

PROCEEDINGS

# A Classifier-Free Guided Diffusion Model for the Manufacturability-Aware Design of TPMS-Based Heat Exchangers

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## ABSTRACT

The demand for next-generation thermal management has to realize complex, compact heat exchangers. Additive Manufacturing (AM) provided a new perspective for manufacturing complex structure, such as Triply Periodic Minimal Surface (TPMS). However, the inverse design of these structures is severely hindered by the need to satisfy both extreme performance demands and manufacturing constraints, such as overhang angles and enclosed voids. This paper proposes a novel, performance-driven generative design framework that intrinsically couples structural manufacturability. The workflow begins by generating a large, diverse dataset of parameterized (TPMS) based heat exchanger geometries, each evaluated in terms of surface-to-volume ratio and manufacturability metrics. Building upon this data, a conditional diffusion-based architecture is deployed. A classifier-free guidance is adopted to enable performance-aware generation of novel heat exchanger designs. Results indicate that the intelligently guided framework successfully produces structurally viable designs that drastically maximize the S/V ratio. Comparative analyses reveal substantial superiority over traditional parametric models and unconditional generative approaches. Ultimately, this research provides a generalized, scalable, and AI-native methodology to accelerate the development of highly efficient, ready-to-print heat transfer devices.

## KEYWORDS

Generative design; additive manufacturing; heat exchanger; diffusion model; TPMS

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