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Investigation of Pipe Flattening on Internal Turbulent Heat Transfer: A Large Eddy Simulation (LES) Study

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ABSTRACT

Modifying fluid flow behavior using flow control has attracted much attention from researchers applying various techniques to achieve desirable results in thermofluidic applications. In this study, flattening the pipe as a favorable solution is investigated to alter internal turbulent flow characteristics at a low Reynolds number range of 5,000 to 10,000, and its effects on heat transfer are studied. A deep understanding of fluid dynamics inside the pipe, along with the changing cross section, plays a crucial role in manipulating the flow accurately for the targeted outcome, considering the hydrodynamics and heat transfer simultaneously. The LES numerical investigation is conducted in pipes with different cross sections, including the round and two flattened pipes with aspect ratios of 2 and 4. Exploring the effect of varying cross-sectional areas on fluid dynamics is performed through significant parameters, including Reynolds stresses, Turbulent Kinetic Energy (TKE), and coherent structures, to provide more knowledge about flow structure, especially in the near-wall region. Moreover, heat transfer coefficient and pressure drop data are obtained to carry out thermal performance analysis, and energy equation terms are reviewed to find the governing mechanism of heat transfer. Finally, the causes of augmentation heat transfer are elaborated, taking into account the more turbulent fluctuations produced near the wall inside flattened pipes than the round pipe at the same Reynolds number, which remarkably influences momentum transport and thermal mixing.