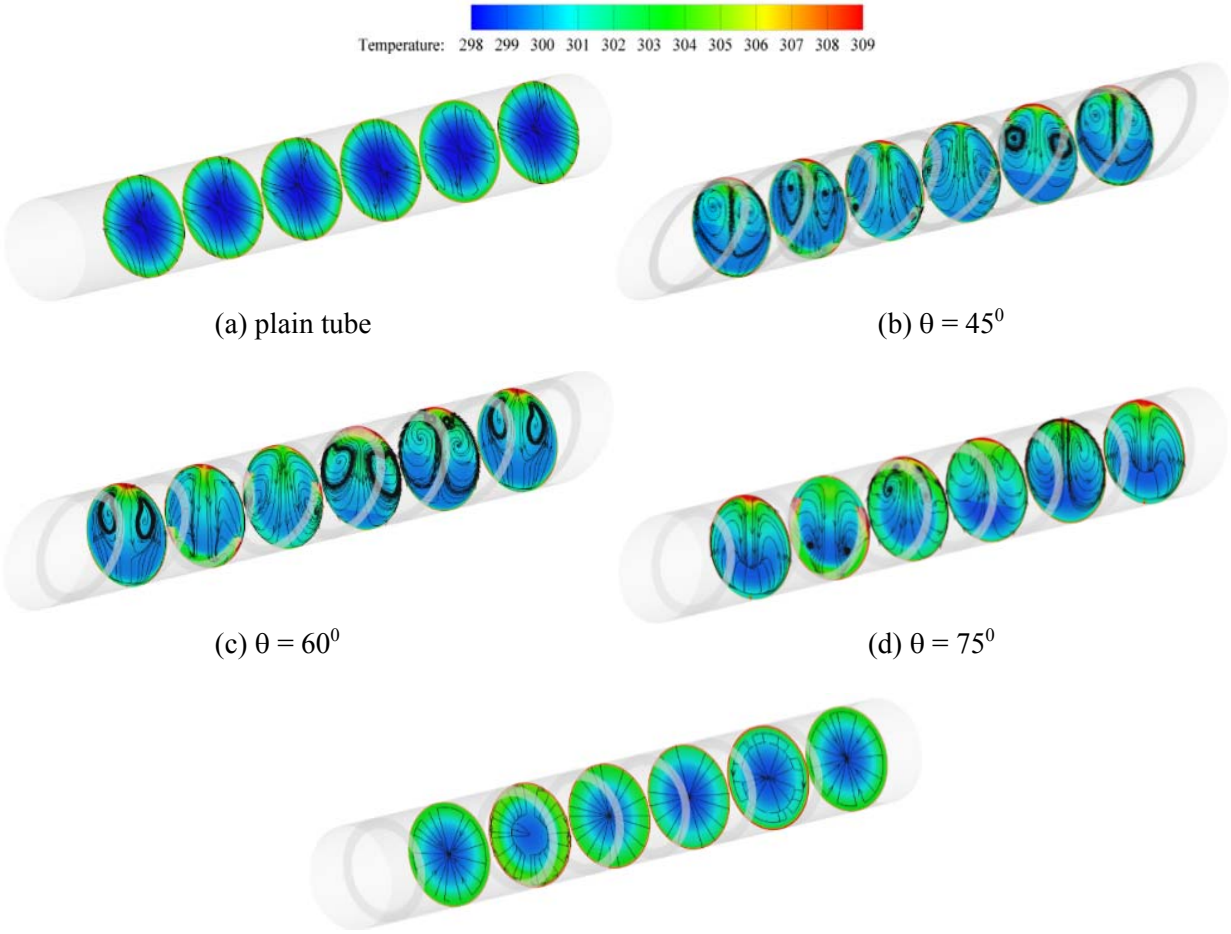


(a) plain tube (b) $\theta = 45^0$

(c) $\theta = 60^0$ (d) $\theta = 75^0$

(e) $\theta = 90^0$

Figure : Streamlines in the streamwise plane of tubes equipped with circular-rings

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# INFLUENCE OF INCLINED CIRCULAR-RING TURBULATORS ON THERMOHYDRAULIC CHARACTERISTICS

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The present research reports the numerical results of heat transfer enhancement, friction factor and thermal performance characteristics of the tubes inserted with inclined circular-rings (i-CRs) and transverse circular-rings. The inclined circular-rings with different inclination angles of 45°, 60° and 75° and the transverse circular-rings 90°), were numerically tested under uniform heat flux condition. The figure shows the secondary flow patterns in transverse planes in tubes equipped with the circular-rings, vortex/secondary flow exist in front of the inserts while recirculation zones appear behind the inserts. As inclination angle decreases, the sizes of the vortex/secondary flow and recirculation-zone signifcantly become larger. However, in case of the transverse circular-rings ($\theta = 90^o$) only recirculation zones appear together with dead zones which significantly suppress fluid mixing. The contour plots of temperature fields along the transverse plane of tube equipped with the inclined circular-rings and the transverse circular-rings at Re = 5000 are shown in the figure. Evidently, all inclined circular-rings ($\theta = 45^o$, $60^o$ and $75^o$) cause more significant change of temperature field than the transverse ones ($\theta = 90^o$), attributed to the presence of vortex/secondary flows or high turbulent zones. This indicates that the inclined circular-rings give better fluid mixing and thus, high convection heat transfer than the transverse ones.