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Numerical analysis termal fluid in a heat exchanger with baffles inclination

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Abstract

A research on Thermo-hydraulic performance carried out on three types of heat exchanger with different baffles inclination 15°, 25°, 45° by the computer code Fluent, the model achievable is turbulence k-ε. The results show big recirculation zones and lower temperature peaks on the outlet for the decreased angles, the average heat transfer coefficient decreased by 1 %, pressure loss decreased by 1.2%, amount of heat exchanged between the tubes and the water increases by 1.2%.

Keywords: Baffle**;** Fluent; Pressure loss; Angle .

1. Introduction

The increase in energy performance requires the implantation of obstacles in the flow's vein in the channels, for several years, heat exchangers have been the subject of multiple research projects, the main purpose of which is to improve their performance. Anas et al. [1], have made a comparison of three types of exchangers and show that the baffles lattice holes has higher thermal performance. Gabriel et al. [2], noted a difference of 0.12 K with two software packages, HTRI and Fluent 15.0. Fettaka et al. [3], carried an optimization study to minimize the pumping power and the exchange surface according to the design variables. Ponce et al. [4], have shown that the Bell-Delaware method gives a good results. Andrews et al. [5], have shown that the better results with helical baffles compared to conventional baffles. Jian et al. [6], compared experimentally two heat exchanger and show that the performance of the folded baffle was higher than that of the transverse baffle. Cong et al. [7], showed that, the folded baffles are obviously higher performance than those transverse baffles. Youcef et al. [8] a numerical simulations for wing baffles showed that the new shape baffles improve the performance of the heat exchanger. Ahmed et al. [9, 10] showed after comparative numerical simulation that the heat transfer coefficient increased by 1.86% and pressure loss increased by 21.67%.

In our study the performance of baffles inclination angle namely 15 °, 25 °, 45 ° and the different thermo-hydraulic parameters are investigated.

2. Mathematical formulation of the problem

2.1 Problem geometry

It gives in figure 1, the baffles placed in alternate orientations to create flow paths on the tube bundle. The geometric model created by varying the angle of inclination of the baffle by 15 °, 25 °, 45°. I explain the geometric modeling of the heat exchanger below, shell diameter, D_s=90 mm with length, L=600mm, tube diameter d=20mm.

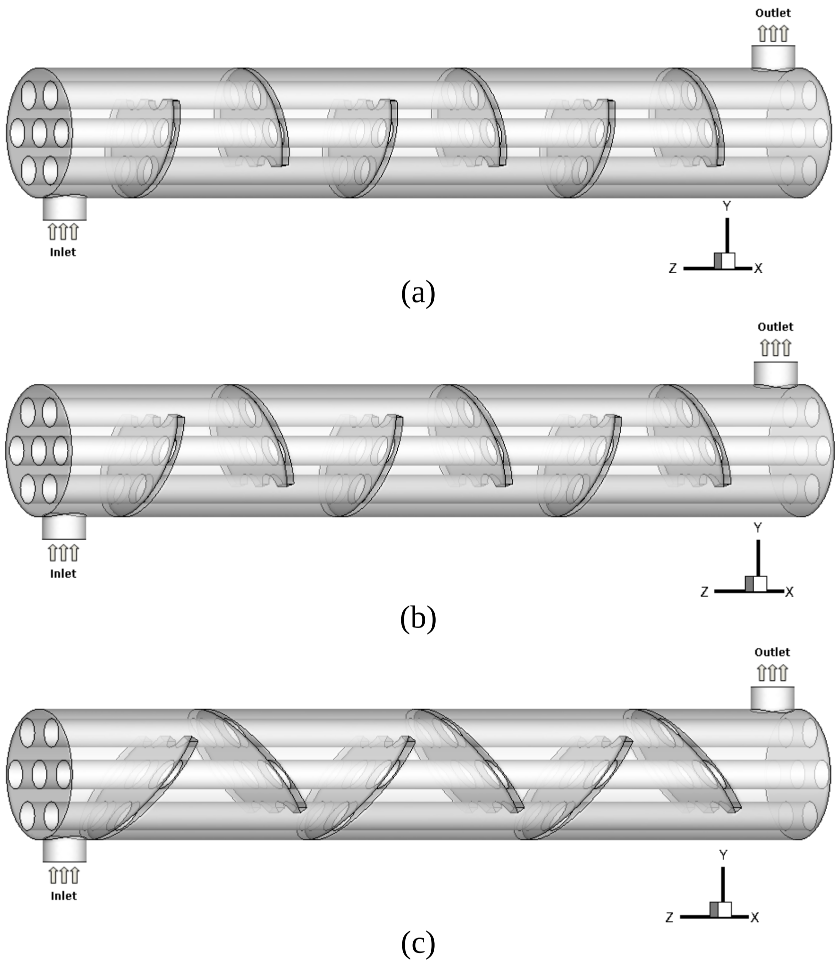


Fig 1. Problem geometry (a) 15°, (b) 25°, (c) 45°.

2.2 Governing equations

Continuity:

$$\frac{\partial(\rho.u_i)}{\partial x_i}=0 \tag{1}$$

Momentum:

$$\frac{\partial u_i u_j}{\partial x_i}=-\frac{1}{\rho}\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left((\nu+\nu_t)\left(\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i}\right)\right) \tag{2}$$

Energy:

$$\frac{\partial(u_i T)}{\partial x_i}=\rho\frac{\partial}{\partial x_i}\left(\left(\frac{\nu}{\mathrm{Pr}}+\frac{\nu_t}{\mathrm{Pr}_t}\right)\frac{\partial T}{\partial x_i}\right) \tag{3}$$

2.3 Boundary conditions

We have applied a constant velocity and temperature for a hydraulic and thermal boundary condition in the inlet of the computation domain and constant temperature at the tube.

3. Results and discussion

We will present the evolution of the velocity and of the temperature in the very important sections which impose variations for these two parameters in the heat exchanger.

Table 1. Reynolds number

Inclination°	Re
10°	24749
20°	25241
40°	26591

3.1 Transverse velocity profile

The transverse velocity contour has been shown in figure 2 for the three baffles inclinations. There is a high velocity at the two tubes in the middle and near the inner wall of the grille in the section z = 0.02 m, this velocity remains elevated to the outlet. The higher inclination causes a high fluid velocity because they decrease the resistance of the baffle.

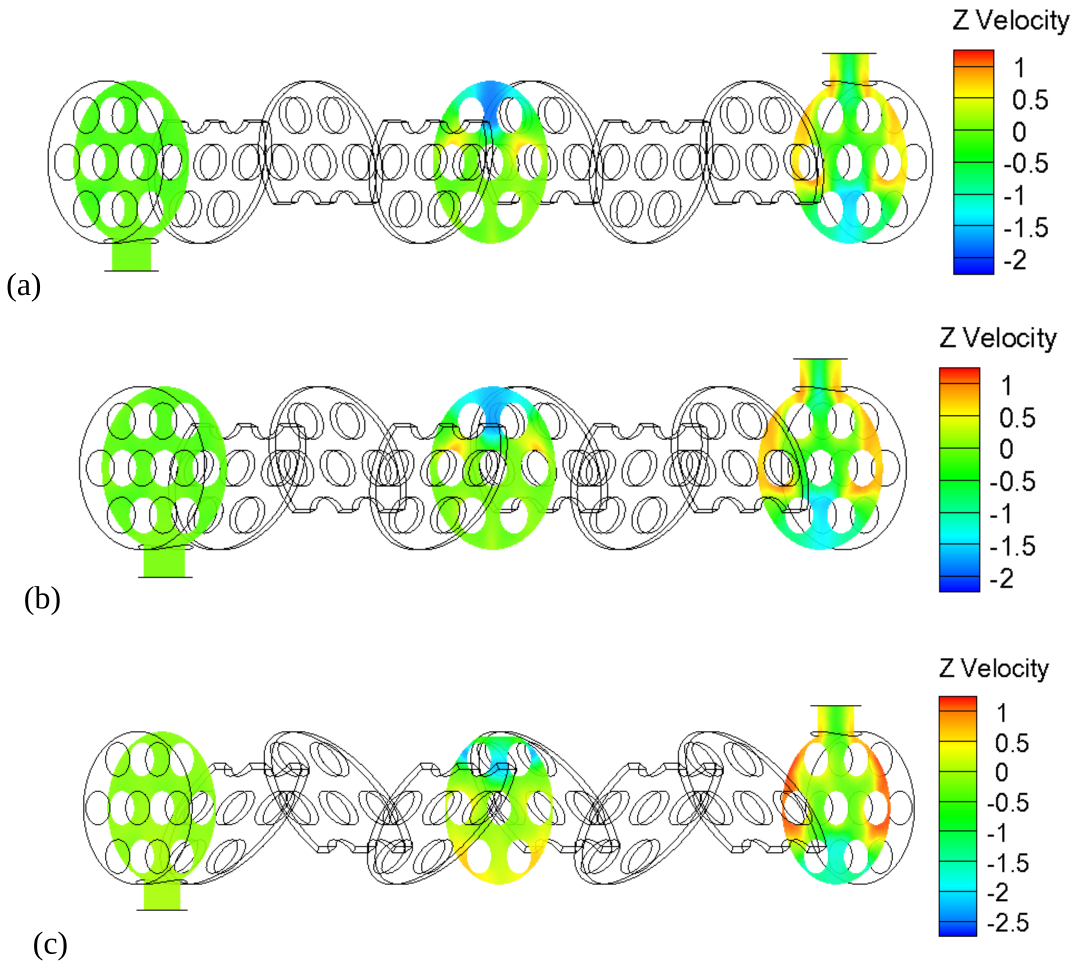


Fig 2. Temperature contour for (a) 15°, (b) 25°, (c) 45°

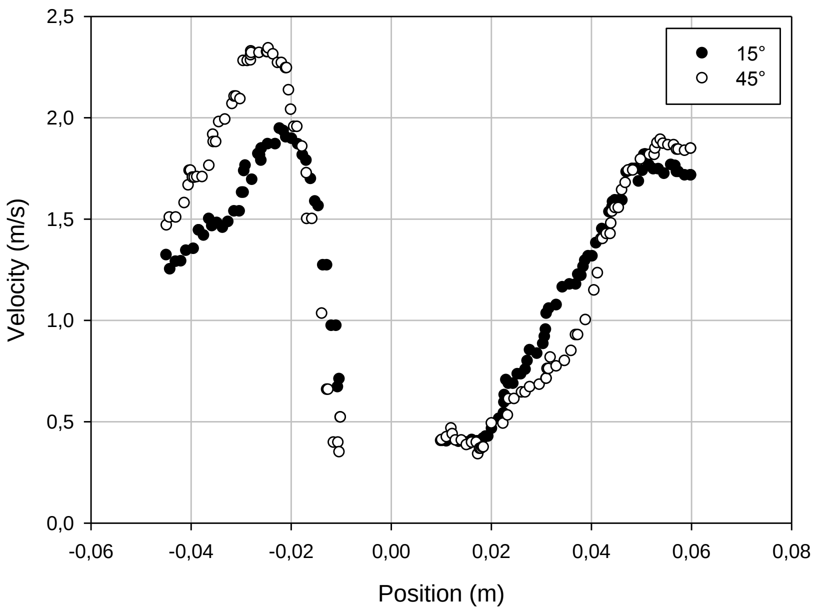
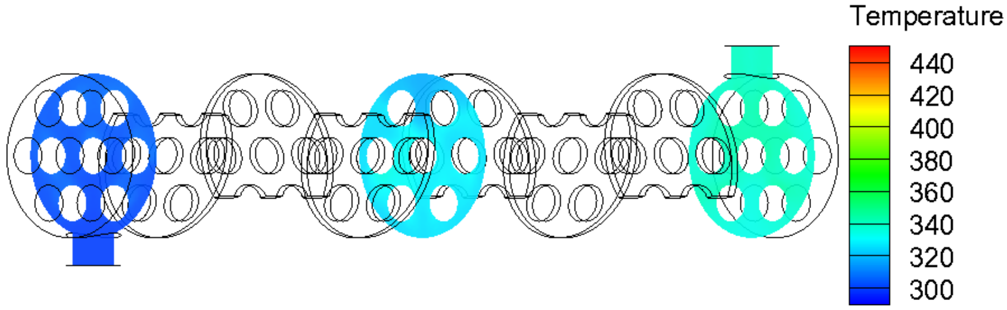


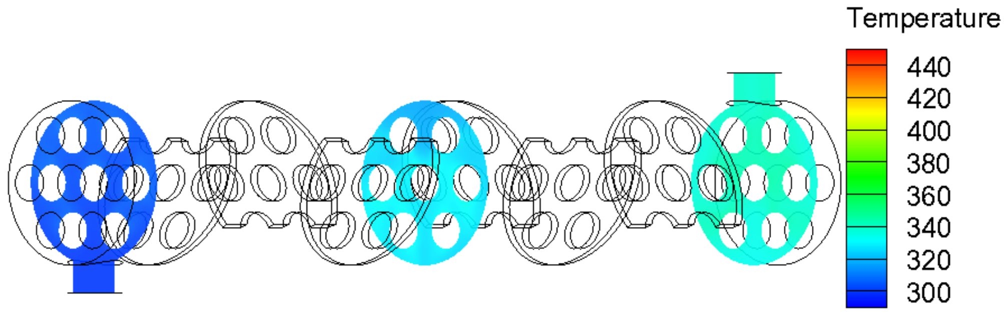
Fig 3. Velocity profile z = 0.02 m for 15°, 45°

The velocity distribution for the two configurations 15°, 45° shown in Figure 3. Below the central tube the flow velocity for the 15° angle reach 1.96 m/s and decrease to 1.75 m/s at the outlet. For the inclination of 45° the velocity reaches a value of 2.35 m/s and decreased to 1.85 m/s at the outlet of the shell, we see that there is a strong gradient of the velocity for the angle of 45°. In great baffles inclinations the transversal component of the velocity is dominant.

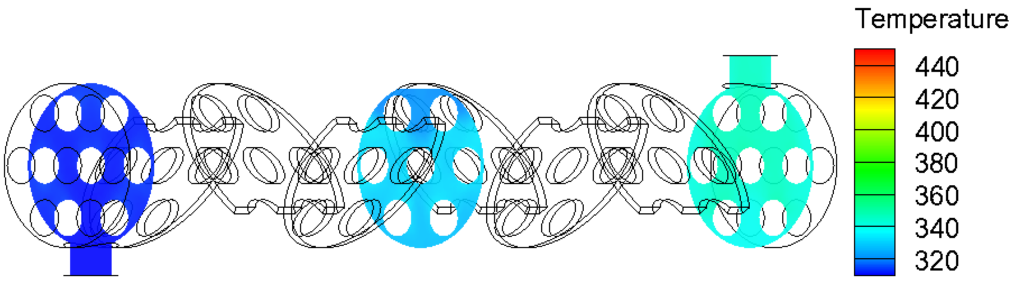
3.2 Transverse temperature profile



(a)



(b)



(c)

Fig 4. Temperature contour for (a) 15°, (b) 25°, (c) 45°

Figure 4 shows the variations of the shell temperature for the three baffles inclinations. For these configurations, the distribution of the temperature field becomes more homogeneous because there is a smoother guide of fluid towards the tubes which cause an increase in the water temperature.

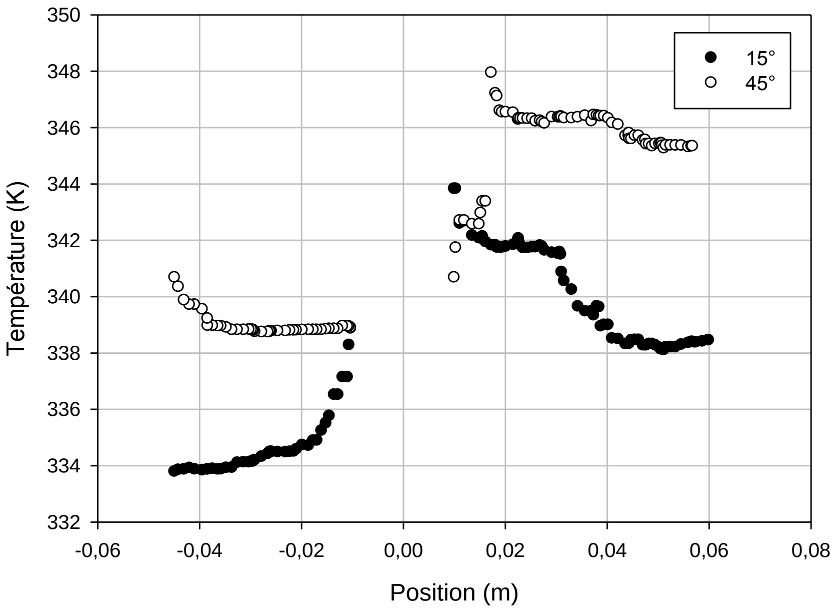


Fig 5. Temperature distribution for 15°, 45°.

The temperature curve are presented in Figure 5 at the outlet for the inclination angle of 15° and 45°. For both cases the fluid temperature increased near the central tube and decrease when away from. The average temperature for the angle 45° above the central tube is about 346 K and the average temperature for the angle 15° in the same region is 340 K.

3.3 Total heat transfer rate

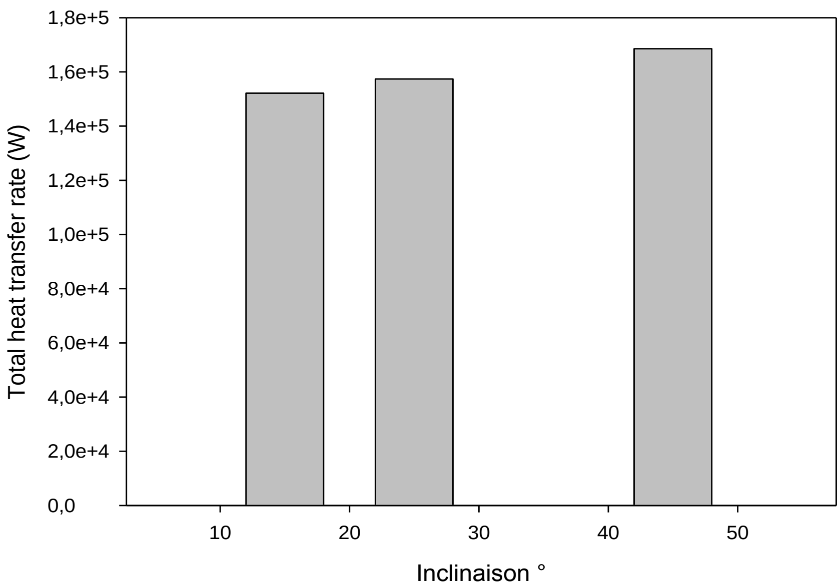


Fig 6. Total heat transfer rate

A presentation of the total heat transfer rate for different baffles inclinations show in Figure 6.

This parameter increases with the increase of inclination angle, that when the baffle inclination increases by 15°, 25° to 45°, the heat transfer rate increases by 1.03% and 1, 11%. We can see it that the heat exchanger with baffles inclination of 45° gives better values.

4. Conclusion

In this study, the shell design studied numerically by modeling a heat exchanger using ANSYS Fluent. The study focuses on the performance of the heat exchanger for a baffle free segment of 36% by varying the inclination angle.

The simulation results, temperature outlet, pressure drop, heat transfer coefficient, recirculation near the baffles, the average outlet temperature increases by 4 K, the amount of heat exchanged between the tubes and the water increases by 1.11%, with the increase from 15° to 45°.

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