Master's Thesis Defense Announcement Mechanical and Aerospace Engineering Department University of Texas at Arlington

Steady state and transient analysis of heat transfer in a porous fin with radially outwards pressure-driven flow

By: Muhammad Mehdi Abbas

Thesis Advisor: Dr. Ankur Jain 01:00 pm, Tuesday, April 25th, 2023 Woolf Hall, Room 413

Abstract

Thermal management and energy storage problems often utilize extended surfaces, also known as fins for enhanced heat transfer. Today fins are used in a wide range of devices including but not limited to microelectronic components and large heat exchanger. Traditional fins as well as porous fins with flow orthogonal to fin direction have been subject of past research. There is very few academic literatures available on porous fins with pressure driven flow along fin direction. While thermal conduction is usually the dominant mode of heat transfer in a solid fin, the use of porous fins that include advective thermal transport due to porous fluid flow has also been investigated. In particular, the steady state and transient thermal performance of a porous fin with pressure-driven radially outwards flow has been studied. It is shown that the transient temperature field in the fin is governed by a convection-diffusion-reaction (CDR) equation, the solution for which is based in the form of Bessel functions. Fin performance is classified for both steady state as well as transient cases with the help of various performance parameters. The steady state case shows that thermal properties of the fin as well as ambient convective conditions strongly impact the relationship between fin porosity and fin performance. While in some cases, it is found that an optimum porosity exists that maximizes heat removal, in other cases, the use of a porous fin is found to be not desirable at all. The analysis presented here helps fully understand these trade-offs and provides useful guidelines for porous fin design for maximum heat removal. Since fin porosity improves advective thermal transport but suppresses diffusive transport at different rates at different times, therefore, it is shown that the impact of fin porosity on heat removal rate depends on the total time over which the fin operates. Consequently, it is important to consider transient effects in determining whether the use of a porous is beneficial at all, and, if so, the optimal fin porosity. This work contributes towards porous fin theory and offers practical design guidelines for improving and optimizing the performance of porous fins.