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Effect of Composite Coldplate on Thermal Performance of a EV Battery Module

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Extended Abstract

Electric cars have been growing in popularity as it is anticipated that they will help reduce the usage of fossil fuels by 2030. One of the most important components of these vehicles is the battery. Lithium-ion batteries are commonly used in electric cars due to their higher life cycles, energy density, and lower cost compared to alternative options. While the generally acceptable operating temperature range for lithium-ion batteries is between -20 °C and 60 °C [1], the optimal operating temperature range is between 15 °C and 35 °C. High operating temperatures accelerate battery degradation, and extreme temperatures can cause chemical decomposition of cells, leading to thermal runaway [2]. Therefore, proper thermal management of these batteries is essential for their longevity and safety.

Air cooling, liquid cooling, and cooling using phase change materials are the three most common methods for battery thermal management. While air cooling often falls short in removing energy from the system, phase change materials require precise temperature control, regular replacement, and are expensive. Thus, liquid cooling is generally used for battery cooling. Liquid cooling is implemented through a cold plate, which acts as an interface between the battery pack and the working fluid. Cold plates need to have high thermal conductivity to transfer heat, be lightweight to reduce stress on the battery, and be durable to prevent leakage. While two of these properties are easily found in common materials, there is no single affordable and feasible material that provides all three properties simultaneously. For this reason, in this study, it was considered that composite materials would be an excellent area for plate design to provide all these properties with certain trade-offs. Aluminium and copper are the most common materials for cold plate design. Although aluminium has lower thermal conductivity compared to copper, it is significantly lighter, less expensive, and easier to machine. Therefore, aluminium and copper are considered for designing composite plates.

The aim of the study is to determine the effect of silicon thickness on battery performance of aluminium-silicon composite plates at different charge/discharge rates. A battery module consists of 36 pouch-type batteries (12 in series, 3 in parallel configuration), and various serpentine-type aluminium-silicon composite plates are designed. Multi Scale-Multi Domain (MSMD) and Newman, Tiedemann, Gu, Kim (NTDK) models are used to specify charge/discharge characteristics and volumetric heat generation of the battery, respectively. The K-epsilon turbulence model with standard wall function is used to simulate fluid flow. A 50-50 glycol-water mixture is used as the working fluid.

The results show that the initially designed plates ensure that the battery module remains within the operating temperature range for different discharge rates. Additionally, an increase in silicon thickness reduces the heat transfer rate, consequently increasing the battery temperature. This is expected as the thermal conductivity of silicon is three orders of magnitude lower than that of aluminium. However, it is predicted that the cold plate will have an optimum heat transfer-to-weight ratio that can affect the thermal performance of the battery module.

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