A design approach for pillow-plate heat exchangers and an analysis of their thermo-hydraulic performance based on numerical results

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Pillow-plate heat exchangers (PPHE) represent an innovative heat exchanger design and a promising alternative to conventional heat exchangers used in the process industry. They are characterised by the wavy “pillow-shaped” surface, providing a good thermo-hydraulic performance. Further advantages comprise a fully welded construction with a high structural stability, light weight and easy and cheap manufacturing. Nevertheless, the use of PPHE in production processes remains limited, mostly due to the lack of reliable design methods. To close this gap, our group has been carrying out comprehensive investigations on fluid dynamics and heat transfer in PPHE.

In this contribution, a flow-pattern-oriented design approach for turbulent single-phase flow in pillow-plates, the so-called “two-zone-model”, is proposed. The underlying concept for this approach is based on phenomenological observations of the fluid flow in the pillow-plates, which show a characteristic two-zone structure. The flow patterns for various operating conditions and pillow-plate geometries were identified by thorough CFD simulations. Furthermore, in order to determine the most favourable design, the influence of the pillow-plate geometry on the thermo-hydraulic performance is analysed. Finally, a comparison of PPHE with a conventional heat exchanger is given, which permits conditions at which PPHE are superior to be identified.