CFD Study for Shell and Tube Heat Exchanger Design: Novel Baffle and Tube Arrangements

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For continuous thermal processing of liquid food products, heat exchangers hold a significant place in industry. Shell and tube heat exchangers are the most common ones in industrial applications, and various technical designs have been proposed to improve their thermal performances. Configuration and arrangement of the baffles and tubes were also demonstrated to have a profound impact on the performance of these heat exchangers.

In this study, novel baffle and tube arrangements were considered, and the effects of the segmental baffle (PS), novel baffles with three different bend angles (PR25, PR40 and PR60), and various sequences accompanied with tube arrangements (perforation, square, circular and pentagonal) were studied. CFD studies were carried out using Solidworks Flow Simulation software (Ver. 2018). The superheated steam of 450 K was used as a shell-side fluid and the milk at 277 K as a tube-side fluid. The temperature difference obtained across the tube side of the heat exchanger and total pressure drops across the shell side were determined for the effects of various arrangements.

To compare the temperature difference obtained across the tube side of the heat exchanger, 11.44 and 22.63% difference over the novel baffles with highest bended angle (PR60) were represented by segmental baffle (PS) and conventional (P0) shell and tube heat exchangers, respectively. In addition, PR was determined to lead to a lower pressure loss (35.1 and 0.27% lower compared to the PS and P0, respectively). Besides, P0 was found to have 2.27, 1.77 and 2.29 times higher than circular (D0), square (T0) and pentagonal arrangements (B0) in temperature difference per unit pressure loss, respectively.

A significant observation of this study was that shell and tube heat exchangers with baffles at different bending angles outperformed compared to the conventional segmental baffles. In addition, shell and tube heat exchangers containing baffles with the highest bending angle were also determined to have a higher thermal efficiency, and the perforation type showed the best performance for the thermal and hydraulic criteria for all arrangements.