Coherent structures and secondary motions in open duct flow

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Abstract

Fluid flow through a straight open duct with a rectangular cross-section has a broad range of engineering applications. Such flow exhibits turbulence-induced secondary motion of small amplitude (only few percent of the bulk velocity), but with large consequences for momentum, heat and mass transport. In order to study the detailed mechanism of the secondary motions, a series of fully-resolved pseudo-spectral direct numerical simulations were performed for Reynolds number ranging from marginal to moderate limits, with the duct aspect ratios (A, ratio of the duct half-span to the duct full-height) varied between 0.5 and 8. Over the course of the current study, we found that the preferential locations and dynamics of the turbulent coherent structures are responsible for the secondary flow formation. Moreover, new marginal secondary flow states were observed for $A = 0.5$ and 2 for the first time during the current study. Furthermore, the appearance of the well-known velocity *dip-phenomenon*, referring a fact that the maximum streamwise velocity is found somewhat below the free surface under certain flow conditions, was observed to depend not only on a critical aspect ratio, but also the flow Reynolds number. The structural explanations of those newly-observed phenomena will be the main focus of the talk.

Note that this presentation is purposed to be a rehearsal for the author's doctoral examination.

KEYWORDS: duct flow, secondary flow, coherent structure, direct numerical simulation, pseudo-spectral methods