

Numerical Investigation of Mass and Heat Transfer in a New Coaxial with Shell-and-Tube Heat Exchanger



Chabane Medjdoub^{1*}, Abdelhakim Benslimane¹, Djamel Sadaoui¹, Karim Bekkour²

¹Laboratoire de Mécanique, Matériaux et Energétique (L2ME), Faculté de Technologie, Université de Bejaia, Bejaia 06000, Algeria

²ICube Mechanical Department, CNRS/University of Strasbourg, Strasbourg 67000, France

Corresponding Author Email: chabane.medjdoub@univ-bejaia.dz

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ABSTRACT

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In the present article, a novel coaxial with shell-and-tube (CWST) heat exchanger is developed and simulated using Ansys-Fluent®, and its results are compared with those of the shell-and-tube heat exchanger from which it is derived. The geometry of this new exchanger was given, specifying the different types of fluids it can contain and their circulations, and a theoretical calculation based on the NTU method (number of transfer units method) is used to validate the simulations. In order to be able to analyse the phenomena occurring inside this exchanger, the fluid temperature, pressure, and velocity distribution figures are given with the evolutionary curve of some performance parameters (the heat, the pressure losses, the ratio between heat and pressure losses, the heat flux and the overall heat transfer coefficient) as a function of the cold fluid volume rate. At the end the various advantages it can give to enhance the efficiency of heat transfer, to reduce manufacturing and operating costs, as well as its potential for further research on the improvement of the design were explained.

1. INTRODUCTION

While various types of heat exchangers exist, including tube coil and plate heat exchangers, the shell-and-tube heat exchanger (STHE) stands out as the most widely utilized in the industry due to its superior exchange surfaces, efficient heat transfer capabilities, and compact design. These heat exchangers are used for industries that require heat transfer in order to support the chemical processes such as distillation, synthesis or combustion, which takes place in the pharmaceutical, food and petrochemical industries. They can also be used for the conversion of fossil or atomic energy into electricity as in nuclear power plants, and they are employed for heat pumps, heating and air conditioning which use heat transfer to change or maintain the temperature in enclosed spaces such as cold rooms.

The lack of energy resources, climate change due to pollution and the desire for economic prosperity of countries makes research into improving the performance of heat exchangers more than necessary. There is an important number of works in the literature dealing with heat exchangers, both from a numerical and experimental point of view, and whose main objective remains the optimization and improvement of heat transfer in these devices. Below, we discuss some studies and methods for enhancing heat exchanger performance:

Characteristics of the tubes used in heat transfer are essential for the performance of the heat exchangers; some research has focused on their shapes which can be twisted,

coiled or finned. Tan et al. [1] investigated, through CFD simulation, heat exchangers utilizing finned tubes and twisted oval tubes, both of which offer enhanced turbulence compared to smooth circular tubes. The authors observed that the exchangers that use finned tubes increase the transfer area which increases the rate of the exchanged heat. In the twisted oval tube heat exchanger, it was discovered that the torsion pitch's length had a greater impact on heat transfer performance. In an experimental research employing turbulent water flow on a heat exchanger using twisted tubes, Zhang et al. [2] found that reducing the torsion pitch increases both the heat transfer and friction coefficient. In an experimental investigation, Dizaji et al. [3] found that inserting air bubbles into a vertical heat exchanger with coil tubes increases the exchanger's efficiency and NTU. Genic et al. [4] studied experimentally spiral tube (coil) heat exchanger and concluded that the heat transfer is improved by increasing the diameter and the pitch length of the coil as well as increasing the flow rate.

In other hand, some other studies have focused on baffles and their different features. Zhang et al. [5] carried out an experimental study to compare between shell-and-tube heat exchanger using segmented baffles with shell-and-tube heat exchanger using overlapped helical baffles. And they were able to determine that the second kind of heat exchanger exhibits better heat transfer per unit pressure drop and had less pressure drop across the shell than the first type. In their studies of shell-and-tube heat exchangers with helical baffles, Zhang et al. [6, 7] used simulation and experimentation,