

BATTERY SHREDDING APPARATUS AND METHOD

TECHNICAL FIELD

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

BACKGROUND

10 Batteries such as lithium rechargeable batteries have become 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 environmental concern, posing challenges to the sustainability of social developments. Industrial players have been making continuous efforts to develop effective and practical
15 solutions for rechargeable battery aiming to reduce potential environmental pollution and enhance the reuse of the valuable metals and other materials from used batteries.

 Conventional battery recycling technologies processes used and discarded batteries by shredding the batteries in open environments. As oftentimes the batteries retain residual
20 electrical charges, battery shredding in this manner may give rise to safety concerns due to the possibility of short circuits taking place during the shredding process, which could even result in a fire. It is therefore desirable to provide a solution to address these safety issues.

SUMMARY

25 According to one aspect, the present invention provides a battery shredding apparatus. In one embodiment, the apparatus comprises a housing having a shredding chamber at a lower portion thereof, a conveyor movably coupled to the housing and positioned above the shredding chamber, and a pair of lids pivotally mounted to the housing.
30 The shredding chamber has a shredder entrance at a top side thereof, a shredder exit at a bottom side thereof and a shredder unit disposed in the shredding chamber. The conveyor has a top port for receiving batteries into the conveyor and a bottom port closable for carrying the batteries in the conveyor and openable for unloading the batteries from the

conveyor. The conveyor is movable relative to the shredding chamber between a first conveyor position upwardly away from the shredding chamber and a second conveyor position to stack on and engage the shredding chamber. Each of the pair of lids being pivotable relative to the housing between a first lid position to open the top port to allow loading of batteries into the conveyor, and a second lid position to cover the top port. Before the conveyor reaching the second conveyor position, the pair of lids is kept at the first lid position, and the bottom port is closed, for carrying batteries received in the conveyor. Upon the conveyor reaching the second conveyor position, the pair of lids moves to the second lid position to cover the top port of the conveyor. The bottom port of the conveyor and the shredder entrance are openable to establish communication between the conveyor and the shredding chamber for unloading the batteries from the conveyor into the shredding chamber. The shredder exit is closed such that the conveyor and the shredding chamber form an isolated space, in which the shredder unit is operable to break the batteries received in the shredding chamber into fragments, for further steps of battery recycling processes.

Optionally, the apparatus further comprises a pair of brackets. Each of the pair brackets is mounted to the housing and each one of the pair of lids is pivotally mounted to a corresponding one of the pair of brackets, via a joint on each of the pair of brackets. Each joint is positioned between a top rim of the conveyor when the conveyor being at the first conveyor position, and the top rim of the conveyor when the conveyor is at the second conveyor position. Upon being at the first conveyor position, the conveyor blocks a movement path of each of the pair of lids pivoting toward the second lid position and after the top rim is positioned below each joint, the conveyor clears the movement path to allow the pair of lids to pivot toward the second lid position..

The apparatus may further comprise a set of first resilient members coupled to the housing and acting against the conveyor along an upward direction, to maintain the conveyor at the first conveyor position for receiving batteries into the conveyor.

The set of first resilient members is configured to allow the conveyor to move to the second conveyor position upon a total weight of batteries received in the conveyor reaching a predetermined level.

The apparatus may further comprise a pair of second resilient members, each of the second resilient member is coupled to one of the joints, to bias a corresponding one of the lids toward the second lid position.

5 The apparatus may further comprise a pair of conveyor doors movably coupled to the bottom port of the conveyor and a pair of entrance doors movably coupled to the shredder entrance. The pair of conveyor doors are engageable to the pair of entrance doors upon the conveyor being at the second conveyor position, by which, movement of the pair of entrance doors carries the pair of conveyor doors to move between an open door position
10 to establish the communication between the conveyor and the shredding chamber, and a close door position to separate the conveyor and shredding chamber.

 The apparatus may further comprise a pair of magnetic components. Each of the pair of magnetic components is mounted to one of the pair of conveyor doors for attaching
15 the pair of conveyor doors to each other, when the pair of conveyor doors are at the close door position.

 The conveyor may further comprise a pair of slots. Each slot is positioned at one side of the bottom port. The pair of slots each has a slot opening facing each other, such
20 that one of the conveyor doors is movably receivable into a corresponding slot.

 The apparatus may further comprise a pair of third resilient members. Each of the third resilient member is disposed in one of the pair of the slots to bias against one of the conveyor doors toward each other.
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 The apparatus may further comprise a motor mounted to the housing, a leadscrew having a first threaded segment and a second threaded segment and coupled to a main shaft of the motor, a first slider coupled to the first segment of the leadscrew; a second slider coupled to the second segment of the leadscrew; a first entrance door plate connected to the
30 first slider and a second entrance door plate connected to the second slider, and a first port door plate and a second port door plate slidably coupled to the bottom port of the conveyor. The first entrance door plate and the second entrance door plate are slidably coupled to the shredder entrance. Each of the first entrance door plate and the second entrance door plate

has a respective first and second driving pin extending upwardly therefrom. Each of the first port door plate and the second port door plate has a respective first and second driven hole detachably engageable to the respective first driving pin and the second driving pin. Upon the conveyor being at the second conveyor position, the first and second driving pins
5 fit into the respective first and second driven recesses, such that movement of the first and second entrance door plates carries the respective first and second port door plates to move together, to open or close the bottom port of the conveyor and the shredder entrance.

Upon activated, the motor rotates the leadscrew to move the first slider and the
10 second slider, to open or close the shredder entrance and the bottom port of the conveyor.

The apparatus may further comprise a worm rod coupled to the leadscrew, a worm gear engaged to the worm rod, a connecting shaft mounted to the worm gear, a pinion gear rotatably mounted to the conveyor, and a pair of gear racks slidably mounted to the conveyor
15 and engaged to the pinion gear. Upon the conveyor being at the second conveyor position, the pinion gear is brought to coupling with the connecting shaft. When activated, the motor rotates the worm rod, the worm gear, the connecting shaft and the pinion gear to slide the pair of gear racks along a sidewall of the housing and toward a front wall and a back wall of the housing. During the process of opening or closing of the bottom port of the conveyor
20 and the shredder entrance, one of the gear racks is brought into engagement with or disengagement from the housing, to lock the conveyor to the housing.

The apparatus may further comprise a retractor coaxially coupled to the pinion gear for rotating the pinion gear in a reverse direction.

The conveyor may have a pair of sloped bottom surfaces formed at a respective first and second side of the bottom port. The sloped bottom surface is inclined toward the bottom port, to assist unloading the batteries from the conveyor through the bottom port.

The shredder exit may have a side opening and a bottom opening joining at a bottom corner of the shredding chamber, and a pivot support passing through the bottom corner in a direction parallel to the side opening and the bottom opening. The apparatus further comprises a swing door having a hinge shaft pivotally mounted to pivot support. The swing

door has four vanes radially extending from the hinge shaft. Upon one of the four vanes being positioned to close the bottom opening, an adjacent one of the four vanes is positioned to close the side opening.

5 According to another aspect, the present invention provides a battery shredding method. In one embodiment, a battery shredding method comprises loading batteries into a conveyor at a first conveyor position, lowering the conveyor to a second conveyor position to stack on a shredding chamber, closing a top port of the conveyor and closing a shredder exit to form the conveyor and the shredder into an isolated space. Subsequently, the method
10 opens a shredder entrance of the shredding chamber and a bottom port of the conveyor to transfer the batteries from the conveyor into the shredding chamber, and the method further opens the shredder exit to discharge the fragments from the shredding chamber.

 Optionally, the step of lowering the conveyor toward the second conveyor maybe
15 performed by loading a predetermined quantity of batteries into the conveyor.

 Optionally, the step of opening the shredder entrance comprises carrying the pair of bottom port plate to open the bottom port of the conveyor together.

20 Optionally, opening the shredder exit comprises rotating a first swing door vane downwardly away from a bottom opening of the shredding chamber to discharge the fragments collected on the first swing door vane, rotating a second swing door vane away from a side opening of the shredding chamber toward the bottom opening, and rotating a third swing door toward the shredding chamber to close the side opening. Preferably, the
25 steps 262, 264 and 266 are implemented at the same time.

 The method may further comprise, during the process of opening the shredder entrance and the bottom port of the conveyor, a step of locking the conveyor to a sidewall of a housing to which the shredding chamber is mounted. Optionally, the step of locking
30 the conveyor to the housing comprises sliding a locking pin in a horizontal groove formed on a sidewall of the housing, during opening of the bottom port and the shredder entrance.

Optionally, the method may further comprise, after the step of sliding a locking pin in a horizontal groove formed on a sidewall of the housing and before the step of shredding the batteries into fragments in the shredding chamber, a step of locking the conveyor to a back wall of the housing.

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Optionally, the method may further comprise, after opening the shredder entrance and the bottom port of the conveyor and upon the batteries being fully transported into the shredding chamber, a step of closing the shredder entrance and the bottom port of the conveyor and unlocking the conveyor from the shredding chamber to allow the conveyor to move to the first conveyor position.

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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:

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Figure 1 is a perspective view showing a battery shredding apparatus according to one embodiment of the present invention;

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Figure 2 is a partial cross sectional view of Figure 1;

Figure 3 is a partial view of Figure 2 showing the conveyor of the apparatus at a first conveyor position;

Figure 4 is a partial view of Figure 2 showing the conveyor at a second conveyor position;

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Figure 5 is a partial cross sectional front view of Figure 4 and an enlarged partial view showing a pair of lids for opening and closing a top port of the conveyor;

Figure 6 is a partial enlarged perspective view of Figure 2 showing the bottom port of the conveyor closed;

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Figure 7 is a partial enlarged perspective view of Figure 2 showing the bottom port of the conveyor and the shredder entrance opened;

Figure 8 is a partial sectional view of Figure 2 showing further details of the pair of port doors of the conveyor and the pair of entrance doors of the shredding chamber;

Figure 9 is a partial sectional view of Figure 2 showing further details of the control mechanism of the pair of port doors and the pair of entrance doors;

Figure 10 is a partial enlarged view of Figure 9;

Figure 11 is a perspective partial view of Figure 8 showing the first and second port door plates;

Figure 12 is a bottom perspective view of Figure 11;

Figure 13 is a perspective partial view of Figure 2 viewing from another angle showing batteries loaded in the conveyor and when the conveyor is at the first conveyor position;

Figure 14 is a perspective partial view of Figure 2 viewing from another angle and with batteries loaded in the conveyor and when the conveyor is at the second conveyor position;

Figure 15 is a partial front view of Figure 13;

Figure 16 is a front view of Figure 15 showing the conveyor halfway moving to the second conveyor position;

Figure 17 is a partial front view of Figure 15;

Figure 18 is an enlarged partial perspective view of Figure 2 showing the conveyor at the first conveyor position;

Figure 19 is an enlarged partial perspective view of Figure 2 showing the conveyor at the second conveyor position and when the bottom port is closed;

Figure 20 is an enlarged partial perspective view of Figure 2 showing the conveyor being locked to the second conveyor position and when the bottom port starts to open and the conveyor being locked to the sidewall of the housing;

Figure 21 is an enlarged partial perspective view of Figure 2 showing the conveyor being locked to the second conveyor position when the bottom port is fully opened and the conveyor being locked to the sidewall and back wall of the housing;

Figures 22 to 24 are partial front views of Figure 2 showing operations of the shredder exit;

Figures 25 to 32 are flow charts showing a battery shredding method according to embodiments of the present invention.

DETAILED DESCRIPTION

As shown in Figures 1 to 4, according to one embodiment, a battery shredding apparatus 100 comprises a housing 110 having a pair of sidewalls 112, a back wall 114 and a front wall 116, a shredder chamber 170 formed at a lower portion of the housing 110, and a conveyor 140 movably coupled to and positioned in the housing 110 and above the shredding chamber 170. The shredding chamber 170 has a shredder entrance 172 at a top side of the shredding chamber 170, a shredder exit 178 at a bottom side of the shredding chamber 170, and a shredder unit 175 disposed in the shredding chamber 170. A pair of entrance doors 176a, 176b are slidably coupled to the shredder entrance 172, and the pair of entrance doors 176a, 176b are operable to open or close the shredder entrance 172. The apparatus 100 may also have a set of legs 109 mounted to a bottom side of the housing 110, for supporting the housing 110 on a working surface, e.g. a ground surface, and raise up the shredder exit 178 above the work surface for easy operation.

The conveyor 140 has a top port 142 for receiving batteries into the conveyor 140 and a bottom port 148. The bottom port 148 can be closed for carrying batteries received in the conveyor 140, and can be opened for unloading the batteries off the conveyor 140. A pair of port doors 146a, 146b are slidably coupled to the bottom port 148, and the pair of port doors 146a, 146b are operable to open or close the bottom port 148. The conveyor 140 is movable relative to the shredding chamber 170 between a first conveyor position 140a upwardly away from the shredding chamber 170 and a second conveyor position 140b to stack on and engage the shredding chamber 170. The conveyor 140 may have a pair of slopped bottom surfaces 147 formed at a respective first and second side of the bottom port 148 and inclined toward the bottom port 148. The slopped surfaces 147 helps direct the batteries to drop out of the conveyor 140, by gravity, when the bottom port 148 is open for unloading.

The apparatus 100 may further comprise a set of first resilient members 144, e.g. helical springs, coupled to the housing 110 and acting against the conveyor 140, along an upward direction 144a, to maintain the conveyor 140 at the first conveyor position 140a for receiving batteries into the conveyor 140. The set of first resilient members 144 is elastically deformable, to allow the conveyor 140 to move to the second conveyor position 140b, along

a downward direction 144b, upon a total weight of batteries received in the conveyor 140 reaching a predetermined level. For example, the set of first resilient members 144 is configured to allow the conveyor 140 to move to the second conveyor position 140b to stack on and engage the shredding chamber 170, upon the total weight of batteries received in the conveyor 140 reaching the predetermined level. The set of first resilient members 144 is also configured to resume the conveyor 140 back to the first conveyor position 140a once the batteries are fully unloaded from the conveyor 140.

As shown in Figures 3 to 5, the apparatus 100 comprises a pair of lids 120 pivotally mounted to the housing 110. The pair of lids 120 is pivotable relative to the housing 110 along a movement path 120p, between a first lid position 120a and a second lid position 120b. When at the first lid position 120a, the pair of lids 120 opens the top port 142 of the conveyor 140, to allow the batteries to be loaded into the conveyor 140. When at the second lid position 120b, the pair of lids 120 covers and closes the top port 142 of the conveyor 140.

The apparatus 100 may further comprise a pair of brackets 130 fixedly mounted to the housing 110. The pair of lids 120 are each pivotally mounted to a corresponding one of the pair of brackets 130, via a joint 132 formed on each corresponding one of the pair of brackets 130. Each joint 132 is so positioned such that when the conveyor 140 is at the first conveyor position 140a, the joint 132 is below the top rim 141 of the conveyor 140 and when the conveyor 140 is at the second conveyor position 140b, the joint 132 is above the top rim 141. Accordingly, upon being at the first conveyor position 140a and before reaching the second conveyor position 140b, the conveyor 140 blocks the movement path 120p to retain each of the pair of lids 120 at the first lid position 140a. Upon the conveyor 140 reaching the second conveyor position 140b, the top rim 141 is positioned below each joint 132, at which, the conveyor 140 clears the movement path 120p, to allow the pair of lids 120 to pivot toward the second lid position 120b to cover and close the top port 142.

As shown in Figures. 6 and 7, when the conveyor 140 reaches the second conveyor position 140b and stacked on the shredding chamber 170, the shredder entrance 172 and the bottom port 148 can be opened such that the conveyor 140 and the shredding chamber 170 are communicated to each other and in the meantime, the pair of lids 120 moves to the

second lid position 120b, and the shredder exit 178 is closed such that the conveyor 140 and the shredding chamber 170 form an isolated space in the conveyor 140 and the shredding chamber 170. Accordingly, the shredder unit 175 is operable in the isolated space, to shred and break the batteries received in the shredding chamber 170 into battery fragments. As the shredding process is performed in the isolated space, the risk of possible fire caused by short circuits of the batteries during the shredding process can be reduced.

As shown in Figures 8 to 11, the apparatus 100 may further comprise a pair of second resilient members 134 coupled to each one of the joints 132, to bias a corresponding one of the lids 120 toward the second lid position 120b. When the conveyor 140 moves to the second conveyor position 140b and clears the movement path 120p, the pair of lids 120 can be driven by the pair of second resilient members 134 to pivot toward the second lid position 120b, to cover and close the top port 142 of the conveyor 140.

Each of the pair of conveyor doors 146a, 146b has a driven hole 146c formed thereon. Each of the pair of entrance doors 176a, 176b has a driving pin 176c extending toward and in alignment with a corresponding driven hole 146c. Upon the conveyor 140 being at the second conveyor position 140b, each driving pin 176c is inserted into a corresponding driven hole 146c, by which, the first conveyor door 146a is engaged to the first entrance door 176a, and the second conveyor door 146b is engaged to second entrance door 176b. Thereafter, movement of the pair of entrance doors 176a, 176b carries the pair of conveyor doors 146a, 146b to move between a close door position (Figure 6) to separate the conveyor 140 and shredding chamber 170 and an open door position (Figure 7) to establish communication between the conveyor 140 and the shredding chamber 170.

The conveyor 140 may further comprise a pair of slots 149 each being formed at one side of the bottom port 148, and one of the conveyor doors 146a, 146b is movably receivable into a corresponding slot 149. The apparatus 100 may further comprise a pair of third resilient members 196, e.g. compressing springs. Each of the third resilient members 196 is disposed in one of the pair of slots 149 to bias against one of the conveyor doors 146a, 146b toward each other.

The apparatus 100 may further comprise a pair of magnetic components 192 each being mounted to one of the pair of conveyor doors 146a, 146b, for attaching the pair of conveyor doors 146a, 146b to each other when the pair of conveyor doors 146a, 146b is driven by the pair of entrance door plates 176a, 176b. In embodiments where the pair of conveyor doors is made of non-ferromagnetic material, for example engineering plastic, the pair of magnetic components 192 may include one permanent magnet and one piece of steel plate, or both may be permanent magnets, which are attachable to each other when placed closed to each other within the magnetic field of each permanent magnet. In embodiments where the pair of conveyor doors 146a, 146b is made of ferromagnetic material, such as carbon steel, the steel plate may be omitted, and the permanent magnet serves to attach the pair of conveyor doors 146a, 146b to each other. In either type of embodiment, the magnetic components 192 serve to assist in resuming the pair of conveyor doors 146a, 146b to a position in contact with each other, when the pair of conveyor doors 146a, 146b is driven by the pair of entrance doors 176 via the engagement between the driving pins 176c and the driven holes 146c.

As shown in Figures 10, 13 and 14, the apparatus 100 may further comprise a motor 162 mounted to the housing 110, a leadscrew 163 coupled to the main shaft 162a of the motor 162, a first slider 165 connected to the first entrance door plate 176a, and a second slider 166 connected to the second entrance door plate 176b. The leadscrew 163 has a first threaded segment 164 and a second threaded segment 167 formed thereon. The first slider 165 is threadedly coupled to the first threaded segment 164. The second slider 166 is threadedly coupled to the second threaded segment 167. The first threaded segment 164 and the second threaded segment 167 are threaded with opposite directions, e.g. one being a right-handed thread and the other one being a left-handed thread. Accordingly, rotation of the leadscrew 163 drives the first and second sliders 165 and 166 to move along opposite directions.

The first entrance door plate 176a is connected to, and hence movable together with, the first slider 165. The second entrance door plate 176b is connected to, and hence movable together with, the second slider 166. The first entrance door plate 176a and the second entrance door plate 176b are slidably coupled to the shredder entrance 172.

When the conveyor 140 moves to the second conveyor position 140b and stacked on the shredding chamber 170, the motor 162 rotates the leadscrew 163 to linearly move the first slider 165 and the second slider 166. In the meantime, the first slider 165 and the second slider 166 moves the respective first entrance door plate 176a, the first port door plate 146a, the second entrance door plate 176b and the second port door plate 146b, to open the shredder entrance 172 and the bottom port 148 of the conveyor 140.

In use, as shown in Figures 15 to 17, when the conveyor 140 is positioned at the first conveyor position 140a and loaded with a predetermined quantity of batteries 80 therein through the top port 142, and when the total weight of the loaded batteries and the conveyor 140 reaches a level to overcome the spring force of the second set of resilient members 144, the battery-loaded conveyor 140 is lowered down to the second conveyor position 140b, and engages the shredding chamber 170.

Upon the conveyor 140 reaching the second conveyor position 140b, stacked on and engaged to the shredding chamber 170, the motor 162 can be started to rotate the leadscrew 163 which drives the first slider 165 to carry the first entrance door plate 176a and the first port door plate 146a, as well as the second entrance door plate 176b and the second port door plate 146b to move away from each other, to open the bottom port 148 of the conveyor 140 and the shredder entrance 172. With the bottom port 148 and the shredder entrance 172 both opened, the batteries loaded in the conveyor 140 can then be unloaded onto the shredder unit 175 in the shredding chamber 170, by the self-weight of the batteries. The shredder unit 175, for example a pair of shredding rollers will then start to process shredding of the batteries into battery fragments, for recycling of battery materials.

As shown in Figures 18 to 21, the apparatus 100 may further comprise a worm rod 152 coupled to the leadscrew 163 between the first threaded segment 164 and the second threaded segment 166, a worm gear 153 engaged to the worm rod 152, a connecting shaft 154 mounted to the worm gear 153, a support plate 151 mounted to the conveyor 140, a pinion gear 155 rotatably mounted to the support plate 151 and coaxially aligned with the connecting shaft 154, and a first gear rack 156 and a second gear rack 157 slidably mounted to the support plate 151 and engaged to the pinion gear 155. A sliding groove 117 is formed vertically on one of the sidewalls 112 of the housing 110 adjacent to the second gear rack

157. A locking groove 119 is formed horizontally at the sidewall 112 and joins the sliding groove 117 at junction 118. A locking pin 158 is fixedly mounted to the second gear rack 157 and extended toward the housing 110.

5 When the conveyor 140 is positioned between the first conveyor position 140a second conveyor position 140b, the locking pin 158 is positioned in the sliding groove 117. Movement of the conveyor 140 between the first conveyor position 140a second conveyor position 140b carries the locking pin 158 to move along the sliding groove 117. When the conveyor 140 is at the second conveyor position 140b to stack on the shredding chamber 10 170, the locking pin 158 is positioned at the junction 118 of the sliding groove 117 and the locking groove 119.

 In the meantime, upon the conveyor 140 reaching the second conveyor position 140b and engaged to the shredding chamber 170, the pinion gear 155 is brought into engagement 15 with the connecting shaft 154, by which, during the process of the leadscrew 163 driving the first slider 165 and the second slider 166 to slide away from each other, the rotational movement driven by the leadscrew 163 is also transmitted to the pinion gear 155, via the worm rod 152, the worm gear 153 and the connecting shaft 154. The pinion gear 155 then rotates and drives the first gear rack 156 and the second gear rack 157 to move along the 20 sidewall 112, and toward the respective back wall 114 of the housing 110. Sliding movement of the second gear rack 157 carries the locking pin 158 to slide along the locking groove 119, to lock the conveyor 140 at the second conveyor position 140b, during the process of the first port door plate 146a and second port door plate 146b moving away from each other to open the bottom port 148 for unloading of the batteries into the shredding 25 chamber 170.

 Additionally, one or both the back wall 114 and the front wall 116 may have a locking recess 116 formed thereon (only the locking recess 116 formed on the back wall 114 is shown in Figures 20 and 21 for illustration, as the front wall is omitted to show 30 internal structure of the apparatus), each being positioned in alignment with a respective first gear rack 156 and second gear rack 157. The length and movement distance of each of the first gear rack 156 and second gear rack 157 are configured such that when the first port door plate 146a and second port door plate 146b open to the endmost position, i.e. when the

bottom port 148 and the shredder entrance 172 are fully opened, the tip of each of the first gear rack 156 and second gear rack 157 is inserted into the locking recess 116 on the respective back wall 114 and front wall 116, to further secure the conveyor 140 at the second conveyor position 140b.

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After the batteries in the conveyor 140 are fully unloaded into the shredding chamber 170, first port door plate 146a and second port door plate 146b can be moved back, as driven by the respective one of the pair of entrance doors 176a, 176b, to close the bottom port 148 and the shredder entrance 172. Such backwards-movement of the first port door plate 146a and second port door plate 146b withdraws the first gear rack 156 and the second gear rack 157 from the respective locking recess 116, to unlock the conveyor 140 from the back wall 114 and the front wall 116. Further, once the bottom port 148 and the shredder entrance 172 are fully closed, the second gear rack 157 moves the locking pin 158 to the junction 118 and position the locking pin 158 in alignment with the vertical groove 117, to unlock the conveyor 140 from the sidewall 112. The elastic energy stored in the first resilient members 144 can now be allowed to release, which drives the conveyor 140 to move back toward the first conveyor position 140a. In the meantime, movement of the conveyor 140 toward the first position pushes the pair of lids 120 to pivot away from each other to open the top port 142, for the next cycle of battery loading into the conveyor 140.

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As shown in Figures 2, 22, 23 and 24, the shredder exit 178 has a side opening 178a and a bottom opening 178c joining at a bottom corner 178b of the shredding chamber 170. A pivot support 179 e.g. a pair of coaxially aligned through holes is formed on the shredder exit 178, by passing through the bottom corner 178b in a direction parallel to the side opening 178a and the bottom opening 167c. The apparatus 100 further comprises a swing door 180 having a hinge shaft 186 pivotally mounted to the pivot support 179. The swing door 180 has four vanes 181, 182, 183, 184 radially extending from the hinge shaft 186. Upon one of the four vanes e.g. first vane 181 being positioned to close the bottom opening 178c, an adjacent one of the four vanes, i.e. the second vane 182 is positioned to close the side opening 178a.

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In use, the swing door 180 is positioned with one of the vanes, e.g. the first vane 181 as shown in Figures 22 and 23 covering the bottom opening 178c, a second vane 182 covers

the side opening 178a. Shredding operations performed by the shredding unit 175 is therefore processed in the shredding chamber 170 which is a closed and isolated environment, i.e. with relatively low level of oxygen as compared to the surrounding atmosphere and accordingly, the possibilities of fire or burning caused by the battery shredding process can be reduced.

The swing door 180 is rotatable relative to the shredding chamber 170 about the pivot support 179. When a predetermined amount of battery fragments 82 as produced by the shredding unit 175 are received on the first vane 181, the swing door 180 can be rotated to flip the first vane 181 downwardly away from the shredding chamber 170. Battery fragments 85 collected on the first vane 181 are then discharged from the shredding chamber 170, and received in a tank or container 90 placed under the bottom opening 187c for further steps of processing.

Following the first vane 181 flipping downward and away from the shredding chamber 170, the second vane 182 rotates from the side opening 178a toward the bottom opening 178c. When the second vane 182 is positioned horizontally and covers the bottom opening 178c, the third vane 183 is positioned vertically and covers the side opening 178a. The swing door 180 is now in a position ready for receiving battery fragments to be produced by the shredding unit 175, in subsequent and continuous shredding process, and discharge a second batch of battery fragments collected on the second vane 182 into the container 90. The swing door 180 is operable in the above-illustrated manner, by rotating the vanes 181, 182 183 and 184 in a cyclic and periodical manner, in line with the continuous operation of the apparatus 100 for battery shredding processing.

In another aspect, as shown in Figure 25, the present invention provides a battery shredding method 200 which comprises, a step 210 of loading batteries into a conveyor at a first conveyor position, a step 220 of lowering the conveyor to a second conveyor position to stack on a shredding chamber, and a step 230 of closing a top port of the conveyor and closing a shredder exit to form the conveyor and the shredder into an isolated space. At step 240, the method 100 opens a shredder entrance of the shredding chamber and a bottom port of the conveyor to transfer the batteries from the conveyor into the shredding chamber, followed by a step 250 of shredding the batteries into fragments in the shredding chamber

which is an isolated space. At a subsequent step 260, the method 100 opens the shredder exit to discharge the fragments from the shredding chamber.

5 Optionally, as shown in Figure 26, the step 220 of lowering the conveyor toward the second conveyor maybe performed by a step 222 of loading a predetermined quantity of batteries into the conveyor.

10 Optionally, as shown in Figure 27, the step 230 of opening the shredder entrance comprises a step 232 of carrying the pair of bottom port plate to open the bottom port together.

15 Optionally, as shown in Figure 28, the step 260 of opening the shredder exit comprises a step 262 of rotating a first swing door vane downwardly away from a bottom opening of the shredding chamber to discharge the fragments collected on the first swing door vane, a step 264 of rotating a second swing door vane away from a side opening of the shredding chamber toward the bottom opening, and a step 266 of rotating a third swing door toward the shredding chamber to close the side opening. Preferably, the steps 262, 264 and 266 are implemented at the same time.

20 Optionally, as shown in Figure 29, the method 200 may further comprise, during the process of opening the shredder entrance and the bottom port of the conveyor at step 240, a step 242 of locking the conveyor to a sidewall of a housing to which the shredding chamber is mounted.

25 Optionally, as shown in Figure 30, the step 242 of locking the conveyor to the housing comprises a step 242a of sliding a locking pin in a horizontal groove formed on a sidewall of the housing, during opening of the bottom port and the shredder entrance.

30 Optionally, as shown in Figure 31, the method 200 further comprises, after the step 242a of sliding a locking pin in a horizontal groove formed on a sidewall of the housing and before the step 250 of shredding the batteries into fragments in the shredding chamber, a step 244 of locking the conveyor to a back wall of the housing.

Optionally, as shown in Figure 32, the method 200 may further comprise, after opening the shredder entrance and the bottom port of the conveyor at step 240 and upon the batteries being fully transported into the shredding chamber, a step 245 of closing the shredder entrance and the bottom port of the conveyor and unlocking the conveyor from the shredding chamber to allow the conveyor to move to the first conveyor position.

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 shredding method comprising:
 - loading batteries into a conveyor at a first conveyor position;
 - 5 lowering the conveyor toward a second conveyor position to rest on a shredding chamber;
 - closing a top port of the conveyor and closing a shredder exit to form the conveyor and the shredder into an isolated space;
 - opening a shredder entrance and a bottom port of the conveyor to transport the
 - 10 batteries into the shredding chamber;
 - shredding the batteries into fragments in the isolated space, and
 - opening the shredder exit to discharge the fragments.
2. The method as recited in claim 1, wherein lowering the conveyor toward the second conveyor is performed by loading a predetermined quantity of batteries into the
- 15 conveyor.
3. The method as recited in claim 1, wherein opening the shredder entrance comprises carrying the pair of bottom port plate to open the bottom port together.
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4. The method as recited in claim 1, wherein opening the shredder exit comprises
 - rotating a first swing door vane downwardly away from a bottom opening of the shredding chamber to discharge the fragments collected on the first swing door
 - vane;
 - 25 rotating a second swing door vane away from a side opening of the shredding chamber toward the bottom opening, and
 - rotating a third swing door toward the shredding chamber to close the side opening.
5. The method as recited in claim 1, further comprising, after the conveyor is stacked on
- 30 the shredding chamber and before opening the shredder entrance and the bottom port of the conveyor, locking the conveyor to a sidewall of a housing to which the shredding chamber is mounted.

6. The method as recited in claim 5, wherein locking the conveyor to the housing comprises a step of sliding a locking pin in a horizontal groove formed in a sidewall of the housing during opening of the bottom port and the shredder entrance.