In conclusion, through an actual thermal runaway operation, the target heat production model is determined, and through a simulated thermal runaway operation, the safety of the target battery pack is determined according to the target heat production model, which saves the test cost and simplifies a cell safety prediction system; and at the same time, the method reduces requirements of mechanism modeling for basic data, and generally improves the efficiency and accuracy in the prediction of the cell safety.

[0043] As an optional implementation, the first state parameter includes one or more of the

following: a cell surface temperature, a charging current and a cell voltage, the target heat production model includes a target overcharging model, and the determining the target heat production model corresponding to each target cell according to the first state parameter includes:

establishing a single cell overcharging model corresponding to each target cell according to the first state parameter, and determining a third state parameter in each single cell overcharging model;

where the single cell overcharging model includes an electrochemical reaction heat production model and a decomposition reaction heat production model; and

optimizing each third state parameter to obtain a target state parameter, and determining the target overcharging model corresponding to each target cell according to the target state parameter and each single cell overcharging model.

[0044] In the implementation, the single cell overcharging model of each target cell can be established through the first state parameter, the third state parameter to be optimized is determined in the single cell overcharging model, the corresponding optimization process is performed according to data features of the third state parameter to obtain each target state parameter, thereby determining the target overcharging model, thus improving the effectiveness of the target overcharging model and improving the efficiency for establishing the target overcharging model; through an actual thermal runaway operation, the target heat production model is determined, and through a simulated thermal runaway operation, the safety of the target battery pack is determined according to the target overcharging model, which saves the test cost and simplifies a cell safety prediction system; and at the same time, the method reduces requirements of mechanism modeling for basic data, and generally improves the efficiency and accuracy in the prediction of the cell safety.

[0045] As an optional implementation, the optimizing each third state parameter to obtain the target state parameter includes:

determining a target boundary and a target order of magnitude of each third state parameter;

determining a state parameter change gradient corresponding to each third state parameter according to the target order of magnitude of each third state parameter;

adjusting each third state parameter in the target boundary according to the state parameter change gradient corresponding to each third state parameter;

under different values of each third state parameter, determining a measured value of a cell surface temperature corresponding to each target cell, and a calculated value of the cell surface temperature corresponding to each target cell calculated according to the single cell overcharging model;

determining a first thermal runaway initial temperature according to the measured value, determining a second thermal runaway initial temperature according to the calculated value, determining a thermal runaway initial temperature difference according to the first thermal runaway initial temperature and the second thermal runaway initial temperature, and determining a sum of squares of the difference according to the measured value and the calculated value; and

determining candidate parameter values of the third state parameter under a condition that the sum of squares of the difference is less than a preset threshold of the sum of squares, and/or the thermal runaway initial temperature difference is less than a preset difference threshold, and determining the target state parameter from the candidate parameter values.

[0046] It should be noted that the thermal runaway initial temperature difference and the sum of squares of the difference are only an optional screening condition, and in the actual application scene, indexes that can measure the difference between the first thermal runaway initial temperature and the second thermal runaway initial temperature can be used as the screening condition. In the target boundary, the process of adjusting each third state parameter according to the state parameter change gradient corresponding to each third state parameter is essentially a grid optimization process, which is simple in application, but may have certain error; and in some scenes with higher accuracy requirements, other optimization models can also be used for parameter optimization.

[0047] In the implementation, an optimization change gradient is determined through the parameter boundary and an order-of-magnitude distribution of the third state parameter, each third state parameter is changed according to the corresponding change gradient, the measured value of the cell surface temperature corresponding to the target cell and the calculated value of the cell surface temperature corresponding to the target cell calculated according to the single cell overcharging model are determined through a grid optimization way under different values

of the third state parameter, and the first thermal runaway initial temperature and the second thermal runaway initial temperature are determined according to the measured value and the calculated value so as to obtain the candidate parameters of the third state parameter, and the target state parameter are further selected from the candidate parameters, thereby determining the target overcharging model.

[0048] As a result, the effectiveness of the target overcharging model is improved, and the efficiency for establishing the target overcharging model is improved; through an actual thermal runaway operation, the target heat production model is determined, and through a simulated thermal runaway operation, the safety of the target battery pack is determined according to the target overcharging model, which saves the test cost and simplifies a cell safety prediction system; and at the same time, the method reduces requirements of mechanism modeling for basic data, and generally improves the efficiency and accuracy in the prediction of the cell safety.

[0049] As an optional implementation, the establishing the structural model of the target battery pack, and performing the second thermal runaway operation on the structural model includes:

determining an electrical component structure and a mechanical component structure of the target battery pack, and establishing the structural model of the target battery pack according to the electrical component structure and the mechanical component structure;

where the electrical component structure includes a cell structure and a connection bank structure;

establishing a first heat production model corresponding to the cell structure according to the target overcharging model of each target cell; determining a quantity of ohmic heat production corresponding to the connection bank structure, and establishing a second heat production model; and determining a convective heat transfer coefficient and a radiation emissivity corresponding to the mechanical component structure, and establishing a third heat production model; and

performing simulative overcharging on the structural model according to a target charging time and a target charging current to perform the second thermal runaway operation, and determining a thermal runaway condition;

where the thermal runaway condition is associated with the first heat production

model, the second heat production model and the third heat production model and used to indicate a corresponding thermal physical condition under which the safety of the target battery pack meets a preset safety requirement.

[0050] In the implementation, through the actual structure of the target cell, the modeling is performed, and a corresponding heat production formula and the thermal runaway condition are determined; and in the process of simulating the overcharging on the structural model according to the target charging time and the target charging current and performing the second thermal runaway operation, the second state parameter can be obtained according to the determined target heat production model, and the safety of the target battery pack can be judged according to the second state parameter. Therefore, through an actual thermal runaway operation, the target heat production model is determined, and through a simulated thermal runaway operation, the safety of the target battery pack is determined according to the target heat production model, which saves the test cost and simplifies a cell safety prediction system; and at the same time, the method reduces requirements of mechanism modeling for basic data, and generally improves the efficiency and accuracy in the prediction of the cell safety.

[0051] In an application scene, according to the solution provided by the present application, after the single cell is first over-charged with different currents to a cut-off voltage under a thermal insulation condition, the cell is then gradually heated in a radiation heating way until the thermal runaway occurs, and in the whole process, the voltage, current and surface temperature of the battery are recorded. Then according to the measurement result of the single cell, the quantity of heat production in the electrochemical reaction and the quantity of heat production in the decomposition side reaction when the single cell is overcharged are calculated, i.e. the electrochemical reaction heat production model and the decomposition reaction heat production model abovementioned are calculated. A rate of electrochemical reaction is an exponentially correlated function of the state of charge of the battery when the cell is over-charged and the rate of decomposition reaction. The rate of decomposition side reaction follows Arrhenius equation, a concentration of reactants of the decomposition side reaction is related to a percentage of active substances inside the cell, the rate of the decomposition side reaction and the state of charge of the overcharged battery. The electrochemical reaction and the decomposition reaction are coupled. All parameters in the equation can be automatically solved by an optimization

algorithm, and when a difference between a measured temperature rise and a calculated temperature rise on the cell surface is less than a set value, a group of optimal equation parameters is selected from a group of parameters satisfying the condition. Thereafter, a three-dimensional model can be established according to the actual design of the battery pack in finite element calculation software, and the quantity of heat production that varies with the state of charge and temperature of the overcharged battery is assigned to each single cell. The overcharging process in the actual test is simulated by taking a current as an input quantity, so that the state of charge of the cell in the battery pack increases, the temperature rises, and the electrochemical and decomposition reactions are accelerated. When the thermal runaway phenomenon occurs in the cells in the battery pack, it represents that the overcharging test of the battery pack has a risk of fire, and the design needs to be adjusted. A criterion for determining the thermal runaway diffusion phenomenon may be that the thermal runaway occurs in a plurality of batteries successively, at the same time, a rate of temperature rise reaches a preset threshold under a current working condition, and a duration exceeds a preset determination duration. If no thermal runaway diffusion occurs, an experiment of real batteries can be carried out directly according to the design to verify whether the fire happens, thereby determining the safety.

[0052] Specifically, in a scene where the overcharging test with current of I_C is performed with a preset parameter on the battery pack consisting of a plurality cells to verify whether the thermal runaway occurs, the method of the present application can be implemented according to the following form.

[0053] Single cell overcharging and heating test is performed under the thermal insulation condition.

[0054] After the battery is fully charged, a plurality of temperature measurement points are arranged on the surface of the battery. The battery is arranged in a device capable of creating a thermal insulation environment, after the data recorded at the temperature measurement points is stable, and no heat exchange occurs between the cell and peripheral environment (that is, the temperature distribution inside and outside the cell and inside the device is uniform and stable), the overcharging is performed under a charging and stopping condition set according to the prediction requirements.

[0055] If the thermal runaway already occurs at the overcharging, the subsequent heating does not need to be performed. If the thermal runaway does not occur after the overcharging is ended, the temperature inside a thermal insulation device increases gradually at a certain temperature gradient, after the temperature at the temperature point of cell surface is equal to a temperature set value of the thermal insulation device and stable, the temperature of the thermal insulation device further increases until the thermal runaway occurs in the cell.

[0056] The cell surface temperature, the charging current and the cell voltage are recorded in the whole process of the test.

[0057] If the definite convective heat transfer coefficient and radiation emissivity of the single cell are known, the test can be carried out not in a thermal insulation environment, but can be carried out in a constant-temperature or variable-temperature environment at any temperature.

[0058] Furthermore, the overcharging condition can also be changed to various conditions that electrical parameters are constant/variable, such as current constant/variable and power constant/variable according to the actual situation. The present application is described by taking the overcharging as an example, but shall not be limited thereto.

[0059] The single cell overcharging model can be established in the finite element calculation software, and a heat production calculation formula can be deduced based on the data obtained in the previous step.

[0060] An expression of heat production in overcharging reaction is as shown in formula (1)-formula (3):

$$R_{\mathrm{c}} = A_{\mathrm{c}} * e^{\frac{E_{a_{\mathrm{c}}}}{R_{const}*T}} * c_{\mathrm{c}} \qquad (t \le t0)$$

$$R_{\mathrm{c}} = 0 \qquad (t > t0) \qquad \text{Formula (1)}$$

$$\frac{dc_{\mathrm{c}}}{dt} = \left(\frac{c_{\mathrm{act}}*I*t}{Ah} - R_{\mathrm{de}}\right) \qquad \text{Formula (2)}$$

$$Q_{\mathrm{c}} = \rho * H_{\mathrm{c}} * R_{\mathrm{c}} \qquad \text{Formula (3)}$$

[0061] In the formula, R_{c} is an overcharging reaction rate, A_{c} is a pre-exponential factor of the overcharging reaction, E_{a_c} is an activation energy of the overcharging reaction, R_{const} is a molar gas constant, T is a thermodynamic temperature, c_{c} is a volume fraction of active substances of the overcharging reaction, t0 is an overcharging duration, c_{act} is a ratio between a core volume and a cell volume, I is an overcharging current, Ah is a rated capacity of the

battery, R_{de} is a decomposition reaction rate, Q_{c} is a heat production rate of the overcharging reaction, and H_{c} is an enthalpy of the overcharging reaction.

[0062] An expressions for heat production in the decomposition reaction is as shown in formula (4)-formula (6):

$$R_{\mathrm{de}} = A_{\mathrm{de}} * e^{\frac{E_{a_\mathrm{de}}}{R_{const}*T}} * c_{\mathrm{de}} \quad \text{Formula (4)}$$

$$\frac{dc_{\mathrm{de}}}{dt} = \frac{dc_{\mathrm{c}}}{dt} - R_{\mathrm{de}} \quad \text{Formula (5)}$$

$$Q_{\mathrm{de}} = \rho * H_{\mathrm{de}} * R_{\mathrm{de}} \quad \text{Formula (6)}$$

[0063] In the formula, A_{de} is a pre-exponential factor of decomposition reaction, E_{a_de} is an activation energy of the decomposition reaction, c_{de} is a volume fraction of active substances of the overcharging reaction, Q_{de} is a heat production rate of the decomposition reaction, and H_{de} is an enthalpy of the decomposition reaction.

[0064] An expression for ohmic heat production during charging is as shown in formula (7):

$$Q_{\mathrm{ohm}} = I^2 * R_0 \quad \text{Formula (7)}$$

[0065] In the formula, Q_{ohm} is an ohmic heat production rate, R_0 is a direct current internal resistance of the cell when SOC is under the preset condition, and the change of the internal resistance caused by the overcharging is reflected by the heat production rate of the overcharging reaction.

[0066] Since the cell is arranged in the thermal insulation environment, the heat dissipation capacity is 0.

[0067] A multi-parameter optimization method is used to search best-matched target parameters A_{de}, A_{c}, H_{de}, E_{a_c} and E_{a_de} at possible upper and lower boundaries of the target parameter under a stop condition that a sum of squares of the difference between a calculated result and a measured result of a simulation temperature at different positions of the cell is less than a certain value. Since the difference of the magnitude of the five parameters is great, a step change rate of each parameter needs to be constrained when the optimization algorithm is set, which is conducive to rapidly obtaining a matched result.

[0068] Except a minimal sum of squares of the difference between the calculated value and the measured value, a difference between the thermal runaway initial temperature (a temperature rise rate of the cell is greater than a preset temperature rise rate threshold) of the calculated value

and the measured value needs to be controlled to be less than a certain value.

[0069] Thereafter, the overcharging thermal runaway model of the battery pack can be established in the finite element calculation software. Whether the thermal runaway may occur in a heat transfer process during the overcharging and after stopping the overcharging is predicted.

[0070] The three-dimensional model of the battery pack including the cells, the connection banks and other structural components is established according to the actual design of the battery pack. The ohmic heat production is represented in a thermoelectric coupling manner at the connection bank. The heat production of the overcharging reaction and decomposition reaction of each cell is set independently according to the obtained target parameter, which indicates that the reaction heat of each cell depends on the temperature of the cell and the volume fraction of the active substances. The charging time of the battery pack is equal to an actual measured result that the single cell is overcharged to reach the stop condition under the charging current.

[0071] Corresponding convective heat transfer coefficient and radiation emissivity are set on a position of the battery pack contacting the exterior according to the actual condition.

[0072] If the thermal runaway does not occur in the battery pack after the overcharging is ended, whether a heat exchange amount in the environment is greater than the heat produced in the decomposition reaction that is still undergoing is an important condition for the occurrence of the thermal runaway. Since the cell in the center of the battery pack is surrounded by peripheral cells, the heat produced by the center cell is difficult to dissipate to the exterior, so that the thermal runaway is mostly likely to occur in the center cell earlier than the cells on other positions.

[0073] Whether the battery pack design can ensure the safety when the battery pack is overcharged is judged according to a calculated result.

[0074] A probe is arranged on a preset position of each cell in the battery pack model to obtain the temperature rise rate calculated at each cell, and examine whether the thermal runaway or thermal runaway diffusion occurs (the thermal runaway occurs successively in the cells on adjacent positions). If the thermal runaway or the thermal runaway diffusion occurs, it indicates that the current design has a risk existing therein and needs to be adjusted. If there is no thermal runaway or thermal runaway diffusion, the actual test can be performed for real verification.

[0075] The present embodiment determines a first environmental parameter, and performs a first thermal runaway operation on a target cell according to the first environmental parameter until thermal runaway occurs in the target cell; obtains a first state parameter of the target cell during the process to determine a target heat production model according to the first state parameter, performs three-dimensional modeling on a battery structure, and performs a second thermal runaway operation according to the three-dimensional model, and obtains a the second state parameter during the second thermal runaway operation according to the determined target heat production model, so that safety of a target battery pack can be judged according to the second state parameter. Therefore, through an actual thermal runaway operation, the target heat production model is determined, and through a simulated thermal runaway operation, the safety of the target battery pack is determined according to the target heat production model, which saves the test cost and simplifies a cell safety prediction system; and at the same time, the method reduces requirements of mechanism modeling for basic data, and generally improves the efficiency and accuracy in the prediction of the cell safety.

[0076] Embodiment II

[0077] An embodiment of the present application further provides a cell safety prediction apparatus to implement the aforementioned method. Referring to FIG. 2, FIG. 2 is a structural schematic diagram of a cell safety prediction apparatus provided by an embodiment of the present application. As shown in FIG. 2, the apparatus includes:

a determination module 31, configured to determine a first environmental parameter of a target area;

a processing module 32, configured to perform a first thermal runaway operation on a target cell according to the first environmental parameter until a thermal runaway phenomenon occurs in the target cell, and obtain a first state parameter of the target cell during the first thermal runaway operation;

where the processing module 32 is further configured to determine a target heat production model corresponding to each target cell according to the first state parameter, where the target heat production model is used to indicate a quantity of heat production of each target cell under a preset working parameter;

the processing module 32 is further configured to establish a structural model of a

target battery pack, perform a second thermal runaway operation on the structural model, and determine a second state parameter of each target cell according to each target heat production model during the second thermal runaway operation; and

the processing module 32 is further configured to determine safety of the target battery pack according to the second state parameter, where the second state parameter is used to indicate a thermal runaway condition of each target cell.

[0078] The present embodiment determines a first environmental parameter, and performs a first thermal runaway operation on a target cell according to the first environmental parameter until thermal runaway occurs in the target cell; obtains a first state parameter of the target cell during the process to determine a target heat production model according to the first state parameter, performs three-dimensional modeling on a battery structure, and performs a second thermal runaway operation according to the three-dimensional model, and obtains a the second state parameter during the second thermal runaway operation according to the determined target heat production model, so that safety of a target battery pack can be judged according to the second state parameter. Therefore, through an actual thermal runaway operation, the target heat production model is determined, and through a simulated thermal runaway operation, the safety of the target battery pack is determined according to the target heat production model, which saves the test cost and simplifies a cell safety prediction system; and at the same time, the apparatus reduces requirements of mechanism modeling for basic data, and generally improves the efficiency and accuracy in the prediction of the cell safety.

[0079] As an optional implementation, the first environmental parameter includes a thermal insulation parameter, and the thermal insulation parameter is used to indicate an environmental parameter for a situation in which a thermal insulation condition is maintained in the target area;

before the determination module 31 determines the first environmental parameter of the target area, the processing module 32 is further configured to:

charge the target cell until each target cell is in a fully-charged state;

determine a plurality of first measurement points associated with the target cell; and

where the first measurement point is used to obtain a temperature parameter of each target cell; and

a specific way in which the processing module 32 performs the first thermal runaway

operation on the target cell according to the first environmental parameter until the thermal runaway phenomenon occurs in the target cell after the determination module 31 determines the first environmental parameter of the target area includes:

determining the first environmental parameter of the target area, and performing the first thermal runaway operation on the target cell according to the first environmental parameter;

determining whether the thermal runaway phenomenon occurs in the target cell according to the temperature parameter corresponding to each first measurement point; and

if the thermal runaway phenomenon does not occur in the target cell, adjusting the first environmental parameter according to a preset environmental parameter change gradient until the thermal runaway phenomenon occurs in the target cell.

[0080] The preliminary preparation of the first thermal runaway operation is completed by pre-charging the target cell until the target cell is fully charged before the first thermal runaway operation and determining the plurality of first measurement points for obtaining the temperature parameter; at the same time, the thermal insulation environment is created for the first thermal runaway operation according to the determined first environmental parameter, the first thermal runaway operation is performed on the target cell in the thermal insulation environment, and according to an actual state of the target cell in the first thermal runaway operation, the first environmental parameter is adjusted until the thermal runaway phenomenon actually occurs in the target cell, thus ensuring the effectiveness and practicability of the first thermal runaway operation process; and moreover, during the first thermal runaway operation, the parameter related to the overcharged thermal runaway phenomenon of the target cell can be successfully obtained, which can provide effective basic data for the target heat production model. In conclusion, through an actual thermal runaway operation, the target heat production model is determined, and through a simulated thermal runaway operation, the safety of the target battery pack is determined according to the target heat production model, which saves the test cost and simplifies a cell safety prediction system; and at the same time, the apparatus reduces requirements of mechanism modeling for basic data, and generally improves the efficiency and accuracy in the prediction of the cell safety.

[0081] As an optional implementation, the first state parameter includes one or more of the following: a cell surface temperature, a charging current and a cell voltage, the target heat

production model includes a target overcharging model, and a specific way in which the processing module 32 determines the target heat production model corresponding to each target cell according to the first state parameter includes:

establishing a single cell overcharging model corresponding to each target cell according to the first state parameter, and determining a third state parameter in each single cell overcharging model;

where the single cell overcharging model includes an electrochemical reaction heat production model and a decomposition reaction heat production model; and

optimizing each third state parameter to obtain a target state parameter, and determining the target overcharging model corresponding to each target cell according to the target state parameter and each single cell overcharging model.

[0082] The single cell overcharging model of each target cell can be established through the first state parameter, the third state parameter to be optimized is determined in the single cell overcharging model, the corresponding optimization process is performed according to data features of the third state parameter to obtain each target state parameter, thereby determining the target overcharging model, thus improving the effectiveness of the target overcharging model and improving the efficiency for establishing the target overcharging model; through an actual thermal runaway operation, the target heat production model is determined, and through a simulated thermal runaway operation, the safety of the target battery pack is determined according to the target overcharging model, which saves the test cost and simplifies a cell safety prediction system; and at the same time, the apparatus reduces requirements of mechanism modeling for basic data, and generally improves the efficiency and accuracy in the prediction of the cell safety.

[0083] As an optional implementation, a specific way in which the processing module 32 optimizes each third state parameter to obtain the target state parameter includes:

determining a target boundary and a target order of magnitude of each third state parameter;

determining a state parameter change gradient corresponding to each third state parameter according to the target order of magnitude of each third state parameter;

adjusting each third state parameter in the target boundary according to the state

parameter change gradient corresponding to each third state parameter;

under different values of each third state parameter, determining a measured value of a cell surface temperature corresponding to each target cell, and a calculated value of the cell surface temperature corresponding to each target cell calculated according to the single cell overcharging model;

determining a first thermal runaway initial temperature according to the measured value, determining a second thermal runaway initial temperature according to the calculated value, determining a thermal runaway initial temperature difference according to the first thermal runaway initial temperature and the second thermal runaway initial temperature, and determining a sum of squares of the difference according to the measured value and the calculated value; and

determining candidate parameter values of the third state parameter under a condition that the sum of squares of the difference is less than a preset threshold of the sum of squares, and/or the thermal runaway initial temperature difference is less than a preset difference threshold, and determining the target state parameter from the candidate parameter values.

[0084] An optimization change gradient is determined through the parameter boundary and an order-of-magnitude distribution of the third state parameter, each third state parameter is changed according to the corresponding change gradient, the measured value of the cell surface temperature corresponding to the target cell and the calculated value of the cell surface temperature corresponding to the target cell calculated according to the single cell overcharging model are determined through a grid optimization way under different values of the third state parameter, and the first thermal runaway initial temperature and the second thermal runaway initial temperature are determined according to the measured value and the calculated value so as to obtain the candidate parameters of the third state parameter, and the target state parameter are further selected from the candidate parameters, thereby determining the target overcharging model, thus improving the effectiveness of the target overcharging model, and improving the efficiency for establishing the target overcharging model; through an actual thermal runaway operation, the target heat production model is determined, and through a simulated thermal runaway operation, the safety of the target battery pack is determined according to the target overcharging model, which saves the test cost and simplifies a cell safety prediction system; and at the same time, the apparatus reduces requirements of mechanism modeling for basic data, and

generally improves the efficiency and accuracy in the prediction of the cell safety.

[0085] As an optional implementation, a specific way in which the processing module 32 establishes the structural model of the target battery pack, and performs the second thermal runaway operation on the structural model includes:

determining an electrical component structure and a mechanical component structure of the target battery pack, and establishing the structural model of the target battery pack according to the electrical component structure and the mechanical component structure;

where the electrical component structure includes a cell structure and a connection bank structure;

establishing a first heat production model corresponding to the cell structure according to the target overcharging model of each target cell; determining a quantity of ohmic heat production corresponding to the connection bank structure, and establishing a second heat production model; and determining a convective heat transfer coefficient and a radiation emissivity corresponding to the mechanical component structure, and establishing a third heat production model; and

performing simulative overcharging on the structural model according to a target charging time and a target charging current to perform the second thermal runaway operation, and determining a thermal runaway condition;

where the thermal runaway condition is associated with the first heat production model, the second heat production model and the third heat production model and used to indicate a corresponding thermal physical condition under which the safety of the target battery pack meets a preset safety requirement.

[0086] Through the actual structure of the target cell, the modeling is performed, and a corresponding heat production formula and the thermal runaway condition are determined; and in the process of simulating the overcharging on the structural model according to the target charging time and the target charging current and performing the second thermal runaway operation, the second state parameter can be obtained according to the determined target heat production model, and the safety of the target battery pack can be judged according to the second state parameter. Therefore, through an actual thermal runaway operation, the target heat production model is determined, and through a simulated thermal runaway operation, the safety

of the target battery pack is determined according to the target heat production model, which saves the test cost and simplifies a cell safety prediction system; and at the same time, the apparatus reduces requirements of mechanism modeling for basic data, and generally improves the efficiency and accuracy in the prediction of the cell safety.

[0087] Embodiment III

[0088] The present application further provides an electronic device, including:

at least one processor; and

a memory communicatively connected with the at least one processor, where

the memory stores instructions capable of being executed by the at least one processor, and the instructions, when being executed by the at least one processor, enable the at least one processor to execute the method as described in any one of the embodiments.

[0089] The present application further provides a computer readable storage medium, where the computer readable storage medium stores computer execution instructions, and the computer execution instructions, when being executed by a processor, are used to implement the method as described in any one of the embodiments.

[0090] Referring to FIG. 3, FIG. 3 is a structural schematic diagram of an electronic device provided by an embodiment of the present application. As shown in FIG. 3, the electronic device may include:

a processor 291, a memory 292 storing executable program codes, a communication interface 293 and a bus 294. The processor 291, the memory 292 and the communication interface 293 can be communicated with each other through the bus 294. The communication interface 293 can be configured for information transmission. The processor 291 is coupled with the memory 292, and the processor 291 can invoke a logic instruction (the executable program code) in the memory 292 to perform the method in any one of above embodiments.

[0091] Furthermore, the logic instruction in the memory 292 can be implemented in the form of a software functional unit and sold or used as an independent product, and can be stored in a computer readable storage medium.

[0092] The memory 292, as a computer readable storage medium, may be configured to store software programs and computer executable programs, such as a program instruction/module corresponding to the method in the embodiments of the present application. The processor 291

executes functional applications and data processing, i.e. implementing the method in the method embodiments by running software programs, instructions and modules stored in the memory 292.

[0093] The memory 292 can include a program storage area and a data storage area, where the program storage area can store an operating system and the application program required by at least one function; and the data storage area can store data created according to the use of terminal devices. Furthermore, the memory 292 can include a high-speed random access memory, and can also include a non-volatile memory.

[0094] An embodiment of the present application further provides a computer readable storage medium, where the computer readable storage medium stores computer execution instructions, and the computer execution instructions, when being invoked, are used to implement the method as described in any one of the embodiments.

[0095] An embodiment of the present application further discloses a computer program product, where the computer program product includes a non-transient computer readable storage medium storing computer programs, and the computer programs can be operated to cause a computer to execute steps in the method as described in any one of the embodiments.

[0096] The apparatus embodiments described above are only illustrative; and the modules serving as separate components may or may not be physically separated, and the components serving as module display may or may not be physical modules, that is, the modules may be located in one place or may be distributed on a plurality of network modules. Some or all of the modules may be selected according to actual needs to achieve the purposes of the solutions of the embodiments. The solutions can be understood and implemented by those ordinary skilled in the art without creative labor.

[0097] Through the above description of the embodiments, those skilled in the art can clearly know that each embodiment can be implemented by virtue of software with necessary universal hardware platform, and of course, can also be implemented by virtue of hardware. Based on the understanding, the essence of the above technical solution or the part contributed to the prior art can be embodied in the form of a software product; and the software product can be stored in a computer readable storage medium including a Read-Only Memory (ROM), a Random Access Memory (RAM), a Programmable Read-only Memory (PROM), an erasable programmable

read-only memory (EPROM), a one-time programmable read-only memory (OTPROM), an electrically erasable programmable read-only memory (EEPROM), a Compact Disc Read-Only Memory (CD-ROM) or other optical disc, magnetic disk, magnetic tapes, or any other computer readable medium that can be used to carry or store data.

[0098] Other embodiments of the present application may readily occur to those skilled in the art after considering the specification and practicing the present application disclosed herein. The present application is intended to cover any modification, use or adaptability changes of the present application, which follows the general principles of the present application and includes common knowledge or conventional technical means in the prior art that are not recorded in the present application. The specification and embodiments are only regarded as being exemplary. The actual scope and spirit of the present application are defined by the claims.

[0099] It should be understood that the present application is not limited to the precise structure described above and shown in the accompanying drawings, and various modifications and changes can be made without departing from the scope. The scope of the present application should be defined only by the appended claims.

CLAIMS

1. A cell safety prediction method, comprising:

determining a first environmental parameter of a target area, performing a first thermal runaway operation on a target cell according to the first environmental parameter until a thermal runaway phenomenon occurs in the target cell, and obtaining a first state parameter of the target cell during the first thermal runaway operation;

determining a target heat production model corresponding to each target cell according to the first state parameter, wherein the target heat production model is used to indicate a quantity of heat production of each target cell under a preset working parameter;

establishing a structural model of a target battery pack, performing a second thermal runaway operation on the structural model, and determining a second state parameter of each target cell according to each target heat production model during the second thermal runaway operation; and

determining safety of the target battery pack according to the second state parameter, wherein the second state parameter is used to indicate a thermal runaway condition of each target cell.

2. The method according to claim 1, wherein the first environmental parameter comprises a thermal insulation parameter, and the thermal insulation parameter is used to indicate an environmental parameter for a situation in which a thermal insulation condition is maintained in the target area;

before the determining the first environmental parameter of the target area, and performing the first thermal runaway operation on the target cell according to the first environmental parameter until the thermal runaway phenomenon occurs in the target cell, the method further comprises:

charging the target cell until each target cell is in a fully-charged state;

determining a plurality of first measurement points associated with the target cell; and

wherein the first measurement point is used to obtain a temperature parameter of each target cell; and

the determining the first environmental parameter of the target area, and performing the first thermal runaway operation on the target cell according to the first environmental parameter until the thermal runaway phenomenon occurs in the target cell comprises:

determining the first environmental parameter of the target area, and performing the first

thermal runaway operation on the target cell according to the first environmental parameter;

determining whether the thermal runaway phenomenon occurs in the target cell according to the temperature parameter corresponding to each first measurement point; and

if the thermal runaway phenomenon does not occur in the target cell, adjusting the first environmental parameter according to a preset environmental parameter change gradient until the thermal runaway phenomenon occurs in the target cell.

3. The method according to claim 1, wherein the first state parameter comprises one or more of the following: a cell surface temperature, a charging current and a cell voltage, the target heat production model comprises a target overcharging model, and the determining the target heat production model corresponding to each target cell according to the first state parameter comprises:

establishing a single cell overcharging model corresponding to each target cell according to the first state parameter, and determining a third state parameter in each single cell overcharging model;

wherein the single cell overcharging model comprises an electrochemical reaction heat production model and a decomposition reaction heat production model; and

optimizing each third state parameter to obtain a target state parameter, and determining the target overcharging model corresponding to each target cell according to the target state parameter and each single cell overcharging model.

4. The method according to claim 3, wherein the optimizing each third state parameter to obtain the target state parameter comprises:

determining a target boundary and a target order of magnitude of each third state parameter;

determining a state parameter change gradient corresponding to each third state parameter according to the target order of magnitude of each third state parameter;

adjusting each third state parameter in the target boundary according to the state parameter change gradient corresponding to each third state parameter;

under different values of each third state parameter, determining a measured value of a cell surface temperature corresponding to each target cell, and a calculated value of the cell surface temperature corresponding to each target cell calculated according to the single cell overcharging model;

determining a first thermal runaway initial temperature according to the measured value, determining a second thermal runaway initial temperature according to the calculated value, determining a thermal runaway initial temperature difference according to the first thermal runaway initial temperature and the second thermal runaway initial temperature, and determining

a sum of squares of the difference according to the measured value and the calculated value; and

determining candidate parameter values of the third state parameter under a condition that the sum of squares of the difference is less than a preset threshold of the sum of squares, and/or the thermal runaway initial temperature difference is less than a preset difference threshold, and determining the target state parameter from the candidate parameter values.

5. The method according to claim 3, wherein the establishing the structural model of the target battery pack, and performing the second thermal runaway operation on the structural model comprises:

determining an electrical component structure and a mechanical component structure of the target battery pack, and establishing the structural model of the target battery pack according to the electrical component structure and the mechanical component structure;

wherein the electrical component structure comprises a cell structure and a connection bank structure;

establishing a first heat production model corresponding to the cell structure according to the target overcharging model of each target cell; determining a quantity of ohmic heat production corresponding to the connection bank structure, and establishing a second heat production model; and determining a convective heat transfer coefficient and a radiation emissivity corresponding to the mechanical component structure, and establishing a third heat production model; and

performing simulative overcharging on the structural model according to a target charging time and a target charging current to perform the second thermal runaway operation, and determining a thermal runaway condition;

wherein the thermal runaway condition is associated with the first heat production model, the second heat production model and the third heat production model and used to indicate a corresponding thermal physical condition under which the safety of the target battery pack meets a preset safety requirement.

6. A cell safety prediction apparatus, comprising:

a determination module, configured to determine a first environmental parameter of a target area;

a processing module, configured to perform a first thermal runaway operation on a target cell according to the first environmental parameter until a thermal runaway phenomenon occurs in the target cell, and obtain a first state parameter of the target cell during the first thermal runaway operation;

wherein the processing module is further configured to determine a target heat production

model corresponding to each target cell according to the first state parameter, wherein the target heat production model is used to indicate a quantity of heat production of each target cell under a preset working parameter;

the processing module is further configured to establish a structural model of a target battery pack, perform a second thermal runaway operation on the structural model, and determine a second state parameter of each target cell according to each target heat production model during the second thermal runaway operation; and

the processing module is further configured to determine safety of the target battery pack according to the second state parameter, wherein the second state parameter is used to indicate a thermal runaway condition of each target cell.

7. The apparatus according to claim 6, wherein the first environmental parameter comprises a thermal insulation parameter, and the thermal insulation parameter is used to indicate an environmental parameter for a situation in which a thermal insulation condition is maintained in the target area;

before the determination module determines the first environmental parameter of the target area, the processing module is further configured to:

charge the target cell until each target cell is in a fully-charged state;

determine a plurality of first measurement points associated with the target cell; and

wherein the first measurement point is used to obtain a temperature parameter of each target cell; and

a specific way in which the processing module performs the first thermal runaway operation on the target cell according to the first environmental parameter until the thermal runaway phenomenon occurs in the target cell after the determination module determines the first environmental parameter of the target area comprises:

determining the first environmental parameter of the target area, and performing the first thermal runaway operation on the target cell according to the first environmental parameter;

determining whether the thermal runaway phenomenon occurs in the target cell according to the temperature parameter corresponding to each first measurement point; and

if the thermal runaway phenomenon does not occur in the target cell, adjusting the first environmental parameter according to a preset environmental parameter change gradient until the thermal runaway phenomenon occurs in the target cell.

8. The apparatus according to claim 6, wherein the first state parameter comprises one or more of the following: a cell surface temperature, a charging current and a cell voltage, the target heat production model comprises a target overcharging model, and a specific way in which the

processing module determines the target heat production model corresponding to each target cell according to the first state parameter comprises:

establishing a single cell overcharging model corresponding to each target cell according to the first state parameter, and determining a third state parameter in each single cell overcharging model;

wherein the single cell overcharging model comprises an electrochemical reaction heat production model and a decomposition reaction heat production model; and

optimizing each third state parameter to obtain a target state parameter, and determining the target overcharging model corresponding to each target cell according to the target state parameter and each single cell overcharging model.

9. An electronic device, comprising:

at least one processor; and

a memory communicatively connected with the at least one processor, wherein

the memory stores instructions capable of being executed by the at least one processor, and the instructions, when being executed by the at least one processor, enable the at least one processor to execute the method according to any one of claims 1-5.

10. A computer readable storage medium, wherein the computer readable storage medium stores computer execution instructions, and the computer execution instructions, when being executed by a processor, are used to implement the method according to any one of claims 1-5.