Wrocław, data 2025-09-25

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Dyscyplina naukowa: inżynieria chemiczna
Numer albumu: 10043
Numer PESEL: 95092612406

Abstract of the PhD thesis: CFD modeling of a double pipe heat exchanger with turbulators

In this work, CFD simulations of a double pipe heat exchanger were performed. The inner tube of the exchanger was filled with various turbulators: brush, stamped sheet, spiral packing, Pall rings, spring, and twisted tape. The geometry of most of them is fairly complex and difficult to recreate; therefore, the space they occupied was simulated using the porous media model. There are numerous examples in literature of utilizing this model to simulate heat exchangers with fins, but it was never used for turbulators. Considering how important the effectiveness of heat transfer is in industry, how many studies focus on analyzing and optimizing turbulators, and also how crucial the reduction of computational power usage and calculation time is, it was considered a research gap worth filling. The Darcy-Forchheimer equation coefficients needed for implementation of the model were calculated based on experimental measurements of the pressure drop in a double pipe heat exchanger, gathered by the Master students of Wrocław University of Science and Technology in their theses. The results of simulations were compared with the experimental data. The porous media model describes brush turbulators well – the average relative error for pressure drop was 9,7% and 15% for the heat flux. Twisted tapes resulted in over 60% average relative error for both parameters. The reasons behind this were discussed. In the second part of the work, more focus was given to the spring turbulators. New experimental data were gathered by the author, using the modernized measuring equipment. Three spring turbulators differing in diameter, pitch, and material were considered. For each case, the classic real geometry simulations were performed to compare both approaches. The porous media model yielded even better results in pressure drop calculations, and the differences between heat fluxes in both approaches were not significant. Considering over four times shorter calculation time (as well as much quicker preparation of the numerical mesh), the porous media approach to modeling turbulators is worthy of consideration, despite its lower accuracy. In the last section, the possibility of deriving Darcy-Forchheimer equation coefficients from simulated results was discussed, as well as the relationship between these coefficients and the geometry of the turbulator and the chances of predicting them on that basis. Developing a universal approach to simulating turbulators with the use of the porous media model still requires more work; nevertheless, this thesis is an important first step in that direction and opens possibilities for refining this method in the future.