Investment casting and experimental testing of heat sinks designed by topology optimization

Topology optimization (TO) is an attractive numerical tool to obtain optimized engineering designs, which has been originally developed for mechanical optimization and extended to the area of conjugate heat transfer. With rapid developments in topology optimization models, promising designs have been proposed and presented recently for conjugate heat transfer problems. However, only a very small number of experimental validations of TO heat transfer devices have been reported. In this paper, investment casting (IC) using 3D stereolithography (SLA) printed patterns is proposed to fabricate 3D metal heat transfer devices designed by TO. Three heat sinks for natural convection are designed by a previously reported topology optimization model and five reference pin-fin heat sinks are devised for comparison. From those designs six heat sinks are cast in Britannia metal, fully reproducing the complex 3D optimized designs. It shows that SLA-assisted IC is a very promising technology with low cost and high accuracy for fabricating TO metal parts, which is not limited to heat transfer devices and can be extended to other areas such as structural optimization. A natural convection experimental setup is used to experimentally study the performance of the fabricated heat sinks. The results show that the tested TO heat sinks can always realize the best heat dissipation performance compared to pin-fin heat sinks, when operating under the conditions used for the optimization. Moreover, validation simulations have been conducted to investigate the temperature distribution, fluid flow pattern and local heat transfer coefficient for the TO and pin-fin designs, further evidencing that TO designs always perform better under the design conditions. In addition, the impact of heat sink orientation and radiation are presented.