Constructal Design of Y-Shaped Conductive Pathways for Cooling a Heat-Generating Body

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Abstract

This paper applies constructal design to discover the configuration that facilitates the access of the heat that flows through Y-shaped pathways of high-conductivity material embedded within a square-shaped heat-generating medium of low-conductivity to cooling this finite-size volume. The objective is to minimize the maximal excess of temperature of the whole system, i.e. the hot spots, independent of where they are located. The total volume of the square-shaped heat generating medium, and the total volume of the materials of higher thermal conductivity are fixed. However, the volumes and the thermal conductivity of the stem and the branches of the Y-shaped pathway, as well as the lengths of the stem and the branches can vary. We compared the performance of several configurations, I-shaped, Y-shaped, and X-shaped, using different volume fractions and thermal conductivities. The results indicate that complexity is not a guarantee of better performance. There is no an absolute winner: the best design depends on the parameters and selected materials.

Keywords Constructal design, enhanced heat transfer, heat conduction, high thermal conductivity.