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Inventeur(s):

ZENG Fancong - Chine

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Mandataire(s):

Patent42 SA - 4081 Esch-sur-Alzette (Luxembourg)

47

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Titulaire(s):

JIANGHAN UNIVERSITY - 430056 Hubei (Chine)

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METHOD, DEVICE AND PROCESSING EQUIPMENT FOR EVALUATING CONSISTENCY OF LITHIUM BATTERIES IN THE SAME BATCH.

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The invention provides a method, a device and processing equipment for evaluate the consistency of lithium batteries in the same batch. The method comprises the following steps: on the basis of cell mass m , specific heat capacity C_p , self-generated heat temperature $T_{\text{generation}}$ and current environment temperature T_a , determining the cell energy H released at any moment in the whole charging and discharging process of the battery; determining the thermal energy Q from chemical reaction on the basis of cell volume V , normalized concentration dC/dt and cell energy H ; calculating the instantaneous heat generating power P of the battery during charging and discharging on the basis of thermal energy Q ; charging and discharging different batteries, and recording charging and discharging time and temperature rise inertia temperature difference; comparing the standard deviation coefficient of instantaneous heat generation power P , charging and discharging time and temperature rise inertia temperature difference between different batteries.

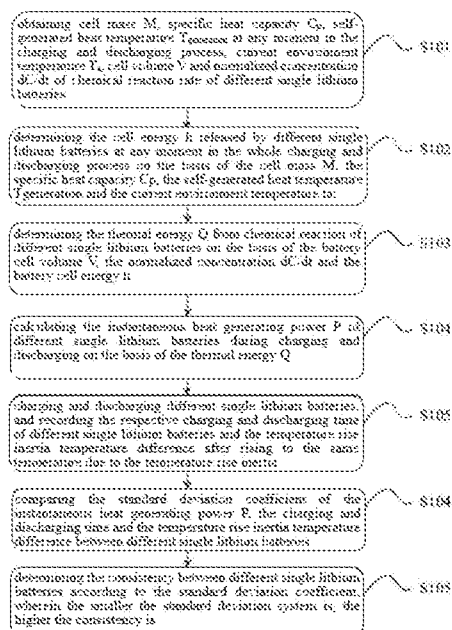


FIG. 1

METHOD, DEVICE AND PROCESSING EQUIPMENT FOR EVALUATING CONSISTENCY OF LITHIUM BATTERIES IN THE SAME BATCH

TECHNICAL FIELD

The application relates to the field of lithium batteries, in particular to a method, a device and processing equipment for evaluating consistency of lithium batteries in the same batch.

BACKGROUND

Lithium battery is widely used as a new energy source and electric energy storage device because of its high energy density and long cycle life. A lithium battery module is composed of several single lithium batteries in series and parallel. When the lithium battery runs beyond the standard range of temperature, voltage, charging and discharging current or charging state stipulated by the national standard, it will lead to battery performance degradation and even failure or thermal runaway. When the thermal runaway spreads from one or several lithium batteries to other lithium batteries, the thermal runaway chain reaction will occur due to the thermal runaway, so the thermal runaway will easily lead to serious consequences, such as electrolyte leakage, release of toxic substances, fire and even explosion.

The internal causes of thermal runaway are very complicated, and the most important one is the inconsistency between single lithium batteries. The inconsistency of lithium battery parameters mainly refers to the inconsistency of capacity, internal resistance, open circuit voltage and heating power. The initial inconsistency accumulates with the continuous charging and discharging cycles of the battery in the operation process, which leads to greater differences in the conditions (state of charge, voltage, etc.) of each single battery, and the operation environment in the lithium battery pack is different for each single battery. These complex factors lead to the gradual amplification of the inconsistency of the single battery in the operation process, and then accelerate the attenuation of the functions of some single lithium batteries in some cases, and eventually lead to the premature failure of the lithium battery pack.

The main reasons for the inconsistency of lithium batteries are as follows: there are differences in technology, manufacturing and uneven materials in the manufacturing process, which makes the materials of lithium batteries very different. After the lithium battery pack is put into use, each single lithium battery in the lithium battery pack is affected by the differences in electrolyte density, temperature and ventilation conditions, self-discharge degree and charging and discharging process, and the capacity and internal resistance of the same model battery in the same batch may be different.

In the research process of existing related technologies, the inventors found that the most commonly used methods for evaluating the consistency of lithium batteries are range coefficient method, standard deviation coefficient method and threshold method, and then combined with cluster analysis, the battery can be scientifically classified according to the shape, distance and area of the battery charge-discharge curve formed by each detection point within a set time interval, so as to judge the consistency of the battery. On the basis of capacity or voltage threshold, the shape of charge-discharge curve, the distance between curves and the area enclosed by curves are calculated, and the parameters that can reflect the consistency of curves are selected for judgment. In the process of charging and discharging, the batteries with similar curves, smaller relative distance, smaller area surrounded by curves and smaller differences between groups are selected for matching, so as to realize the optimal consistent matching. However, in the specific application, the disadvantage of this consistency evaluation method is that the judgment process is complicated, and it is necessary to formulate a reasonable battery balancing strategy to balance the management of batteries. It is difficult to detect the parameters of each single lithium battery and master the inconsistent development law of single batteries during the use of lithium batteries.

SUMMARY

The invention provide a method, a device and processing equipment for evaluate consistency of lithium batteries in the same batch, which are used for providing a convenient evaluation mechanism for the consistency of lithium battery, so that the consistency among

single lithium batteries can be determined stably, rapidly and accurately, and reliable data support is provided for the application of lithium batteries.

In a first aspect, the present application provides a method for evaluating consistency of lithium batteries in the same batch, comprising:

obtaining cell mass M , specific heat capacity C_p , self-generated heat temperature $T_{\text{generation}}$ at any moment in the charging and discharging process, current environment temperature T_a , cell volume V and normalized concentration dC/dt of chemical reaction rate of different single lithium batteries;

determining the cell energy H released by different single lithium batteries at any moment in the whole charging and discharging process on the basis of the cell mass M , the specific heat capacity C_p , the self-generated heat temperature $T_{\text{generation}}$ and the current environment temperature T_a ;

determining the thermal energy Q from chemical reaction of different single lithium batteries on the basis of the battery cell volume V , the normalized concentration dC/dt and the battery cell energy H ;

calculating the instantaneous heat generating power P of different single lithium batteries during charging and discharging on the basis of the thermal energy Q ;

charging and discharging different single lithium batteries, and recording the respective charging and discharging time of different single lithium batteries and the temperature rise inertia temperature difference after rising to the same temperature due to the temperature rise inertia;

comparing the standard deviation coefficient of the instantaneous heat generating power P , the charging and discharging time and the temperature rise inertia temperature difference between different single lithium batteries;

determining the consistency between different single lithium batteries according to the standard deviation coefficient, wherein the smaller the standard deviation system is, the higher the consistency is.

In connection with that first aspect of the present application, in a first possible implementation of the first aspect of the present application, determining the cell energy H

released by different single lithium batteries at any time during the whole charging and discharging process on the basis of the cell mass M , the specific heat capacity C_p , the self-generated heat temperature $T_{\text{generation}}$ and the current ambient temperature T_a comprises:

determining the battery energy H released by different single lithium batteries at any time during the whole charging and discharging process by combining the following first formula on the basis of the battery mass M , the specific heat capacity C_p , the self-generated heat temperature $T_{\text{generation}}$ and the current environment temperature T_a :

$$H=M \times C_p \times (T_{\text{generation}}-T_a).$$

In combination with the first aspect of the application, in the second possible implementation of the first aspect of the application, determining the thermal energy Q from chemical reaction of different monomer lithium batteries on the basis of the cell volume V , the normalized concentration dC/dt and the cell energy H comprises:

determining the thermal energy Q from chemical reaction of different single lithium batteries by combining the following second formula on the basis of the battery cell volume V , the normalized concentration dC/dt and the battery cell energy H :

$$Q=1/V \times H \times dC/dt.$$

In combination with the first aspect of the application, in the third possible implementation of the first aspect of the application, the charging and discharging are carried out at a temperature of $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ and under the conditions of GB/T31485-2015 standard, comprising:

discharging at a constant current of 1C until reaching the discharge cut-off voltage;

standing for 30 min;

charging with 1C constant current to the charging cut-off voltage, and then charging at constant voltage until the charging current drops to 0.05 C;

standing for 30 min;

discharging at a constant current of 1C until reaching the discharge cutoff voltage;

standing for 30 min;

charging the battery with 1C constant current rate until the cut-off voltage is reached, and then charging at constant voltage until the charging current drops to 0.05C.

In combination with the first aspect of the application, in the fourth possible implementation of the first aspect of the application, charging and discharging different single lithium batteries, recording the respective charging and discharging time of different single lithium batteries and the temperature rise inertia temperature difference after rising to the same temperature comprise:

charging and discharging different single lithium batteries for N rounds, and recording the charging and discharging time of different single lithium batteries for N rounds and the inertia temperature difference of temperature rise for N rounds after being heated to the same temperature due to the inertia effect of temperature rise;

taking the average value as the final data according to the N rounds of charging and discharging time and the N rounds of temperature rise inertia temperature difference of different single lithium batteries.

In combination with the fourth possible implementation of the first aspect of the present application, in the fifth possible implementation of the first aspect of the present application, the number of n is specifically 5.

In combination with the first aspect of the application, in the sixth possible implementation of the first aspect of the application, the different single lithium batteries are specifically four lithium batteries of the same manufacturer, the same model and the same batch.

In a second aspect, the present application provides a device for evaluating the consistency of lithium batteries in the same batch, comprising:

an acquisition unit, used for acquiring cell mass M , specific heat capacity C_p , self-generated heat temperature $T_{\text{generation}}$ at any moment in the charging and discharging process, current ambient temperature T_a , cell volume V and normalized concentration dC/dt of chemical reaction rate of different single lithium batteries;

a determining unit, configured to determine the battery cell energy H released by different single lithium batteries at any time during the whole charging and discharging process on the basis of the battery cell mass m , the specific heat capacity C_p , the self-generated heat temperature $T_{\text{generation}}$ and the current environmental temperature T_a ;

a determining unit, used for determining the thermal energy Q from chemical reaction of different single lithium batteries on the basis of the battery cell volume V , the normalized concentration dC/dt and the battery cell energy H ;

a calculation unit, used for calculating the instantaneous heat generating power P of different single lithium batteries during charging and discharging on the basis of the thermal energy Q ;

a charging and discharging unit, used for charging and discharging different single lithium batteries, and recording the respective charging and discharging time of different single lithium batteries and the temperature rise inertia temperature difference due to the temperature rise inertia action after being raised to the same temperature;

a comparison unit, used for comparing the instantaneous heat generating power P , the charging and discharging time and the standard deviation coefficient of the temperature rise inertia temperature difference between different single lithium batteries;

a determining unit, further used for determining the consistency between different single lithium batteries according to the standard deviation coefficient, wherein the smaller the standard deviation system is, the higher the consistency is.

Combined with the second aspect of the application, in the first possible implementation of the second aspect of the application, the determining unit is specifically used for:

on the basis of cell mass M , specific heat capacity C_p , self-generated heat temperature $T_{\text{generation}}$ and current ambient temperature T_a , the cell energy H released by different single lithium batteries at any time during the whole charging and discharging process is determined by combining the following first formula:

$$H=M \times C_p \times (T_{\text{generation}}-T_a),$$

Combined with the second aspect of the application, in the second possible implementation of the second aspect of the application, the determining unit is specifically used for:

on the basis of cell volume V , normalized concentration dC/dt and cell energy H , the thermal energy Q from chemical reaction of different single lithium batteries is determined by combining the following second formula:

$$Q=1/V \times H \times dC/dt.$$

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Combined with the second aspect of the application, in the third possible implementation of the second aspect of the application, the charging and discharging is carried out at a temperature of $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ and under the conditions of GB/T 31485-2015 standard, including:

discharging at a constant current of 1C until reaching the discharge cutoff voltage;

standing for 30 min;

charging with 1C constant current to the charging cut-off voltage, and then

standing for 30 min;

discharging at a constant current of 1C until reaching the discharge cutoff voltage;

standing for 30 min;

charging the battery with 1C constant current rate until the cut-off voltage is reached, and then charging at constant voltage until the charging current drops to 0.05C.

Combined with the second aspect of the application, in the fourth possible implementation of the second aspect of the application, the charging and discharging unit is specifically used for:

charging and discharging different single lithium batteries for N rounds, and recording the charging and discharging time of different single lithium batteries for N rounds, and the temperature rise inertia temperature difference of N rounds after rising to the same temperature due to the temperature rise inertia;

According to the N-round charging and discharging time and the N-round maximum temperature of different single lithium batteries, the average value is taken as the final data.

Combining with the fourth possible implementation of the second aspect of the application, in the fifth possible implementation of the second aspect of the application, the number of n is specifically 5.

Combined with the second aspect of the application, in the sixth possible implementation of the second aspect of the application, different single lithium batteries are specifically four lithium batteries of the same manufacturer, the same model and the same batch.

In the third aspect, the application provides a processing device, which comprises a processor and a memory, wherein a computer program is stored in the memory, and when the processor calls the computer program in the memory, the method provided by the first aspect of the application or any possible implementation of the first aspect of the application is executed.

In the fourth aspect, the application provides a computer-readable storage medium, and the computer-readable storage medium stores a plurality of instructions which are suitable for being loaded by a processor to execute the method provided by the first aspect of the application or any possible implementation of the first aspect of the application.

From the above, it can be concluded that the application has the following beneficial effects.

Aiming at the requirements of consistency evaluation between single lithium batteries, the application focuses on the instantaneous heat generation power P calculated by parameters, as well as the standard deviation coefficients of charging and discharging time and temperature rise inertia temperature difference measured by charging and discharging, and determines the consistency between different single lithium batteries through these three standard deviation coefficients. Under this evaluation mechanism, it has the advantage of convenient operation cost, avoids the problem that the existing evaluation scheme is too complicated to lead to higher application cost, and can stably, quickly and accurately determine the consistency between single lithium batteries, which provides reliable data support for the application of lithium battery pack.

BRIEF DESCRIPTION OF THE FIGURES

In order to explain the technical scheme in the embodiments of the application more clearly, the drawings needed in the description of the embodiments will be briefly introduced below. Obviously, the drawings in the following description are only some embodiments of the

application. For those skilled in the art, other drawings can be obtained according to these drawings without creative work.

Fig. 1 is a flow chart of the consistency evaluation method of lithium batteries in the same batch of the application;

Fig. 2 is a schematic structural diagram of a device for evaluating the consistency of lithium batteries in the same batch;

Fig. 3 is a structural schematic diagram of the processing equipment of the present application.

DESCRIPTION OF THE INVENTION

In the following, the technical scheme in the embodiment of the application will be clearly and completely described with reference to the drawings in the embodiment of the application. Obviously, the described embodiment is only a part of the embodiment of the application, but not the whole embodiment. Based on the embodiments in this application, all other embodiments obtained by those skilled in the art without creative work belong to the protection scope of this application.

The terms "first" and "second" in the specification and claims of this application and the above drawings are used to distinguish similar objects, and are not necessarily used to describe a specific order or sequence. It should be understood that the data thus used can be interchanged under appropriate circumstances, so that the embodiments described herein can be implemented in other orders than those illustrated or described herein. Furthermore, the terms "including" and "having" and any variations thereof are intended to cover non-exclusive inclusion, for example, a process, method, system, product or equipment that includes a series of steps or modules is not necessarily limited to those explicitly listed, but may include other steps or modules not explicitly listed or inherent to these processes, methods, products or equipment. The naming or numbering of steps in this application does not mean that the steps in the method flow must be executed in the time/logical order indicated by the naming or numbering, and the execution order of the named or numbered process steps can be changed according to the technical purpose to be achieved, as long as the same or similar technical effects can be achieved.

The division of modules in this application is a logical division. In practical application, there may be other ways of division. For example, multiple modules can be combined or integrated into another system, or some features can be ignored or not implemented. In addition, the mutual coupling or direct coupling or communication connection shown or discussed can be through some interfaces, and the indirect coupling or communication connection between modules can be electrical or other similar forms, which are not limited in this application. Moreover, the module or submodule described as a separate component may or may not be physically separated, may or may not be a physical module, or may be distributed among a plurality of circuit modules, and some or all of the modules may be selected according to actual needs to achieve the purpose of the application scheme.

Before introducing the consistency evaluation method of lithium batteries in the same batch provided by this application, the background content involved in this application is first introduced.

The method, the device and the computer-readable storage medium for evaluating the consistency of lithium batteries in the same batch provided by the application can be applied to processing equipment, and are used for providing a convenient evaluation mechanism for the consistency of lithium batteries, so that the consistency among single lithium batteries can be determined stably, rapidly and accurately, and reliable data support can be provided for the application of lithium batteries.

The execution subject of the consistency evaluation method for lithium batteries in the same batch mentioned in this application can be the consistency evaluation device for lithium batteries in the same batch, or different types of processing equipment such as servers, physical hosts or User Equipment (UE) integrated with the consistency evaluation device for lithium batteries in the same batch. Among them, the device for evaluating the consistency of lithium batteries in the same batch can be realized by hardware or software, the UE can be terminal devices such as smart phones, tablet computers, notebook computers, desktop computers or Personal Digital Assistant (PDA), and the processing devices can be set in the way of device clustering.

Among them, for the processing equipment, in practical application, the relevant special equipment or special components that may be involved in the scheme of this application can be included in the processing equipment, so that the processing equipment can complete the corresponding functional processing, or the processing equipment can urge it to perform the corresponding functional processing in the form of control or trigger.

Next, the consistency evaluation method of lithium batteries in the same batch provided by this application will be introduced.

First, refer to Fig. 1, which shows a flow chart of the consistency evaluation method of lithium batteries in the same batch in the application. The consistency evaluation method of lithium batteries in the same batch provided by the application can specifically include the following steps S101 to S107:

S101, obtaining cell mass M , specific heat capacity C_p , self-generated heat temperature $T_{\text{generation}}$ at any moment in the charging and discharging process, current ambient temperature T_a , cell volume V and normalized concentration dC/dt of chemical reaction rate of different single lithium batteries;

It can be understood that the consistency between single lithium batteries is determined by combining static and dynamic aspects.

For the static aspect, the purpose of this application is to obtain the instantaneous heat generation power P of each single lithium battery in the subsequent charging and discharging process, and some preset parameters of the single lithium battery can be retrieved and extracted for processing.

Specifically, these parameters include cell mass M , specific heat capacity C_p , self-generated heat temperature $T_{\text{generation}}$ at any moment during charging and discharging, current ambient temperature T_a , cell volume V and normalized concentration dC/dt of chemical reaction rate.

In addition, it should be understood that these parameters can be obtained by real-time detection or real-time analysis in specific applications, even though they are static parameters.

Among them, as a practical implementation method, the consistency evaluation strategy configured in this application can be carried out in units of four lithium batteries, and it can also

be four lithium batteries of the same model and batch selected by the same manufacturer. That is to say, the single lithium batteries that are evaluated for consistency each time use the same model and the same conditions of the same batch from the same manufacturer. Under this setting, consistency evaluation has the advantages of low cost and convenient processing.

S102, on the basis of cell mass M , specific heat capacity C_p , self-generated heat temperature $T_{\text{generation}}$ and current environmental temperature T_a , determine the cell energy H released by different single lithium batteries at any time during the whole charging and discharging process;

After obtaining the parameters such as cell mass M , specific heat capacity C_p , self-generated heat temperature $T_{\text{generation}}$ at any moment during charging and discharging, current ambient temperature T_a , cell volume V and normalized concentration dC/dt of chemical reaction rate, the corresponding parameters can be processed to obtain instantaneous heat generating power P .

Here, the energy H released by the battery at any time during the whole charging and discharging process can be obtained through the four parameters of battery mass M , specific heat capacity C_p , self-generated heat temperature $T_{\text{generation}}$ and current environmental temperature T_a , which provides data support for the thermal energy Q of the following battery from chemical reaction.

Specifically, as another practical implementation, the determination of battery energy H can be carried out through the following contents:

On the basis of cell mass M , specific heat capacity C_p , self-generated heat temperature $T_{\text{generation}}$ and current ambient temperature T_a , the cell energy H released by different single lithium batteries at any time during the whole charging and discharging process is determined by combining the following first formula:

$$H=M \times C_p \times (T_{\text{generation}}-T_a).$$

(1) S103, on the basis of cell volume V , normalized concentration dC/dt and cell energy H , thermal energy Q from chemical reaction of different monomer lithium batteries is determined;

after determining the cell energy H released by the single lithium battery at any time during the whole charging and discharging process, it may continue to determine the thermal energy Q from the chemical reaction of the battery for further data support.

As another practical implementation, the treatment of thermal energy Q from chemical reaction of single lithium battery here can be realized in the following ways:

On the basis of cell volume V , normalized concentration dC/dt and cell energy H , the thermal energy Q from chemical reaction of different single lithium batteries is determined by combining the following second formula:

$$Q=1/V \times H \times dC/dt.$$

(2) S104, based on the thermal energy Q , calculate the instantaneous heat generating power P of different single lithium batteries during charging and discharging;

It is easy to understand that the thermal energy Q is obtained by the accumulation of the relationship between the instantaneous heat generating power P and the charging and discharging process, so the instantaneous heat generating power P can be obtained in the form of differentiation.

Specifically, as another practical implementation, the instantaneous heat generating power p can be obtained by the following third formula:

$$P=dQ/dt,$$

where t is the charging and discharging time.

(3) S105, charge and discharge different single lithium batteries, and record the respective charge and discharge time of different single lithium batteries, and the temperature rise inertia temperature difference after rising to the same temperature due to the temperature rise inertia;

In addition to the static instantaneous heat generation power P mentioned above, this application also needs to obtain two dynamic parameters corresponding to charging and discharging, namely, the charging and discharging time of different single lithium batteries and the temperature rise inertia temperature difference after rising to the same temperature due to the inertia effect of temperature rise.

In this regard, it may charge and discharge each single lithium battery participating in the consistency evaluation, and record the charging and discharging time of different single lithium batteries and the temperature rise inertia temperature difference after rising to the same temperature due to the temperature rise inertia.

It can be understood that in this application, four lithium batteries can be selected as the evaluation objects of consistency, and these batteries can be configured from the same manufacturer, the same model and the same batch.

In the specific application, it is easy to understand that the deviation may come from the difference between battery samples, test operation and data acquisition process, and the selection of lithium battery samples of the same manufacturer, the same model and the same batch greatly reduces the influence of the difference between battery samples, and then all the treatments are completed according to the standard test scheme with the same instruments and even operators, so as to minimize the influence of test operation and data acquisition on the evaluation results.

As an example, it is found that the diameter, height, weight, anode and cathode materials and charge-discharge cutoff voltage of the four lithium batteries are the same, but the different parameters are rated capacity and rated energy.

Further, as another practical implementation, the charging and discharging treatment involved in this application can specifically include the following contents:

The charging and discharging are carried out at the temperature of $25^{\circ}\text{C}\pm 5^{\circ}\text{C}$ and under the conditions of GB/T 31485-2015 standard, and the specific contents include:

1. Discharge at 1C constant current until reaching the discharge cut-off voltage;
2. Stand for 30 min;
3. Charge with 1C constant current to the charging cut-off voltage, and then charge at constant voltage until the charging current drops to 0.05C;
4. Stand for 30 min;
5. Discharge at a constant current of 1C until the discharge cut-off voltage is reached (the discharge capacity can be used as the rated capacity of the battery);
6. Stand for 30 min;
7. Charge the battery with 1C constant current rate until the charging cut-off voltage reaches, and then charge at constant voltage until the charging current drops to 0.05C.

Specifically, under the same charge-discharge rate, the charge-discharge time when the battery temperature rises to the same temperature (set temperature) is recorded. When the temperature of lithium battery rises to the same temperature (set temperature), stop charging and discharging it, let it cool naturally, and exchange heat with air by convection. At this time, due to the temperature rise inertia, the temperature of the lithium battery will continue to rise to the highest temperature, and the highest temperature will be recorded, and the difference between the highest temperature and the set temperature will be calculated, and the difference result will be recorded as the adopted data of the temperature rise inertia temperature difference.

S106, comparing the instantaneous heat generation power P , the charging and discharging time and the standard deviation coefficient of the temperature rise inertia temperature difference between different single lithium batteries;

It can be understood that after the previous processing, three parameters, namely, instantaneous heat generating power P , charging and discharging time and temperature rise inertia temperature difference of each single lithium battery can be obtained. At this time, the standard deviation coefficient of the same parameter index can be processed between single lithium batteries to quantify the consistency and difference between single lithium batteries.

Further, it can be understood that the charging and discharging treatment in this application can also involve multiple rounds of charging and discharging, so as to better meet the actual parameters.

Specifically, as another practical implementation, the charging and discharging treatment can also be:

Charging and discharging different single lithium batteries for N rounds, and recording the charging and discharging time of different single lithium batteries for N rounds, and the temperature rise inertia temperature difference of N rounds after rising to the same temperature due to the temperature rise inertia;

According to the N -round charging and discharging time and the N -round maximum temperature of different single lithium batteries, the average value is taken as the final data.

It can be understood that the final data is determined by taking the average value here. DE504943
 course, in specific applications, under N rounds of charging and discharging, other strategies can also be adopted to extract the final data from N rounds of data, which is considered to be more in line with the actual use or with less error.

Among them, for the N rounds of charging and discharging, the application can be specifically configured as follows: the number of N is specifically 5.

S107, according to the standard deviation coefficient, the consistency between different single lithium batteries is determined, wherein the smaller the standard deviation system is, the higher the consistency is.

It can be understood that for this application, the key parameters in the consistency evaluation of single lithium batteries are heat generating power P, charging and discharging time and temperature rise inertia temperature difference. After obtaining the three parameters, the standard deviation coefficients of instantaneous heat generating power P, charging and discharging time and temperature rise inertia temperature difference will be further calculated. At this time, if the standard deviation coefficients of instantaneous heat generating power P, charging and discharging time and temperature rise inertia temperature difference between two single lithium batteries are closer, the consistency between two lithium batteries will be better.

As can be seen from the embodiment shown in Fig. 1, in view of the consistency evaluation requirements between single lithium batteries, the application focuses on the instantaneous heat generation power P calculated by parameters, as well as the standard deviation coefficients of charging and discharging time and temperature rise inertia temperature difference measured by charging and discharging, and determines the consistency between different single lithium batteries through these standard deviation coefficients. Under this evaluation mechanism, it has the advantage of convenient operation cost, avoids the problem of high application cost caused by the complexity of the existing evaluation scheme, and can determine the single battery stably, quickly and accurately.

The above is the introduction of the consistency evaluation method of lithium batteries in the same batch provided by the application. In order to better implement the consistency evaluation method of lithium batteries in the same batch provided by the application, the application also provides a consistency evaluation device of lithium batteries in the same batch from the perspective of functional modules.

Referring to Fig. 2, Fig. 2 is a structural schematic diagram of a lithium battery consistency evaluation device in the same batch of this application. In this application, the lithium battery consistency evaluation device 200 in the same batch may specifically include the following structure.

An acquisition unit 201, used for acquiring the cell mass M , specific heat capacity C_p , self-generated heat temperature $T_{\text{generation}}$ at any moment during the charging and discharging process, current ambient temperature T_a , cell volume V and normalized concentration dC/dt of chemical reaction rate of different single lithium batteries;

A determination unit 202, used to determine the battery cell energy H released by different single lithium batteries at any time during the whole charging and discharging process on the basis of the battery cell mass M , the specific heat capacity C_p , the self-generated heat temperature $T_{\text{generation}}$ and the current environmental temperature T_a ;

A determining unit 202, also used to determine the thermal energy Q of different lithium batteries from chemical reaction based on the battery cell volume V , the normalized concentration dC/dt and the battery cell energy H ;

A calculation unit 203, used to calculate the instantaneous heat generating power P of different lithium batteries during charging and discharging based on the thermal energy Q ;

A charging and discharging unit 204, used for charging and discharging different single lithium batteries, and recording the respective charging and discharging time of different single lithium batteries and the temperature rise inertia temperature difference due to the temperature rise inertia action after rising to the same temperature;

The determining unit 202 is also used to determine the thermal energy q of different lithium batteries from chemical reaction based on the battery cell volume v , the normalized concentration dC/dt and the battery cell energy H ;

A calculation unit 203, used to calculate the instantaneous heat generating power P of different lithium batteries during charging and discharging based on the thermal energy Q ;

A charging and discharging unit 204, used for charging and discharging different single lithium batteries, and recording the respective charging and discharging time of different single lithium batteries and the temperature rise inertia temperature difference due to the temperature rise inertia action after rising to the same temperature;

In another exemplary implementation, the determining unit 202 is specifically configured to:

On the basis of cell mass M , specific heat capacity C_p , self-generated heat temperature $T_{\text{generation}}$ and current ambient temperature T_a , the cell energy H released by different single lithium batteries at any time during the whole charging and discharging process is determined by combining the following first formula:

$$H=M \times C_p \times (T_{\text{generation}}-T_a).$$

In another exemplary implementation, the determining unit 202 is specifically configured to:

On the basis of cell mass M , specific heat capacity C_p , self-generated heat temperature $T_{\text{generation}}$ and current ambient temperature T_a , the cell energy H released by different single lithium batteries at any time during the whole charging and discharging process is determined by combining the following first formula:

$$Q=1/V \times H \times dC/dt.$$

In another exemplary implementation, the charging and discharging are carried out at a temperature of $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ and under the conditions of GB/T31485-2015 standard, and the contents include:

Discharging at a constant current of 1C until reaching the discharge cutoff voltage;

Stand for 30 min;

Charge with 1C constant current to the charging cut-off voltage, and then charge at constant voltage until the charging current drops to 0.05 C;

Stand for 30 min;

Discharging at a constant current of 1C until reaching the discharge cutoff voltage;

Stand for 30 min;

Charge the battery with 1C constant current rate until the charging cut-off voltage is reached, and then charge at constant voltage until the charging current drops to 0.05C.

In another exemplary implementation, the charging and discharging unit 204 is specifically used for:

Charging and discharging different single lithium batteries for N rounds, and recording the charging and discharging time of different single lithium batteries for N rounds, and the temperature rise inertia temperature difference of N rounds after rising to the same temperature due to the temperature rise inertia;

According to the N-round charging and discharging time and the N-round maximum temperature of different single lithium batteries, the average value is taken as the final data.

In yet another exemplary implementation, the number of n is specifically 5.

In another exemplary implementation, different single lithium batteries are specifically four lithium batteries of the same manufacturer, the same model and the same batch.

The application also provides a processing device from the perspective of hardware structure. Refer to Figure 3, which shows a structural schematic diagram of the processing device of the application. Specifically, the processing device of the application may include a processor 301, a memory 302 and an input/output device 303. The processor 301 is used to implement the steps of the consistency evaluation method of the same batch of lithium batteries in the corresponding embodiment of Figure 1 when executing the computer program stored in the memory 302. The processor 301 is used to realize the functions of each unit in the corresponding embodiment of fig. 2 when executing the computer program stored in the memory 302, and the memory 302 is used to store the computer program required by the processor 301 to execute the conformity evaluation method of the same batch of lithium batteries in the corresponding embodiment of fig. 1.

Illustratively, a computer program can be divided into one or more modules/units, and one or more modules/units are stored in the memory 302 and executed by the processor 301 to complete the application. One or more modules/units can be a series of computer program

instruction segments that can accomplish specific functions, and the instruction segments are used to describe the execution process of computer programs in computer devices.

Processing devices may include, but are not limited to, a processor 301, a memory 302, and an input-output device 303. It can be understood by those skilled in the art that the schematic is only an example of a processing device and does not constitute a limitation on the processing device. It may include more or less components than the schematic, or combine some components, or different components. For example, the processing device may also include a network access device, a bus, etc. The processor 301, the memory 302, the input and output device 303, etc. are connected by a bus.

The processor 301 may be a Central Processing Unit (CPU), other general processors, a Digital Signal Processor (DSP), an application specific integrated circuit (ASIC), ASIC), Field-Programmable Gate Array (FPGA) or other programmable logic devices, discrete gate or transistor logic devices, discrete hardware components, etc. The general processor can be a microprocessor or any conventional processor, etc. The processor is the control center of the processing equipment and connects all parts of the whole equipment with various interfaces and lines.

The memory 302 can be used to store computer programs and/or modules, and the processor 301 realizes various functions of the computer device by running or executing the computer programs and/or modules stored in the memory 302 and calling the data stored in the memory 302. The memory 302 may mainly include a storage program area and a storage data area, wherein the storage program area may store an operating system, an application program required by at least one function, and the like; the storage data area may store data created according to the use of the processing device, etc. In addition, the memory may include high-speed random access memory and non-volatile memory, such as hard disk, memory, plug-in hard disk, Smart Media Card (SMC), SecureDigital (SD) card, Flash Card, at least one disk memory device, flash device, or other volatile solid-state memory devices.

When the processor 301 is used to execute the computer program stored in the memory 302, it can specifically realize the following functions:

Obtaining cell mass m , specific heat capacity C_p , self-generated heat temperature $T_{\text{generation}}$ at any moment in the charging and discharging process, current ambient temperature T_a , cell volume V and normalized concentration dC/dt of chemical reaction rate of different single lithium batteries;

On the basis of cell mass M , specific heat capacity C_p , self-generated heat temperature $T_{\text{generation}}$ and current environmental temperature T_a , the energy H released by different lithium batteries at any time during the whole charging and discharging process is determined;

On the basis of cell volume V , normalized concentration dC/dt and cell energy H , the thermal energy Q of different lithium batteries from chemical reaction is determined.

On the basis of thermal energy Q , the instantaneous heat generation power P of different single lithium batteries during charging and discharging is calculated;

Charging and discharging different single lithium batteries, and recording the respective charging and discharging time of different single lithium batteries and the temperature rise inertia temperature difference after rising to the same temperature due to the temperature rise inertia;

Comparing the standard deviation coefficient of instantaneous heat generation power P , charging and discharging time and temperature rise inertia temperature difference between different single lithium batteries;

According to the standard deviation coefficient, the consistency between different single lithium batteries is determined, in which the smaller the standard deviation system, the higher the consistency.

It can be clearly understood by those skilled in the art that, for the convenience and conciseness of description, the specific working processes of the consistency evaluation device, processing equipment and corresponding units of the same batch of lithium batteries described above can refer to the description of the consistency evaluation method of the same batch of lithium batteries in the corresponding embodiment of Fig. 1, and the details are not repeated here.

It can be understood by those skilled in the art that all or part of the steps in various methods of the above embodiments can be completed by instructions or by controlling related

hardware by instructions, which can be stored in a computer-readable storage medium and loaded and executed by a processor. U504943

Therefore, the application provides a computer-readable storage medium, in which a plurality of instructions are stored, which can be loaded by a processor to execute the steps of the method for evaluating the consistency of lithium batteries in the same batch in the corresponding embodiment of the application as shown in Fig. 1. For specific operations, please refer to the description of the method for evaluating the consistency of lithium batteries in the same batch in the corresponding embodiment of Fig. 1, which is not repeated here.

The computer-readable storage medium may include Read Only Memory (ROM), Random Access Memory (RAM), magnetic disk or optical disk, etc.

Due to the instructions stored in the computer-readable storage medium, the steps of the method for evaluating the consistency of lithium batteries in the same batch in the corresponding embodiment of Fig. 1 can be executed, so the beneficial effects that can be achieved by the method for evaluating the consistency of lithium batteries in the same batch in the corresponding embodiment of Fig. 1 can be realized. For details, please refer to the previous description, which will not be repeated here.

The method, device, processing equipment and computer-readable storage medium for evaluating the consistency of the same batch of lithium batteries provided by this application are described in detail. In this paper, the principle and implementation of this application are expounded by using specific examples, and the description of the above embodiments is only used to help understand the method and its core idea of this application. At the same time, according to the idea of this application, there will be changes in the specific implementation and application scope for those skilled in this field. To sum up, the contents of this specification should not be understood as limitations on this application.

1. A method for evaluating consistency of lithium batteries in the same batch, comprising:
 - obtaining cell mass M , specific heat capacity C_p , self-generated heat temperature $T_{\text{generation}}$ at any moment in the charging and discharging process, current environment temperature T_a , cell volume V and normalized concentration dC/dt of chemical reaction rate of different single lithium batteries;
 - determining the cell energy H released by different single lithium batteries at any moment in the whole charging and discharging process on the basis of the cell mass M , the specific heat capacity C_p , the self-generated heat temperature $T_{\text{generation}}$ and the current environment temperature T_a ;
 - determining the thermal energy Q from chemical reaction of different single lithium batteries on the basis of the battery cell volume V , the normalized concentration dC/dt and the battery cell energy H ;
 - calculating the instantaneous heat generating power P of different single lithium batteries during charging and discharging on the basis of the thermal energy Q ;
 - charging and discharging different single lithium batteries, and recording the respective charging and discharging time of different single lithium batteries and the temperature difference of temperature rise inertia after rising to the same temperature due to the temperature rise inertia;
 - comparing the standard deviation coefficient of the instantaneous heat generating power P , the charging and discharging time and the temperature difference of the temperature rise inertia between different single lithium batteries;
 - determining the consistency between different single lithium batteries according to the standard deviation coefficient, wherein the smaller the standard deviation system is, the higher the consistency is.

2. The method according to claim 1, wherein determining the cell energy h released by different single lithium batteries at any moment in the whole charging and discharging process on the basis of the cell mass M , the specific heat capacity C_p , the self-generated heat temperature $T_{\text{generation}}$ and the current environment temperature T_a comprises:

determining the battery energy H released by different single lithium batteries at any time during the whole charging and discharging process by combining the following first formula on the basis of the battery mass M, the specific heat capacity C_p , the self-generated heat temperature $T_{\text{generation}}$ and the current environment temperature T_a :

$$H=M \times C_p \times (T_{\text{generation}}-T_a).$$

3. The method according to claim 1, wherein determining the thermal energy Q from chemical reaction of different single lithium batteries on the basis of the battery cell volume V, the normalized concentration dC/dt and the battery cell energy H comprises:

determining the thermal energy Q from chemical reaction of different single lithium batteries by combining the following second formula on the basis of the battery cell volume V, the normalized concentration dC/dt and the battery cell energy H:

$$Q=1/V \times H \times dC/dt.$$

4. The method according to claim 1, wherein charging and discharging are carried out at a temperature of $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ under the conditions of GB/T31485-2015 standard, comprising:

discharging at a constant current of 1C until reaching the discharge cut-off voltage;

standing for 30 min;

charging with 1C constant current to the charging cut-off voltage, and then charging at constant voltage until the charging current drops to 0.05 C;

charging the battery with 1C constant current rate until the cut-off voltage is reached, and then charging at constant voltage until the charging current drops to 0.05C.

5. The method according to claim 1, wherein charging and discharging different single lithium batteries, and recording the respective charging and discharging time of different single lithium batteries and the temperature difference of temperature rise inertia after rising to the same temperature due to the temperature rise inertia comprise:

charging and discharging different single lithium batteries for N rounds, and recording the charging and discharging time of different single lithium batteries for N rounds and the

temperature difference of temperature rise inertia for N rounds after rising to the same temperature due to the temperature rise inertia;

taking the average value as the final data according to the N rounds of charging and discharging time and the N rounds of temperature difference of the temperature rise inertia of different single lithium batteries.

6. The method according to claim 5, wherein the number of N is specifically 5.

7. The method according to claim 1, wherein the different single lithium batteries are four lithium batteries of the same manufacturer, the same model and the same batch.

8. A device for evaluating the consistency of lithium batteries in the same batch, comprising:

an acquisition unit, used for acquiring cell mass M , specific heat capacity C_p , self-generated heat temperature $T_{\text{generation}}$ at any moment in the charging and discharging process, current environment temperature T_a , cell volume V and normalized concentration dC/dt of chemical reaction rate of different single lithium batteries;

a determining unit, used for determining the cell energy H released by different single lithium batteries at any moment in the whole charging and discharging process on the basis of the cell mass M , the specific heat capacity C_p , the self-generated heat temperature $T_{\text{generation}}$ and the current environment temperature T_a ;

the determining unit is also used for determining the thermal energy Q from chemical reaction of different single lithium batteries on the basis of the battery cell volume V , the normalized concentration dC/dt and the battery cell energy H ;

a calculation unit, used for calculating the instantaneous heat generating power P of different single lithium batteries during charging and discharging on the basis of the thermal energy Q ;

a charging and discharging unit, used for charging and discharging different single lithium batteries, and recording the respective charging and discharging time of different single lithium

batteries and the temperature difference of temperature rise inertia after rising to the same temperature due to the temperature rise inertia;

a comparison unit, used for comparing the standard deviation coefficient of the instantaneous heat generating power P , the charging and discharging time and the temperature difference of the temperature rise inertia between different single lithium batteries;

the determining unit is further used for determining the consistency between different single lithium batteries according to the standard deviation coefficient, wherein the smaller the standard deviation system is, the higher the consistency is.

9. A processing device, comprising a processor and a memory, wherein a computer program is stored in the memory, and the processor executes the method according to any one of claims 1 - 7 when calling the computer program in the memory.

10. A computer-readable storage medium, wherein the computer-readable storage medium stores a plurality of instructions which are suitable for being loaded by a processor to execute the method according to any one of claims 1 - 7.

1. Ein Verfahren zur Bewertung der Konsistenz von Lithiumbatterien in derselben Charge, umfassend:

Ermittlung der Zellmasse M , der spezifischen Wärmekapazität C_p , der Temperatur der selbst erzeugten Wärme $T_{\text{Erzeugung}}$ zu jedem Zeitpunkt des Lade- und Entladevorgangs, der aktuellen Umgebungstemperatur T_a , des Zellvolumens V und der normierten Konzentration dC/dt der chemischen Reaktionsgeschwindigkeit verschiedener einzelner Lithiumbatterien;

Bestimmung der Zellenergie H , freigesetzt von verschiedenen einzelnen Lithiumbatterien zu jedem Zeitpunkt des gesamten Lade- und Entladevorgangs auf der Grundlage der Zellenmasse M , der spezifischen Wärmekapazität C_p , der Temperatur der selbst erzeugten Wärme $T_{\text{Erzeugung}}$ und der aktuellen Umgebungstemperatur T_a ;

Bestimmung der thermischen Energie Q aus der chemischen Reaktion verschiedener einzelner Lithiumbatterien auf der Grundlage des Batteriezellenvolumens V , der normierten Konzentration dC/dt und der Batteriezellenenergie H ;

Berechnen der momentanen Wärmeerzeugungsleistung P verschiedener einzelner Lithiumbatterien während des Ladens und Entladens auf der Grundlage der thermischen Energie Q ;

Laden und Entladen verschiedener einzelner Lithiumbatterien und Aufzeichnen der jeweiligen Lade- und Entladezeit verschiedener einzelner Lithiumbatterien und der Temperaturdifferenz der Temperaturanstiegsträgheit nach dem Anstieg auf die gleiche Temperatur aufgrund der Temperaturanstiegsträgheit;

Vergleichen des Standardabweichungskoeffizienten der momentanen Wärmeerzeugungsleistung P , der Lade- und Entladezeit und der Temperaturdifferenz der Temperaturanstiegsträgheit zwischen verschiedenen einzelnen Lithiumbatterien;

Bestimmen der Konsistenz zwischen verschiedenen einzelnen Lithiumbatterien gemäß dem Standardabweichungskoeffizienten, wobei die Konsistenz umso höher ist, je kleiner das Standardabweichungssystem ist.

2. Das Verfahren nach Anspruch 1, wobei Bestimmung der Zellenergie h , freigesetzt von verschiedenen einzelnen Lithiumbatterien zu jedem Zeitpunkt des gesamten Lade- und Entladevorgangs auf der Grundlage der Zellenmasse M , der spezifischen Wärmekapazität C_p , der Temperatur der selbst erzeugten Wärme $T_{\text{Erzeugung}}$ und der aktuellen Umgebungstemperatur T_a umfasst:

Bestimmung der Batterieenergie H , freigesetzt von verschiedenen einzelnen Lithiumbatterien zu jedem Zeitpunkt während des gesamten Lade- und Entladevorgangs durch Kombination der folgenden ersten Formel auf der Grundlage der Batteriemasse M , der spezifischen Wärmekapazität C_p , der Temperatur der selbst erzeugten Wärme $T_{\text{Erzeugung}}$ und der aktuellen Umgebungstemperatur T_a :

$$H=M \times C_p \times (T_{\text{Erzeugung}} - T_a).$$

3. Das Verfahren nach Anspruch 1, wobei Bestimmung der thermischen Energie Q aus der chemischen Reaktion verschiedener einzelner Lithiumbatterien auf der Grundlage des Batteriezellenvolumens V , der normierten Konzentration dC/dt und der Batteriezellenenergie H umfasst:

Bestimmung der thermischen Energie Q aus der chemischen Reaktion verschiedener einzelner Lithiumbatterien durch Kombination der folgenden zweiten Formel auf der Grundlage des Batteriezellenvolumens V , der normierten Konzentration dC/dt und der Batteriezellenenergie H :

$$Q=1/V \times H \times dC/dt.$$

4. Das Verfahren nach Anspruch 1, wobei Laden und Entladen bei einer Temperatur von $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ unter den Bedingungen des Standards GB/T31485-2015 durchgeführt werden, umfassend:
Entladung mit einem konstanten Strom von 1C bis zum Erreichen der Entladeschlussspannung;
Stehenlassen für 30 min;
Laden mit konstantem Strom von 1 C bis zur Ladeschlussspannung und dann Laden mit konstanter Spannung, bis der Ladestrom auf 0,05 C sinkt;
Laden der Batterie mit einem konstanten Strom von 1C, bis die Abschaltspannung erreicht ist, und dann Laden mit konstanter Spannung, bis der Ladestrom auf 0,05C sinkt.

5. Das Verfahren nach Anspruch 1, wobei Laden und Entladen verschiedener einzelner Lithiumbatterien und Aufzeichnen der jeweiligen Lade- und Entladezeit verschiedener einzelner Lithiumbatterien und der Temperaturdifferenz der Temperaturanstiegsträgheit nach dem Anstieg auf die gleiche Temperatur aufgrund der Temperaturanstiegsträgheit umfassen:

Laden und Entladen verschiedener einzelner Lithiumbatterien für N Runden, und Aufzeichnen der Lade- und Entladezeit verschiedener einzelner Lithiumbatterien für N Runden und der Temperaturdifferenz der Temperaturanstiegsträgheit für N Runden, nach dem Anstieg auf die gleiche Temperatur aufgrund der Temperaturanstiegsträgheit;

Nehmen des Durchschnittswerts als endgültige Daten entsprechend den N Runden der Lade- und Entladezeit und den N Runden der Temperaturdifferenz der Temperaturanstiegsträgheit verschiedener einzelner Lithiumbatterien.

6. Das Verfahren nach Anspruch 5, wobei die Anzahl von N insbesondere 5 ist.

7. Das Verfahren nach Anspruch 1, wobei die verschiedenen einzelnen Lithiumbatterien vier Lithiumbatterien desselben Herstellers, desselben Modells und desselben Charge sind.

8. Eine Vorrichtung zur Bewertung der Konsistenz von Lithiumbatterien in derselben Charge, umfassend:

eine Erfassungseinheit, verwendet zur Erfassung der Zellmasse M , der spezifischen Wärmekapazität C_p , der Temperatur der selbst erzeugten Wärme $T_{\text{Erzeugung}}$ zu jedem Zeitpunkt des Lade- und Entladevorgangs, der aktuellen Umgebungstemperatur T_a , des Zellvolumens V und der normierten Konzentration dC/dt der chemischen Reaktionsgeschwindigkeit verschiedener einzelner Lithiumbatterien;

eine Bestimmungseinheit, verwendet zur Bestimmung der Zellenergie H , freigesetzt von verschiedenen einzelnen Lithiumbatterien zu jedem Zeitpunkt des gesamten Lade- und Entladevorgangs auf der Grundlage der Zellenmasse M , der spezifischen Wärmekapazität C_p , der Temperatur der selbst erzeugten Wärme $T_{\text{Erzeugung}}$ und der aktuellen Umgebungstemperatur T_a ;

die Bestimmungseinheit wird auch zur Bestimmung der thermischen Energie Q aus der chemischen Reaktion verschiedener einzelner Lithiumbatterien auf der Grundlage des

Batteriezellenvolumens V , der normierten Konzentration dC/dt und der Batteriezellenenergie E verwendet;

eine Berechnungseinheit, verwendet zum Berechnen der momentanen Wärmeenergieleistung P verschiedener einzelner Lithiumbatterien während des Ladens und Entladens auf der Grundlage der thermischen Energie Q ;

eine Lade- und Entladeeinheit, verwendet zum Laden und Entladen verschiedener einzelner Lithiumbatterien und Aufzeichnen der jeweiligen Lade- und Entladezeit verschiedener einzelner Lithiumbatterien und der Temperaturdifferenz der Temperaturanstiegsträgheit nach dem Anstieg auf die gleiche Temperatur aufgrund der Temperaturanstiegsträgheit;

eine Vergleichseinheit, verwendet zum Vergleichen des Standardabweichungskoeffizienten der momentanen Wärmeenergieleistung P , der Lade- und Entladezeit und der Temperaturdifferenz der Temperaturanstiegsträgheit zwischen verschiedenen einzelnen Lithiumbatterien;

die Bestimmungseinheit wird ferner zum Bestimmen der Konsistenz zwischen verschiedenen einzelnen Lithiumbatterien gemäß dem Standardabweichungskoeffizienten verwendet, wobei die Konsistenz umso höher ist, je kleiner das Standardabweichungssystem ist.

9. Eine Verarbeitungsvorrichtung, umfassend einen Prozessor und einen Speicher, wobei ein Computerprogramm in dem Speicher gespeichert ist und der Prozessor das Verfahren nach einem der Ansprüche 1 bis 7 beim Aufrufen des Computerprogramms in dem Speicher ausführt.

10. Ein computerlesbares Speichermedium, wobei das computerlesbare Speichermedium eine Vielzahl von Anweisungen speichert, die geeignet sind, von einem Prozessor geladen zu werden, um das Verfahren nach einem der Ansprüche 1 bis 7 auszuführen.

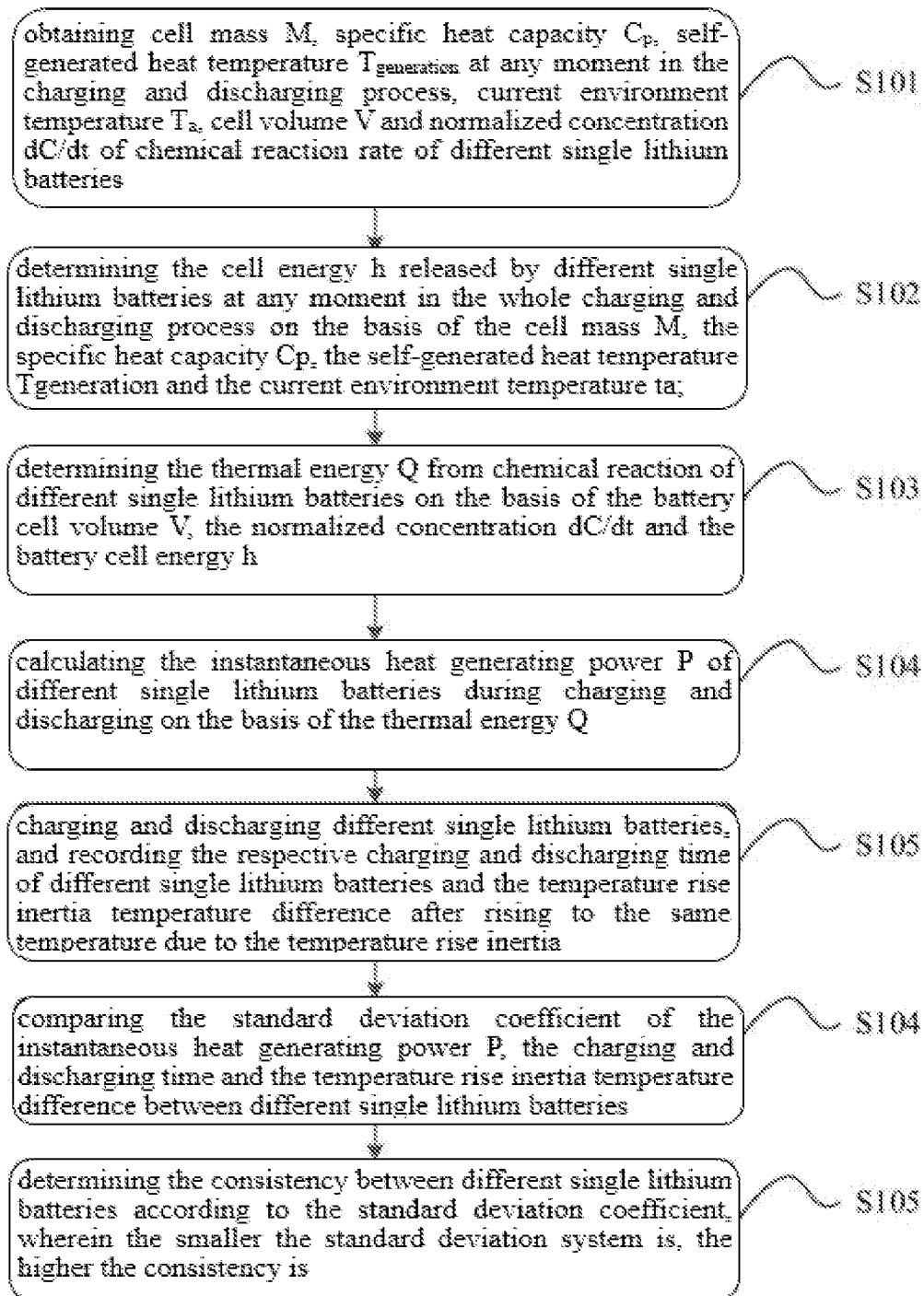


FIG. 1

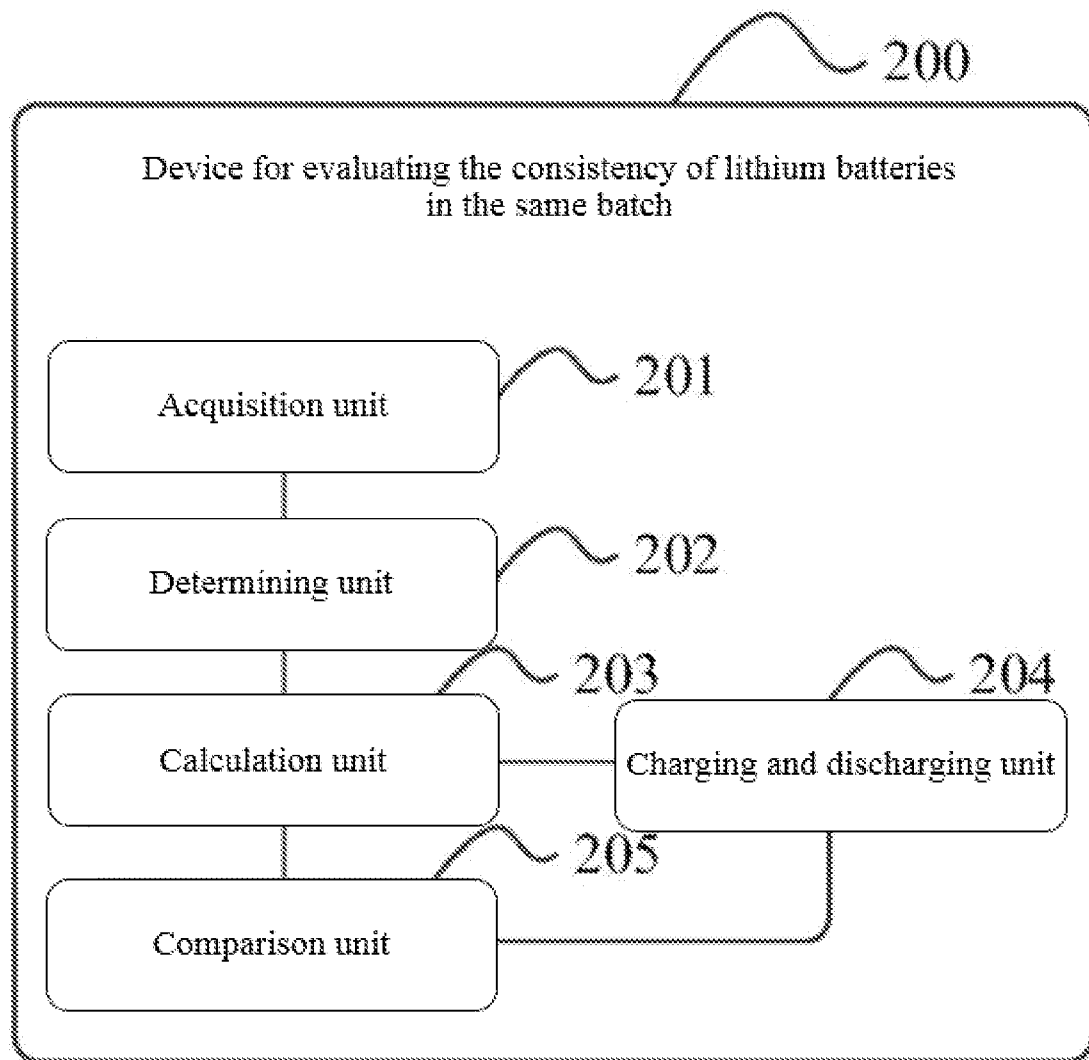


FIG. 2

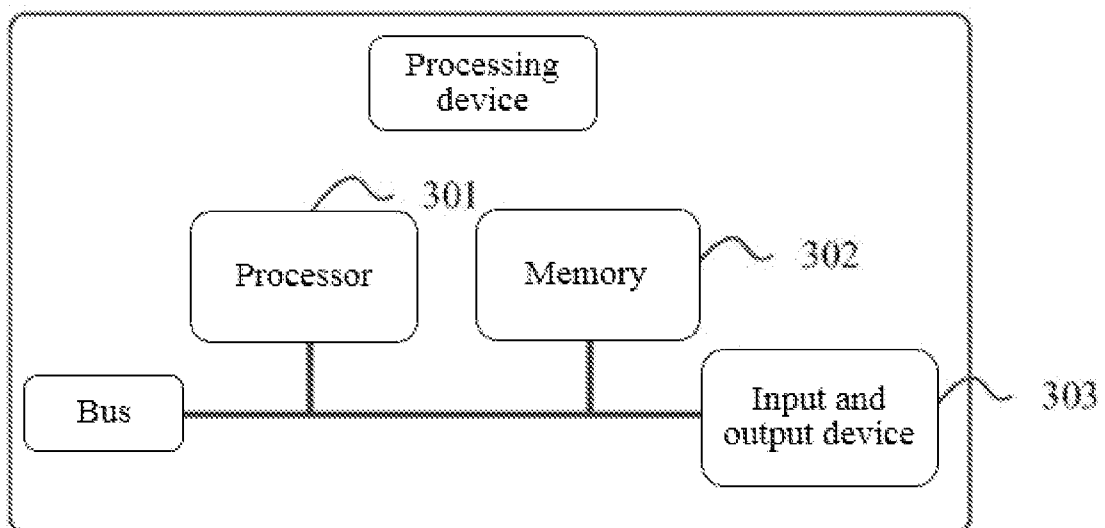


FIG. 3