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Heat transfer and fluid flow in a plate heat exchanger part I. Experimental investigation

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ABSTRACT

This paper presents an experimental investigation of the hydrodynamic and thermal fields in a two-channel chevron-type plate heat exchanger for laminar and turbulent conditions. The friction factor for a Reynolds number up to 850 and the Nusselt number for the hot channel for a Reynolds number up to 1500 are presented. The qualitative influence of the Reynolds number on these two parameters is similar to that established in other published studies. The values of both these parameters obtained in the present study are intermediate between the corresponding extremes previously reported. The observed differences are attributed to the corrugation geometry, the presence of the straight smooth passages along the sides of the channels, the port configuration and the number of plates. On the other hand, the calculated effectiveness of the plate heat exchanger is identical with that obtained from the classical analytical expression for counter-flow heat exchangers. The temperature distributions on the first and the last of the three plates for a laminar case and two turbulent cases are also presented. Distorted isotherm patterns have been observed, likely caused by the presence of the straight smooth passages located along the longitudinal edges of the plates.

1. Introduction

Plate heat exchangers (PHE) are widely used in many applications (food, oil, chemical and paper industries, HVAC, heat recovery, refrigeration, etc.) because of their small size and weight, the ease of cleaning as well as their superior thermal performance compared to other types of heat exchangers.

Several experimental and numerical studies were recently conducted in order to predict the flow and temperature distribution in PHEs; many of the latter use simplifying assumptions.

Lozano et al., in their experimental and numerical work [1], analyzed the flow distribution inside one channel of a PHE for the automotive industry, without considering heat transfer. Their analysis concluded that the flow was non-uniform and preferentially moved along the lateral extreme edges of the plates.

Kanaris et al. [2] studied experimentally and numerically the flow and heat transfer in a PHE. They used a PHE with two channels in order to validate their numerical model. The authors observed a good agreement between the numerical results and the experimental data and concluded that the CFD code was an effective and reliable tool to predict flow characteristics, pressure losses and to estimate heat transfer in this type of equipment.

Tsai et al. [3] investigated the hydrodynamic characteristics and distribution of the flow inside a PHE. Although they used a PHE with two channels, the heat transfer was not considered in this study.

Jain et al. [4] validated their 3D model against experimental data obtained for a PHE with 13 channels. They analyzed the effect of the Reynolds number on the Nusselt number and the friction factor.

Galeazzo et al. [5] studied experimentally and numerically the heat transfer in an industrial PHE with four channels. However, this PHE was a non-chevron type, the five plates being smooth. The authors have investigated parallel and series flow arrangements and validated it with experimental data.

Pantzali et al. [6] investigated experimentally the efficacy of nanofluids as coolants in a commercial herringbone-type PHE. They compared water with nanofluids in terms of heat transfer and pressure drop for the laminar regime.

Okada et al., in their experimental work [7], analyzed the temperature distribution on the first and last plates of a two channels PHE of non-chevron type. They compared the temperature distributions for diagonal and side flow channels, and also for

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