

HEAT TRANSFER TO NEWTONIAN AND NON-NEWTONIAN FLUIDS IN CROSS-CORRUGATED CHEVRON-TYPE PLATE HEAT EXCHANGERS: NUMERICAL APPROACH



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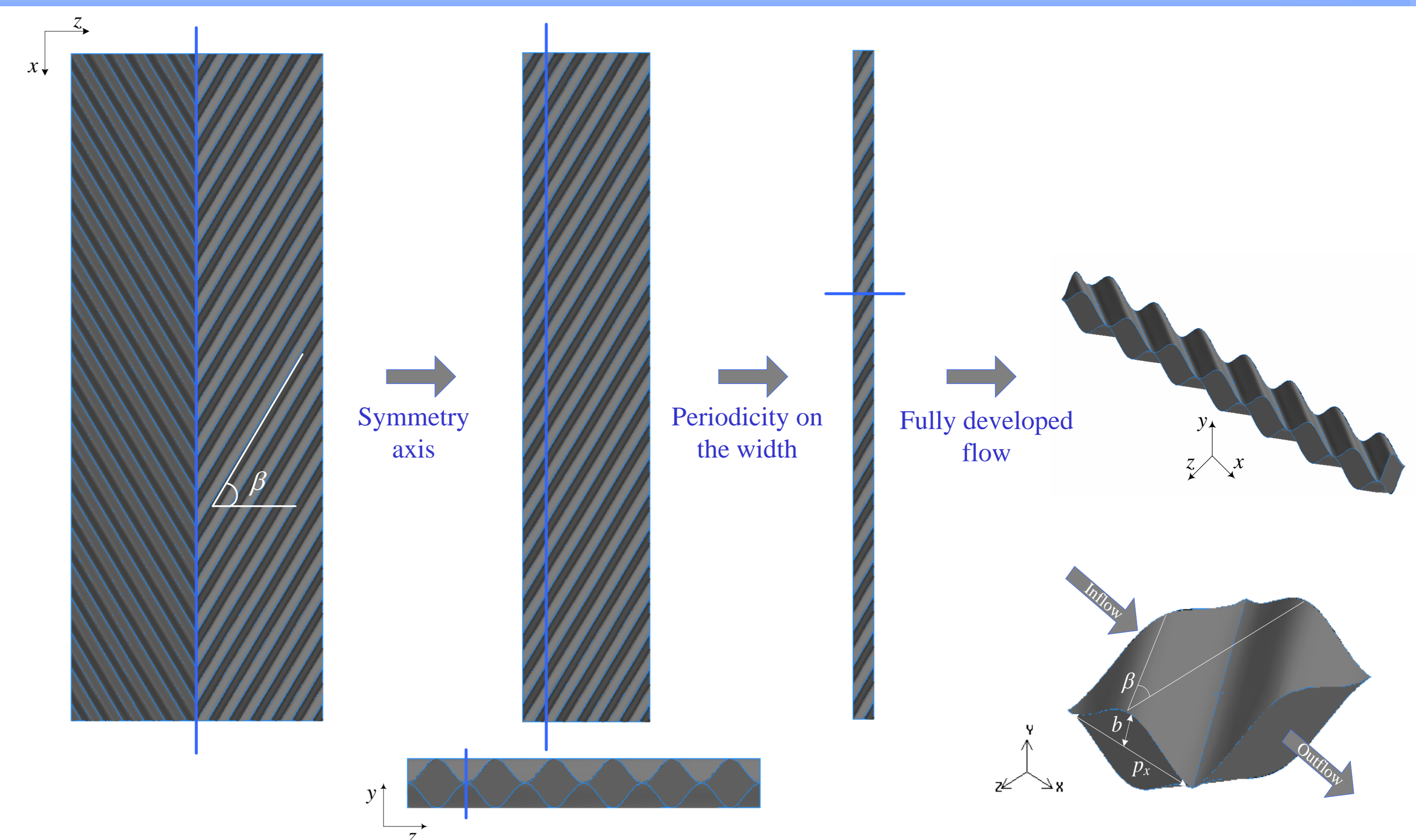
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INTRODUCTION

Research on heat transfer of fluids during thermal processing is useful to optimise the heat exchanger design, as well as to define quality levels of processed fluids. In this study, non-isothermal fully developed laminar flows of distinct fluids in different PHEs passages (main heat transfer area) were numerically studied, in order to evaluate the influence of the geometrical properties of the PHE channels and fluid properties on the thermal-hydraulic performance. The used constitutive model was the power-law model:

$$\eta = \eta_0 \dot{\gamma}^{n-1}$$



GEOMETRICAL PROPERTIES OF CHEVRON-TYPE PHE

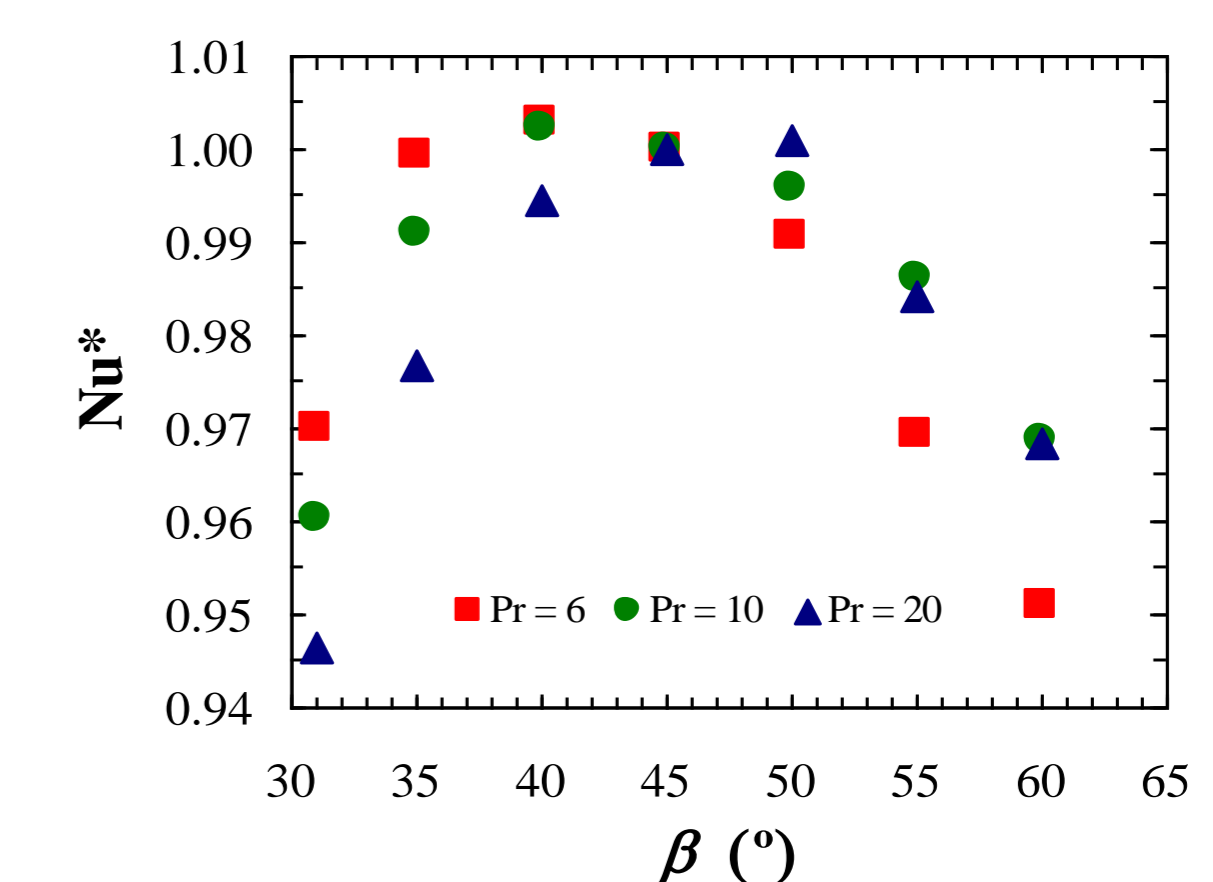
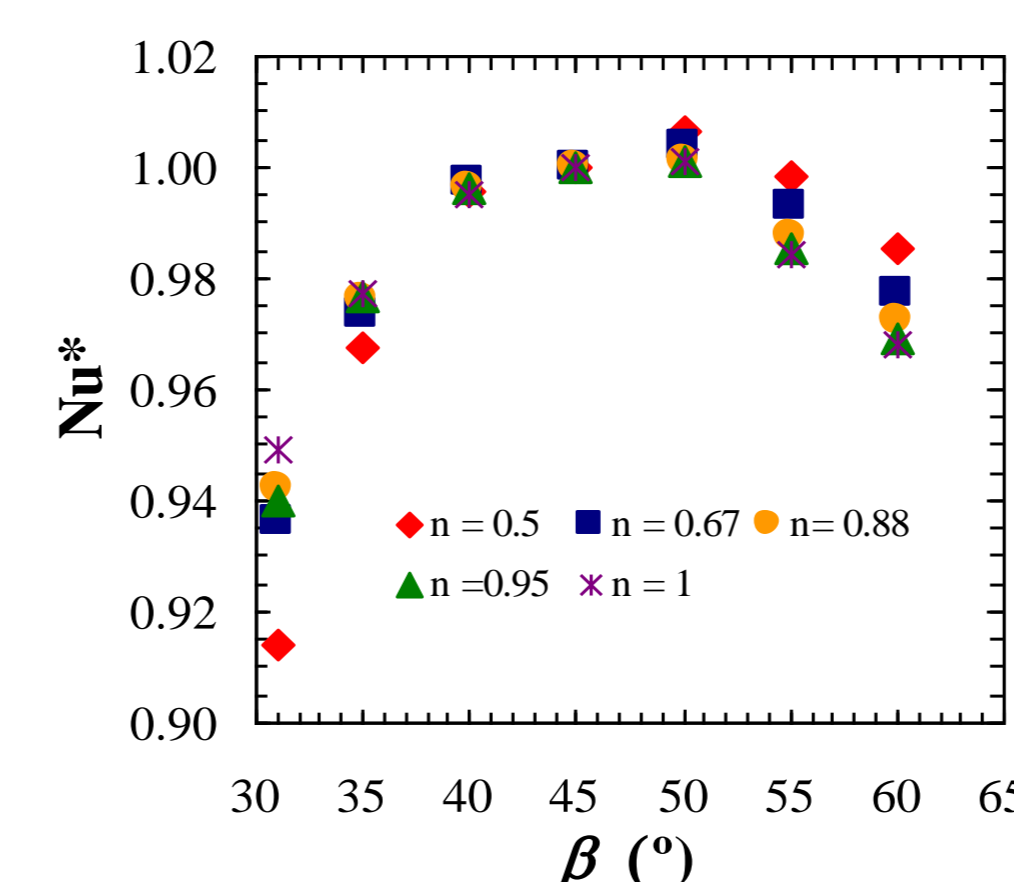
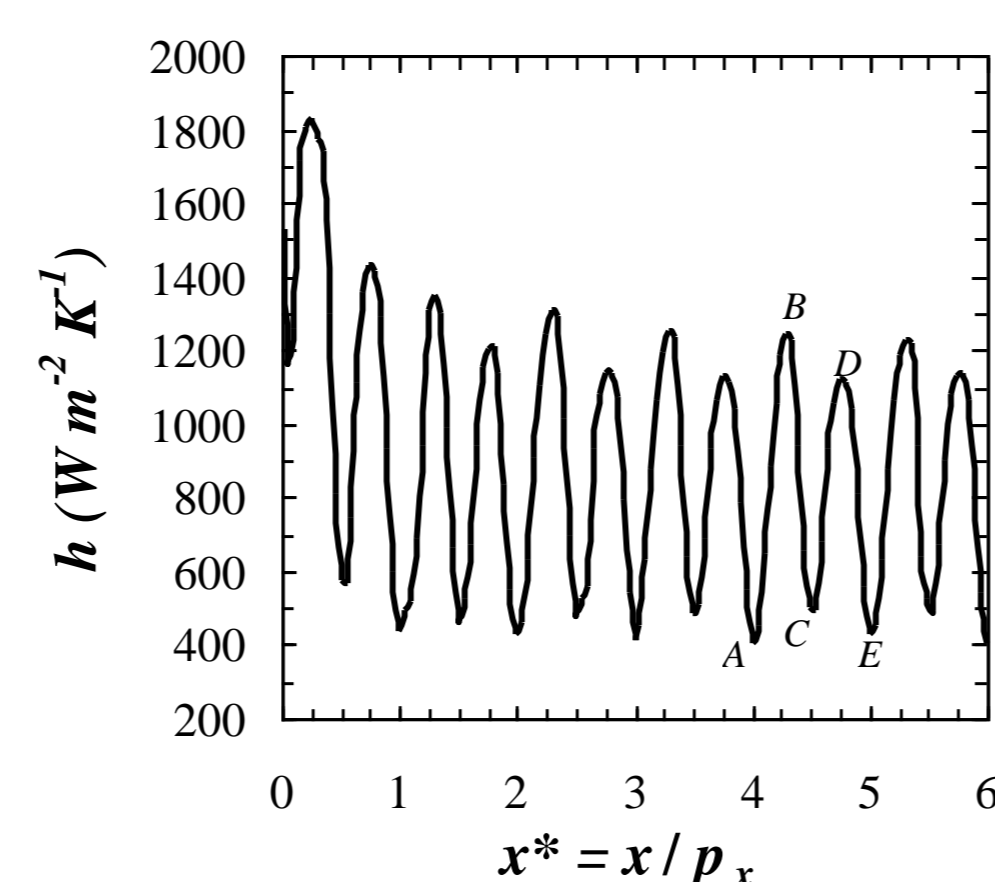
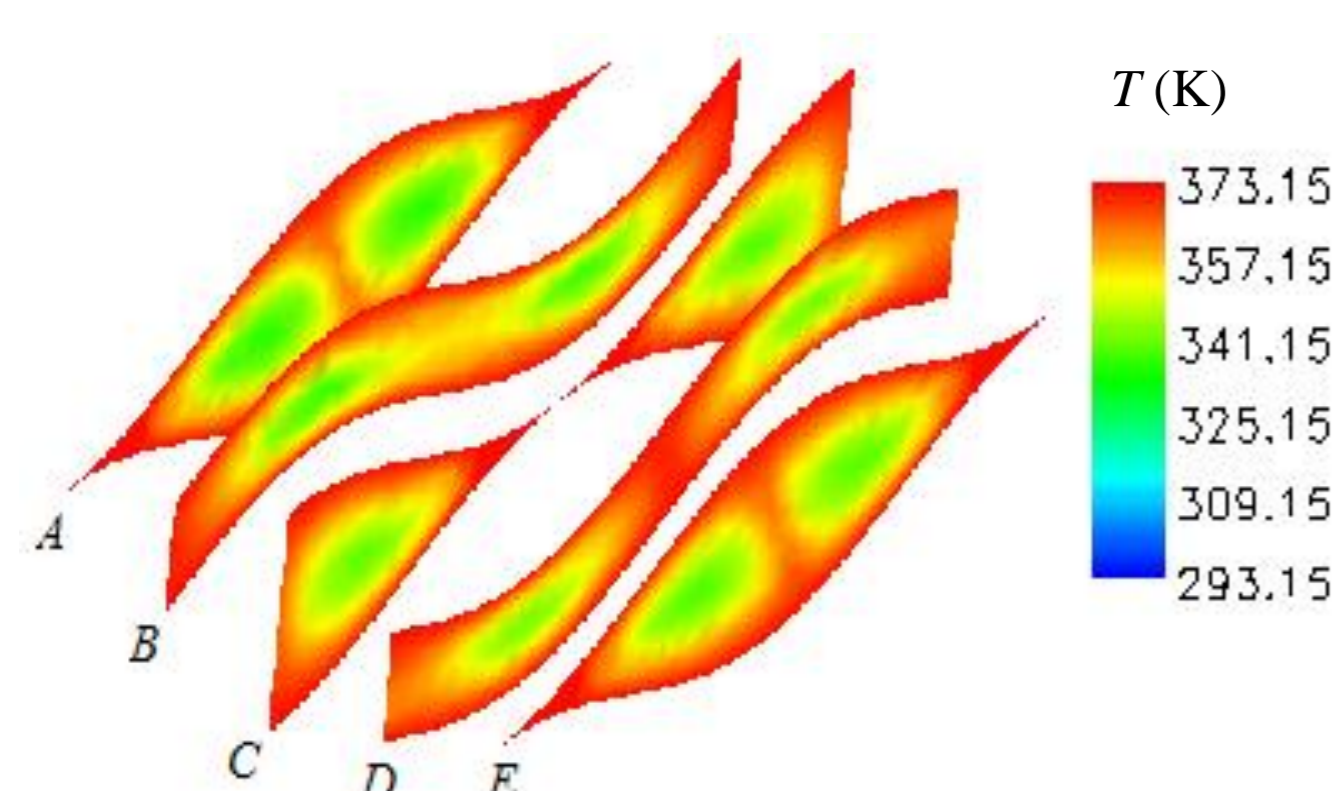
D_H – Hydraulic diameter; ϕ – Area enlargement factor; γ – Channel aspect ratio

$$D_H = \frac{2b}{\phi} \quad \phi = \frac{1}{6} \left\{ 1 + \left[1 + \left(\frac{\pi}{2 \cos(\beta)} \right)^2 \gamma^2 \right]^{0.5} + 4 \left[1 + \left(\frac{\pi}{2\sqrt{2} \cos(\beta)} \right)^2 \gamma^2 \right]^{0.5} \right\} \quad \gamma = \frac{2b}{p_x}$$

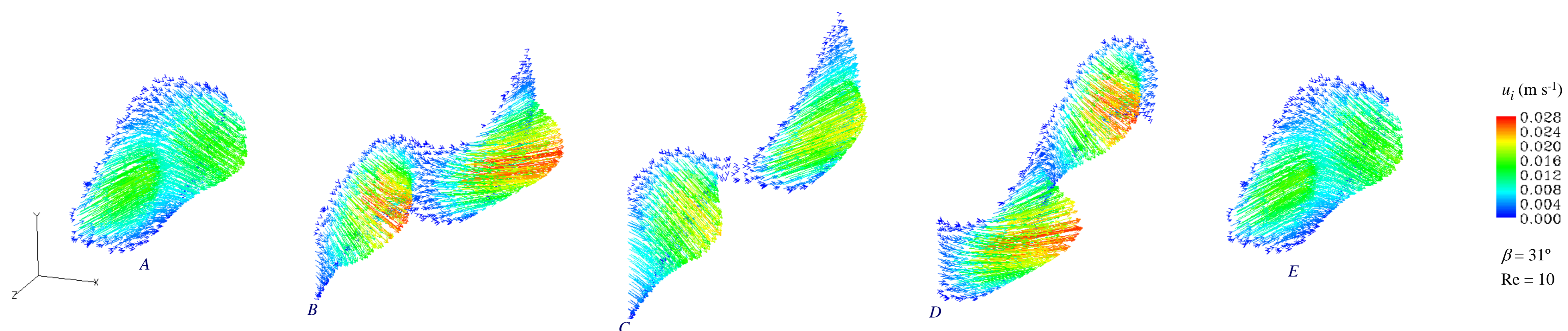
RESULTS & CONCLUSIONS

Knowing the local temperature of the fluid along the channel it is possible to estimate the local convective heat transfer coefficient, h . The average Nusselt number, Nu , can be estimated using the average value of h . In the figures below, it can be observed that the Nu number (fully developed flow) achieved a maximum for β close to 40°-50°.

$$h = \frac{M_v \rho C_p \Delta T_f}{A(T_w - T_f)} \quad Nu = \frac{h D_H}{k} \quad Nu^* = \frac{Nu(\beta)}{Nu(45^\circ)}$$



The tortuosity coefficient, $\tau_i = u_i / u$, is used by PHE manufacturers for the design and optimization of PHE geometries. The numerical results allow the calculation of the local interstitial velocity, u_i , in any plane along the channel and, consequently, τ_i . The local and, therefore, the average value of this coefficient increases with the increase of β and n .



The thermal-hydraulic performance of the PHEs passages can be compared using the area goodness factor, j/f . For a fixed n , j/f increases with the increase of β , this being a consequence of the decrease of the Fanning friction factor, f , with the increase of β .

$$j/f = \frac{Nu}{Re Pr^{1/3} f} \quad f = \frac{\Delta P D_H}{2 L \rho u^2}$$

