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Battery Module and Battery Pack Including the Same

Abstract

A battery module according to one embodiment of the present disclosure includes a battery cell stack including a plurality of stacked battery cells; and at least one cooling member arranged on at least one of both side surfaces of the battery cell stack or between the plurality of battery cells. The cooling member includes a cooling channel that is a space inside the cooling member where a coolant flows, and an air gap that is an empty space separated from the cooling channel.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS
[0001] This application is based on and claims priority from Korean Patent Application No. 10-2024-0020265, filed on Feb. 13, 2024, with the Korean Intellectual Property Office, the disclosure of which is incorporated by reference herein in its entirety.
TECHNICAL FIELD
[0002] The present disclosure relates to a battery module and a battery pack including the same.
BACKGROUND
[0003] In modern society, the use of portable devices such as mobile phones, laptops, camcorders, and digital cameras has become commonplace, leading to an active development in technologies related to these mobile devices. Furthermore, as a solution to the environmental issues such as air pollution caused by fossil fuel-powered vehicles like traditional gasoline vehicles, rechargeable secondary batteries are utilized as a power source for electric vehicles (EVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (P-HEVs), and others. As a result, the need for developments of secondary batteries is increasing.
[0004] Secondary batteries, when exposed to temperatures above optimal levels, may experience performance degradation, and in severe cases, have the risk of explosion or ignition. A battery module or battery pack equipped with multiple secondary batteries, for example, battery cells, may experience a rapid and severe temperature rise due to the accumulation of heat generated by the densely packed battery cells in a confined space. In the case of a battery module with multiple stacked battery cells and a battery pack equipped with the battery module, although a high output may be achieved, it becomes challenging to effectively dissipate the heat generated during charge and discharge. Inadequate heat dissipation in battery cells may accelerate deterioration of battery cells, shorten the lifespan thereof, and increase the likelihood of explosion or ignition.
[0005] As the use of secondary batteries in the form of the battery module with the stacked battery cells and the battery pack becomes more widespread, incidents of ignition and explosion have emerged, highlighting the critical importance of addressing safety concerns in secondary batteries.
SUMMARY
[0006] In one embodiment of the present disclosure, there are provided a battery module having a structure capable of controlling the swelling of battery cells while further enhancing cooling performance, and a battery pack including the same.
[0007] According to one embodiment of the present disclosure, a battery module includes a battery cell stack including a plurality of stacked battery cells; and at least one cooling member arranged on at least one of both side surfaces of the battery cell stack or between the plurality of battery cells. The cooling member includes a cooling channel that is a space inside the cooling member where a coolant flows, and an air gap that is an empty space separated from the cooling channel.
[0008] One surface of the cooling member may come into contact with one surface of at least one battery cell among the plurality of battery cells.
[0009] The cooling member may have a plate shape and may cool at least one battery cell among the plurality of battery cells by surface cooling.
[0010] The air gap may include a first air gap and a second air gap, and the cooling channel may be positioned between the first air gap and the second air gap.
[0011] The first air gap, the cooling channel, and the second air gap may be sequentially positioned in a direction in which the plurality of battery cells are stacked.
[0012] The cooling channel may include a first cooling channel and a second cooling channel, and

the air gap may be positioned between the first cooling channel and the second cooling channel.
[0013] The first cooling channel, the air gap, and the second cooling channel gap may be sequentially positioned in a direction in which the plurality of battery cells are stacked.
[0014] Each of the plurality of battery cells may include an electrode lead, a busbar frame may be arranged in a direction in which the electrode lead protrudes from the plurality of battery cells on the basis of the battery cell stack, and a busbar may be mounted on the busbar frame.
[0015] The cooling member may include an inlet port that supplies the coolant to the cooling channel and an outlet port that discharges the coolant from the cooling channel, and the inlet port and the outlet port may pass through the busbar frame and be connected to a pack coolant supply pipe and a pack coolant discharge pipe, respectively.
[0016] The inlet port and the outlet port may extend farther than the busbar frame on the basis of the battery cell stack.
[0017] According to one embodiment of the present disclosure, a battery pack includes the battery module including a plurality of battery modules; a pack frame that accommodates the plurality of battery modules; and a pack coolant supply pipe and a pack coolant discharge pipe that are connected to the cooling member and are accommodated in the pack frame.
[0018] The cooling member may include an inlet port connected to the pack coolant supply pipe and an outlet port connected to the pack coolant discharge pipe. The inlet port and the outlet port may pass through a busbar frame arranged on one side of the battery cell stack and be connected to the pack coolant supply pipe and the pack coolant discharge pipe, respectively.
[0019] The pack coolant supply pipe and the pack coolant discharge pipe may be arranged in a space between the plurality of battery modules and a side frame of the pack frame.
[0020] According to one embodiment of the present disclosure, a vehicle includes the battery pack.
[0021] According to embodiments of the present disclosure, a cooling member having a cooling channel and an air gap is arranged adjacent to battery cells, thereby enabling the control of the swelling of the battery cells while further enhancing the cooling performance of the battery cells.
[0022] The effects of the present disclosure are not limited to those mentioned above, and other effects that have not mentioned will be clearly understood by those skilled in the art from the description of the claims.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0023] The drawings attached herewith are merely illustrative of embodiments of the present disclosure, and take on the role of further facilitating the understanding of the technical idea of the present disclosure along with the descriptions herein. Thus, the present disclosure should not be construed as being limited to those illustrated in the drawings.
[0024] FIG. **1** is a perspective view of a conventional battery module.
[0025] FIG. **2** is a cross-sectional view taken along the cutting line A-A′ of FIG. **1**.
[0026] FIG. **3** is a perspective view illustrating a battery module according to one embodiment of the present disclosure.
[0027] FIG. **4** is an exploded perspective view of the battery module of FIG. **3**.
[0028] FIG. **5** is an exploded perspective view illustrating a battery cell stack, a first busbar frame, and a second busbar frame included in the battery module of FIG. **4**.
[0029] FIG. **6** is a perspective view illustrating one of battery cells included in the battery cell stack of FIG. **5**.
[0030] FIGS. **7** and **8** are perspective views illustrating battery cells and a cooling member according to one embodiment of the present disclosure.
[0031] FIG. **9** is a perspective view illustrating the cooling member according to one embodiment

of the present disclosure.
[0032] FIG. **10** is a partial perspective view illustrating the cooling member of FIG. **9** as viewed from a different angle.
[0033] FIG. **11** is a cross-sectional view taken along the cutting line B-B′ of FIG. **9**.
[0034] FIG. **12** is a cross-sectional view illustrating a cooling member according to another embodiment of the present disclosure.
[0035] FIG. **13** is a perspective view illustrating a battery cell stack, a first busbar frame, and a second busbar frame according to one embodiment of the present disclosure.
[0036] FIGS. **14** and **15** are a perspective view and a front view, respectively, illustrating the first busbar frame according to one embodiment of the present disclosure.
[0037] FIG. **16** is a plan view illustrating a battery pack according to one embodiment of the present disclosure.
[0038] FIG. **17** is a perspective view illustrating a vehicle including the battery pack according to one embodiment of the present disclosure.
[0039] In some of the attached drawings, corresponding components are given the same reference numerals. Those skilled in the art would appreciate that the drawings depict elements simply and clearly and have not necessarily been drawn to scale. For example, to facilitate understanding of various embodiments, the dimensions of some elements illustrated in the drawings may be exaggerated compared to other elements. Additionally, elements of the known art that are useful or essential in commercially viable embodiments may often not be depicted so as not to interfere with the spirit of the various embodiments of the present disclosure.
DETAILED DESCRIPTION
[0040] Hereinafter, several embodiments of the present disclosure will be described with reference to the accompanying drawings so that those skilled in the art to which the present disclosure pertains can easily implement the present disclosure. The present disclosure may be implemented in various different forms and is not limited to the embodiments described herein.
[0041] To clearly describe the present disclosure, irrelevant parts have been omitted, and the same reference numerals are given to identical or similar components throughout the specification.
[0042] In addition, the size and thickness of each component illustrated in the drawing are arbitrarily represented for convenience of description, and therefore, are not intended to limit the present disclosure necessarily to the illustrations thereof. To clearly represent various layers and regions, thicknesses are illustrated as exaggerated in the drawings. Then, for convenience of description, the thicknesses of some layers and regions are illustrated as exaggerated in the drawings.
[0043] Further, when a part such as a layer, film, region, or plate, is described as being “above” or “on” another part, this includes not only cases where it is “directly above” the other part, but also cases where there is another part in between. Conversely, when a part is described as being “directly above” another part, it means that there is no intervening part. Additionally, the description of a part as being “above” or “on” a reference part refers to the position thereof above or below the reference part, and does not necessarily imply that the part is positioned “above” or “on” the reference part in the direction opposite to gravity.
[0044] Additionally, when a certain part is described as “including” a certain component throughout the specification, it means that, unless otherwise explicitly stated, the part may include additional components, rather than excluding other components.
[0045] Moreover, throughout the specification, “in plan view” refers to viewing a target part from above, while “in cross-sectional view” refers to viewing the cross section of the target part when cut vertically from the lateral side.
[0046] Currently commercialized secondary batteries include nickel cadmium batteries, nickel hydrogen batteries, nickel zinc batteries, lithium secondary batteries, and others. Among these, lithium secondary batteries have advantages over the nickel-based secondary batteries, such as

minimal memory effects, which allows for more flexible charge and discharge, a very low self-discharge rate, and a high energy density.

[0047] A lithium secondary battery may utilize a lithium-based oxide and a carbon material, as a positive electrode active material and a negative electrode active material, respectively. The lithium secondary battery may include an electrode assembly, where a positive electrode plate and a negative electrode plate, each coated with a positive electrode active material or a negative electrode active material, are arranged with a separator therebetween, and a battery case that seals and accommodates the electrode assembly along with an electrolyte.

[0048] Depending on the shape of an exterior material, the lithium secondary battery may be classified into a can-type secondary battery, where the electrode assembly is accommodated in a metallic can, or a pouch-type secondary battery, where the electrode assembly is accommodated in a pouch made of an aluminum laminate sheet.

[0049] Secondary batteries used in small devices may include two or three battery cells, whereas secondary batteries used in medium-to large-scale devices such as vehicles may utilize a battery module, where multiple battery cells are electrically connected. The battery module may enhance capacity and output by forming a stack of battery cells connected in series or parallel. One or more battery modules may be mounted, along with various control and protection systems such as a battery management system (BMS), a battery disconnect unit (BDU), and a cooling system, to form a battery pack.

[0050] The battery pack includes the battery module as a lower-level concept, and the battery module includes the battery cell as a lower-level concept. Then, the number of battery cells in the battery module or the number of battery modules in the battery pack may be determined in various ways according to the output power and capacity requirements of the battery pack for an electric vehicle.

[0051] A battery module included in a vehicle battery pack may be frequently exposed to direct sunlight and may face high-temperature conditions such as in summer or desert regions. Therefore, ensuring stable and effective cooling performance in the battery module and battery pack is critical. A cooling method for the battery module and battery pack may be broadly divided into a water cooling method that utilize a coolant such as water and an air cooling method that utilizes cooling air. Among these, water cooling offers excellent cooling performance, effectively dissipating the high heat generated by a large-capacity battery module or battery pack.

[0052] FIG. **1** is a perspective view of a conventional battery module, and FIG. **2** is a cross-sectional view taken along the cutting line A-A′ of FIG. **1**. For convenience of description, FIG. **2** additionally illustrates a heat sink **30** positioned under a battery module **10**.

[0053] Referring to FIGS. **1** and **2**, the conventional battery module **10** includes a battery cell stack **12**, where a plurality of battery cells **11** are stacked, and a module frame **20** that accommodates the battery cell stack **12**. In this case, the battery cells **11** are pouch-type battery cells with a rectangular sheet structure.

[0054] Since the plurality of battery cells **11** are stacked, the battery module **10** generates a large amount of heat during charge and discharge cycles. Conventionally, a heat transfer path from the edge portion of the battery cells **11** to the heat sink **30** has been implemented to cool the battery module **10**.

[0055] The battery module **10** may include a thermal resin layer **40** located between the battery cell stack **12** and the bottom of the module frame **20**. Further, when the battery module **10** is mounted on a pack frame to form a battery pack, a heat transfer member **50** and the heat sink **30** may be sequentially positioned under the battery module **10**. The heat transfer member **50** may be a heat dissipation pad, and the heat sink **30** may include a cooling flow path **31** through which a coolant such as water flows. The edge of the battery cells **11**, stacked in one direction, comes into contact with the thermal resin layer **40**. The heat generated from the battery cells **11** may be transferred sequentially through the thermal resin layer **40**, the bottom of the module frame **20**, the heat transfer member **50**, and the heat sink **30** to the outside of the battery module **10**. In other words, the conventional battery module **10** employs a water cooling structure that dissipates heat through the edge portion of the battery cells **11**.

[0056] The water cooling structure utilizing the edge portion of the battery cells **11** is relatively simplified in design, but has poor cooling performance and poses a risk of cracks, for example, in pouch cases of the battery cells **11** during the significant swelling of the battery cells **11**.

[0057] The battery cells **11** may experience a phenomenon known as swelling or breathing, in which an internal electrolyte decomposes and a gas is generated during repeated charge and discharge cycles or during initial charge, causing the battery cells **11** to expand.

[0058] As the capacity of battery cells increases, the degree of swelling also increases significantly. Furthermore, the number of battery cells applied to a battery module also gradually increases. Therefore, controlling the swelling of battery cells inside a battery module has become an important issue.

[0059] Referring again to FIG. **2**, the thermal resin layer **40** generally has adhesive properties to fix the battery cells **11** in place. Therefore, when the swelling of the battery cells **11** occurs, high stress is generated at the edge of the battery cells **11**, which may lead to cracks in the pouch cases of the battery cells **11**. The risk of cracks is greater for the battery cells **11** located at the outermost positions of the battery cell stack **12** since these battery cells are subjected to higher stress due to swelling.

[0060] If a conventional edge portion-based water cooling method is applied to a battery module including such swelling-prone battery cells, there is a high risk of cracks in the battery cells. Additionally, excessive stress may be applied, which may compromise the structural safety of the battery module.

[0061] Therefore, there is a need for a battery module having a novel cooling structure that may control the swelling of battery cells while further enhancing cooling performance.

[0062] FIG. **3** is a perspective view illustrating a battery module according to one embodiment of the present disclosure. FIG. **4** is an exploded perspective view of the battery module of FIG. **3**. FIG. **5** is an exploded perspective view illustrating a battery cell stack, a first busbar frame, and a second busbar frame included in the battery module of FIG. **4**. FIG. **6** is a perspective view illustrating one of battery cells included in the battery cell stack of FIG. **5**.

[0063] Referring to FIGS. **3** to **6**, a battery module **100** according to one embodiment of the present disclosure includes a battery cell stack **120** where a plurality of battery cells **110** are stacked; and at least one cooling member **600***a* arranged on at least one of both side surfaces of the battery cell stack **120** or between the battery cells **110**. The cooling member **600***a* may include a cooling channel, which is a space inside the cooling member **600***a* where a coolant flows, and an air gap, which is an empty space separated from the cooling channel. The shape of the cooling member **600***a* will be described later.

[0064] The battery cells **110** according to the present embodiment may take various shapes, and for example, may be pouch-type battery cells, prismatic battery cells, or cylindrical battery cells. For example, as illustrated in FIGS. **4** to **6**, the battery cells **110** according to the present embodiment may be pouch-type battery cells. Although the following description focuses on pouch-type battery cells, the battery cells **110** according to the present embodiment are not limited to this type and may encompass various types of battery cells.

[0065] Each battery cell **110** according to the present embodiment may include an electrode assembly, which includes electrode leads **111** protruding in one or both directions, accommodated in a pouch case **114**. Such a battery cell **110** may have a rectangular sheet shape. The battery cell **110** may be formed by accommodating the electrode assembly in the pouch case **114** made of a laminate sheet that includes a resin layer and a metal layer, followed by bonding the outer periphery of the pouch case **114**. For example, the battery cell **110** may have a structure in which two electrode leads **111** protrude respectively in opposite directions from one end **114***a* and the other end **114***b* of a cell body **113**. In another embodiment, all the electrode leads **111** of the battery cell **110** may protrude in one direction. One of the electrode leads **111** is a positive electrode lead and the other electrode lead is a negative electrode lead.

[0066] The battery cell **110** may be prepared by bonding both of the ends **114***a* and **114***b* of the pouch case **114** and one side portion **114***c* connecting the both ends **114***a* and **114***b*, while accommodating the electrode assembly (not illustrated) in the pouch case **114**. In other words, the battery cell **110** according to one embodiment of the present disclosure has a total of three sealing portions **114***s*, which are sealed by, for example, fusion. The remaining side portion may be configured as a folded portion **115**. In other words, the battery cell **110** according to the present embodiment may be a pouch-type secondary battery where the electrode assembly is accommodated inside the pouch case **114**, and the outer peripheral sides of the pouch case **114** are sealed to form the sealing portions **114***s*. In FIG. **6**, the sealing portions **114***s* are illustrated only at both of the ends **114***a* and **114***b* of the pouch case **114**. The side facing the folded portion **115** does not show a sealing portion because, for efficient use of space, the sealing portion at the side facing the folded portion **115** is folded to one side after the sealing is completed.

[0067] The pouch case **114** made of a laminate sheet may include an inner resin layer for sealing, a metal layer for preventing the penetration of substances, and an outer resin layer at the outermost position. On the basis of the electrode assembly inside the pouch case **114**, the inner resin layer may be positioned at the innermost side, the outer resin layer may be positioned at the outermost side, and the metal layer may be positioned between the inner resin layer and the outer resin layer.

[0068] The outer resin layer may have an excellent tensile strength relative to the thickness thereof, weather resistance, and electrical insulation, to protect the electrode assembly from external conditions. The outer resin layer may include polyethylene terephthalate (PET) resin or nylon resin. The metal layer may prevent or suppress substances such as air and moisture from entering the pouch-type secondary battery. The metal layer may include aluminum (Al). The inner resin layer may be thermally fused with itself when subjected to heat and/or pressure, with the electrode assembly embedded therein. The inner resin layer may include casted polypropylene (CPP) or polypropylene (PP).

[0069] The pouch case **114** may be divided into two sections, and a recessed compartment, in which the electrode assembly may be seated, may be formed in at least one of the two sections. The inner resin layers of the two sections of the pouch case **114** may be joined to each other along the outer perimeter of the compartment to form the sealing portions **114***s*. In this way, the pouch case may be sealed, completing the preparation of the battery cell **110**, which is a pouch-type secondary battery.

[0070] The battery module **100** may incorporate the plurality of battery cells **110** therein. For example, the plurality of battery cells **110** may be stacked in one direction so as to be electrically connected to each other to form the battery cell stack **120**. For example, the plurality of battery cells **110** may be stacked upright in a direction parallel to the X-axis. The battery cells **110** may be stacked from one side surface portion **210***b* to the other side surface portion **210***b* of a module frame **200** to be described later, with one surface of the battery cells **110** parallel to the side surface portion **210***b*. Accordingly, the electrode leads **111** may protrude in a direction perpendicular to the direction in which the battery cells **110** are stacked. In each battery cell **110**, one electrode lead **111** may protrude in the Y-axis direction, while the other electrode lead **111** may protrude in the-Y-axis direction. When the electrode leads **111** protrude in only one direction from the battery cell, the electrode leads **111** may protrude in either the Y-axis direction or the-Y-axis direction.

[0071] Meanwhile, the battery module **100** according to the present embodiment may include the module frame **200** that accommodates the battery cells **110**. For example, the module frame **200** according to the present embodiment may include a lower frame **210**, on which the battery cells **110** are placed, and an upper cover **220** that covers the top of the battery cells **110**.

[0072] The lower frame **210** and the upper cover **220** are joined, for example, by welding corresponding corners thereof, so that the module frame **200** may cover the upper side, lower side, and both lateral sides of the battery cell stack **120**. Although not specifically illustrated, a module frame according to another embodiment of the present disclosure may be a mono-frame where the ceiling, bottom, and both side surface portions are integrated.

[0073] The lower frame **210** according to the present embodiment may include a bottom **210***a* and both side surface portions **210***b*. Both the side surface portions **210***b* may extend upward from along opposing sides of the bottom **210***a* in a direction perpendicular to one surface of the bottom **210***a*. The bottom **210***a* and both the side surface portions **210***b* may cover a lower surface and both side surfaces of the battery cell stack **120**. As described above, one surface of the battery cells **110** inside the battery cell stack **120** may be parallel to the side surface portions **210***b* of the lower frame **210**, and the battery cells **110** may be stacked in a direction from one side surface portion **210***b* to the other side surface portion **210***b*.

[0074] Meanwhile, in the battery module **100** according to the present embodiment, a first end plate **310** and a second end plate **320** may be arranged, respectively, on the opposing surfaces of the battery cell stack **120** in the direction in which the electrode leads **111** protrude from the battery cell stack **120**. These first and second end plates **310** and **320** may be joined to the module frame **200** by, for example, welding. The module frame **200**, first end plate **310**, and second end plate **320** may include a metal material to have a predetermined strength. The battery cell stack **120** may be covered by the module frame **200**, first end plate **310**, and second end plate **320** to thereby be protected from external shocks or vibrations.

[0075] Meanwhile, the battery module **100** according to the present embodiment may include a first busbar frame **410** and a second busbar frame **420**, which cover respective opposite sides of the battery cell stack **120** in the direction in which the electrode leads **111** protrude from the battery cell stack **120**. The first busbar frame **410** may be positioned between the battery cell stack **120** and the first end plate **310**, and the second busbar frame **420** may be positioned between the battery cell stack **120** and the second end plate **320**. The first and second busbar frames **410** and **420** may include an electrical insulating material, and may prevent or suppress a short circuit caused by contact between a busbar **510** or terminal busbar **520** to be described later and other parts of the battery cell **110** other than the electrode leads **111**.

[0076] The busbar **510**, the terminal busbar **520**, and a module connector **530** may be

[0077] mounted on each of the first busbar frame **410** and the second busbar frame **420**. The busbar **510**, terminal busbar **520**, and module connector **530** may be mounted on the surface of the first or second busbar frame **410** or **420** opposite to the surface facing the battery cell stack **120**. The bus bar **510** may be electrically connected to the electrode lead **111** of the battery cell **110**. For example, the bus bar **510** and the electrode lead **111** may be joined by welding. A slit is formed in the first and second busbar frames **410** and **420**, and the electrode lead **111** may pass the these slit and be connected to the busbar **510**. The battery cells **110** may be electrically connected in series or parallel via the bus bar **510**.

[0078] The terminal bus bar **520** may be electrically connected to the electrode lead **111**, and a portion thereof may be exposed to the outside of the battery module **100**. For example, a terminal busbar opening **321** may be formed in the second end plate **320**. A portion of the terminal bus bar **520** may be exposed to the outside of the battery module **100** through the terminal busbar opening **321**. The battery module **100** may form a high voltage (HV) connection with other battery modules or electrical components through the terminal busbar **520**. Here, the HV connection refers to a power supply connection required for a high voltage operation, which means a connection between battery cells or between battery modules.

[0079] The module connector **530** is a member for a low voltage (LV) connection of the battery module **100**. The LV connection refers to an electrical connection that requires a relatively low voltage, for example, between battery electrical components. For example, a sensing member (not illustrated) may sense voltage data of the battery cells **110** or temperature data inside the battery module **100**, and the module connector **530** connected to the sensing member may transmit the sensed voltage data or temperature data to a battery management system (BMS) located outside the battery module **100**. Thus, a portion of the module connector **530** may also be exposed to the outside of the battery module **100**. For example, a module connector opening **322** may be formed in the second end plate **320**. The module connector **530** may be exposed to the outside of the battery module **100** through the module connector opening **322**, and may be connected to an external BMS and others.

[0080] Hereinafter, a cooling member according to the present embodiment will be described.

[0081] FIGS. **7** and **8** are perspective views illustrating battery cells and a cooling member according to one embodiment of the present disclosure. FIG. **9** is a perspective view illustrating the cooling member according to one embodiment of the present disclosure. FIG. **10** is a partial perspective view illustrating the cooling member of FIG. **9** as viewed from a different angle. FIG. **11** is a cross-sectional view taken along the cutting line B-B′ of FIG. **9**.

[0082] Referring to FIGS. **4** to **11** collectively, the cooling member **600***a* according to the present embodiment includes a cooling channel **600**C, which is a space inside the cooling member **600***a* where a coolant flows, and an air gap **600**G, which is an empty space separated from the cooling channel **600**C. One surface of the cooling member **600***a* may come into contact with one surface of the battery cell **110**. In other words, the cooling member **600***a* may cool the battery cell **110** by surface cooling in a plate-like form. The coolant may be cooling water. The battery module **100** according to the present embodiment may have a water cooling structure.

[0083] In contrast to the conventional battery module **10** illustrated in FIGS. **1** and **2**, which has an edge cooling structure in which heat is dissipated through the edge portion of the battery cells **11**, the battery module **100** according to the present embodiment may have a surface cooling structure in which the cooling member **600***a* having the cooling channel **600**C comes into contact with one surface of the cell body **113** of the battery cell **110**. Since one surface of the cell body **113** of the battery cell **110** may come into contact with the cooling member **600***a*, the cooling area is significantly wider, resulting in superior cooling performance compared to the conventional battery module **10**.

[0084] There are no special limitations on the number or size of cooling members **600***a* inside the battery module **100** as long as surface cooling of the battery cells **110** may be performed. A plurality of cooling members **600***a* may be provided inside the battery module **100**. Some cooling members **600***a* may be positioned between the battery cells **110**, while other cooling members **600***a* may be arranged on both side surfaces of the battery cell stack **120**. For example, in FIGS. **7** and **8**, three cooling members **600***a* are arranged between the battery cells **110**, and two cooling members **600***a* are each arranged on either side surface of the battery cell stack **120**. Additionally, in another embodiment, the cooling members **600***a* may be arranged anywhere between the battery cells **110**. The number of cooling members **600***a* may be appropriately changed in consideration of factors such as the size, capacity, and heat generation amount of the battery module **100**. Moreover, there are no special limitations on the size of the cooling member **600***a* as long as the cooling member **600***a* may cover at least about 60% of the area of one surface of the battery cell **110**.

[0085] As described above, the battery cells **110** may experience a phenomenon known as swelling, in which an internal electrolyte decomposes and a gas is generated during repeated charge and discharge cycles, causing the battery cells **110** to expand. In the swelling phenomenon of the battery cells **110**, the battery cells **110** expand in the thickness direction. In other words, the battery cells **110** may expand in the direction in which the battery cells **110** are stacked (for example, the direction parallel to the X-axis in FIG. **5**). Since the cooling member **600***a* according to the present embodiment includes the air gap **600**G therein, the cooling member **600***a* may absorb the swelling of the battery cells **110**. Conventionally, a compression pad made of a foam material was interposed between the battery cells **110** to absorb the swelling of the battery cells **110**. In the present embodiment, the cooling member **600***a* positioned between the battery cells **110** may absorb the swelling of the battery cells **110**, thereby replacing the function of the conventional compression pad. In other words, the cooling member **600***a* according to the present embodiment may perform not only the surface cooling function for the battery cells **110** but also the function of absorbing the swelling of the battery cells **110**. Accordingly, the deformation of the battery module **100** beyond the deformation limit due to the swelling of the battery cells **110** may be prevented or suppressed.

[0086] Meanwhile, in the conventional battery module **10**, since the edge of the battery cells **11** are bonded and fixed to the thermal resin layer **40**, high stress is generated at the edge of the battery cells **11** when swelling occurs, potentially leading to cracks in the battery cells **11**. In the case of the battery module **100** according to the present embodiment, since the cooling members **600***a* are arranged between the battery cells **110**, the battery cells **110** are not bonded or fixed to specific points. This may provide a certain degree of structural flexibility in the stacking direction of the battery cells **110** even if high swelling occurs in the battery cells **110**, thereby preventing or suppressing cracks in the battery cells **110**.

[0087] Meanwhile, as illustrated in FIGS. **8** and **11**, the air gap **600**G according to the present embodiment may include a first air gap **600**G**1** and a second air gap **600**G**2**. The cooling channel **600**C may be positioned between the first air gap **600**G**1** and the second air gap **600**G**2**. The first air gap **600**G**1**, cooling channel **600**C, and second air gap **600**G**2** may be positioned sequentially in the direction in which the battery cells **110** are stacked (the direction parallel to the X-axis, see FIG. **8**). In the present embodiment, since the first air gap **600**G**1** or the second air gap **600**G**2** may be positioned adjacent to the battery cells **110**, the swelling of the battery cells **110** may be absorbed more effectively.

[0088] FIG. **12** is a cross-sectional view illustrating a cooling member according to another embodiment of the present disclosure.

[0089] Referring to FIGS to **12**, a cooling member **600***b* according to another embodiment of the present disclosure includes the cooling channel **600**C, which is a space inside the cooling member **600***b* where a coolant flows, and the air gap **600**G, which is an empty space separated from the cooling channel **600**C. One surface of the cooling member **600***b* may come into contact with one surface of the battery cell **110**. In other words, the cooling member **600***b* may cool the battery cell **110** by surface cooling in a plate-like form. As with the cooling member **600***a* described above, the cooling member **600***b* according to the present embodiment also includes the cooling channel **600**C and the air gap **600**G, and therefore, may perform both the surface cooling function for the battery cells **110** and the function of absorbing the swelling of the battery cells **110**. Meanwhile, the cooling channel **600**C of the cooling member **600***b* according to the present embodiment may include a first cooling channel **600**C**1** and a second cooling channel **600**C**2**. The air gap **600**G may be positioned between the first cooling channel **600**C**1** and the second cooling channel **600**C**2**. The first cooling channel **600**C**1**, air gap **600**G, and second cooling channel **600**C**2** may be positioned sequentially in the direction in which the battery cells **110** are stacked (the direction parallel to the X-axis, see FIG. **8**). In the present embodiment, since the first cooling channel **600**C**1** or the second cooling channel **600**C**2** may be positioned adjacent to the battery cells **110**, the cooling performance of the battery cells **110** may be further enhanced.

[0090] FIG. **13** is a perspective view illustrating the battery cell stack, first busbar frame, and second busbar frame according to one embodiment of the present disclosure. FIGS. **14** and **15** are a perspective view and a front view, respectively, illustrating the first busbar frame according to one embodiment of the present disclosure.

[0091] Referring to FIGS. **5**, **8** to **11** and **13** to **15** collectively, as described above, the battery cell **110** according to the present embodiment may include the electrode leads **111**, the busbar frames **410** and **420** may be arranged in the direction in which the electrode leads **111** protrude from the battery cell **110** on the basis of the battery cell stack **120**, and the busbar **510** may be mounted on each of the busbar frames **410** and **420**. For example, the first busbar frame **410** and the second busbar frame **420** may be arranged on either side of the battery cell stack **120**.

[0092] The cooling member **600***a* according to the present embodiment may include an inlet port **610** for supplying a coolant to the cooling channel **600**C and an outlet port **620** for discharging the coolant from the cooling channel **600**C. The inlet port **610** and the outlet port **620** may pass through the first busbar frame **410** and be connected to a pack coolant supply pipe and a pack coolant discharge pipe, respectively. The pack coolant supply pipe and pack coolant discharge pipe will be described later with reference to FIG. **16**.
[0093] The inlet port **610** and the outlet port **620** may be pipe-shaped members extending from one side of the cooling member **600***a*. The coolant may be introduced into the cooling channel **600**C through the inlet port **610**, and then be discharged from the cooling channel **600**C through the outlet port **620**. In other words, the cooling member **600***a* may have a coolant circulation structure through the inlet port **610** and the outlet port **620**.
[0094] The first busbar frame **410** may be provided with an inlet hole **410**H**1** and an outlet hole **410**H**2**. The inlet port **610** of the cooling member **600***a* may pass through the inlet hole **410**H**1** of the first busbar frame **410**, and the outlet port **620** of the cooling member **600***a* may pass through the outlet hole **410**H**2** of the first busbar frame **410**. The inlet port **610** and the outlet port **620** may extend farther than the first busbar frame **410** on the basis of the battery cell stack **120**, and may pass through the inlet hole **410**H**1** and the outlet hole **410**H**2**, respectively. The inlet port **610** and the outlet port **620** having passed respectively through the inlet hole **410**H**1** and the outlet hole **410**H**2** may be connected to the pack coolant supply pipe and the pack coolant discharge pipe, which will be described later. Each of the inlet hole **410**H**1** and the outlet hole **410**H**2** may be formed in the first busbar frame **410** in a quantity corresponding to the number of cooling members **600***a*.
[0095] As in the present embodiment, since the inlet port **610** and the outlet port **620** pass through the first busbar frame **410** and extend farther than the location of the first busbar frame **410**, the connection point of the inlet port **610** with the pack coolant supply pipe or the connection point of the outlet port **620** with the pack coolant discharge pipe may be distanced from electrical connection points such as electrode leads or busbars. In other words, the insulation of the cooling member **600***a* may be secured by separating the cooling connection points from the electrical connection points.
[0096] In addition, since the inlet port **610** and the outlet port **620** pass through the inlet hole **410**H**1** and the outlet hole **410**H**2** while being fitted into the inlet hole **410**H**1** and the outlet hole **410**H**2**, the inlet port **610** and the outlet port **620** may be fixed in the inlet hole **410**H**1** and the outlet hole **410**H**2**. This may ensure that the inlet port **610** and the outlet port **620** have safety against external vibrations or shocks and may prevent or suppress coolant leakage from the inlet port **610** or the outlet port **620**.
[0097] Meanwhile, referring to FIGS. **4**, **5**, and **13** to **15** collectively, as described above, the battery module **100** may include the first end plate **310**, and the first busbar frame **410** may be positioned between the first end plate **310** and the battery cell stack **120**. The first end plate **310** may have an external inlet hole **310**H**1** and an external outlet hole **310**H**2**. Each of the external inlet hole **310**H**1** and the external outlet hole **310**H**2** may be positioned to correspond to the inlet hole **410**H**1** and the outlet hole **410**H**2** of the first busbar frame **410**.
[0098] The inlet port **610** having passed through the inlet hole **410**H**1** of the first busbar frame **410** may pass through the external inlet hole **310**H**1** of the first end plate **310** to thereby be exposed to the outside of the battery module **100**, and may then be connected to the pack coolant supply pipe to be described later. The outlet port **620** having passed through the outlet hole **410**H**2** of the first busbar frame **410** may pass through the external outlet hole **310**H**2** of the first end plate **310** to thereby be exposed to the outside of the battery module **100**, and may then be connected to the pack coolant discharge pipe to be described later.
[0099] Hereinafter, a battery pack according to one embodiment of the present disclosure will be described.

[0100] FIG. **16** is a plan view illustrating a battery pack according to one embodiment of the present disclosure.
[0101] Referring to FIGS. **4**, **5**, and **16** collectively, a battery pack **1000** according to one embodiment of the present disclosure includes the battery modules **100**; a pack frame **1100** that accommodates the battery modules **100**; and a pack coolant supply pipe **1200** and a pack coolant discharge pipe **1300**, which are connected to the cooling member **600***a* and are accommodated in the pack frame.
[0102] As described above, the cooling member **600***a* may include the inlet port **610** connected to the pack coolant supply pipe **1200** and the outlet port **620** connected to the pack coolant discharge pipe **1300**. The inlet port **610** and the outlet port **620** may pass through the first busbar frame **410** and be connected to the pack coolant supply pipe **1200** and the pack coolant discharge pipe **1300**, respectively. For example, the inlet port **610** having passed through the inlet hole **410**H**1** of the first busbar frame **410** and the external inlet hole **310**H**1** of the first end plate **310** may be connected to the pack coolant supply pipe **1200**. In addition, the outlet port **620** having passed through the outlet hole **410**H**2** of the first busbar frame **410** and the external outlet hole **310**H**2** of the first end plate **310** may be connected to the pack coolant discharge pipe **1300**. The pack coolant supply pipe **1200** and the pack coolant discharge pipe **1300** may be connected to a coolant circulation system (not illustrated) located inside or outside the battery pack **1000**. In other words, the coolant moving along the pack coolant supply pipe **1200** from the coolant circulation system may be introduced into the cooling channel **600**C through the inlet port **610**. Then, the coolant discharged from the cooling channel **600**C through the outlet port **620** may be returned to the coolant circulation system again along the pack coolant discharge pipe **1300**. Through this process, the coolant circulation structure may be implemented inside the battery pack **1000**.
[0103] The pack frame **1100** according to the present embodiment may include a bottom frame **1110** on which battery modules **100** are placed and a side frame **1120**, which extends along the edge of the bottom frame **1110**. The side frame **1120** may extend in a direction perpendicular to one surface of the bottom frame **1110**. The bottom frame **1110** and the side frame **1120** may define an internal space with an open top, in which the battery modules **100** may be accommodated. Meanwhile, a pack cover (not illustrated) may cover the open top of the pack frame **1100**.
[0104] The pack coolant supply pipe **1200** and the pack coolant discharge pipe **1300** according to the present embodiment may be arranged in the space between the battery modules **100** and the side frame **1120** of the pack frame **1100**. Additionally, some of the battery modules **100** may be arranged such that the second end plates **320** face each other. As described above, the second end plate **320** may have the terminal busbar opening **321**, through which the terminal busbar **520** may be exposed. The space between the battery modules **100** where the second end plates **320** face each other may be a space where a high voltage (HV) connection is made by the terminal busbars **520**. In other words, HV lines connected to the terminal busbars **520** may be arranged in the space between the battery modules **100**.
[0105] The pack coolant supply pipe **1200** and the pack coolant discharge pipe **1300** may be arranged in the space between the battery modules **100** and the side frame **1120** of the pack frame **1100**, in order to be connected to the inlet port **610** and the outlet port **620** having passed through the external inlet hole **310**H**1** and the external outlet hole **310**H**2** of the first end plate **310**, respectively.
[0106] Thus, from the perspective of any one battery module **100**, the pack coolant supply pipe **1200** and the pack coolant discharge pipe **1300** may be positioned on the opposite side of the HV lines. In other words, the pack coolant supply pipe **1200** and the pack coolant discharge pipe **1300** may be positioned at the outer side of the first end plate **310**, while the HV lines connected to the terminal busbar **520** may be positioned at the outer side of the second end plate **320**.
[0107] By positioning the pack coolant supply pipe **1200** and the pack coolant discharge pipe **1300** far away from the HV lines, issues such as a short circuit caused when the coolant leaking from the

pack coolant supply pipe **120** and the pack coolant discharge pipe **1300** comes into contact with the HV lines, may be prevented or suppressed. In other words, in the battery pack **1000** according to the present embodiment, the insulation performance and safety against coolant leakage may be secured by spatially separating the pack coolant supply pipe **1200** and the pack coolant discharge pipe **1300**, through which the coolant flows, from the HV lines.

[0108] In the present embodiment, terms such as front, rear, left, right, up, and down are used to describe directions, but these terms are only for convenience of description and may depend on the position of a target object or the location of an observer.

[0109] One or more battery modules according to the present embodiment described above may be mounted along with various control and protection systems such as a battery management system (BMS), a battery disconnect unit (BDU), and a cooling system to form a battery pack.

[0110] The battery module or battery pack may be applied to various devices. For example, it may be applied to transportation vehicles such as electric bicycles, electric vehicles, and hybrids, as well as energy storage systems (ESS), but is not limited thereto, and may be applied to various devices that may use secondary batteries.

[0111] FIG. **17** is a diagram illustrating a vehicle **2000** including the battery pack according to one embodiment of the present disclosure. As illustrated in FIG. **17**, the vehicle **2000** may include the battery pack **1000** according to the present disclosure. In addition, the vehicle **2000** may include the battery module **100** according to the present disclosure. The vehicle **2000** according to the present disclosure may further include various other components included in the vehicle **2000**, in addition to the battery pack **1000** or the battery module **100**. For example, the vehicle **2000** according to the present disclosure may further include a vehicle body, a motor, and a control device such as an electronic control unit (ECU).

[0112] In the above description, although the present disclosure has been described by limited embodiments and drawings, the above description is merely an example of the technical idea of the present disclosure, and those skilled in the art will appreciate that various modifications and variations may be made without departing from the essential characteristics of the present disclosure. Accordingly, the various embodiments disclosed herein are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

Claims

1. A battery module comprising: a battery cell stack including a plurality of stacked battery cells; and at least one cooling member arranged on at least one of both side surfaces of the battery cell stack or between the plurality of battery cells, wherein the cooling member includes a cooling channel that is a space inside the cooling member where a coolant flows, and an air gap that is an empty space separated from the cooling channel.

2. The battery module according to claim 1, wherein one surface of the cooling member comes into contact with one surface of at least one battery cell among the plurality of battery cells.

3. The battery module according to claim 1, wherein the cooling member has a plate shape and cools at least one battery cell among the plurality of battery cells by surface cooling.

4. The battery module according to claim 1, wherein the air gap includes a first air gap and a second air gap, and wherein the cooling channel is positioned between the first air gap and the second air gap.

5. The battery module according to claim 4, wherein the first air gap, the cooling channel, and the second air gap are sequentially positioned in a direction in which the plurality of battery cells are stacked.

6. The battery module according to claim 1, wherein the cooling channel includes a first cooling channel and a second cooling channel, and wherein the air gap is positioned between the first cooling channel and the second cooling channel.

7. The battery module according to claim 6, wherein the first cooling channel, the air gap, and the second cooling channel gap are sequentially positioned in a direction in which the plurality of battery cells are stacked.
8. The battery module according to claim 1, wherein each of the plurality of battery cells includes an electrode lead, wherein a busbar frame is arranged in a direction in which the electrode lead protrudes from the plurality of battery cells on the basis of the battery cell stack, and wherein a busbar is mounted on the busbar frame.
9. The battery module according to claim 8, wherein the cooling member includes an inlet port that supplies the coolant to the cooling channel and an outlet port that discharges the coolant from the cooling channel, and wherein the inlet port and the outlet port pass through the busbar frame and are connected to a pack coolant supply pipe and a pack coolant discharge pipe, respectively.
10. The battery module according to claim 9, wherein the inlet port and the outlet port extend farther than the busbar frame on the basis of the battery cell stack.
11. A battery pack comprising: a plurality of battery modules in which at least one of the battery modules is the battery module according to claim 1; a pack frame that accommodates the plurality of battery modules; and a pack coolant supply pipe and a pack coolant discharge pipe that are connected to the cooling member and are accommodated in the pack frame.
12. The battery pack according to claim 11, wherein the cooling member includes an inlet port connected to the pack coolant supply pipe and an outlet port connected to the pack coolant discharge pipe, and wherein the inlet port and the outlet port pass through a busbar frame arranged on one side of the battery cell stack and are connected to the pack coolant supply pipe and the pack coolant discharge pipe, respectively.
13. The battery pack according to claim 12, wherein the pack coolant supply pipe and the pack coolant discharge pipe are arranged in a space between the plurality of battery modules and a side frame of the pack frame.
14. A vehicle comprising the battery pack according to claim 11.