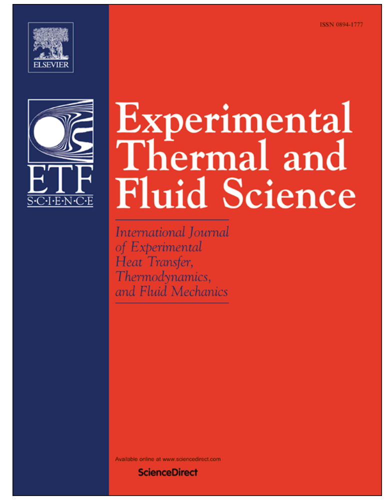

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Abstract

Metal-based additive manufacturing is a disruptive technology with the capability to transform industries. The increased design space the technology offers is enticing to designers, who are given an opportunity to develop components that exceed prior performance levels; optimization tools can be used to provide guidance. However, the nature of surface roughness in additively manufactured parts is highly irregular, and computational models generally cannot properly capture the surface morphology. How, then, can current numerical tools predict the performance of additively manufactured components, or aid designers in developing products that meet their needs?

The current study aims to provide insight into the current capabilities of both design tools and the additive manufacturing process for microchannels intended for cooling components. A commercially-available optimization scheme was used to improve the design of four microchannel cooling configurations. These optimized geometries were printed using a metal-based additive manufacturing process; only some objective functions were achieved experimentally. In the current study, the same optimized geometries were printed using a stereolithography process, which built smooth channels as simulated in the optimization scheme. Experiments were performed to gather friction factor data, and results showed that the design intents were largely validated. Analyses of the metal test coupons alongside the plastic coupons showcase the direct effects of surface roughness: the influence of surface roughness on the performance of the channels was predominantly tied to the goal of the shape change.

Keywords

Microchannel cooling, additive manufacturing, Laser Power Bed Fusion, 3D printing, shape optimization, computational fluid dynamics, heat transfer

Introduction

Additive manufacturing (AM) has generated widespread excitement for a variety of applications. The advanced manufacturing technique can create near net shape geometries, including at the micro-scale, and its applications range from prototypes to production-level components.