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Evolution of secondary cross-flow in turbulent duct flow[1] CHANDRIMA JANA MAITI, URMILA GHIA, Dept.Mechanical and Materials Engineering, U.Cincinnati, LEONID A. TURKEVICH, Natl.Inst.for Occupational Safety and Health (NIOSH)-CDC — In addition to the primary axial flow, fully developed turbulent flow in a square duct differs from turbulent pipe flow in that it exhibits mean secondary Nikuradse cross-flow. In order to study the appearance and evolution of this cross-flow, we have performed a series of RANS-RSM simulations of this duct flow for Reynolds number Re <10,000. At a critical Reynolds number Re_c =704, the flow becomes turbulent, with the pressure drop, dp/dx, discontinuously increasing and a weak cross-flow discontinuously developing. For the square duct geometry, the cross-flow consists of alternating Nikuradse vortices located in each octant, with flow directed diagonally towards the corners and away along the sides. Associated with each vortex, opposite vorticity shear develops at the walls. We quantify the cross-flow by the circulation around each octant. For Re >2500, the bulk Nikuradse vortex contributes $\sim$ 9/5, and the wall vorticity $\sim$ - 4/5 to the circulation. The octant circulation increases sub-linearly with Re (exponent $\sim$ 0.85); similarly, dp/dx $\sim$ $Re^{1.64}$, consistent with pipe flow scaling. Near the transition, Re <750, both octant circulation and dp/dx exhibit downward curvature, characteristic of a second-order transition; however, the transition appears to occur abruptly.

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