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ANALYSIS OF THE THERMAL PERFORMANCE OF SINGLE AND MULTI-LAYERED MICROCHANNELS WITH FIXED VOLUME CONSTRAINT

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Abstract. This study presents a numerical analysis of forced convection heat transfer and steady, laminar, incompressible fluid flow through single-, two- and three-layered microchannels with different flow arrangements and fixed total volume constraint. Previous studies on multi-layered microchannel heat sinks have shown that these types of heat sinks perform better than single-layered microchannel in terms of reducing thermal resistance and pressure drop, but this is obtained with increased total volume of the solid substrate because equal volumes of the single-layered microchannel are stacked to obtain the number of desired layers. In this paper, the total volume of the solid substrate for all the microchannels considered was fixed at 0.9 mm^3 and the geometries of the different microchannels were optimised based on the objective of maximising the thermal conductance using a computational fluid dynamics package with a goal-driven optimisation tool. The results show that for a fixed total volume and fixed inlet fluid velocity, the pumping power of the two-layered microchannel with the different flow arrangements was 10% less than that required for the single-layered microchannel but was increased by about 12% when the number of layers was increased to three. The results obtained from this study show that the multi-layered microchannels give very good results without increasing the total volume of the solid substrate as presented in previous investigations.

Key words: Forced convection, Maximised thermal conductance, Pumping power, Pressure drop, Temperature rise, Fluid velocity.