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### Traction battery coolant assembly and thermal management method

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#### Abstract

A traction battery assembly includes battery arrays and a thermal exchange assembly of a battery pack. The thermal exchange assembly has passageways that each communicate coolant from a first side of the battery pack to an opposite, second side of the battery pack. An inlet conduit is on the first side. The inlet conduit is arranged such that the delivering of coolant to a first one of the passageways is upstream from the delivering of coolant to a second one of the passageways. An outlet conduit is on the second side. The outlet conduit is arranged such that the receiving of coolant from the first one of passageways to the outlet conduit is upstream from the receiving of coolant from the second one of the passageways to the outlet conduit.

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## Background/Summary

### TECHNICAL FIELD

(1) This disclosure relates generally to communicating coolant through a battery pack in a way that reduces flow pressure loss.

### BACKGROUND

(2) Electrified vehicles differ from conventional motor vehicles because electrified vehicles are selectively driven using one or more electric machines powered by a traction battery. The electric machines can drive the electrified vehicles instead of, or in addition to, an internal combustion engine. Example electrified vehicles include hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), fuel cell vehicles (FCVs), and battery electric vehicles (BEVs).

(3) The traction battery is a relatively high-voltage battery that selectively powers the electric machines, and potentially other electrical loads of the electrified vehicle. The traction battery can include battery arrays each including a plurality of interconnected battery cells that store energy.

Coolant can be move through the traction battery to manage thermal energy levels.

## SUMMARY

(4) In some aspects, the techniques described herein relate to a traction battery assembly, including: a plurality of battery arrays of a battery pack; a thermal exchange assembly having a plurality of passageways that each communicate coolant from a first side of the battery pack to an opposite, second side of the battery pack; an inlet conduit on the first side, the inlet conduit configured to deliver the coolant to a first one of the plurality of passageways and to deliver the coolant to a second one of the plurality of passageways, the inlet conduit arranged such that the delivering of coolant to the first one of the plurality of passageways is upstream from the delivering of coolant to the second one of the plurality of passageways; and an outlet conduit on the second side, the outlet conduit configured to receive the coolant from the first one of the plurality of passageways and receive the coolant from the second one of the plurality of passageways, the outlet conduit arranged such that the receiving of coolant from the first one of the plurality of passageways is upstream from the receiving of coolant from the outlet conduit to the second one of the plurality of passageways.

(5) In some aspects, the techniques described herein relate to a traction battery assembly, wherein the plurality of battery arrays are disposed along a pack axis that extends from a front end of the battery pack to a rear end of the battery pack.

(6) In some aspects, the techniques described herein relate to a traction battery assembly, wherein the inlet conduit and the outlet conduit both extend through the rear end of the battery pack.

(7) In some aspects, the techniques described herein relate to a traction battery assembly, wherein the inlet conduit and the outlet conduit both extend through the front end of the battery pack or both extend through the rear end of the battery pack, wherein one of the inlet conduit or the outlet conduit is looped such that coolant moves axially in a first direction and then in an opposite, second axial direction.

(8) In some aspects, the techniques described herein relate to a traction battery assembly, wherein the battery arrays each include a plurality of battery cells disposed along a respective array axis that is perpendicular to the pack axis.

(9) In some aspects, the techniques described herein relate to a traction battery assembly, wherein the battery pack is a multi-tier battery pack such that a first battery module of the plurality of battery arrays and the first one of the plurality of passageways are vertically beneath a second battery module of the plurality of battery arrays and the second one of the plurality of passageways, wherein the inlet conduit and the outlet conduit both extend through a front end of the battery pack or both extend through a rear end of the battery pack.

(10) In some aspects, the techniques described herein relate to a traction battery assembly, wherein openings to the first and second passageways from the inlet conduit are the same diameter, and openings from the first and second passageways to the outlet conduit are the same diameter.

(11) In some aspects, the techniques described herein relate to a traction battery assembly, wherein the inlet conduit and the outlet conduit are flexible or rigid hoses.

(12) In some aspects, the techniques described herein relate to a traction battery assembly, wherein the coolant is a liquid coolant.

(13) In some aspects, the techniques described herein relate to a traction battery assembly, wherein the plurality of battery arrays are disposed atop the thermal exchange assembly such that first one of the plurality of passageways is beneath one of the plurality of arrays, and a second one of the plurality of battery arrays is beneath another one of the plurality of arrays.

(14) In some aspects, the techniques described herein relate to a traction battery assembly, wherein the first side is driver side and the second side is a passenger side.

(15) In some aspects, the techniques described herein relate to a traction battery, wherein upstream with reference to a general direction of flow through the respective inlet conduit or outlet conduit.

(16) In some aspects, the techniques described herein relate to a thermal management method for a

battery pack, including: delivering coolant from an inlet conduit to a first passageway of a thermal exchange assembly; delivering coolant from the inlet conduit to a second passageway of the thermal exchange assembly, the inlet conduit arranged such that delivering of coolant to the first passageway from the inlet conduit is upstream from the delivering of coolant to the second passageway from the inlet conduit; receiving coolant from the first passageway at an outlet conduit; and receiving coolant from the second passageway at the outlet conduit, the outlet conduit arranged such that the coolant from the first passageway is received upstream from the receiving of coolant of the coolant from the second passageway.

(17) In some aspects, the techniques described herein relate to a thermal management method, wherein upstream is with reference to a general direction of flow through the inlet conduit and the outlet conduit.

(18) In some aspects, the techniques described herein relate to a thermal management method, wherein the inlet conduit and the outlet conduit both extend through a front end of the battery pack or both extend through a rear end of the battery pack.

(19) In some aspects, the techniques described herein relate to a thermal management method, wherein the battery pack is a multi-tier battery pack such that the first passageway is vertically beneath the second passageway.

(20) In some aspects, the techniques described herein relate to a thermal management method, wherein one of the inlet conduit or the inlet conduit is looped such that coolant moves axially in a first direction and then in an opposite, second axial direction.

(21) In some aspects, the techniques described herein relate to a thermal management method, further including managing thermal energy in a first battery module using the first passageway, and managing thermal energy in a second battery module using the second passageway.

(22) In some aspects, the techniques described herein relate to a thermal management method, wherein a diameter of an opening to the first passageway is the same as a diameter of an opening to the second passageway, wherein a diameter of an opening from the first passageway is the same as a diameter of an opening from the second passageway.

(23) The embodiments, examples and alternatives of the preceding paragraphs, the claims, or the following description and drawings, including any of their various aspects or respective individual features, may be taken independently or in any combination. Features described in connection with one embodiment are applicable to all embodiments, unless such features are incompatible.

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## Description

### BRIEF DESCRIPTION OF THE FIGURES

(1) The various features and advantages of the disclosed examples will become apparent to those skilled in the art from the detailed description. The figures that accompany the detailed description can be briefly described as follows:

(2) FIG. 1 illustrates a highly schematic view of a powertrain for an electrified vehicle.

(3) FIG. 2 illustrates how a battery pack of the powertrain of FIG. 1 can be positioned within the electrified vehicle according to an exemplary aspect of the present disclosure.

(4) FIG. 3 illustrates a perspective view of the battery pack of FIG. 2 with selected portions removed to reveal an interior area of battery pack.

(5) FIG. 4 illustrates a top view of selected portion of the battery pack of FIG. 3 in highly schematic form.

(6) FIG. 5 illustrates a schematic perspective view of a selected portions of a battery pack according to another exemplary embodiment of the present disclosure.

### DETAILED DESCRIPTION

(7) This disclosure details assemblies and methods associated with moving coolant through a

battery pack. The coolant is moved through the battery pack in a way that helps to reduce pressure losses associated with moving the coolant through the battery.

(8) FIG. 1 schematically illustrates a powertrain **10** for an electrified vehicle. Although depicted as a hybrid electrified vehicle (HEV), it should be understood that the concepts described herein are not limited to HEVs and could extend to other electrified vehicles, including, but not limited to, plug-in hybrid electrified vehicles (PHEVs), fuel cell vehicles (FCVs), and battery electrified vehicles (BEVs).

(9) In one embodiment, the powertrain **10** is a powersplit powertrain system that employs a first drive system and a second drive system. The first drive system includes a combination of an engine **14** and a generator **18** (i.e., a first electric machine). The second drive system includes at least a motor **22** (i.e., a second electric machine), the generator **18**, and a battery pack **24**. In this example, the second drive system is considered an electric drive system of the powertrain **10**. The first and second drive systems generate torque to drive one or more sets of vehicle drive wheels **28** of the electrified vehicle.

(10) The engine **14**, which is an internal combustion engine in this example, and the generator **18** may be connected through a power transfer unit **30**. In one non-limiting embodiment, the power transfer unit **30** is a planetary gear set that includes a ring gear **32**, a sun gear **34**, and a carrier assembly **36**. Of course, other types of power transfer units, including other gear sets and transmissions, may be used to connect the engine **14** to the generator **18**.

(11) The generator **18** can be driven by engine **14** through the power transfer unit **30** to convert kinetic energy to electrical energy. The generator **18** can alternatively function as a motor to convert electrical energy into kinetic energy, thereby outputting torque to a shaft **38** connected to the power transfer unit **30**. Because the generator **18** is operatively connected to the engine **14**, the speed of the engine **14** can be controlled by the generator **18**.

(12) The ring gear **32** of the power transfer unit **30** may be connected to a shaft **40**, which is connected to vehicle drive wheels **28** through a second power transfer unit **44**. The second power transfer unit **44** may include a gear set having a plurality of gears **46**. Other power transfer units may also be suitable. The gears **46** transfer torque from the engine **14** to a differential **48** to ultimately provide traction to the vehicle drive wheels **28**. The differential **48** may include a plurality of gears that enable the transfer of torque to the vehicle drive wheels **28**. In this example, the second power transfer unit **44** is mechanically coupled to an axle **50** through the differential **48** to distribute torque to the vehicle drive wheels **28**.

(13) The motor **22** (i.e., the second electric machine) can also be employed to drive the vehicle drive wheels **28** by outputting torque to a shaft **52** that is also connected to the second power transfer unit **44**. In one embodiment, the motor **22** and the generator **18** cooperate as part of a regenerative braking system in which both the motor **22** and the generator **18** can be employed as motors to output torque. For example, the motor **22** and the generator **18** can each output electrical power to the battery pack **24**.

(14) The battery pack **24** is an example type of electrified vehicle battery assembly. The battery pack **24** may have the form of a high-voltage battery that is capable of outputting electrical power to operate the motor **22** and the generator **18**. The battery pack **24** is a traction battery pack as the battery pack **24** can provide power to propel the vehicle drive wheels **28**. The battery pack **24** includes a plurality of battery arrays **54**.

(15) With reference to FIG. 2-4, the battery pack **24** can be secured to an electrified vehicle **58** and, in particular, to an underside of the electrified vehicle **58**. The battery pack **24**, in this example, includes two battery arrays **54** held within an interior area provided by an enclosure **62**. In other examples, the battery pack **24** could include more than two battery arrays, or a single battery array, within the enclosure **62**. Each of the battery arrays **54** can include a plurality of individual battery cells **64**. The battery cells **64** for each of the battery arrays **54** are distributed along a respective array axis A.sub.A.

(16) The example enclosure **62** includes a cover **66** and a tray **70**. The cover **66** and tray **70** can be polymer-based. Alternatively, the cover **66**, the tray **70**, or both can be a metal or metal alloy.

(17) The battery arrays **54** are disposed along a pack axis A.sub.p that extends from a front end **74** of the battery pack **24** to a rear end **78** of the battery pack **24**. Front and rear are with reference to the general orientation of the battery pack **24** when the battery pack **24** is installed within the vehicle **58**. The pack axis A.sub.P runs parallel with a longitudinal axis of the vehicle **58** in this example. The array axes A.sub.A are perpendicular to the pack axis A.sub.P in this example

(18) During operation of the vehicle **58**, operation of the battery pack **24**, or both, thermal energy levels within the battery pack **24** can change. Coolant can be moved through areas within the battery pack **24** to exchange thermal energy with areas of the battery pack **24**, which can cool or heat these areas. The coolant can be a liquid coolant.

(19) In this example, the battery pack **24** includes a thermal exchange assembly **84** that helps to communicate coolant and manage thermal energy within the battery pack **24**. The battery arrays **54** are disposed adjacent the thermal exchange assembly **84**. Thermal energy can move, for example, from the battery arrays **54**, to the thermal exchange assembly **84**, and to coolant communicating through the thermal exchange assembly **84**.

(20) The example thermal exchange assembly **84** includes a first passageway **90** and a second passageway **94** that is separate and distinct from the first passageway **90**. The first passageway **90** extends through the thermal exchange assembly **84** directly beneath one of the battery arrays **24**. The second passageway **94** extends through the thermal exchange assembly **84** directly beneath the other one of the battery arrays **24**. The thermal exchange assembly **84** can include separate plate structures that each provide one of the first or the second passageways **90**, **94**. The thermal exchange assembly **84** could instead be a single monolithic structure.

(21) The first and second passageways **90**, **94** are each beneath only one of the battery arrays **54** in this example. In other examples, the first and second passageways **90**, **94** could each extend beneath or adjacent to more than one of the battery arrays **54**.

(22) In this example, an inlet conduit **100** and an outlet conduit **104** are used to communicate coolant between the thermal exchange assembly **84** and an exterior of the battery pack **24**. The inlet conduit **100** and the outlet conduit **104** could be a polymer-based material such as rubber, a metal, or a metal alloy. The inlet conduit **100** and the outlet conduit **104** are flexible hoses in this example. Notably, several individual structures can be joined together to provide the inlet conduit **100**. Similarly, several individual structures can be joined together to provide the outlet conduit **104**.

(23) The inlet conduit **100** and the outlet conduit **104** are on opposite sides of the battery pack **24**. In this example, the inlet conduit **100** is on a first side **110** of the battery pack **24** and the outlet conduit **104** is on a second side **114** of the battery pack **24**. The first side **110** is on the driver side and the second side **114** is the passenger side in this example. The first and second passageways **90**, **94** deliver coolant from the first side **110** to the second side **114**.

(24) The inlet conduit **100** delivers coolant to the thermal exchange assembly **84** and, more particularly, delivers coolant to both the first passageway **90** and the second passageway **94** defined by the thermal exchange assembly **84**. The outlet conduit **104** receives coolant from the thermal exchange assembly **84** and, more particularly, from both the first passageway **90** and the second passageway **94**.

(25) In this example, a pump **120** outside the battery pack **24** circulates coolant through the inlet conduit **100**, the thermal exchange assembly **84**, and the outlet conduit **104**. Coolant from the outlet conduit **104** moves to a thermal energy exchanger **124**, which, when the coolant is a liquid coolant, can be a liquid-to-air heat exchanger.

(26) In this example, the inlet conduit **100** and the outlet conduit **104** both extend through the front end **74** of the battery pack **24**. In another example the inlet conduit **100** and the outlet conduit **104** both extend through the rear end **78** of the battery pack **24**.

(27) One of the inlet conduit **100** or the outlet conduit **104**, here the outlet conduit **104**, is looped or

doubled back. Due to the looping, coolant moves through the outlet conduit **104** in a first axial direction **D1** and then turns and moves through the outlet conduit **104** in an opposite, second axial direction **D2**.

(28) Without the looping of the outlet conduit **104**, the coolant that is moved through the first passageway **90** would travel a greater distance than the coolant moved through the battery pack **24**. The looping helps to ensure that the coolant moved through the battery pack **24** all travels about the same distance when circulating through the battery pack **24**.

(29) In this example, the inlet conduit **100** is arranged such that the delivering of coolant to passageway **94** is upstream from the delivering of coolant to the passageway **90**. The outlet conduit **104** is arranged such that the receipt of coolant from the passageway **94** is upstream from the receipt of coolant from the passageway **90**. Upstream with reference to a general direction of flow through the inlet conduit **100** and outlet conduit **104**. Accordingly, to exit the battery pack **24**, coolant that has moved through the passageway **94** travels a further distance than coolant that has moved through the passageway **90**. This compensates for the greater distances that the coolant moved through the passageway **90** must travel to reach the passageway **90** when compared to the coolant moved through the passageway **94**.

(30) In the past, because of, among other things, different distances that coolant travels within a battery pack, resulted in flow pressure losses associated with moving coolant through the battery pack. To reduce these flow pressure losses, many battery packs incorporated restrictors within the coolant flow path. For example, a diameter of the shortest flow path would be reduced relative to a diameter of a longer flow path. Incorporating restrictors, among other things, added build complexity and further increases flow pressure losses.

(31) In this example, an opening to the passageway **90** has a diameter that is the same as a diameter opening to the passageway **94**. Also, an opening from the passageway **90** has a diameter that is the same as a diameter of an opening from the passageway **94**.

(32) Returning again to FIGS. **3** and **4**, due to the looping of the inlet conduit **100** or the outlet conduit **104**, the flow pressure loss associated with circulating coolant through the battery pack **24** is reduced. This can reduce or eliminate the need for restrictors.

(33) With reference to FIG. **5**, this approach can be incorporated into a multi-tier battery pack **24A** where battery arrays and thermal exchange assemblies **84A** are on a lower tier that is vertically beneath other battery arrays and thermal exchanges assemblies **84B** on an upper tier. Vertical is with reference to ground and a general orientation of the vehicle **58** (FIG. **2**) during operation.

(34) An inlet conduit **100A** delivers coolant to passageways **90A** associated with battery arrays of a vertically lower tier, and then to passageways **90B** associated with battery arrays of a vertically upper tier. An outlet conduit **104A** receives coolant from the passageways **90A** of the lower tier and then from the passageways **90B** of the upper tier. Accordingly, coolant exiting the multi-tier battery pack **24A** all travels about the same distance within the battery pack **24A**.

(35) The inlet conduit **100A** and the outlet conduit **104A** interfaces with a common end of the battery pack **24A**. The inlet conduit **100A** and the outlet conduit **104A** are on opposite sides of the battery pack **24A**.

(36) The preceding description is exemplary rather than limiting in nature. Variations and modifications to the disclosed examples may become apparent to those skilled in the art that do not necessarily depart from the essence of this disclosure. Thus, the scope of protection given to this disclosure can only be determined by studying the following claims.

## Claims

1. A traction battery assembly, comprising: a plurality of battery arrays of a battery pack; a thermal exchange assembly having a plurality of passageways that each communicate coolant from a first side of the battery pack to an opposite, second side of the battery pack; an inlet conduit on the first

side, the inlet conduit configured to deliver the coolant to a first one of the plurality of passageways and to deliver the coolant to a second one of the plurality of passageways, the inlet conduit arranged such that the delivering of coolant to the first one of the plurality of passageways is upstream from the delivering of coolant to the second one of the plurality of passageways; and an outlet conduit on the second side, the outlet conduit configured to receive the coolant from the first one of the plurality of passageways and receive the coolant from the second one of the plurality of passageways, the outlet conduit arranged such that the receiving of coolant from the first one of the plurality of passageways is upstream from the receiving of coolant from the second one of the plurality of passageways, the plurality of battery arrays are disposed along a pack axis that extends from a front end of the battery pack to a rear end of the battery pack; and the inlet conduit and the outlet conduit both extend through the rear end of the battery pack.

2. A traction battery assembly, comprising: a plurality of battery arrays of a battery pack; a thermal exchange assembly having a plurality of passageways that each communicate coolant from a first side of the battery pack to an opposite, second side of the battery pack; an inlet conduit on the first side, the inlet conduit configured to deliver the coolant to a first one of the plurality of passageways and to deliver the coolant to a second one of the plurality of passageways, the inlet conduit arranged such that the delivering of coolant to the first one of the plurality of passageways is upstream from the delivering of coolant to the second one of the plurality of passageways; and an outlet conduit on the second side, the outlet conduit configured to receive the coolant from the first one of the plurality of passageways and receive the coolant from the second one of the plurality of passageways, the outlet conduit arranged such that the receiving of coolant from the first one of the plurality of passageways is upstream from the receiving of coolant from the second one of the plurality of passageways, wherein the inlet conduit and the outlet conduit both extend through the front end of the battery pack or both extend through the rear end of the battery pack, wherein one of the inlet conduit or the outlet conduit is looped such that coolant moves axially in a first direction and then in an opposite, second axial direction.

3. The traction battery assembly of claim 1, wherein the battery arrays each include a plurality of battery cells disposed along a respective array axis that is perpendicular to the pack axis.

4. A traction battery assembly, comprising: a plurality of battery arrays of a battery pack; a thermal exchange assembly having a plurality of passageways that each communicate coolant from a first side of the battery pack to an opposite, second side of the battery pack; an inlet conduit on the first side, the inlet conduit configured to deliver the coolant to a first one of the plurality of passageways and to deliver the coolant to a second one of the plurality of passageways, the inlet conduit arranged such that the delivering of coolant to the first one of the plurality of passageways is upstream from the delivering of coolant to the second one of the plurality of passageways; and an outlet conduit on the second side, the outlet conduit configured to receive the coolant from the first one of the plurality of passageways and receive the coolant from the second one of the plurality of passageways, the outlet conduit arranged such that the receiving of coolant from the first one of the plurality of passageways is upstream from the receiving of coolant from the second one of the plurality of passageways, wherein the battery pack is a multi-tier battery pack such that a first battery array of the plurality of battery arrays and the first one of the plurality of passageways are vertically beneath a second battery array of the plurality of battery arrays and the second one of the plurality of passageways, wherein the inlet conduit and the outlet conduit both extend through a front end of the battery pack or both extend through a rear end of the battery pack.

5. The traction battery assembly of claim 1, wherein openings to the first and second passageways from the inlet conduit are the same diameter, and openings from the first and second passageways to the outlet conduit are the same diameter.

6. The traction battery assembly of claim 1, wherein the inlet conduit and the outlet conduit are flexible hoses.

7. The traction battery assembly of claim 1, wherein the coolant is a liquid coolant.



8. The traction battery assembly of claim 1, wherein the plurality of battery arrays are disposed atop the thermal exchange assembly such that first one of the plurality of passageways is beneath one of the plurality of arrays, and a second one of the plurality of battery arrays is beneath another one of the plurality of arrays.
  9. The traction battery assembly of claim 1, wherein the first side is driver side and the second side is a passenger side.
  10. The traction battery of claim 1, wherein upstream is with reference to a general direction of flow through the respective inlet conduit or outlet conduit.
  11. The traction battery of claim 1, wherein the thermal exchange assembly is a separate and distinct component from the plurality of battery arrays of the battery pack.
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