Optimizing Thermal Management and Spatial Efficiency in Electric Vehicle Battery Modules Using Hexagonal Cells with Zig-Zag Cooling Channels

Authors : Emmanuel Ikegwuonu, Sixtus Afam, Godslove Uwumwonse, David Val-Izevbigie, Goodnews Imakpokpomwan

Abstract : The growing demand for electric vehicles has intensified the need for efficient battery thermal management systems to enhance performance, safety, and longevity. This study investigates the spatial efficiency and thermal performance of battery modules utilizing hexagonal cells integrated with a zig-zag liquid cooling channel and makes a comparative analysis with conventional cylindrical cells with serpentine cooling channels. The results revealed that the hexagonal cells offer superior spatial efficiency, occupying less area per cell due to their compact packing structure. This efficiency not only reduces the overall module footprint but also creates opportunities to incorporate additional batteries or enhance thermal management systems, potentially increasing battery capacity and thermal performance. Numerical analysis on ANSYS Fluent showed that the zig-zag cooling channel effectively minimized temperature gradients within the modules. Compared to cylindrical cells, hexagonal cells demonstrated improved thermal uniformity, with lower maximum and average cell temperatures due to their tighter packing and enhanced contact with the coolant. The findings emphasize the combined advantages of hexagonal cells and zig-zag cooling channels in optimizing battery performance for electric vehicles. This research provides valuable insights for the development of next-generation battery modules with enhanced spatial and thermal efficiency, contributing to the advancement of electric vehicle and renewable energy storage technology.

Keywords : battery module, cylindrical cells, electric vehicle, hexagonal cells, serpentine cooling channels, spatial efficiency, thermal management, zig-zag cooling channels
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