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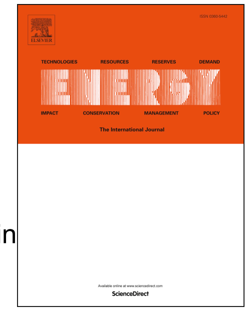

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Thermo-hydraulic characterization of a self-pumping corrugated wall heat exchanger

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Abstract

Compactness, efficiency and thermal control of the heat exchanger are of critical significance for many electronic industry applications. In this view, a new concept of heat exchanger at millimeter scale is proposed and numerically studied. It consists in dynamically deforming at least one of its walls by a progressive wave in order to create an active corrugated channel.

Systematic studies were performed in single-phase flow on the different deformation parameters that allow obtaining the thermo-hydraulic characteristics of the system. It has been observed the dynamic wall deformation induces a significant pumping effect. Intensification of heat transfer remains very important even for highly degraded waveforms although the pumping efficiency is reduced in this case.

The mechanical power applied on the upper wall to deform it dynamically is linked to the wave shape, amplitude, frequency and outlet-inlet pressure difference. The overall performance of the proposed system has been evaluated and compared to existing static channels. The performance of the proposed heat exchanger evolved in two steps for a given wall deformation. It declines slightly up to a critical value of mechanical power applied on the wall. When this critical value is exceeded, it deteriorates significantly, reaching the performance of existing conventional systems.

Keywords: Heat transfer enhancement, Wall morphing, Dynamic deformation, Pressure gain, Mobile heat exchanger

1. Introduction

Due to growing demands of energy in various industrial sectors, design and conception of heat exchanger devices are very crucial for performance of numerous energetic systems. Heat exchanger devices are present at various scales. Their applications can be found in large scale industries, e.g. power plants, to mini scale industries, e.g. electronic industries.

The temperature control and associated heat flux management is crucial in many applications: microelectronics, embedded or fixed power electronics systems, power station, air conditioners, heat pumps, as well as in the field of industrial thermal processes metallurgy, chemistry, food, etc. The will to increase the performance and efficiency of these systems greatly amplifies this need as, in many situations; it becomes the limiting factor in optimizing system performance. Moreover, lifetime and reliability of many systems are very strongly related to the quality of the thermal management.

This situation is clearly identified, for example, in power electronics where the electrical power passing through an elementary component could be increased by a factor 10 or more