February 2021

Integrated Liquid Cooling for Battery Enclosures

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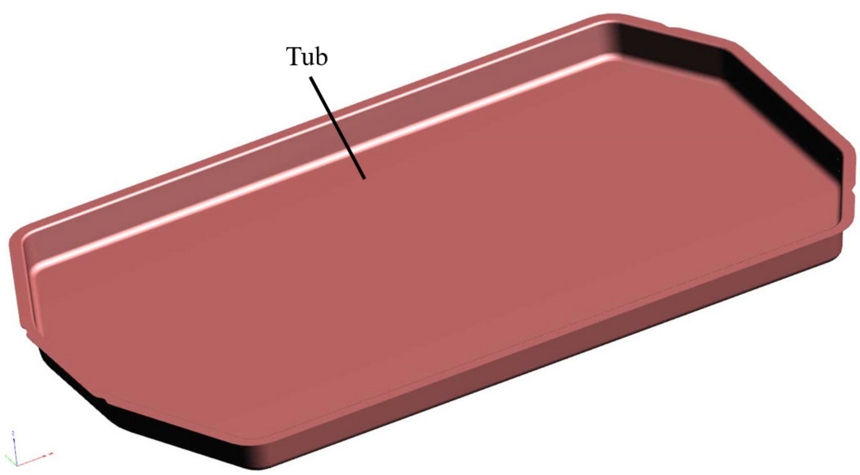
INTEGRATED LIQUID COOLING FOR BATTERY ENCLOSURES

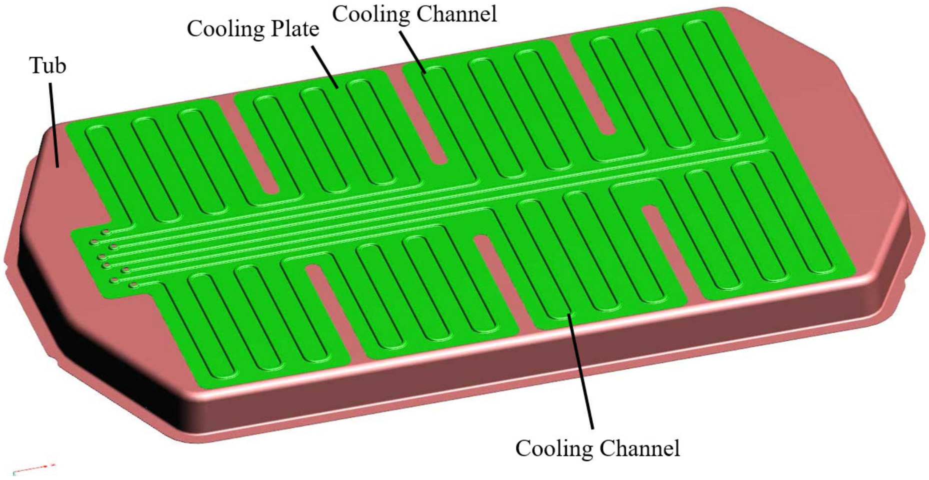
Cooling structures for electronic components such as a battery may utilize liquid cooling, which often uses a mixture of water and glycol similar to the fluid in radiators. The cooling has to ensure optimum thermal conditions for the batteries to be able to quick charge at high rates, such as up to 250 kW, and as such is often provided at a flow rate of approximately 30 L/min. In addition to enabling a quick charge at high rates, the same system needs to be able to warm the battery to a comfortable temperature range in cold weather (or other external temperatures). For optimum heat transfer the cooling plate should be in close contact with the cells. However, putting the cooling plates in the same volume as the battery cells can be dangerous in case of a water leak. For example, if the lithium-ion cells contact water, a fire is almost inevitable.

Disclosed herein is an improved cooling structure that includes a cooling plate integrated with a tub. In particular, the cooling structure includes a thin, single layer aluminum sheet (as a cooling plate) that is welded or bonded to a bottom of a single-piece aluminum sheet tub. This construction eliminates a one-sheet layer and any Thermal Interface Material (TIM). Together, the two parts may form cooling channels that bring cooling fluid in direct contact with the tub, which may provide improved thermal transfer compared to adhesive bonding of a conventional cooling plate. Moreover, in the event of a leak, water cannot get to the cells because the tub has no perforations.

An example of the cooling structure is illustrated below. As illustrated, the tub of the cooling structure does not include any perforations or holes, and the bottom face of the tub is provided with the integrated cooling plate. In various examples, the cooling plate can be structured to allow discrete control over different segments of the battery. Discrete control of different areas may be preferable in certain embodiments to get a portion of the battery more quickly to the desired temperature. In the embodiment illustrate, the cooling structure allows for four sections of the batter ty be selectively heated or cooled.



Top View of Cooling Structure



Bottom View of Cooling Structure

The cooling structure described herein may be formed via various suitable mechanisms or techniques as desired.

In some embodiments, the cooling structure may be a welded assembly. As one example, the cooling structure may be formed by welding the cooling plate to the tub via laser welding or other welding techniques as desired. In some embodiments, the cooling plate is formed in a press to shape the channels, and the cooling plate is then mechanically clamped down to the bottom face of the tub. Because the welds around the edge of the cooling plate (i.e., perimeter welds) must be water leak tight, the perimeter welds would be formed first. The cooling tub may then be subjected to a vacuum, which may allow for control of the weld quality, and the natural air pressure will push the entire surface of the cooling plate to the tub ensuring a minimum gap. In some embodiments, the welds inside the perimeter may be produced very fast (e.g., around 30 m/min.) by remote laser welding or other welding techniques as desired.

In other embodiments, the cooling structure may be a bonded assembly. In such embodiments, a double-sided adhesive film may be cut with a cutter, and the adhesive may bond the cooling plate to the bottom of the tub. In some cases, forming the cooling structure via bonding may be a faster process than via welding.

With the cooling structure described herein, the integrated cooling plate will reduce the number of parts and reduce weight and cost. The number of joints, which over time due to vibration could leak, is reduced. Moreover, should the liquid cooling system be damaged in a crash, a subsequent leak could not reach the battery cells but could drain out without causing additional harm. While the cooling structure is described in the context of batteries, such cooling structures may also be used to actively cool other electronic components, including but not limited to inverters, motors, control circuits, and/or solar panels.