January 2023

Thermal Management of Rack Batteries

n/a

Thermal Management of Rack Batteries

ABSTRACT

This disclosure describes techniques for thermal management of batteries in data center racks. Superior battery thermal management is realized by separation of the battery thermal cooling path and the flame propagation path. Thermal energy is conducted away from the regions where the heat is generated, e.g., the core cell pack, which is cooled using a combination of different external surfaces and/or airflow. In some implementations, a metal plate is provided at an upper surface of the batteries such that it is in contact with the battery cell holders and can conduct heat away from the battery cells. The metal plate is attached to a heat sink that is located in a separate enclosure and which dissipates the heat. In some implementations, heat pipes, thermo-electric coolers, phase change materials, and/or cold plates can be utilized for superior thermal management of the batteries.

KEYWORDS

- Flame propagation path
- Cooling path
- Server rack
- Thermal performance
- Battery temperature
- Thermal management
- Phase change material (PCM)
- Thermo-electric cooling (TEC)
- Heat exchanger
- Heat pipe
- Heat sink
- Cold plate

BACKGROUND

In order to facilitate uninterrupted operation, racks deployed in data centers utilize batteries to serve as power backup during power failure events. Thermal management of batteries can provide better battery performance. Safety considerations in a data center necessitate the use of a flame propagation path that requires restriction of flames using flame arresters during a fire event. State-of-the-art cooling designs of batteries commonly utilize the same flow path for both cooling air and flame propagation. The flame arresters also act as airflow blockers and thus restrict cooling capabilities. Besides, the environmental air can be at relatively high temperatures, thereby limiting its cooling ability.

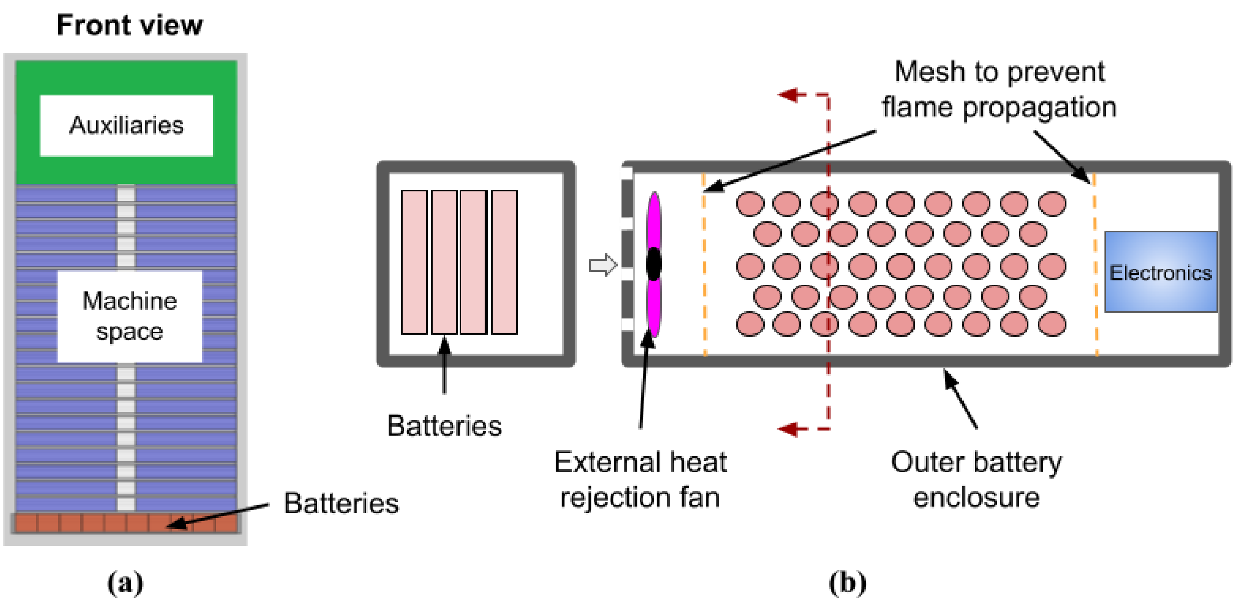

Fig. 1: Rack configuration and battery cooling architecture

Fig. 1 depicts an example configuration of a rack utilized in a data center. As depicted in Fig. 1(a), the rack includes auxiliaries disposed towards an upper portion of the rack, a machine space to house computing devices (e.g., servers), and batteries that are disposed towards the lower portion of the rack.

Fig. 1(b) depicts cross-sectional and side views of the lower portion of the rack. As depicted in Fig. 1(b), an external heat rejection fan is utilized to provide airflow through the battery cells for thermal management of the batteries and to keep the batteries from attaining high temperatures which can degrade their performance. The battery enclosure also includes flame propagation meshes to prevent flame propagation in the event of a fire.

This configuration can be insufficient for optimal thermal management since the batteries can attain higher temperatures due to heat transfer from the environment around batteries since the environmental air is in direct contact with batteries. For example, hot air from the aisle, heating effects from neighboring hardware, and back pressure in the hot aisle can lead to high battery temperatures. Additionally, the flame propagation mesh restricts airflow and limits the cooling of the batteries.

DESCRIPTION

This disclosure describes techniques for thermal management of batteries in data center racks. Per techniques of this disclosure, superior battery thermal management is realized by separation of the battery thermal cooling path and the flame propagation path. This enables additional design choices for battery design by alleviating the tradeoff between thermal performance and flame containment design. Thermal energy is conducted away from the regions where the heat is generated, e.g., the core cell pack, which is cooled using a combination of different external surfaces and/or airflow.

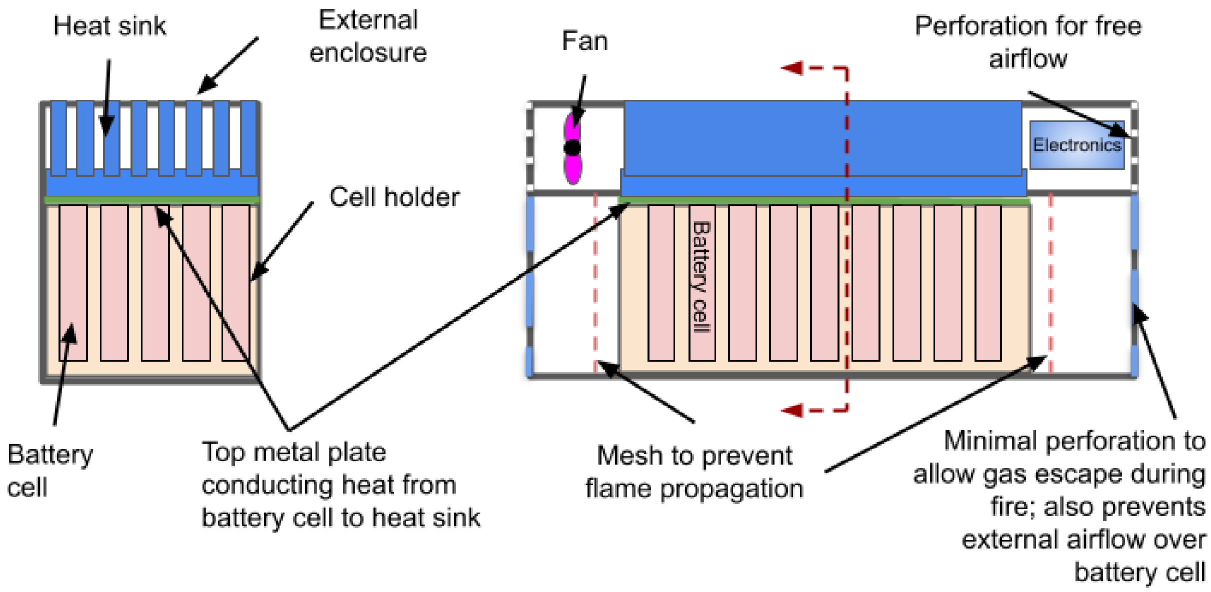

Fig. 2: A heat sink is utilized to dissipate heat from the battery cells

Fig. 2 depicts an example configuration for battery thermal management, per techniques of this disclosure. The batteries are housed in an enclosure that includes meshes to prevent flame propagation. The battery enclosure includes minimal perforation designed to allow gas to escape in the event of a fire, while restricting contact of the batteries with the environmental (hot) air.

As depicted in Fig. 2, a metal plate is provided at an upper surface of the batteries. The metal plate is in contact with the battery cell holders and can conduct heat away from the battery cells. The metal plate is attached to a heat sink that is located in a separate enclosure and which dissipates the heat. A fan is provided to facilitate airflow through the heat sink and to the outside via a perforated enclosure. Separation of the cooling air and the flame propagation paths provides enhancement in cooling capacity due to the airflow for cooling being less restricted. Additionally, separation of the environmental airflow from the batteries further prevents temperature buildup in the batteries.

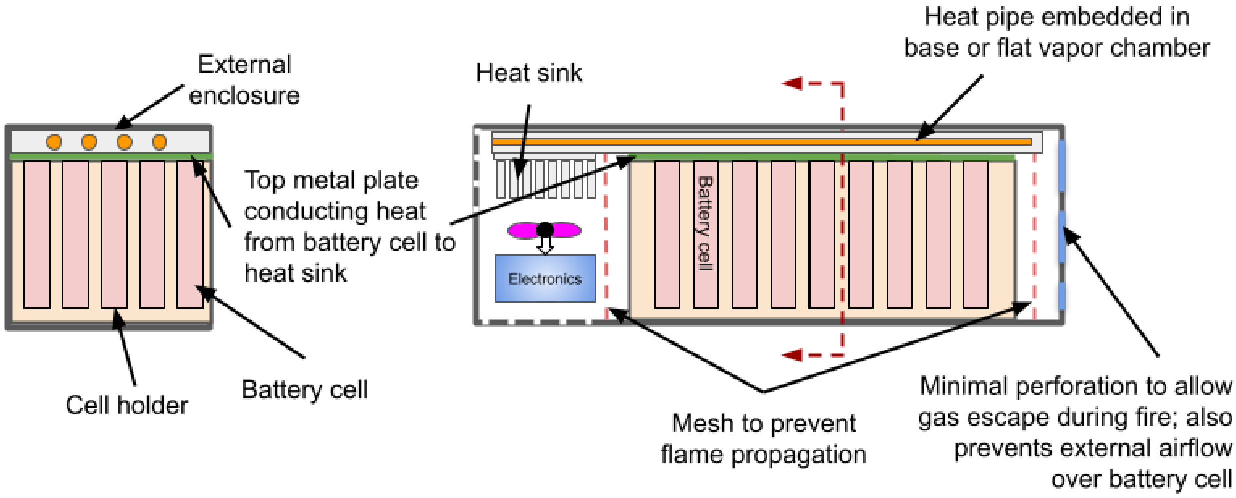

Fig. 3: A heat pipe is utilized for additional heat transfer

Fig. 3 depicts another example configuration for battery thermal management, per techniques of this disclosure. In this configuration, a heat pipe is provided for additional heat transfer from the batteries to a heat sink which dissipates the heat. As depicted in Fig. 3, the heat pipe is embedded in a base or flat vapor chamber.

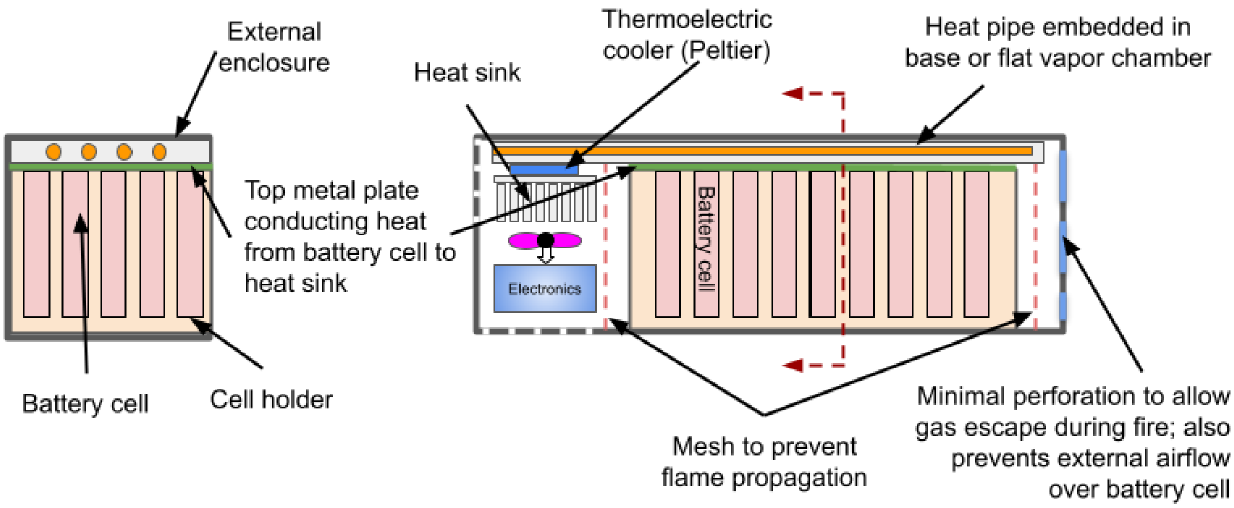

Fig. 4: A Thermoelectric cooler (TEC) is utilized for lower cooling temperatures

Fig. 4 depicts another example configuration for battery thermal management, per techniques of this disclosure. In this configuration, in addition to a heat sink and heat pipe, thermo-electric cooling is utilized to provide additional heat extraction from the batteries. As depicted in Fig. 4, a thermo-electric cooler (TEC) is placed in contact with the heat sink and the heat pipe to provide additional cooling. The TECs can attain temperatures that are below the environmental air temperatures, thus allowing lower cooling temperatures.

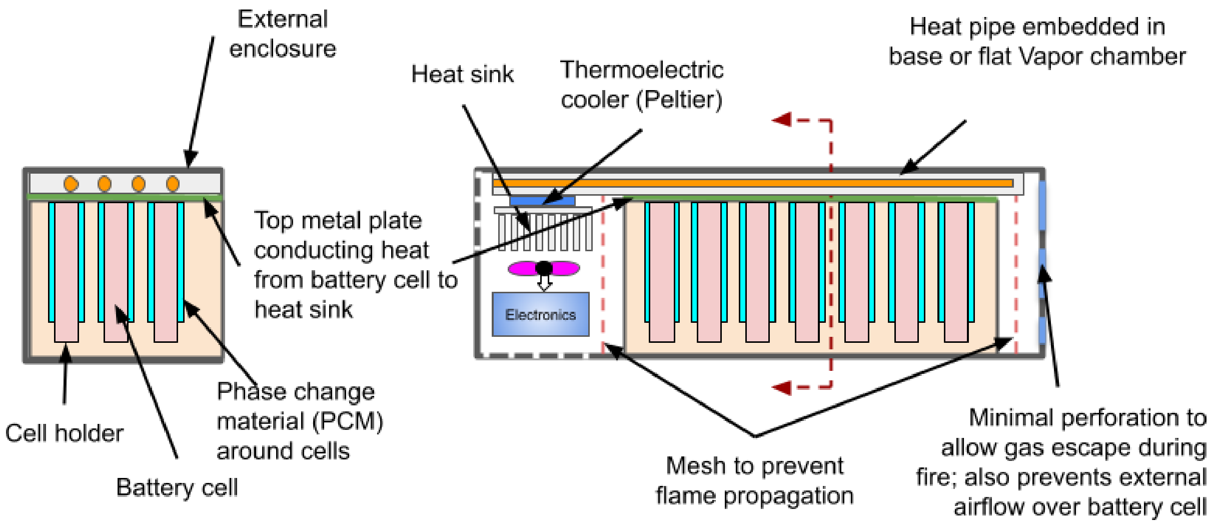

Fig. 5: Phase change Material (PCM) utilized to increase thermal mass of batteries

Fig. 5 depicts another example configuration for battery thermal management, per techniques of this disclosure. In this configuration, phase change material (PCM) is provided around the battery cells for battery pack cooling, as depicted in Fig. 5. The phase change material increases the thermal mass of batteries, and the TECs enable cooling of this larger thermal mass at temperatures substantially lower than those attained in current state-of-the-art designs. The larger thermal mass of the batteries at lower temperatures reduces the likelihood that the batteries reach their temperature limits during short duration events that cause battery heating, e.g., discharge, charge, health check.

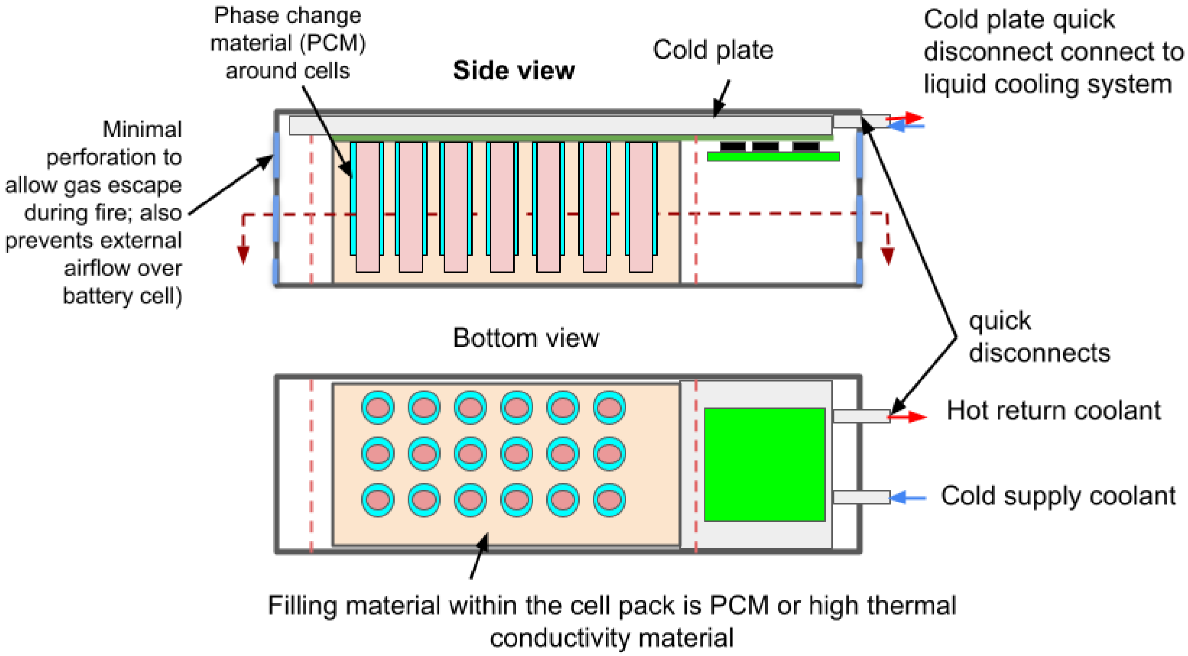

Fig. 6: A cold plate and heat exchanger system utilized for thermal management

Fig. 6 depicts another example configuration for battery thermal management, per techniques of this disclosure. In this configuration, a cold plate is coupled to a rack cooling system by utilizing a quick disconnect. The rack cooling system can be a rack level coolant distribution unit (CDU), an external CDU, or a liquid/air heat exchanger (HX) that is provided inside the rack. The coolant temperature is lower than the environment air which can provide superior thermal management when compared to state-of-the-art cooling techniques.

Techniques of this disclosure can be utilized in different combinations to provide superior thermal management of batteries in racks.

CONCLUSION

This disclosure describes techniques for thermal management of batteries in data center racks. Superior battery thermal management is realized by separation of the battery thermal cooling path and the flame propagation path. Thermal energy is conducted away from the regions where the heat is generated, e.g., the core cell pack, which is cooled using a combination of different external surfaces and/or airflow. In some implementations, a metal plate is provided at an upper surface of the batteries such that it is in contact with the battery cell holders and can conduct heat away from the battery cells. The metal plate is attached to a heat sink that is located in a separate enclosure and which dissipates the heat. In some implementations, heat pipes, thermo-electric coolers, phase change materials, and/or cold plates can be utilized for superior thermal management of the batteries.