Structural and Thermal Performance Evaluation of Microchannel Heat Exchanger Headers Through Ansys-Based Comparative Analysis

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Abstract:

This study presents a comprehensive evaluation of the structural and thermal performance of left and right headers in a microchannel heat exchanger (MCHE) using finite element analysis (FEA) in ANSYS. Microchannel heat exchangers are widely utilized in automotive, aerospace, and electronic cooling systems due to their compact size, high surface-area-to-volume ratio, and superior heat transfer efficiency. The research aims to investigate how variations in header design and orientation influence critical parameters such as deformation, total heat flux, directional heat flux, temperature distribution, and safety under operational conditions. A detailed 3D model of the headers was created using Unigraphics NX-8 and fabricated via 3D printing to validate the simulation results. Thermal boundary conditions were applied at a temperature of 86.8 °C, and the results revealed significant performance differences between the two configurations. The right header exhibited lower deformation (0.18985 mm) compared to the left header (0.19625 mm), indicating improved structural integrity. It also demonstrated reduced total heat flux (3.76E-12 W/mm²) and directional heat flux (2.26E-12 W/mm²), suggesting enhanced heat management and minimized thermal stresses. Additionally, the right header achieved a higher factor of safety (0.95468) compared to the left header (0.81), reflecting superior reliability under thermal loading conditions. These results highlight the importance of header geometry in optimizing thermal performance and mechanical stability in MCHEs. The findings provide valuable insights for engineers and designers seeking to improve the efficiency, durability, and safety of microchannel heat exchangers in advanced thermal management systems for automotive and industrial applications.

Keywords:

Header, Left Header, Right Header, Model, Microchannel, Thermal Analysis, Temperature, Heat Flux, MCHE.