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Single phase pressure drop and two-phase distribution in an offset strip fin compact heat exchanger

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ABSTRACT

Experiments have been conducted in a compact heat exchanger with two-phase inlet conditions and vertical upflow in order to study the flow behavior. The test section consists of an offset strip fin heat exchanger with a rectangular cross-section (dimensions: 1 m × 1 m × 7.13 mm). The distributor was designed to optimize two-phase flow distribution. In a preliminary step, pressure drop of single phase flow in offset strip fins is needed to assess the quality of the distribution in the single phase case. For that, pressure drop of single phase flow has been measured in the experimental loop. Pressure drop has also been analysed numerically via CFD simulations. For low Reynolds numbers, numerical results show good agreement with experimental measurements. In a second step, the two-phase flow distribution at the outlet was characterized using air and water as working fluids and for different operating conditions. This characterization consists of the measurement of gas and liquid flow rates in different zones evenly distributed at the outlet. We observed that high air flow rates led to a more homogenous distribution.

1. Introduction

The use of compact heat exchangers for both single and two-phase flow applications in industrial processes has increased in the recent years. Among them, offset strip fin heat exchangers are of particular interest because they achieve high heat transfer areas per unit volume and mass. Design and optimization of such devices require a quantitative evaluation of their performances in terms of pressure drop and heat transfer. Extensive works have been performed to predict friction factor and heat transfer coefficient in such complex geometries, mostly in single phase flow.

But the question remains open for two phase flows, where the various flow patterns introduce another degree of complexity in the problem. Moreover, the geometry of the compact plate and fin heat exchanger channels are far from tubular or multitubular ones, geometries which have been previously used for establishing experimental correlations and two phase flow maps. In the literature, different ways to extrapolate these tube correlations and maps to the plate and fin heat exchanger case were investigated, both numerically and experimentally. In particular, one of the factors that strongly influences the performance of compact heat exchangers is the degree of flow rate uniformity across the parallel channels (Marchitto et al. [1]).

In general, maldistribution in offset strip fin compact heat exchangers is caused by:

- Unequal distribution of local pressure in the inlet/outlet manifolds, due to the location of the inlet/outlet pipes (co-current or counter-current inlet of gas and liquid phases) or to the distributor design.
- Fouling of micro channels and damage of the fins are the major troubles occurring in the plate fin heat exchangers. They cause variations in channel dimensions and flow lengths and, consequently, in pressure drops.
- Density and viscosity variations due to temperature gradients and gas-liquid distributions lead to different pressure drops from one part to another one.

The problems of maldistribution in plate fin heat exchangers can decrease their thermo-hydraulic performance or even cause the destruction of some components. When heat transfer takes place in real heat exchangers, investigations on the system to identify zones presenting heat transfer problems and the corresponding local flow rates of vapour and liquid phases are difficult. A cold flow study of the gas-liquid hydrodynamics can allow to identify the impact of the fluid distribution at the inlet (distributor design, co-current or

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