SUMMARY OF THE DISCLOSURE

[0006] In a first ~~aspect~~ example of the disclosure, there is provided a battery module comprising: at least one cell enclosure for housing a plurality of battery cells; and a cooling assembly: comprising a cooling channel extending from an aperture in a first side of the battery module to an aperture in a second side of the battery module; and positioned such that heat generated within the cell enclosure may be transferred to a cooling fluid flowing, via the cooling channel, from the first side of the battery module to the second side of the battery module. Thus, a first exterior side of the module may be fluidly connected to a second exterior side of the module.

[0007] The battery module may further comprise an exhaust assembly comprising an exhaust channel extending from an aperture in one side of the battery module to an aperture in another side of the battery module; and an exhaust port extending from the cell enclosure to the exhaust channel. The exhaust channel may extend from an aperture in the first side of the battery module to an aperture in the second side of the battery module.

[0008] The battery module may further comprise a seal sealing the exhaust port and configured to open in response to a pressure within the cell enclosure reaching a critical pressure and thereby allowing exhaust gases to flow from the cell enclosure to the exhaust channel. The seal may be configured to open in response to thermal runaway occurring within the cell enclosure.

[0009] The exhaust port may extend through the cooling channel.

[0010] The cooling assembly may be located between the cell enclosure and the exhaust assembly.

[0011] The at least one cell enclosure may comprise first and second cell enclosures on respective sides of the battery module, and the cooling channel may extend between the first and second cell enclosures. The cooling channel may extend along a length of each of the first and second cell enclosures.

[0012] The battery module may further comprise a heat sink provided on one or more sides of the battery module. The heat sink may comprise one or more cooling fins. The heat sink may comprise a spreader plate or heat pipes for directing heat to the cooling assembly.

[0013] The battery module may further comprise at least one first locking member extending from an upper or lower edge of the battery module. The battery module may further comprise at least one first locking member extending from an upper or lower corner of the battery module.

[0021] The battery module may further comprise a heat sink adjacent the cell enclosure. The heat sink may fluidly connect the cooling channel and an exterior of the battery module; and heat generated within the cell enclosure may be transferred away from the battery module by being transferred to a cooling fluid flowing from the cooling channel to the exterior of the battery module, via the heat sink. The heat sink may comprise a fluid flow path extending from the cooling channel into the heat sink via one or more inlets, and returning from the heat sink into the cooling channel via one or more outlets; and heat generated within the cell enclosure may be transferred away from the battery module by being transferred to a cooling fluid entering the cooling channel from the first side of the battery module, flowing to the fluid flow path, returning to the cooling channel, and exiting the cooling channel to the second side of the battery module.

[0022] One or more of the cooling channel, the exhaust channel, and the power socket may extend through the heat sink.

[0023] The cooling fluid may comprise one or more of: forced air, liquid coolant, or air flowing by convection.

[0024] The battery module may further comprise one or more male connectors on one of a top side and a bottom side of the battery module, and one or more female connectors on the other of the top side and the bottom side of the battery module, and at least one of the connectors may comprise a tapered portion. For example, the one or more female connectors may comprise a tapered portion.

[0025] The one or more male connectors may comprise the at least one first locking member, and the one or more female connectors may comprise the at least one second locking member.

[0026] The one or more male connectors may comprise one or more power pins, and the one or more male connectors may comprise one or more power sockets.

[0027] In a further ~~aspect~~ example of the disclosure, there is provided a battery module stack comprising multiple battery modules, each battery module comprising: at least one cell enclosure for housing a plurality of battery cells; and a cooling assembly comprising a cooling channel: extending from an aperture in a first side of the battery module to an aperture in a second side of the battery module; and positioned such that heat generated within the cell enclosure may be transferred to a cooling fluid flowing, via the cooling channel, from the first side of the battery module to the second side of the battery module, wherein the battery modules are arranged in a stacked formation such that the cooling channel of at least one battery module is aligned with the cooling channel of at least one adjacent battery module.

[0027a] In one aspect, the present disclosure refers to a battery module stack comprising:

multiple battery modules, each battery module comprising:

at least one cell enclosure for housing a plurality of battery cells; and

a cooling assembly comprising a cooling channel:

extending from an aperture in a lower side of the battery module to an aperture in an upper side of the battery module; and

positioned such that heat generated within the cell enclosure may be transferred to a cooling fluid flowing, via the cooling channel, from the first side of the battery module to the second side of the battery module,

wherein the battery modules are arranged in a vertically stacked formation such that the cooling channel of at least one battery module is aligned with the cooling channel of at least one adjacent battery module, and wherein the cooling channel of an uppermost battery module of the stack is sealed.

[0028] The battery module stack may further comprise a base at a bottom of the stacked formation; and an air delivery device configured to cause air to flow through the base and through the

battery module in response to a further battery module being stacked on top of the immediately adjacent upper battery module.

[0037] In a further ~~aspect~~ example of the disclosure, there is provided a method of assembling a battery module stack by stacking multiple battery modules to form a stacked formation, wherein: each battery module comprises: at least one cell enclosure for housing a plurality of battery cells; and a cooling assembly: comprising a cooling channel extending from an aperture in a first side of the battery module to an aperture in a second side of the battery module; and positioned such that heat generated within the cell enclosure may be transferred to a cooling fluid flowing, via the cooling channel, from the first side of the battery module to the second side of the battery module; and wherein the stacked formation is such that the cooling channel of at least one battery module is aligned with the cooling channel of at least one adjacent battery module.

[0037a] In another aspect, the present disclosure refers to a method of assembling a battery module stack by vertically stacking multiple battery modules to form a stacked formation, wherein:

each battery module comprises:

at least one cell enclosure for housing a plurality of battery cells; and

a cooling assembly:

comprising a cooling channel extending from an aperture in a first side of the battery module to an aperture in a second side of the battery module; and

positioned such that heat generated within the cell enclosure may be transferred to a cooling fluid flowing, via the cooling channel, from the first side of the battery module to the second side of the battery module; and

wherein the stacked formation is such that the cooling channel of at least one battery module is aligned with the cooling channel of at least one adjacent battery module, and wherein the cooling channel of an uppermost battery module of the stack is sealed.

[0038] The method may further comprise positioning a cover on top of the stacked formation such that the cooling channel of the uppermost battery module of the stacked formation is sealed. The method may further comprise using a stabilizing mechanism to apply compression to the stacked formation for stabilizing the stacked formation.

[0039] In a further ~~aspect~~ example of the disclosure, there is provided a method of using a battery module stack, the battery module stack comprising multiple battery modules, each battery

module comprising: at least one cell enclosure for housing a plurality of battery cells; a cooling assembly comprising a cooling channel: extending from an aperture in a first side of the battery module to an aperture in a second side of the battery module; and positioned such that heat generated within the cell enclosure may be transferred to a cooling fluid flowing, via the cooling channel, from the first side of the battery module to the second side of the battery module, wherein the battery modules are arranged in a stacked formation such that the cooling channel of at least one battery module is aligned with the cooling channel of at least one adjacent battery module, the method comprising: identifying a battery module in need of removal from the stacked formation; engaging a lifting mechanism with the battery module immediately above the identified battery module; and using the lifting mechanism to lift the battery modules above the identified battery module from the stacked formation.

[0039a] In another aspect, the present disclosure refers to a method of using a battery module stack, the battery module stack comprising multiple battery modules, each battery module comprising:

at least one cell enclosure for housing a plurality of battery cells;

a cooling assembly comprising a cooling channel:

extending from an aperture in a lower side of the battery module to an aperture in an upper side of the battery module; and

positioned such that heat generated within the cell enclosure may be transferred to a cooling fluid flowing, via the cooling channel, from the first side of the battery module to the second side of the battery module,

wherein the battery modules are arranged in a vertically stacked formation such that the cooling channel of at least one battery module is aligned with the cooling channel of at least one adjacent battery module, and wherein the cooling channel of an uppermost battery module of the stack is sealed, the method comprising:

identifying a battery module in need of removal from the stacked formation;

engaging a lifting mechanism with the battery module immediately above the identified battery module; and

using the lifting mechanism to lift the battery modules above the identified battery module from the stacked formation.

[0040] In a further aspect of the disclosure, there is provided a method of making a battery module stack, comprising: using a lifting mechanism to position a battery module stack as disclosed herein into a predetermined location relative to an interface base, wherein in the predetermined location the cooling channels of the battery module stack are aligned within one or more apertures formed in the interface base, such that air delivered through the interface base may flow into the cooling channels of the battery module stack.

CLAIMS

1. A battery module comprising:

at least one cell enclosure for housing a plurality of battery cells; and

a cooling assembly:

comprising a cooling channel extending from an aperture in a first side of the battery module to an aperture in a second side of the battery module; and

positioned such that heat generated within the cell enclosure may be transferred to a cooling fluid flowing, via the cooling channel, from the first side of the battery module to the second side of the battery module.

2. The battery module of claim 1, further comprising:

an exhaust assembly comprising an exhaust channel extending from an aperture in one side of the battery module to an aperture in another side of the battery module; and

an exhaust port extending from the cell enclosure to the exhaust channel.

3. The battery module of claim 2, wherein the exhaust channel extends from an aperture in the first side of the battery module to an aperture in the second side of the battery module.

4. The battery module of claim 2 or 3, further comprising a seal sealing the exhaust port and configured to open in response to a pressure within the cell enclosure reaching a critical pressure and thereby allowing exhaust gases to flow from the cell enclosure to the exhaust channel.

5. The battery module of claim 4, wherein the seal is configured to open in response to thermal runaway occurring within the cell enclosure.

6. The battery module of any one of claims 2-5, wherein the exhaust port extends through the cooling channel.

7. The battery module of any one of claims 1-6, wherein the cooling assembly is located between the cell enclosure and the exhaust assembly.

8. The battery module of any one of claims 1-7, wherein the at least one cell enclosure comprises first and second cell enclosures on respective sides of the battery module, and wherein the cooling channel extends between the first and second cell enclosures.

9. The battery module of claim 8, wherein the cooling channel extends along a length of each of the first and second cell enclosures.

10. The battery module of any one of claims 1-9, further comprising a heat sink provided on one or more sides of the battery module.

11. The battery module of claim 10, wherein the heat sink comprises one or more cooling fins.

12. The battery module of any one of claims 1-11, further comprising at least one first locking member extending from an upper or lower edge of the battery module.

13. The battery module of claim 12, further comprising at least one first locking member extending from an upper or lower corner of the battery module.

14. The battery module of claim 12 or 13, further comprising at least one second locking member located in an edge or corner of the battery module that is opposite an edge or corner of the battery module from which the at least one first locking member extends.

15. The battery module of any one of claims 1-14, further comprising a power and communication assembly comprising one or more of circuitry and a processor configured to monitor one or more battery cells housed within the battery module.

16. The battery module of claim 15, wherein the power and communication assembly is located at a first end of the battery module, and wherein the cooling assembly is located at an opposite, second end of the battery module.

17. The battery module of claim 16, wherein the power and communication assembly is located at a front end of the battery module, and wherein the cooling assembly is located at a rear end of the battery module.

18. The battery module of any one of claims 15-17, wherein the power and communication assembly comprises a power pin movable between a retracted position an extended position.

19. The battery module of claim 18, further comprising a switch configured, when actuated, to cause the power pin to move between the first and second positions.

20. The battery module of any one of claims 15-19, wherein the power and communication assembly further comprises a power socket located on an exterior surface of the battery module.

~~21. The battery module of claim 20, wherein the power socket is located on an underside of the battery module, and wherein the power pin, when in the second position, extends out of an upper side of the battery module.~~

~~22. The battery module of claim 20 or 21, wherein the power pin and the power socket are located directly opposite one another.~~

~~23. The battery module any one of claims 15-22, further comprising a removable panel on a front surface of the battery module for accessing one or more components of the power and communication assembly.~~

~~24. The battery module of any one of claims 15-23, wherein the power and communication assembly further comprises a first optical communication port on one side of the battery module and a second optical communication port on another side of the battery module.~~

~~25. The battery module of any one of claims 15-23, wherein the power and communication assembly further comprises a wireless communications module for communicating with one or more other battery modules.~~

~~26. The battery module of any one of claims 1-25, further comprising a heat sink adjacent the cell enclosure.~~

~~27. The battery module of claim 26, wherein:~~

~~the heat sink fluidly connects the cooling channel and an exterior of the battery module; and~~

~~heat generated within the cell enclosure may be transferred away from the battery module by being transferred to a cooling fluid flowing from the cooling channel to the exterior of the battery module, via the heat sink.~~

~~28. The battery module of claim 27, wherein:~~

~~the heat sink comprises a fluid flow path extending from the cooling channel into the heat sink via one or more inlets, and returning from the heat sink into the cooling channel via one or more outlets; and~~

~~heat generated within the cell enclosure may be transferred away from the battery module by being transferred to a cooling fluid entering the cooling channel from the first side of the battery module, flowing to the fluid flow path, returning to the cooling channel, and exiting the cooling channel to the second side of the battery module.~~

~~29. The battery module of any one of claims 1-28, wherein one or more of the cooling channel, the exhaust channel, and the power socket extends through the heat sink.~~

~~30. The battery module of any one of claims 1-29, wherein the cooling fluid comprises one or more of: forced air, liquid coolant, or air flowing by convection.~~

~~31. The battery module of any one of claims 1-30, further comprising one or more male connectors on one of a top side and a bottom side of the battery module, and one or more female connectors on the other of the top side and the bottom side of the battery module, and wherein at least one of the connectors comprises a tapered portion.~~

~~32. The battery module of claim 31, wherein the one or more male connectors comprise the at least one first locking member, and wherein the one or more female connectors comprise the at least one second locking member.~~

~~33. The battery module of claim 31 or 32, wherein the one or more male connectors comprise one or more power pins, and wherein the one or more male connectors comprise one or more power sockets.~~

~~34. The battery module of any one of claims 1-30, further comprising one or more male power connectors and one or more female male power connectors, wherein at least one of the power connectors is configured to float relative to the cell enclosure.~~

~~35.~~1. A battery module stack comprising:

multiple battery modules, each battery module comprising:

at least one cell enclosure for housing a plurality of battery cells; and

a cooling assembly comprising a cooling channel:

extending from an aperture in a ~~first~~ lower side of the battery module to an aperture in an ~~second~~ upper side of the battery module; and

positioned such that heat generated within the cell enclosure may be transferred to a cooling fluid flowing, via the cooling channel, from the first side of the battery module to the second side of the battery module,

wherein the battery modules are arranged in a vertically stacked formation such that the cooling channel of at least one battery module is aligned with the cooling channel of at least one adjacent

battery module, and wherein the cooling channel of an uppermost battery module of the stack is sealed.

2. The battery module stack of claim 1, wherein gaps are provided between adjacent modules of the stack to direct cooling fluid out of the sides of the stack.

~~36.~~3. The battery module stack of claim ~~35~~1 or 2, further comprising:

a base at a bottom of the stacked formation; and

an air delivery device configured to cause air to flow through the base and through the cooling channels of the stacked battery modules, via a cooling channel formed within the base and in fluid communication with the cooling channels of the stacked battery modules.

~~37.~~4. The battery module stack of ~~claim 35 or 36~~any one of claims 1 to 3, wherein:

each battery module further comprises:

an exhaust assembly comprising an exhaust channel extending from an exhaust aperture in the lower~~a first~~ side of the battery module to an exhaust aperture in the upper~~a second~~ side of the battery module; and

an exhaust port extending from the cell enclosure to the exhaust channel; and

the exhaust channel of at least one battery module is aligned with the exhaust channel of at least one adjacent battery module.

~~38.~~5. The battery module stack of claim ~~37~~4 when dependent from claim 3, wherein the base comprises an exhaust outlet in fluid communication with the exhaust channels of the stacked battery modules.

~~39.~~6. The battery module stack of any one of claims ~~35-38~~1 to 5, further comprising a pack controller communicatively coupled with the battery modules, and operable to control operation of the battery modules.

~~40.~~7. The battery module stack of claim ~~39~~6, wherein the pack controller is stacked with the battery modules.

~~41.~~8. The battery module stack of any one of claims ~~35-40~~1 to 7, further comprising a cover positioned on top of the stacked formation ~~such that~~to seal the cooling channel of ~~an~~ the uppermost battery module of the stack~~ed formation is sealed~~.

42.9. The battery module stack of any one of claims 35-411 to 8, further comprising a stabilizing mechanism configured to apply compression to the stacked formation for stabilizing the stacked formation.

43.10. The battery module stack of claim 9 when dependent from claim 842, wherein the stabilizing mechanism comprises one or more cables or bars attached to the cover and to one or more points at least as low as a lowermost battery module of the stacked formation.

44.11. The battery module stack of any one of claims 35-431 to 10, wherein each battery module further comprises one or more locking members engaging with corresponding locking members of one or more of an immediately adjacent upper battery module and an immediately adjacent lower battery module.

45.12. The battery module stack of claim 4411, wherein the one or more locking members of a battery module are configured to engage with the corresponding locking members of an immediately adjacent upper battery module in response to a further battery module being stacked on top of the immediately adjacent upper battery module.

46.13. A method of assembling a battery module stack by vertically stacking multiple battery modules to form a stacked formation, wherein:

each battery module comprises:

at least one cell enclosure for housing a plurality of battery cells; and

a cooling assembly:

comprising a cooling channel extending from an aperture in a first side of the battery module to an aperture in a second side of the battery module; and

positioned such that heat generated within the cell enclosure may be transferred to a cooling fluid flowing, via the cooling channel, from the first side of the battery module to the second side of the battery module; and

wherein the stacked formation is such that the cooling channel of at least one battery module is aligned with the cooling channel of at least one adjacent battery module, and wherein the cooling channel of an uppermost battery module of the stack is sealed.

47.14. The method of claim 1346, further comprising:

positioning a cover on top of the stacked formation ~~such that~~to seal the cooling channel of the uppermost battery module of the stacked formation ~~is sealed~~.

~~48.~~15. The method of claim ~~47~~14, further comprising using a stabilizing mechanism to apply compression to the stacked formation for stabilizing the stacked formation.

~~49.~~16. A method of using a battery module stack, the battery module stack comprising multiple battery modules, each battery module comprising:

at least one cell enclosure for housing a plurality of battery cells;

a cooling assembly comprising a cooling channel:

extending from an aperture in a ~~first~~ lower side of the battery module to an aperture in an ~~second~~ upper side of the battery module; and

positioned such that heat generated within the cell enclosure may be transferred to a cooling fluid flowing, via the cooling channel, from the first side of the battery module to the second side of the battery module,

wherein the battery modules are arranged in a vertically stacked formation such that the cooling channel of at least one battery module is aligned with the cooling channel of at least one adjacent battery module, and wherein the cooling channel of an uppermost battery module of the stack is sealed, the method comprising:

identifying a battery module in need of removal from the stacked formation;

engaging a lifting mechanism with the battery module immediately above the identified battery module; and

using the lifting mechanism to lift the battery modules above the identified battery module from the stacked formation.

~~50.~~17. A method of making a battery module stack, comprising:

using a lifting mechanism to position a battery module stack according to ~~any one of claims 34-44~~claim 1 into a predetermined location relative to an interface base, wherein in the predetermined location the cooling channels of the battery module stack are aligned within one or more apertures formed in the interface base, such that air delivered through the interface base may flow into the cooling channels of the battery module stack.