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C2Po1E-03: Development of a metal 3D printed air foil heat sink for cryocoolers

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The cryogenic heat sink attached to the cold head of the cryogenic cooler is used to cool cryogenic fluids such as helium, neon, and hydrogen. The performance of the heat sink involves the pressure drop, the heat transfer area, and the overall size. In order to improve the thermal-hydraulic performance of the heat sink within a limited size, it is necessary to reduce the pressure drop and increase the heat transfer area of the heat sink. Airfoil-shaped fins are known to show less pressure drop while keeping good heat transfer characteristics. In this study, the thermal-hydraulic performance of the heat sink is investigated for the various configurations of the fins using computational fluid dynamics (CFD) analysis. The average friction coefficient and heat transfer coefficient are calculated to select the most appropriate heat sinks with overall dimensions of 50 mm width, 50 mm length, and 20 mm height. Although the CFD simulation result shows superior thermal-hydraulic performance compared to the heat sink manufactured by conventional machining processing, the designed heat sink is fabricated using powder bed fusion (PBF) metal 3D printing due to its fine pin structure. An experiment is conducted to evaluate the performance of the heat sink using a characteristic evaluation apparatus including a cryogenic blower and a cryocooler. The airfoil heat sink is tested at a maximum mass flow rate of 30 g/s, a maximum pressure of 5 bar, and a temperature range of 20 to 60 K.

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