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United States Patent Application Publication 20250260148
Kind Code A1
Publication Date August 14, 2025
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BATTERY CELL ELECTROLYTE WETTING SYSTEM AND METHOD

Abstract

A system includes a battery cell having a cell housing having at least a wall and a side wall, an electrolyte inlet opening formed on the wall, and an air hole formed on the side wall, and a sump including a sump housing configured to hold electrolyte therein. The electrolyte inlet opening is fluidly coupled to the sump housing to allow for the electrolyte to be fed from the sump housing into the cell housing.

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Family ID: **1000007869082**

Appl. No.: **18/440201**

Filed: **February 13, 2024**

Publication Classification

Int. Cl.: **H01M50/682** (20210101); **H01M50/30** (20210101); **H01M50/627** (20210101)

U.S. Cl.:

CPC **H01M50/682** (20210101); **H01M50/30** (20210101); **H01M50/627** (20210101);

Background/Summary

INTRODUCTION
[0001] The subject disclosure relates to vehicles, and in particular to a system and method for wetting a battery cell with electrolyte.

[0002] A vehicle battery cell may be wetted with electrolyte. Accordingly, it is desirable to provide an efficient system and method for filling the battery cell with the electrolyte.

SUMMARY

[0003] In one exemplary embodiment, a system comprises a battery cell comprising a cell housing having at least a wall and a side wall, an electrolyte inlet opening formed on the wall, and an air hole formed on the side wall, and a sump comprising a sump housing configured to hold electrolyte therein. The electrolyte inlet opening is fluidly coupled to the sump housing to allow for the electrolyte to be fed from the sump housing into the cell housing.

[0004] In addition to one or more of the features described herein, the battery cell is oriented such that the side wall faces a direction opposite a gravitational direction.

[0005] In addition to one or more of the features described herein, the battery cell is oriented such that the wall faces a direction perpendicular to a gravitational direction.

[0006] In addition to one or more of the features described herein, the battery cell comprises a stack including a first electrode active material and a second electrode active material.

[0007] In addition to one or more of the features described herein, the stack comprises a wick formed at least in part by the first electrode active material and the second electrode active material.

[0008] In addition to one or more of the features described herein, the sump comprises a maximum fill line corresponding to an uppermost portion of the wick of the stack.

[0009] In addition to one or more of the features described herein, the first electrode active material is an anode active material, and the second electrode active material is a cathode active material.

[0010] In addition to one or more of the features described herein, the system further comprises a first electrode terminal disposed on the wall.

[0011] In addition to one or more of the features described herein, the stack further comprises a first electrode tab contacting the first electrode active material and electrically connected to the first electrode terminal via a first electrode connector.

[0012] In addition to one or more of the features described herein, the wall and the side wall face directions perpendicular to each other.

[0013] In another exemplary embodiment, a method for wetting a wick of a stack of a battery cell comprises forming an electrode inlet opening in a wall of a cell housing of the battery cell, forming an air hole in a side wall of the cell housing of the battery cell, fluidly coupling a sump to the electrode inlet opening, and feeding electrolyte from the sump into the cell housing via the electrode inlet opening.

[0014] In addition to one or more of the features described herein, the method further comprises orienting the battery cell such that the side wall faces a direction opposite a gravitational direction.

[0015] In addition to one or more of the features described herein, the method further comprises orienting the battery cell such that the wall faces a direction perpendicular to a gravitational direction.

[0016] In addition to one or more of the features described herein, the wick is formed at least in part by a first electrode active material and a second electrode active material.

[0017] In addition to one or more of the features described herein, the method further comprises filling a sump housing of the sump with electrolyte at or below a maximum fill line corresponding to an uppermost portion of the wick of the stack.

[0018] In addition to one or more of the features described herein, the first electrode active material is an anode active material and the second electrode active material is a cathode active material.

[0019] In addition to one or more of the features described herein, the wall and the side wall face directions perpendicular to each other.

[0020] In addition to one or more of the features described herein, the method further comprises stopping the feeding of the electrolyte into the cell housing when the wick is sufficiently wetted.

[0021] In addition to one or more of the features described herein, the method further comprises

venting from the air hole air released from the wick when displaced by the electrolyte fed into the cell housing.
[0022] In yet another exemplary embodiment, a system comprises a battery cell comprising a cell housing having at least a wall and a side wall, the battery cell oriented such that the wall faces a lateral direction perpendicular to a gravitational direction and the side wall faces an upward direction opposite the gravitational direction, a stack disposed within the cell housing and comprising an anode active material, an anode tab, a cathode active material, and a cathode tab, a wick of the stack formed at least in part by the anode active material and the cathode active material, an electrolyte inlet opening formed on the wall, an air hole formed on the side wall, an anode terminal disposed on the wall that is electrically connected to the anode tab via an anode connector, and a cathode terminal disposed on the wall that is electrically connected to the cathode tab via a cathode connector, and a sump comprising a sump housing configured to hold electrolyte therein. The electrolyte inlet opening is fluidly coupled to the sump housing to allow for the electrolyte to be fed from the sump housing into the cell housing. The sump comprises a maximum fill line corresponding to an uppermost portion of the wick of the stack.
[0023] The above features and advantages, and other features and advantages of the disclosure are readily apparent from the following detailed description when taken in connection with the accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0024] Other features, advantages and details appear, by way of example only, in the following detailed description, the detailed description referring to the drawings in which:
[0025] FIG. **1** is a left side view of a vehicle including an electric motor assembly according to one or more embodiments;
[0026] FIG. **2** is a perspective view of a battery cell according to one or more embodiments;
[0027] FIG. **3** is a stack of a battery cell according to one or more embodiments;
[0028] FIG. **4**. is a perspective view of a battery cell according to one or more embodiments;
[0029] FIG. **5** is a cross-sectional view of the battery cell of FIG. **4** taken at line **5**-**5**;
[0030] FIG. **6** is a cross-sectional view of the battery cell of FIG. **5** fluidly coupled to a sump according to one or more embodiments;
[0031] FIGS. **7**A-**7**F are schematic views demonstrating an example wetting process of a wick of a stack of a battery cell according to one or more embodiments;
[0032] FIG. **8** is a perspective view of a battery cell according to one or more embodiments; and
[0033] FIG. **9** is a flow chart showing a process for wetting a wick of a stack of a battery cell according to one or more embodiments.
DETAILED DESCRIPTION
[0034] The following description is merely exemplary in nature and is not intended to limit the present disclosure, its application or uses. It should be understood that throughout the drawings, corresponding reference numerals indicate like or corresponding parts and features.
[0035] A vehicle **10** according to a non-limiting example is shown in FIG. **1**. The vehicle **10** includes a body **12** supported on a plurality of wheels **16**. One or more of the plurality of wheels **16** are steerable. The body **12** defines, in part, a passenger compartment **20** having seats **23** positioned behind a dashboard **26**. A steering control **30** is arranged between seats **23** and a dashboard **26**. The steering control **30** is operated to control orientation of the steerable wheel(s) **16**.
[0036] The vehicle **10** includes an electric motor **34** connected to a transmission **36** that provides power to one or more of the plurality of wheels **16**. A rechargeable energy storage system **38** is arranged in the body **12** and provides power to the electric motor **34**. While specific locations are

shown for the electric motor **34**, the transmission **36**, and the rechargeable energy storage system **38** in FIG. **1**, these locations are merely exemplary and not limiting, and locations of these structures may vary.

[0037] The rechargeable energy storage system **38** may include a plurality of battery cells **94**, a non-limiting example of which is shown in FIG. **2**. The battery cell **94** defines an X-axis, a Y-axis, and a Z-axis. The battery cell **94** may include a cell can **98**. The cell can **98** may include a first wall **108**, a second wall **109**, and a plurality of side walls **111** that extend between and connect to first wall **108** and second wall **109**. The plurality of side walls **111** may include a first side wall **113**, a second side wall **114**, a third side wall **115**, and a fourth side wall **116**. As shown in FIG. **2**, the first wall **108** and the second wall **109** may be opposite each other along the Z-axis, the first side wall **113** and the second side wall **114** may be opposite each other along the X-axis, and the third side wall **115** and the fourth side wall **116** may be opposite each other along the Y-axis. The cell can **98** is an example of a cell housing.

[0038] The first wall **108** may support a first electrode terminal **120** which may be an anode terminal and a second electrode terminal **122** which may be a cathode terminal. While specific locations are shown for the first electrode terminal **120** and the second electrode terminal **122** in FIG. **2**, these locations are merely exemplary and not limiting, and locations of these structures may vary. For example, the first electrode terminal **120** and second electrode terminal **122** may be on different walls.

[0039] FIG. **3** shows a stack **200** according to one or more embodiments. The stack **200** may be formed of a plurality of alternating layers including first electrode active materials **210**, first electrode tabs **215** disposed between the first electrode active materials **210**, second electrode active materials **220**, second electrode tabs **225** disposed between the second electrode active materials **220**, and separators **230** between the first electrode active materials **210** and the second electrode active materials **220** as well as on outer ends of the stack **200**.

[0040] According to one or more embodiments, the first electrode active materials **210** may be anode active materials, the first electrode tabs **215** may be anode tabs, the second electrode active materials **220** may be cathode active materials, and the second electrode tabs **225** may be cathode tabs. According to one or more embodiments, the first electrode tab **215** may be a copper tab, and the second electrode tab **225** may be an aluminum tab.

[0041] Permeable layers of the stack **200** may be referred to as wicks. The wicks may include, for example, the first electrode active materials **210**, the second electrode active materials **220**, and/or the separators **230**. When forming the battery cell **94**, the wicks of the stack **200** may be wetted by flowing electrolyte into the cell can **98**. A system and method for wetting the wicks of the stack **200** will be described below with reference to FIGS. **5-8**.

[0042] FIG. **4** shows a battery cell **94** according to one or more embodiments. The battery cell **94** shown in FIG. **4** is similar to that shown in FIG. **2**, but further includes an air hole **130** formed on the first side wall **113** and an electrolyte inlet opening **140** formed on the first wall **108**. The air hole **130** and/or the electrolyte inlet opening **140** may be formed by drilling into the first wall **108** and/or the first side wall **113**. Alternatively, the first wall **108** and/or the first side wall **113** may be formed with the air hole **130** and/or the electrolyte inlet opening **140** pre-formed.

[0043] As shown in FIG. **4**, the battery cell **94** may be oriented such that the air hole **130** faces in an upward direction, i.e., opposite a gravitational direction G. That is, the battery cell **94** may be oriented such that the gravitational direction G is parallel to the X-axis. The electrolyte inlet opening **140** may face a lateral direction, i.e., perpendicular to the gravitational direction G. That is, the battery cell **94** may be oriented such that the gravitational direction G is perpendicular to the Z-axis. Hereinbelow, the direction opposite the gravitational direction G will be defined as an upward direction, and the gravitational direction G will be defined as a downward direction.

[0044] FIG. **5** shows a cross-sectional view of the battery cell **94** taken at line **5-5** in FIG. **4**. A first electrode connector **121** may be disposed in the cell can **98** that electrically connects the first

electrode terminal **120** and the first electrode tab **215** of the stack **200**. A second electrode connector **123** may be disposed in the cell can **98** that electrically connects the second electrode terminal **122** and the second electrode tab **225** of the stack **200**. The first electrode connector **121** may be an anode connector, and the second electrode connector **123** may be a cathode connector.

[0045] FIG. **6** shows the battery cell **94** connected to a sump **300** according to one or more embodiments. The sump **300** may include a sump housing **310** that is configured to hold an electrolyte pool **350**. The sump housing **310** may be a cylindrical housing, a box-shaped housing, or any other structure known in the art for storing a fluid. An electrolyte conduit **325** may extend from the sump **300** and fluidly coupled to the electrolyte inlet opening **140**. A first valve **320** may be formed on a side wall **311** of the sump housing **310** and may open to allow electrolyte to flow from the electrolyte pool **350** within the sump housing **310** of the sump **300** to an inside of the cell can **98** and close to shut off a flow of the electrolyte from the electrolyte pool **350** to the inside of the cell can **98**. According to one or more embodiments, a second valve **330** may be formed on the sump housing **310** that may open to at least partially drain the sump **300**.

[0046] The sump **300** may further a maximum fill line **355** that may correspond to an uppermost portion of the wick of the stack **200** in the orientation shown in FIG. **6**. The electrolyte pool **350** may be filled just below the maximum fill line **355** to prevent overfilling the cell can **98**. According to one or more embodiments, the electrolyte pool **350** may be filled at or below the maximum fill line **355**. Because only the wick of the stack **200** is to be wetted, the maximum fill line **355** may correspond to the uppermost portion of the wick of the stack **200**.

[0047] FIGS. **7**A-**7**F show the wick of the stack **200** being wetted by electrolyte over time according to one or more embodiments. In FIG. **7**A, the wick of the stack **200** is dry. As the electrolyte flows into the cell can **98** from the sump **300** through the electrolyte inlet opening **140**, the electrolyte surrounds the wick of the stack **200** on lateral and bottom portions thereof, and as shown in FIG. **7**B, the electrolyte begins to permeate the wick of the stack **200**. Because the electrolyte pool **350** in the sump housing **310** of the sump **300** is filled just below the maximum fill line **355** that corresponds to the uppermost portion of the wick of the stack **200**, the electrolyte does not fill the cell can **98** above the wick of the stack **200**. As such, the electrolyte does not permeate the wick of the stack **200** from the upper direction. As the electrolyte progressively continues to permeate the wick of the stack **200** as shown in FIGS. **7**C, **7**D, and **7**E, air within the wick of the stack **200** displaced by the electrolyte is pushed in the upward direction and exits the cell can **98** via the air hole **130**. Once the wick of the stack **200** is fully wetted as shown in FIG. **7**F, the electrolyte conduit **325** is decoupled from the electrolyte inlet opening **140** and/or the first valve **320** may be closed to shut off the supply of the electrolyte from the sump **300**. According to one or more embodiments, after the wick of the stack **200** is wetted, for example, through the air hole **130** or the inlet opening **140**.

[0048] As described above, the air within the wick of the stack **200** displaced by the electrolyte is pushed in the upward direction and exits the cell can **98** via the air hole **130**. As such, the wick of the stack **200** may be wetted without formation of air bubbles within the wick of the stack **200**. The inventors unexpectedly discovered that, when the electrolyte is fed into the cell can **98** from a wall disposed in the upward direction, the electrolyte may permeate the wick of the stack **200** from upward, downward, and side directions such that air bubbles may be trapped within the wick of the stack **200**, slowing the wetting process. The inventors further unexpectedly discovered that filling the cell can **98** with electrolyte above the wick of the stack **200** may result the electrolyte permeating the wick of the stack **200** from upward, downward, and side directions such that air bubbles may be trapped within the wick of the stack **200**, slowing the wetting process. One or more of the systems and methods described herein may thus improve efficiency of the wetting process of the wick of the stack **200** of the battery cell **94**.

[0049] As shown in FIG. **8**, once the wick of the stack **200** is fully wetted, the air hole **130** may be closed to form a first closed portion **135** and the electrolyte inlet opening **140** may be closed to

form a second closed portion **145**. The first closed portion **135** and the second closed portion **145** may be formed by welding or any structure or process known in the art for closing holes and/or openings.

[0050] FIG. **9** shows a method for wetting the wick of a stack **200** of a battery cell **94** according to one or more embodiments. In Step S**1**, the electrolyte inlet opening **140** is formed in the first wall **108** and the air hole **130** is formed in the first side wall **113**. In Step S**2**, the cell can **98** is oriented such that the air hole **130** faces an upward direction and the electrolyte inlet opening **140** faces a lateral direction. As described above, the upward direction may be opposite the gravitational direction G and the lateral direction may be perpendicular to the gravitational direction G. In Step S**3**, the sump **300** is fluidly connected to the electrolyte inlet opening **140** of the cell can **98**. In Step S**4**, electrolyte is fed from the sump **300** into the cell can **98** through the electrolyte inlet opening **140** until the wick of the stack **200** is fully wetted. In Step S**5**, the electrolyte inlet opening **140** of the cell can **98** is disconnected from the sump **300**. In step S**6**, the air hole **130** and the electrolyte inlet opening **140** are closed.

[0051] One or more embodiments of the systems and methods described above may be applied to various types of battery cells, including but not limited to pouch cells and cylindrical cells.

[0052] The terms “a” and “an” do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item. The term “or” means “and/or” unless clearly indicated otherwise by context. Reference throughout the specification to “an aspect”, means that a particular element (e.g., feature, structure, step, or characteristic) described in connection with the aspect is included in at least one aspect described herein, and may or may not be present in other aspects. In addition, it is to be understood that the described elements may be combined in any suitable manner in the various aspects.

[0053] When an element such as a layer, film, region, or substrate is referred to as being “on” another element, it can be directly on the other element or intervening elements may also be present. In contrast, when an element is referred to as being “directly on” another element, there are no intervening elements present.

[0054] Unless specified to the contrary herein, all test standards are the most recent standard in effect as of the filing date of this application, or, if priority is claimed, the filing date of the earliest priority application in which the test standard appears.

[0055] Unless defined otherwise, technical and scientific terms used herein have the same meaning as is commonly understood by one of skill in the art to which this disclosure belongs.

[0056] While the above disclosure has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from its scope. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the disclosure without departing from the essential scope thereof. Therefore, it is intended that the present disclosure not be limited to the particular embodiments disclosed, but will include all embodiments falling within the scope thereof.

Claims

1. A system comprising: a battery cell comprising: a cell housing having at least a wall and a side wall, an electrolyte inlet opening formed on the wall, and an air hole formed on the side wall; and a sump comprising a sump housing configured to hold electrolyte therein, wherein the electrolyte inlet opening is fluidly coupled to the sump housing to allow for the electrolyte to be fed from the sump housing into the cell housing.

2. The system of claim 1, wherein the battery cell is oriented such that the side wall faces a direction opposite a gravitational direction.

3. The system of claim 1, wherein the battery cell is oriented such that the wall faces a direction

perpendicular to a gravitational direction.
4. The system of claim 1, wherein the battery cell comprises a stack including a first electrode active material and a second electrode active material.
5. The system of claim 4, wherein the stack comprises a wick formed at least in part by the first electrode active material and the second electrode active material.
6. The system of claim 5, wherein the sump comprises a maximum fill line corresponding to an uppermost portion of the wick of the stack.
7. The system of claim 4, wherein the first electrode active material is an anode active material, and the second electrode active material is a cathode active material.
8. The system of claim 4, further comprising a first electrode terminal disposed on the wall.
9. The system of claim 8, wherein the stack further comprises a first electrode tab contacting the first electrode active material and electrically connected to the first electrode terminal via a first electrode connector.
10. The system of claim 1, wherein the wall and the side wall face directions perpendicular to each other.
11. A method for wetting a wick of a stack of a battery cell, comprising: forming an electrode inlet opening in a wall of a cell housing of the battery cell; forming an air hole in a side wall of the cell housing of the battery cell; fluidly coupling a sump to the electrode inlet opening; and feeding electrolyte from the sump into the cell housing via the electrode inlet opening.
12. The method of claim 11, further comprising orienting the battery cell such that the side wall faces a direction opposite a gravitational direction.
13. The method of claim 11, further comprising orienting the battery cell such that the wall faces a direction perpendicular to a gravitational direction.
14. The method of claim 11, wherein the wick is formed at least in part by a first electrode active material and a second electrode active material.
15. The method of claim 11, further comprising filling a sump housing of the sump with electrolyte at or below a maximum fill line corresponding to an uppermost portion of the wick of the stack.
16. The method of claim 14, wherein the first electrode active material is an anode active material and the second electrode active material is a cathode active material.
17. The method of claim 11, wherein the wall and the side wall face directions perpendicular to each other.
18. The method of claim 11, further comprising stopping the feeding of the electrolyte into the cell housing when the wick is sufficiently wetted.
19. The method of claim 11, further comprising venting from the air hole air released from the wick when displaced by the electrolyte fed into the cell housing.
20. A system comprising: a battery cell comprising: a cell housing having at least a wall and a side wall, the battery cell oriented such that the wall faces a lateral direction perpendicular to a gravitational direction and the side wall faces an upward direction opposite the gravitational direction, a stack disposed within the cell housing and comprising an anode active material, an anode tab, a cathode active material, and a cathode tab, a wick of the stack formed at least in part by the anode active material and the cathode active material, an electrolyte inlet opening formed on the wall, an air hole formed on the side wall, an anode terminal disposed on the wall that is electrically connected to the anode tab via an anode connector, and a cathode terminal disposed on the wall that is electrically connected to the cathode tab via a cathode connector; and a sump comprising a sump housing configured to hold electrolyte therein, wherein the electrolyte inlet opening is fluidly coupled to the sump housing to allow for the electrolyte to be fed from the sump housing into the cell housing, and wherein the sump comprises a maximum fill line corresponding to an uppermost portion of the wick of the stack.