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Feasibility of an LPBF Gyroid-Structured Oil Cooler: Performance Optimization and Cost Trade-Offs

An LPBF-manufactured gyroid oil cooler concept is assessed using a calculation workflow that rapidly screens a thousand design configurations by varying key geometric parameters (cell size, stretch factor, and core diameter) against fixed operating conditions and performance targets. The workflow dimensions each concept by solving the required cooler length to meet the specified cooling power, then derives pressure losses and mass for each configuration. By using mass as a practical proxy for LPBF part price, the method pinpoints which parameter combinations deliver the lowest “cost-down potential” while still meeting pressure-drop and thermal requirements—helping identify where an LPBF gyroid cooler could become feasible as designs, materials, or manufacturing assumptions improve.

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Abstract

This study examines the potential of additively manufactured heat exchangers that use a gyroid lattice as the internal heat transfer core. The work asks whether Laser Powder Bed Fusion (LPBF) can enable heat exchangers that are lighter, more compact, and better performing than conventional designs—while still being economically viable.

A computational assessment workflow is developed to explore a large design space (on the order of thousands of configurations). Key design and manufacturing variables are systematically varied, including heat exchanger core diameter, gyroid cell size and stretch factor, wall thickness, and material selection (e.g., 316L stainless steel, AlSi10Mg, CuNi30). Thermo-hydraulic performance is estimated using established heat transfer and pressure-loss formulations, complemented with correction factors motivated by experimental observations to better reflect gyroid-specific flow behaviour.

The results emphasize trade-offs between maximizing heat transfer and minimizing pressure losses, comparing cross-flow and counter-flow arrangements. The study finds gyroid cores can deliver meaningful mass reductions and pressure-loss improvements while leveraging LPBF's geometric freedom to increase surface area. However, it concludes that current LPBF manufacturing costs are a primary barrier to competitiveness. It also flags practical considerations such as LPBF surface roughness, fouling risk, and the need for post-processing and further validation.

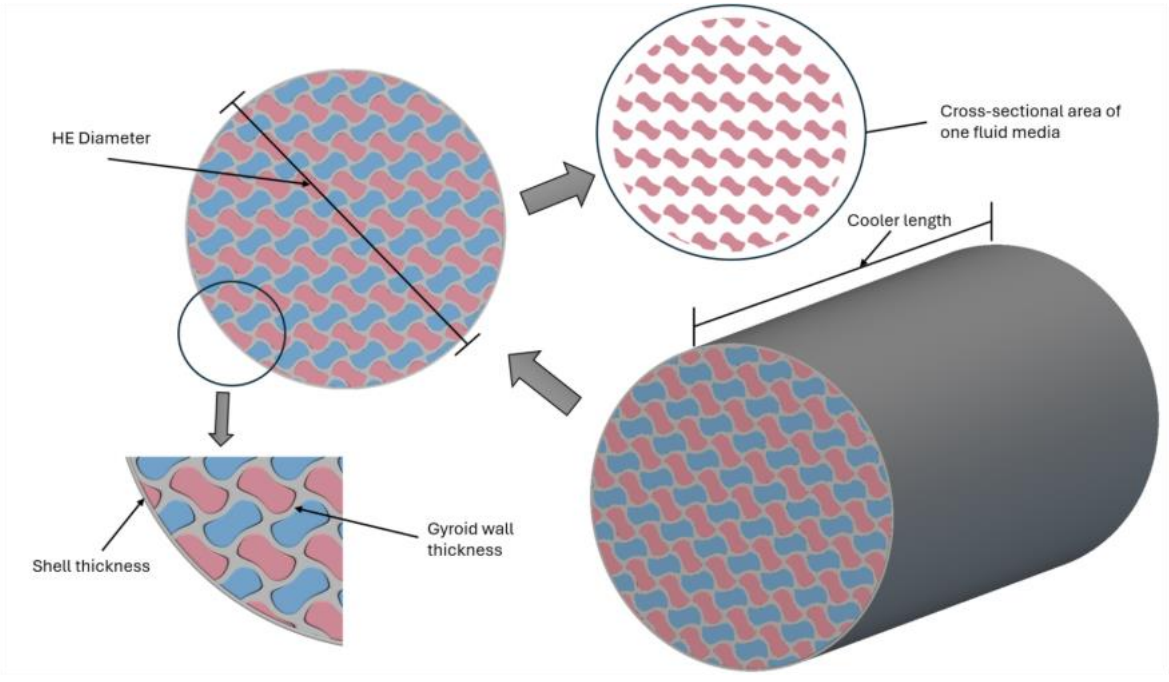

Figure 1. Example of a cylindrical gyroid heat exchanger, with additional views of the cross-section and close view