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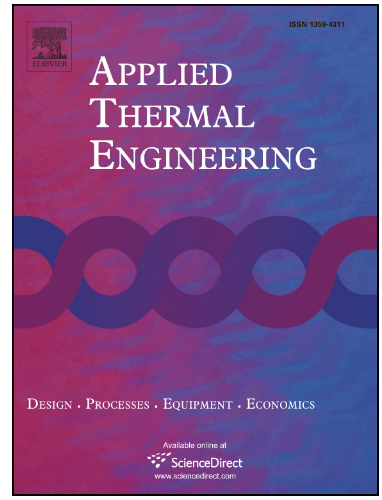

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Abstract

The topic of compact micro heat exchanger is one of the most active areas in heat and mass transfer research today. However, there is a lack of literatures on serpentine channels with parallelogram cross-section. This article provides numerical study of the hydraulic and thermal performance in parallelogram serpentine channels with aspect ratios (α) ranging from 0.25 to 4 and wall included angles (θ) ranging from 45° to 90°. The Reynolds number (*Re*), characterized by channel hydraulic diameter and mean bulk velocity, is varied from 100 to 300. Their influences on the fluid flow and heat transfer characteristics are investigated under constant wall temperature condition. It is newly found that Nusselt number (*Nu*) distributions on bottom and top walls in slant wall channels ($\theta \neq 90°$) are asymmetric and there exists a critical value of α and *Re* for *Nu* and Fanning friction factor (*f*), respectively. Furthermore, two new correlations for overall *Nu* and *f* with respect to α, θ, and *Re* are proposed for laminar flow in parallelogram channels, with maximum errors less than 10% and 20%, respectively, compared with numerical results.

Keywords: Serpentine micro heat exchanger, Parallelogram channel, Included angle, Correlation, Heat transfer.

1. Introduction

In recent decades, compact heat exchangers have been one of the most interesting research areas due to the rapid growth of power consumption and miniaturization of electromechanical systems. To optimize the heat exchanger performance in a limited dimension, there are many types of tortuous channel patterns that have been developed. One of the most common ones is the serpentine channel, which is widely applied to various fields such as underfloor heating/cooling systems, turbine blade/vane internal cooling, on-chip cooling, solar thermal collector, and proton exchange membrane fuel cells (PEMFC). PEMFC is one of the most promising power sources because of higher efficiency (>40%), shorter start-up time, lower temperature range (50-100°C), and cleaner emissions (water only). Therefore, increasing studies about PEMFC applications have been reported in various fields such as transportation industries, stationary power systems, and portable electronic devices. To ensure long durability and high efficiency of PEMFC, proper thermal management techniques are indispensable since PEMFC generates the amount of the waste heat comparable to its power output and only tolerates a small temperature deviation from its design point [1]. According to Faghri and Guo [2], most fuel cell units below 2kW can be cooled with increasing reactant air, but the ones beyond 2kW usually need a separated cooling channel.

Chen et al. [3] conducted a numerical analysis to study the laminar fluid flow and heat transfer between solid plates in coupled cooling process. The uniformity of temperature across the cooling plates was evaluated for three types of serpentine channels and three types of parallel channels. The prediction showed that the cooling effect of serpentine channels could be better than that of parallel ones. Inoue et al. [4] numerically