Battery Sorting Apparatus and Method

Technical Field

The present application relates to battery recycling technology. In particular, the present application relates to a battery sorting apparatus and method for grading batteries.

Background

Batteries such as lithium rechargeable batteries have becoming one of the most widely used mobile energy sources in many industrial and daily life applications. With the usage of rechargeable batteries greatly increasing, aged and discarded batteries have become a major issue of environmental concern and sustainability of social developments. Industrial players have been endeavoured with continuous efforts in developing effective and practical solutions for rechargeable battery recycling for the purposes of possible environmental pollution reduction and the better reusage of the precise metals and other materials from the recycled battery parts.

Known battery recycling technologies processes aged and retired batteries of mixed types together, by firstly discharging all the batteries for safety concerns. As the remaining power levels of such batteries vary, the discharging process has to be configured to adapt to the highest possible remining power of varies types of the same batch. As batteries with lower remaining power level have to be processed for discharging together with those of higher remaining power level, the discharging process encounters problems of longer processing and with high processing costs.

It is therefore desirable to provide a solution to improve the battery recycling efficiency.

Summary

According to one aspect, the present invention provides a battery sorting apparatus. In one embodiment, the apparatus comprises a base, an imaging device mounted to the base, a measurement device mounted to the base, a platform movably coupled to the base, and a controller coupled to the imaging device, the measurement device and the platform. The imaging device is configured to capture an image of a battery carried by the platform to determine an actual orientation of the battery. The platform is moveable relative to the base to align the battery along a predetermined orientation of the measurement device and to position the battery under the measurement device. The measurement device is configured to measure electrical characteristics of the battery to determine a grade of the battery, and the controller is configured to assign the grade to the battery.

Preferably, the apparatus further comprises a slider mounted to the platform, a leadscrew rotatably coupled to the base and threadedly coupled to the slider, and a first motor coupled to the leadscrew and the controller. The first motor is configured to rotate the leadscrew to move the slider and the platform relative to the base.

Preferably, the platform comprises a first stage slidably coupled to the base and a second stage rotatably coupled to the first stage, such that rotation of the second stage aligns the battery from the actual orientation to the predetermined orientation.

Preferably, the apparatus further comprises a second motor coupled between the first stage and the second stage for rotating the second stage relative to the first stage.

Preferably, the apparatus further comprises a fixture mounted to the second stage for clamping a battery to the second stage.

Preferably, the fixture comprises a bracket mounted to the second stage and a pair of clamps movably mounted to the bracket. The pair of clamps is movable towards each other for gripping a battery therebetween and away from each other for releasing the battery.

Preferably, the bracket is movably mounted to the second plate, and the apparatus further comprises a first actuator coupled between the second stage and the bracket. The first actuator is operable to move the bracket and the pair of clamps relative to the second stage.

Preferably, the apparatus further comprises a second actuator coupled between the bracket and the pair of clamps. The second actuator is operable to move the pair of clamps toward each other to grip a battery therebetween and away from each other to release the battery.

Preferably, the measurement device comprises at least two probes coupled to the controller and aligned along the predetermined orientation.

Preferably, the at least two probes comprise a negative probe, a first positive probe and a second positive probe. The first positive probe is spaced apart from the negative probe at a first pitch, and the second probe is spaced apart from the negative probe at a second pitch greater than the first pitch.

Preferably, the measurement device comprises a rack mounted to the base and the at least two probes are movably mounted to the rack. The at least two probes are movable relative to the base to vary a distance between the at least two probes and the base.

Preferably, the apparatus further comprises a third actuator coupled between the bracket and the at least two probes to position the at least two probes at variable heights above the base.

According to another aspect, the present invention provides a battery sorting method. In one embodiment, the method comprises bringing probes of a measurement device into contact with terminals of the battery, obtaining a discharging rate of the battery, determining a grade of the battery based on the discharging rate of the battery, and assigning the grade to the battery.

Preferably, the method further comprises, prior to bringing probes of a measurement device into contact with terminals of the battery, determining an actual orientation of the battery relative to a base and aligning the battery from the actual orientation to a predetermined orientation relative to a base.

Preferably, the step of aligning a battery to a predetermined orientation relative to a base comprises placing the battery onto a platform and rotating the platform relative to the base.

Preferably, the step of obtaining the discharge rate of the battery comprises connecting the battery to a load of given resistance and a measurement device, and measuring an electrical current passing through the load.

Preferably, the step of determining a grade of the battery based on the discharging rate of the battery comprises comparing the discharging rate with a reference discharging rate in a database and matching the grade to a reference grade in the database corresponding to the reference discharging rate.

Brief Description of Drawings

The technical solutions and corresponding technical features of the embodiments will be more comprehensively understood in conjunction with the accompanying drawings, in which:

Fig. 1 is a perspective view showing a battery sorting apparatus according to one embodiment of the present invention;

Fig. 2 is a perspective view showing the apparatus of Fig. 1 with a battery received thereon for processing;

Fig. 3 is a partial cross sectional view of Fig. 1;

Fig. 4 is a partial cross sectional exploded view of Fig. 2;

Fig. 5 is a partial exploded back view of Fig. 1;

Fig. 6 is a perspective view of Fig. 2 showing a battery placed on the apparatus at an undesired orientation;

Fig. 7 is perspective view of Fig. 6 viewing from another angle;

Fig. 8 is a perspective view of Fig. 7 showing the battery aligned to a predetermined orientation and the platform carrying the battery under the measurement device;

Fig. 9 is a perspective of Fig. 8 showing the battery being unloaded after completion of measurement;

Fig. 10 is a perspective view showing the platform returned to the initial position for a subsequent battery testing;

Fig. 11A to 11D are schematic front views showing batteries of various terminal pitches and varies battery heights under the processing by the apparatus according to the present invention;

Fig. 12 is a flow chart showing a battery sorting method according to one embodiment of the present invention;

Fig. 13 is a flow chart showing preferred further steps of the method showing in Fig. 12;

Fig. 14 is a flow chart showing preferred detailed steps of the method showing in Fig. 12

Fig. 15 is a flow chart showing preferred detailed steps of the method showing in Fig. 12

Fig. 16 is a flow chart showing preferred detailed steps of the method showing in Fig. 12.

Detailed Description

As shown in Figs. 1 to 5, according to one embodiment, a battery sorting apparatus 100 for grading and grouping batteries comprises a base 110, an imaging device 120 and a measurement device 130 mounted to the base 110, a platform 140 movably coupled to the base 120, and a controller 105 coupled to and centrally manages the operations of the imaging device 120, the measurement device 130 the platform 140.

The platform 140 is movable relative to the base 110 between an initial position 102 and an end position 108, along a forward direction 141 and a backward direction 149. The imaging device 120 and the measurement device 130 are both mounted to the base 110 between the initial position 102 and the end position 108. Accordingly, the platform 140 is capable to be positioned to carry a battery 50 under the imaging device 120 and the measurement device 130 for the imaging device 120 to capture one or more images of the battery 50, and for the measurement device 130 to measure electrical characteristics of the battery 50.

The imaging device 120 may include an image-capturing apparatus such as a photo camera, a video camera, and/or an optical scanner or the like. In the context, such image-capturing devices are collectively referred to as camera 122. Camera 122 has a field of view 124 and when the platform 140 is positioned under the camera 122, the platform 140 is within the field of view 124 such that the camera 122 is able to capture images of the battery 50 carried on the platform 140.

The measurement device 130 maybe a type of electronic test and measurement instrument capable of measuring electrical characteristics, e.g. voltage, current, resistance, capacitance, and/or inductance, etc, of electronic components and/or electronic circuits involving a battery. Measurement device 130 has a negative probe 132 and one or more positive probes, e.g. first, second and third positive probes 134, 136 and 138 as shown in the figures. The negative probe 132 and the positive probes 134, 136 and 138 are aligned along a predetermined orientation, as depicted in the figures by an imaginative probe orientation vector 131 originated from the negative probe 132 and passing through the positive probes 134, 136 and 138. The positive probes 134, 136 and 138 are each positioned with a respective first, second and third probe pitch 134a, 136a and 138a (Fig. 5) from the negative probe 132. Each probe pitch 134a, 136a and 138a is configured and preset to match the terminal pitch between the negative terminal and the positive terminal of batteries in a group or groups under test. For example, as shown in conjunction with Figs. 11A to 11D, for a group of batteries 50, 60, 70 each having a respective terminal pitch 50a, 60a and 70a, the probe pitch 134a, 136a and 138a are each preset to be the same as the respective first, second and third terminal pitch 50a, 60a and 70a.

As shown in Fig. 3 and Fig. 4, the base 110 has a chamber 115 and a top plate 118 above the chamber 115. A leadscrew 114 is disposed in the chamber 115 and rotatably mounted to the base 110. A first motor 113 is mounted to the base 110 and coaxially coupled to the leadscrew 114 such that activation of the first motor 113 rotates the leadscrew 114 relative to the base 110.

A slider 112 is movably disposed in the chamber 115 and threadedly coupled to the leadscrew 114 such that rotation of the leadscrew 114 carries the slider 112 to linearly move relative to the base 110 between the initial position 102 and the end position 108.

The base 110 has a first gap 116 formed through the top plate 118, and the slider 112 extends through the first gap 116 into the chamber 115. The platform 140 includes a first stage 142 fixedly mounted to the slider 112, a second stage 144 rotatably mounted to the first stage 142 and a second motor 143 coupled between the first stage 142 and the second stage 144. Activation of the first motor 113 rotates the leadscrew 114 relative to the base 110, and rotation of the leadscrew 114 drives the slider 112, the first stage 142, the second motor 143 and the second stage 144 to move linearly relative to the base 110.

Independent from the control and operation of the first motor 113, the second motor 143 is configured to drive the second stage 144 to rotate relative to the first stage 142, to vary an angular position of the second stage 144 relative to the base 110, the imaging device 120 and the measurement device 130.

Coupled to and carried on the second stage 144 there is a fixture 150 for retaining the battery 50 onto the platform 140. The fixture 150 includes a bracket 154 slidably mounted to the second stage 144, a pair of clamps 156 movably mounted to the bracket 154, a first actuator 153 coupled between the second stage 144 and the bracket 154, and a pair of second actuators 155 each coupled between the bracket 154 and one of the pair of clamps 156. The first actuator 153 is operable to move the bracket 154, the pair of second actuators 155 and the pair of clamps 156 relative to the second stage 144, and the pair of second actuators 155 are operable to drive the pair of clamps 156 to move toward each other to grip a battery therebetween, and to drive the pair of clamps 156 to move away from each other to release the battery. The bracket 154 has a hollow center portion 154c and a frame 154a partially surrounding the center portion 154c such that upon a battery being gripped between the pair of clamps 156, the battery is positioned over the hollow center portion 154c.

In use, as shown in Fig. 2 and Fig. 5 to Fig. 10, the apparatus 100 is arranged with the initial position 102 of the base 110 located closer to a battery loading station 20, and with the end position 108 located closer to a battery unloading station 80. At start, a battery under test, e.g. battery 50 as shown in the figures, is picked from the loading station 20 and positioned on the second stage 144 and between the pair of clamps 156. The pair of second actuators 155 are then activated to cause the pair of clamps 156 to move toward each other, so as to grip the battery 50 to the fixture 150.

Thereafter, the platform 140 carries the battery 50 to and within the field of view 124 of the camera 112, for the camera 112 to capture visual information of the battery 50. The visual information captured by the camera 112 may include the external shape and profile of the battery 50, the positions and orientations of the negative terminal 52 and positive terminal 54, any label, logo, barcode and/or QR codes printed on the external surfaces of the battery 50, etc.

The imaging device 120 includes components, circuits, and processors etc, to acquire the battery images captured by the camera 122 and send such information to the controller 105. The controller 105 is configured to determine an actual orientation of the battery 50 as clamped by the fixture 150 on the platform 140, the type and model of the battery 50, etc, based on the battery images captured by the camera 122. In the context, the actual orientation of the battery 50 is depicted by an imaginative terminal orientation vector 51 originating from the negative terminal 52 and passing through the positive terminal 54.

In a first scenario, a show in Fig. 2, the battery 50 as clamped on the second station 144 is determined by the imaging device 120 to have the terminal orientation vector 51 facing a same direction of and parallel to the probe orientation vector 131, under which, the battery 50 is determined to be clamped on the second stage 144 at a preferred orientation.

In a second scenario, as shown in Fig. 6, the battery 50 as clamped on the second station 144 is determined by the imaging device 120 to have the terminal orientation vector 51 facing an opposite direction of the probe orientation vector 131, or any other direction non-parallel to the probe orientation vector 131, under which, the battery 50 is determined to be clamped on the second stage 144 at an undesired orientation. The second motor 143 activates to rotate the second stage 144 relative to the first stage 142, such that the terminal orientation vector 51 faces a same direction of, and parallel to, the probe orientation vector 131. At this new position, the battery 50 is determined to be clamped on the second stage 144 at a desired orientation.

In either scenario, upon the battery 50 being determined to be clamped on the second stage 144 at a desired orientation, the platform 140 carries the battery 50 to move under the measurement device 130, with the negative terminal 52 of the battery 50 aligned with the negative probe 132 of the measurement device 130. The negative probe 132 and the positive probes 134, 136, 138 are then brought into contact with the respective negative terminal 52 and the positive terminal 54, for measuring electrical characteristics of the battery 50.

In one example, as shown in Fig.11A, a battery 50 of a first terminal pitch 50a is carried by the platform 140 for measurement by the measurement device 130. Upon the negative probe 132 and the first, second and third positive probes 134, 136 and 138 being moved towards the battery 50, the negative probe 132 and the first positive probe 134 are brought into contact with the respective battery terminals 52 and 54, for the measurement device 130 to measure electrical characteristics of the battery 50. In the meantime, the second positive probe 136 and the third positive probe 138 are idle i.e. the second positive probe 136 and the third positive probe 138 are not in contact with any terminal of the battery 50.

In another example, as shown in Fig. 11B, a battery 60 of a second terminal pitch 60a, which is greater than the first terminal pitch 50a, is carried by the platform 140 for measurement by the measurement device 130. Upon the negative probe 132 and the first, second and third positive probes 134, 136 and 138 being moved towards the battery 60, the negative probe 132 and the second positive probe 136 are brought into contact with the respective negative and positive battery terminals 62 and 64, for the measurement device 130 to measure electrical characteristics of the battery 60. In the meantime, the first positive probe 134 and the third positive probe 138 are left idle i.e. the first positive probe 134 and the third positive probe 138 are not in contact with any terminal of the battery 60.

Batteries with different terminal pitches i.e. a battery 70 with a third terminal pitch 70a, may be carried by the platform 140 for measurement by the measurement device 130 by which, the negative probe 132 and the third positive probe 138 are brought into contact with the respective negative and positive negative terminals 72 and 74 of battery 70, while the first positive probe 134 and the second positive probe 136 are left idle, as shown in Fig. 11C. Depending on the terminal pitches of various batteries under test, a battery sorting apparatus according to the present invention with corresponding various probe pitches, e.g. two, three or more positive probes with corresponding probe pitches may be used to perform measurement for such batch of batteries.

For a battery of a given terminal pitch, once the negative probe 132 and one of the positive probes 134, 136 or 138 are brought into contact with the respective native terminal and positive terminal, e.g. negative terminal 52 and positive terminal 54 of the battery 50, the measurement device 130 measures an electrical current from the battery 50 flowing through a predetermined load e.g. a resistor of a given resistance, to obtain a discharging rate of the battery 50. The discharging rate is then compared by the controller 105 with a reference rate in a database or a lookup table, to obtain the remaining power level of the battery 50, e.g. 80%, 60%, 40%, 20% or 0% of a battery with full power capacity, and the controller 105 determines and assigns a corresponding grade to the battery just tested.

Upon completion of the electrical characteristics measurement by the measurement device 130 and with a grade determined and assigned to the battery under test, i.e. battery 50 as shown, the platform 140 carries the battery 50 towards the end position 108. The first actuator 153 is activated to push the bracket 154 to move relative to the second stage 144 such that the bracket 154 is positioned to suspend beyond an edge of the second stage 144. The second actuator 155 is activated to move the pair of clamps 156 away from each other to release the battery 50, which allows the battery 50 to be dropped off the fixture 150 through the hollow center portion 154c onto a collection stage 170.

As being assigned thereto a grade determined by the measurement device 130 in a manner illustrate above, the battery 50 received onto the collection stage 170 may be picked up and placed onto the unloading station 80, for a next step of recycling process e.g. in a storage according to the grade. For example, a set of storage containers may be provided and labelled with battery grades of 80%, 60%, 40%, 20% and 0% remaining power capacity, each for receiving batteries with corresponding grade determined and assigned thereto, according to the manner illustrate above.

As shown in Fig. 11A and Fig.11D, the measurement device 130 may include a third actuator 135 coupled between a rack 130a and the negative probe 132, the one or more positive probes 134, 136 and 138. The third actuator 135 is operable to position the negative probe 132, the one or more positive probes 134, 136 and 138 at various distance above the platform 140, to adapt to the height of a battery 80 carried by the platform 140 under the measurement device 130 for measurement. In this manner, the apparatus 100 is capable of measuring electrical characteristics of batteries of varies heights, e.g. a battery 50 of a first height 50h and a battery 80 of a second height 80h which is greater than the first height 50h.

According to another aspect, as shown in Figs. 12 to 16, the present invention provides a battery sorting method 200 which includes, at step 230, bringing probes of a measurement device into contact with terminals of the battery, at step 240, obtaining a discharge rate of the battery, at step 250, determining a grade of the battery based on the discharge rate of the battery and at step 260, assigning the grade to the battery.

The method 200 may further comprise, prior to the step 230 of bringing probes of a measurement device into contact with terminals of the battery, a step 210 of determining an actual orientation of a battery under test relative to a base, and a step 220 of aligning the battery from the actual orientation to a predetermined orientation relative to the base. The steps 210 and 220 may be implemented in situations where the actual orientation of a battery under test is not facing the same direction of, and/or not in parallel to, the predetermined direction.

The step 220 of aligning the battery from the actual orientation to a predetermined orientation relative to a base may comprise a step 222 of placing the battery onto a platform and a step 224 of rotating the platform relative to the base.

The step 240 of obtaining the discharge rate of the battery may further comprise a step 242 of connecting the battery to a load of given resistance and a measurement device, and a step 244 of measuring an electrical current passing through the load.

The step 250 of determining a grade of the battery based on the discharging rate of the battery may further comprise a step 252 of comparing the discharging rate with a reference discharging rate in a database, and a step 254 of matching the grade to a reference grade in the database corresponding to the reference discharging rate.

Embodiments of the present invention are presented above for purposes of illustration and description of the technical solutions and relevant technical features therein, but is not intended to be understood to be exhaustive or limiting. Modifications and/or variations will become apparent to those of ordinary skilled in the art to contemplate and implemented based on the inventive concept and technical solutions disclosed herein. The example embodiments are chosen and described to explain principles and practical application of the present invention, and to enable those of ordinary skilled in the art to understand the disclosure for various embodiments with various modifications as are suited to the particular technical solution contemplated and described. Further, while some technical details may be omitted from the description and drawings, for the purpose of clarity and conciseness, such omissions are not meant to be understood that the omitted features are necessarily absent or missing in the relevant structures, parts, processes and/or steps, as described herein, for understanding and practicing the invention.

Thus, although illustrative example embodiments have been described herein with reference to the accompanying drawings, it is to be understood that this description is not limiting and that various other changes and modifications may be effected therein by one skilled in the art without departing from the scope or spirit of the disclosure as sets out and defined the claims appended hereto.

CLAIMS

1. A battery sorting apparatus comprising:

   a base;

   an imaging device mounted to the base;

   a measurement device mounted to the base;

   a platform movably coupled to the base, and

   a controller coupled to the imaging device, the measurement device and the platform;

   wherein

   the imaging device is configured to capture an image of a battery carried by the platform to determine an actual orientation of the battery;

   the platform is moveable relative to the base to align the battery along a predetermined orientation of the measurement device and to position the battery under the measurement device;

   the measurement device is configured to measure electrical characteristics of the battery to determine a grade of the battery;

   the controller is configured to assign the grade to the battery;

   the measurement device comprises at least two probes coupled to the controller, wherein the at least two probes are aligned along the predetermined orientation, and

   the at least two probes comprise a negative probe, a first positive probe and a second positive probe, wherein the first positive probe is positioned spaced apart from the negative probe at a first pitch, and the second probe is positioned spaced apart from the negative probe at a second pitch greater than the first pitch.

2. The apparatus as recited in claim 1, further comprising a slider mounted to the platform, a leadscrew rotatably coupled to the base and threadedly coupled to the slider, and a first motor coupled to the leadscrew and the controller, wherein the first motor is configured to rotate the leadscrew to move the slider and the platform relative to the base.

3. The apparatus as recited in claim 1, wherein the platform comprises a first stage slidably coupled to the base and a second stage rotatably coupled to the first stage, wherein rotation of the second stage aligns the battery from the actual orientation to the predetermined orientation.

4. The apparatus as recited in claim 3, further comprising a second motor coupled between the first stage and the second stage for rotating the second stage relative to the first stage.

5. The apparatus as recited in claim 3, further comprising a fixture mounted to the second stage for clamping the battery to the second stage.

6. The apparatus as recited in claim 5, wherein the fixture comprises a bracket mounted to the second stage and a pair of clamps movably mounted to the bracket, wherein the pair of clamps is movable towards each other for gripping a battery therebetween and away from each other for releasing the battery.

7. The apparatus as recited in claim 6, wherein the bracket is movably mounted to the second plate and the apparatus further comprises a first actuator coupled between the second stage and the bracket, wherein the first actuator is operable to move the bracket and the pair of clamps relative to the second stage.

8. The apparatus as recited in claim 7, further comprising a second actuator coupled between the bracket and the pair of clamps, wherein the second actuator is operable to move the pair of clamps toward each other to grip a battery therebetween and away from each other to release the battery.

9. The apparatus as recited in claim 1, wherein the measurement device comprises a rack mounted to the base and the at least two probes are movably mounted to the rack, wherein the at least two probes are movable relative to the base to vary a distance between the at least two probes and the base.

10. The apparatus as recited in claim 9, further comprising a third actuator coupled between the bracket and the at least two probes to position the at least two probes at variable heights above the base.