

Apparatus and Method For Recycling Battery

Technical Field

5 The present application relates to battery recycling technology. In particular, the present application relates to an apparatus and a method for recycling battery.

Background

10 Batteries such as lithium batteries have becoming one of the most widely used mobile energy sources in many industrial and daily life applications. With the usage of 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
15 for battery recycling for the purposed of possible environmental pollutions reduction and better reusage of the precise metals and other materials from the recycled battery parts.

 Present battery recycling technologies requires all the batteries be discharged prior to any subsequent processes. The discharge process is implemented by soaking the
20 batteries in e.g. salt solutions or by using dedicated discharging equipment. In either case, battery discharging processes are time consuming, low productivity and require complicated handling and processing.

 It is therefore desirable to provide an improved battery recycling apparatus and
25 method to solve at least one of the problems identified above.

Summary

 According to one aspect, the present invention provides an apparatus for recycling
30 a battery. In one embodiment, the apparatus comprises a sealed chamber, and a vacuum device, a first and a second gas supply device and a cutting device coupled to the sealed chamber, and a conveyor belt disposed in the sealed chamber. The sealed chamber has a loading port formed on an upper portion and an unloading port formed on a lower portion.

The vacuum device is configured to withdraw air from the sealed chamber. The first gas supply device is configured to provide a flame retardant gas into the sealed chamber. The second gas supply is configured to provide a coolant into the sealed chamber. The cutting device is configured to perform a severing operation in the sealed chamber, and the conveyor belt is configured to transport a battery received from the loading port to the cutting device for severing the battery into fragments, and to transport the fragments to the unloading port for collection.

Preferably, the loading port comprises an outer entrance port, an inner entrance port and a transition entrance chamber between the outer entrance port and the inner entrance port. The inner entrance port is closed while the outer entrance port is opened to receive the battery into the transition entrance chamber, and the outer entrance port is closed while the inner entrance port opened to allow the battery to drop from the transition entrance chamber onto the first section of the conveyor belt.

Preferably, the unloading port comprises an inner exit port, an outer exit port and a transition exit chamber between the inner exit port and the outer exit port. The outer exit port is closed while the inner exit port is opened to receive the fragments into the transition exit chamber, and the inner exit port is closed while the outer exit port is opened to allow the fragments to drop from the transition exit chamber out of the sealed chamber through the outer exit port.

Preferably, the cutting device is a laser cutter configured to direct a laser beam onto the third section of the conveyor belt for severing the battery into the fragments.

Preferably, the first gas supply device is configured to provide a nitrogen gas or an inert gas into the sealed chamber.

Preferably, the second gas supply device is configured to provide a cooled nitrogen gas generated by a liquid nitrogen.

Preferably, the second gas supply device is configured to provide a cooled nitrogen gas directly onto the battery at the third section of the conveyor belt to cool the battery before and during cutting.

5 Preferably, the loading port comprises an outer entrance port, an inner entrance port and a transition entrance chamber between the outer entrance port and the inner entrance port; and wherein the inner entrance port is closed while the outer entrance port is opened to receive the battery into the transition entrance chamber, and the outer entrance port is closed while the inner entrance port is opened to allow the battery to drop from the
10 transition entrance chamber onto the first section of the conveyor belt.

Preferably, the vacuum device is configured to maintain an air pressure in the sealed chamber to be lower than the atmosphere.

15 According to another aspect, the present invention provides a method for recycling a battery. In one embodiment, the method comprises placing a battery into a sealed chamber, reducing an air pressure of the sealed chamber, introducing a flame retardant gas into the sealed chamber, reducing a temperature of the sealed chamber, severing the battery into fragments in the sealed chamber, and collecting the fragments.

20 Preferably, the step of reducing an air pressure of the sealed chamber comprises a step of activating a vacuum pump connected to the sealed chamber to withdraw air from the sealed chamber.

25 Preferably, the step of introducing a flame retardant gas into the sealed chamber comprises a step of introducing a nitrogen gas or an inert gas into the sealed chamber.

Preferably, the step of reducing a temperature of the sealed chamber comprises a step of introducing a coolant into the sealed chamber.

30 Preferably, the step of severing the battery comprises a step of directing a laser beam to move across and through the battery.

Preferably, the step of collecting the fragments comprises a step of closing an outer exit port of the sealed chamber, a step of receiving the fragments into a transition exit chamber, a step of closing an inner exit port of the sealed chamber, and a step of opening the outer exit port of the sealed chamber to allow the fragments to be collected outside of the chamber.

With the solutions provided by the present application, the present invention enables battery recycling by eliminating the battery discharge process before the battery cutting and fragmentation. Possible battery burning or explosion during the cutting and fragmentation process are effectively avoided, and the safety level and production efficiency are greatly improved.

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 schematic diagram showing an apparatus for recycling a battery according to one embodiment of the present invention;

Fig. 2 is a flow chart showing a method for recycling a battery according to one embodiment of the present invention;

Fig. 3 is a flow chart showing an exemplary detailed step of the method shown in Fig. 2;

Fig. 4 is a flow chart showing an exemplary detailed step of the method shown in Fig. 2;

Fig. 5 is a flow chart showing an exemplary detailed step of the method shown in Fig. 2;

Fig. 6 is a flow chart showing an exemplary detailed step of the method shown in Fig. 2;

Fig. 7 is a flow chart showing an exemplary detailed step of the method shown in Fig. 2;

Fig. 8 is a flow chart showing an exemplary detailed step of the method shown in Fig. 2.

Detailed Description

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As shown in Fig. 1, according to one embodiment of the present invention, an apparatus 100 for recycling a battery comprises a sealed chamber 1, with a vacuum device 2, a first gas supply device 14, a second gas supply device 15 and a cutting device 16 coupled to the sealed chamber 1, and with a conveying belt 13 disposed in the sealed chamber 100. A loading port 110 is formed at an upper portion of the sealed chamber 100, and an unloading port 120 is formed at a lower portion of the sealed chamber 100.

The conveyor belt 13 has a first section 131, a second section 132 and a third section 133. With respect to a vertical direction 104 of the sealed chamber 1, the first section 131 is positioned under the loading port 110, the second section 132 is positioned above the unloading port 120, and the third section 133 is positioned between the first section 131 and the second section 132 along a horizontal direction 102.

The loading port 110 comprises an outer entrance port 111, an inner entrance port 112 and a transition entrance chamber 113 between the outer entrance port 111 and the inner entrance port 112. The inner entrance port 112 is closed and the outer entrance port 111 is opened, to receive a battery 80 into the transition entrance chamber 113. Thereafter, the outer entrance port 111 is closed and the inner entrance port 112 opened, to allow the battery 80 to drop from the transition entrance chamber 113 onto the first section 131 of the conveyor belt 13.

The cutting device 16 may be a laser cutter configured to direct a laser beam 163 onto the third section 133 of the conveyor belt 13, for severing the battery 80 into the fragments 90.

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The unloading port 120 comprises an inner exit port 121, an outer exit port 122 and a transition exit chamber 123 between the inner exit port 121 and the outer exit port 122. The outer exit port 122 is closed and the inner exit port 121 is opened, to receive the

fragments 90 into the transition exit chamber 123. Thereafter, the inner exit port 121 is closed and the outer exit port 122 is opened, to allow the fragments 90 to drop from the transition exit chamber 123 out of the sealed chamber 1 through the outer exit port 122.

5 The vacuum device 2 serves to withdraw air from the sealed chamber 1, to maintain an air pressure in the sealed chamber 1 at a level lower than the atmosphere. The vacuum device 2 may be further configured to main an air pressure in the sealed chamber 1 at a level lower than the atmosphere. The first gas supply device 14 is configured to provide a flame retardant gas, for example a nitrogen gas or an inert gas, into the sealed
10 chamber 1, to reduce the possibility of battery burning or explosion during the cutting process performed by the cutting device 16. The second gas supply device 15 is configured to provide a coolant, for example a cooled nitrogen gas generated by a liquid nitrogen, into the sealed chamber 1, for lowing the temperature of the battery 80 during the cutting process performed by the cutting device 16. Preferably, the second gas supply
15 device 15 is configured to provide a cooled nitrogen gas directly onto the battery 80, or at an area adjacent to the battery 80 as carried by the conveyor belt 13 at the third section 133, to cool the battery 80 before and during the cutting process.

As shown in Fig. 2, according to one embodiment of the present invention, a
20 method 200 for recycling a battery comprises, a step 220 of placing a battery into a sealed chamber, a step 230 of reducing an air pressure of the sealed chamber, a step 240 of introducing a flame regardant gas into the sealed chamber, and a step 250 of reducing a temperature of the sealed chamber. At step 260, the method 200 severs the battery into fragments in the sealed chamber and thereafter, the fragments are collected at step 270.

25 Preferably, as shown in Fig. 3, the step 220 of placing the battery into the sealed chamber comprises a step 222 of closing an inner entrance port of the sealed chamber, a step 224 of loading the battery into a transition entrance chamber, a step 226 of closing an outer entrance port of the sealed chamber, and a step 228 of opening the inner entrance
30 port of the sealed chamber to allow the battery to drop into the sealed chamber.

Preferably, as shown in Fig. 4, the step 230 of reducing an air pressure of the sealed chamber comprises a step 232 of activating a vacuum pump connected to the sealed chamber to withdraw air from the sealed chamber.

5 Preferably, as shown in Fig. 5, the step 240 of introducing a flame retardant gas into the sealed chamber comprises a step 242 of introducing a nitrogen gas or an inert gas into the sealed chamber.

10 Preferably, as shown in Fig. 6, the step 250 of reducing a temperature of the sealed chamber comprises a step 252 of introducing a coolant into the sealed chamber. Preferably, the coolant comprises a cooled nitrogen gas generated by a liquid nitrogen.

15 Preferably, as shown in Fig. 7, the step 260 of severing the battery comprises a step 262 of directing a laser beam to move across and through the battery.

20 Preferably, as shown in Fig. 8, the step 270 of collecting the fragments comprises a step 272 of closing an outer exit port of the sealed chamber, a step 274 of receiving the fragments into a transition exit chamber, a step 276 of closing an inner exit port of the sealed chamber, and a step 278 of opening the outer exit port of the sealed chamber to allow the fragments to be collected outside of the chamber.

25 This disclosure has been presented for purposes of illustration and description of the embodiments of the present invention, but is not intended to be exhaustive or limiting. For example, while the present invention is presented by making reference to one type of battery as illustrated in the drawings and the description, it should be appreciated that the present invention may be practiced for batteries of various other types, other structures other models and other architectures. Many modifications and variations will be apparent to those of ordinary skilled in the art. The example embodiments are chosen and described to explain principles and practical application of the present invention, and to
30 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.

5 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.

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Claims

1. An apparatus for recycling a battery, the apparatus comprising:
 - a sealed chamber having a loading port formed on an upper portion and an
5 unloading port formed on a lower portion;
 - a vacuum device coupled to the sealed chamber for withdrawing air from the
sealed chamber;
 - a first gas supply device coupled to the sealed chamber for providing a flame
retardant gas into the sealed chamber;
 - 10 a conveyor belt disposed in the sealed chamber, the conveyor belt having a first
section positioned under the loading port, a second section positioned above
the unloading port, with respect to a vertical direction of the sealed chamber,
and a third section between the first section and the second section,
 - a second gas supply device coupled to the sealed chamber for providing a coolant
15 into the sealed chamber;
 - a cutting device coupled to the sealed chamber for performing a severing
operation in the sealed chamber,
 - wherein the conveyor belt is operable to receive a battery received from the
loading port and transport the batter to the third section;
 - 20 wherein the cutting device is operable to sever a battery brought to the third
section by the conveyor belt into fragments, and
 - wherein the conveyor belt is operable to transport the fragments to the second
section and to bring the fragments to the unloading port.
- 25 2. The apparatus as recited in claim 1, wherein the loading port comprises an outer
entrance port, an inner entrance port and a transition entrance chamber between the
outer entrance port and the inner entrance port; and wherein the inner entrance port is
closed while the outer entrance port is opened to receive the battery into the
transition entrance chamber, and the outer entrance port is closed while the inner
30 entrance port opened to allow the battery to drop from the transition entrance
chamber onto the first section of the conveyor belt.

3. The apparatus as recited in claim 1 or 2, wherein the unloading port comprises an inner exit port, an outer exit port and a transition exit chamber between the inner exit port and the outer exit port, and wherein the outer exit port is closed while the inner exit port is opened to receive the fragments into the transition exit chamber, and the
5 inner exit port is closed while the outer exit port is opened to allow the fragments to drop from the transition exit chamber out of the sealed chamber through the outer exit port.
4. The apparatus as recited in claim 1, wherein the cutting device is a laser cutter
10 configured to direct a laser beam onto the third section of the conveyor belt for severing the battery into the fragments.
5. The apparatus as recited in claim 1, wherein the first gas supply device is configured to provide a nitrogen gas or an inert gas into the sealed chamber.
- 15 6. The apparatus as recited in claim 1, wherein the second gas supply device is configured to provide a cooled nitrogen gas generated by a liquid nitrogen.
7. The apparatus as recited in claim 6, wherein the second gas supply device is
20 configured to provide a cooled nitrogen gas directly onto the battery at the third section of the conveyor belt to cool the battery before and during cutting.
8. The apparatus as recited in claim 1, wherein the vacuum device is configured to maintain an air pressure in the sealed chamber to be lower than the atmosphere.
- 25 9. A method for recycling a battery, the method comprising:
placing a battery into a sealed chamber;
reducing an air pressure of the sealed chamber;
introducing a flame retardant gas into the sealed chamber;
30 reducing a temperature of the sealed chamber;
severing the battery into fragments in the sealed chamber;
collecting the fragments.

10. The method as recited in claim 9, wherein placing the battery into the sealed chamber comprises:
- 5 closing an inner entrance port of the sealed chamber;
 loading the battery into a transition entrance chamber;
 closing an outer entrance port of the sealed chamber, and
 opening the inner entrance port of the sealed chamber to allow the battery to drop
 into the sealed chamber.
- 10 11. The method as recited in claim 9, wherein reducing an air pressure of the sealed chamber comprises activating a vacuum pump connected to the sealed chamber to withdraw air from the sealed chamber.
- 15 12. The method as recited in claim 9, wherein introducing a flame retardant gas into the sealed chamber comprises introducing a nitrogen gas or an inert gas into the sealed chamber.
- 20 13. The method as recited in claim 9, wherein reducing a temperature of the sealed chamber comprises introducing a coolant into the sealed chamber.
14. The method as recited in claim 13 wherein the coolant comprises a cooled nitrogen gas generated by a liquid nitrogen.
- 25 15. The method as recited in claim 13 wherein reducing a temperature of the sealed chamber comprises introducing the coolant directly onto the battery.
- 30 16. The method as recited in claim 9, wherein severing the battery comprises directing a laser beam to move across and through the battery.
17. The method as recited in claim 9, wherein collecting the fragments comprises:
 closing an outer exit port of the sealed chamber;
 receiving the fragments into a transition exit chamber;

closing an inner exit port of the sealed chamber, and
opening the outer exit port of the sealed chamber to allow the fragments to be
collected outside of the chamber.