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Flow Analysis in Shell and Tube Heat Exchanger Using Fluent Code

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ABSTRACT

The shell-and-tube heat exchanger is the most versatile type of cross-flow exchangers (Kakac and Liu, 1997) and is the one most widely used in the process and power industries. In the normal configuration, one fluid flows through tubes and second fluid passes around the tubes at 90 degrees angle. Turbulent flow inside the tube bundle depends on the effects of boundary layer separation and interactions of cylinder wakes. In the inline-flow tube bindle, one row of tubes is placed exactly behind the next along the stream-wise direction, without displacement in the cross-flow direction (Ziada and Oengoren, 2000). In staggered arrays, every second row of tubes is displaced resulting in several configurations: symmetric arrays (Balabani, and Yianneskis, 1997), rotated square arrays, normal triangle arrays (Polak, and Weaver, 1995), parallel triangle arrays [5]. All the aforementioned studies are experimental and have revealed very complicated flow features. Recently, the first direct numerical simulations (DNS) in tube bundle flows have appeared in the literature (Moulinec et al., 2004). The Reynolds number (based on the bulk velocity) is equal to 6000. The computational domain comprises of only an elemental (or periodic) „cell", assuming fully developed flow in the stream-wise and cross-stream directions. Polak and Weaver (1995) has examined that the vortices shed out from the shear layers in the staggered array are distorted and dissipated by turbulent buffeting in the turbulence generated by the successive downstream tube rows. Free stream turbulence level has a high impact on the flow characteristics inside the inline tube bundle.

Heat exchangers are being used to in many engineering process like those in refrigeration and air Conditioning systems, power systems, food processing system, chemical reactors and space or aeronautical applications. Many engineering systems including engine cooling systems and climate control typically contain turbulent heat exchanger. The objective of the present work was to analyze turbulent and incompressible flow in a cross flow heat exchanger using FLUENT code. The heat

exchanger was made of uniformly spaced staggered tubes arranged in the direction of cross-fluid flow. The fluid was water.

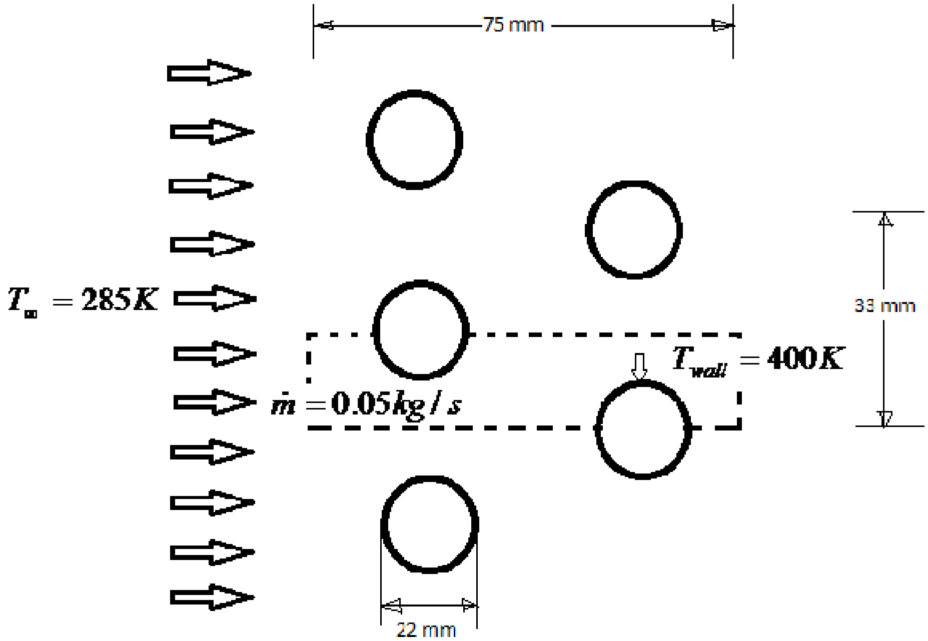

Figure 1:Schematic of shell and tube type heat exchanger.

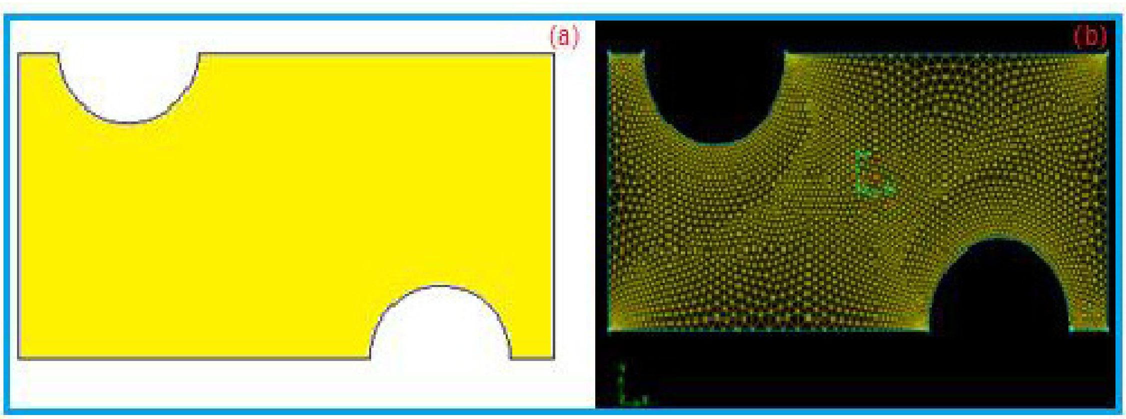

Figure 2:Geometry of the domain (a) and mesh generation for the model (b).

In the present problem, periodic flow and heat transfer in a staggered tube bundle were modeled in FLUENT. The model was set up assuming a known mass flow through the tube bundle and constant wall temperatures. Assuming geometrical model due to the periodic nature of the flow and symmetry of the geometry, only a small piece of the full geometry was modeled. The continuity, momentum and energy equations converged after approximately 9250 iterations when the maximum residual value of 1.0e-3 was assigned. The fluid flow analysis capabilities could solve unsteady flow patterns for incompressible fluid flow and turbulence enable the prediction of turbulent flow (large changes in velocity over small distances) at the same time in the same model. The tube bundle was specifically designed for the efficient transfer of heat. In this work the capability of computational fluid dynamics analysis for complex heat transfer problems was demonstrated. This experience may lead to improvement of numerical schemes.

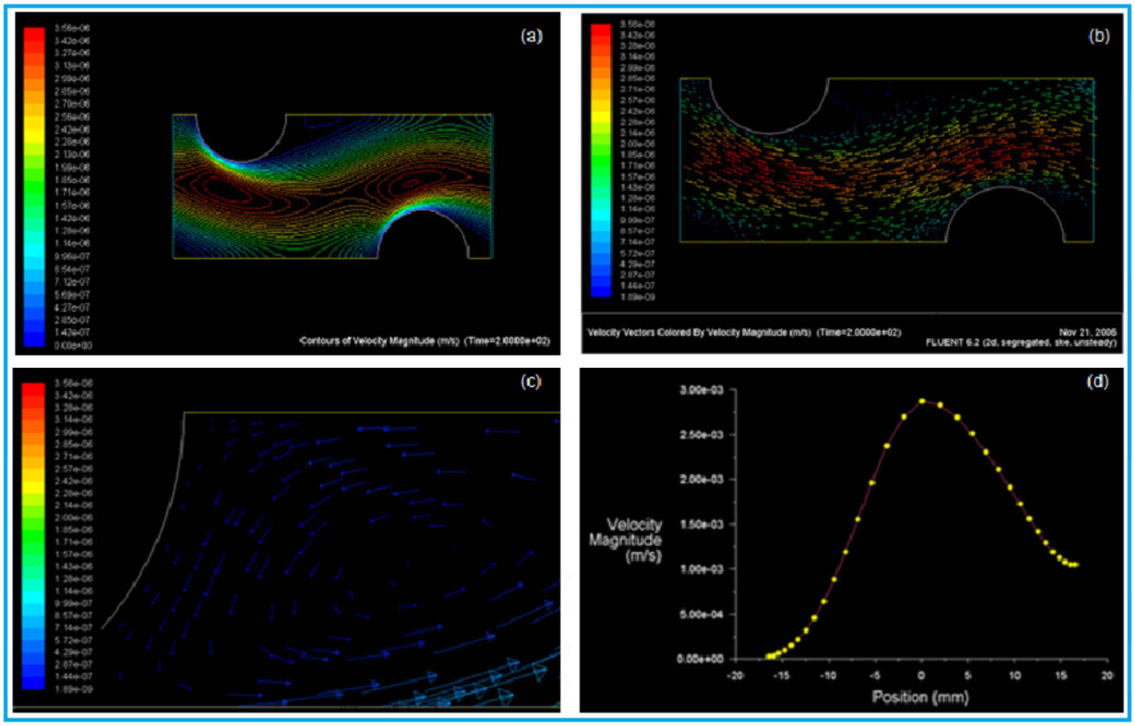

Figure 3:Contours of velocity (a), Zoomed in View of the Velocity Vectors (b), Vectors of velocity (c) and Variation of velocity magnitude along the fluid flow surface (d).

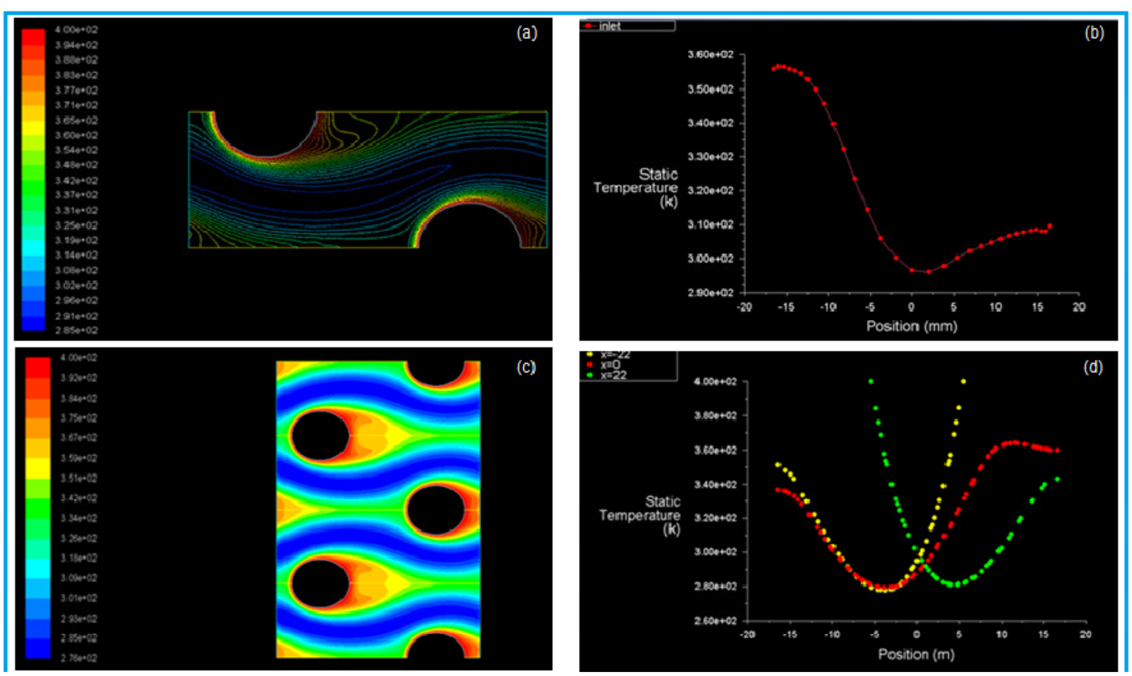

Figure 4: Contours of temperature (a), Static Temperature (b), Mirror image of static temperature (c), and Static temperature at iso-surface (d).

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