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Baffle space impact on the performance of helical baffle shell and tube heat exchangers

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A B S T R A C T

Heat exchange devices are essential components in complex engineering systems related to energy generation and energy transformation in industrial scenes. Modelling of shell and tube heat exchanger, for design and performance evaluation, is now an established technique in industrial fields. In this paper, heat exchangers with non-continuous helical baffles based on periodic boundaries have been simulated by using commercial code of FLUENT. All possible attempts were made to obtain the influence of baffle spaces on fluid flow and heat transfer on the shell side of by using the same geometrical and thermo-physical conditions. Helical baffles corresponded to the helix angles of 40°, and 5 heat exchangers with different baffle spaces were designed. Designed baffle spaces are: for case A: 15 mm (a minimum elected space), for case B: P/16, for case C: P/8 (middle-overlap type), for case D: 3P/16 and for case E: P/4 (end-to-end type). P refers to helix pitch. The results of simulations indicate that for the same mass flow rate, the heat transfer per unit area decreases with the increase of baffle spaces; however, for the same pressure drop, the most extended baffle space (Case E) obtains higher heat transfer. We also found out that the pressure gradient decreases with the increase of baffles space.

1. Introduction

For many years, shell and tube heat exchangers (STHXs) have been the most widely used equipment in the industrial fields including: power plant, petroleum refining, steam generation, etc. STHXs provide relatively large ratios of heat transfer area to volume and weight and can be easily cleaned [1].

Baffles are one of the most important parts of STHXs, they force the fluid of shell side to flow across the tubes to ensure high heat transfer rates and also provide support for tube bundle. There are different types of baffle arrangement used in shell and tube heat exchangers. The most commonly used baffles, called segmental baffles, cause the shell-side fluid to flow in a zigzag manner across the tube bundle. This action improves heat transfer by enhancing turbulence or local mixing on the shell side; however, it also increases the shell side pressure drop and requires a great pumping power and; as a result, increases electricity consumption. High range of dead zones, back flows and high risk of vibration failure on the tube bundle are other disadvantages of above-mentioned baffle types.

Another type of baffle arrangement, which introduced and developed by Lutcha and Nemcansky in the Czech Republic, is called helical baffles. This type of baffle arrangement, also known as Helixchanger, minimizes the principle shortcomings in design of the conventional segmental baffles and the flow patterns produced by this type are also much close to plug flow condition, which cause reduction in shell-side pressure drop and improves heat transfer performance [2–6].

Helical baffles consist of two major types as follow: continuous and non-continuous helical baffles. Continuous baffles are not commonly used types due to difficulties in design and manufacturing, and they are also out from discussion in the present study. The well-known non-continuous helical baffles, which are the main subject to the present discussion, can be described as follow: a triangular shaped plate with elliptical sector base which also can be designed from subtracting a triangular shaped plate out of an elliptical plate. See Fig. 1.

The elliptical sector base varies in accordance of the inclination angle of baffles and shell inside diameter in order to fit in the shell side properly. Each baffle occupies one quadrant of the exchanger's shell cross section and is angled to the axis of the heat exchanger. Adjacent baffles may touch at the periphery, forming an end-to-end non-continuous connection or may touch at any desirable baffle space, forming other connections such as middle overlapped connections [7].

Fig. 2 shows the different baffle spaces of helically baffled STHXs from cases A to E (the cases in this figure are not shown in the same scales).

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