FLOW AND MASS EXCHANGE PROCESSES BETWEEN A CHANNEL AND A CAVITY FILLED WITH A NEUTRALLY BUOYANT OR A DENSE MISCIBLE CONTAMINANT

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The flow past a two-dimensional (2D) cavity situated in a channel is studied using Large Eddy Simulation (LES). The flow just upstream the cavity corresponds to a developing laminar boundary layer profile. First, 3D LES is used to investigate the main instabilities and coherent structures present in this flow. In the 3D case the simulations showed that while the dominant flow feature in the cavity region was the shedding of large spanwise structures at a frequency corresponding to St=0.5, secondary 3D instabilities forced the breaking of these structures into an array of hairpin like vortices (Fig. 1) during their interaction with the cavity trailing edge, followed by their convection downstream the cavity close to the channel bottom.

Then, the unsteady purging mechanism corresponding to ejection of a neutrally buoyant and of a dense miscible contaminant (two non-zero Richardson numbers are considered) introduced in the cavity at a certain time is studied using 2D LES. The simulations showed that the transport mechanism through which contaminant situated originally inside the cavity is purged from the cavity is very different in the non-buoyant case (Ri=0) compared to the buoyant ones (Ri=0.2 and 0.4). Evidence of that is provided by the time histories of the contaminant flux at the top of the cavity and downstream of it shown in Fig. 2 for the three cases. If in the non-buoyant case the dominant mechanism is the interaction among the primary and secondary recirculation eddies inside the cavity with the shear layer near the middle of the cavity (x/D=1) which produces mixing of fluid at the interface and regular ejection of wisp of fluids containing contaminant, in the negatively buoyant cases after some time from the start of the purging process, a wave motion of relatively high amplitude is apparent on the density interface between the lower layer containing heavier fluid and the top layer. This internal wave also interacts with a recirculation eddy formed near the trailing edge corner over the depth of the top layer and with the shear layer to entrain relatively high concentration contaminant from the top layer and from the interface between the top and bottom layer. The process is similar even after the density interface starts interacting with the cavity bottom. As shown in Fig. 3 in which the decay of the contaminant mass in time is represented, the purging process slows down considerably when the Richardson number is increased.

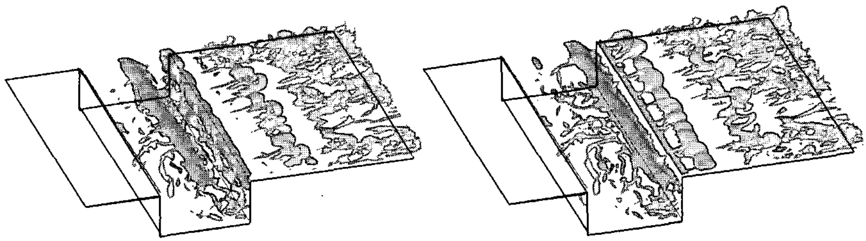

Fig. 1 Coherent structures visualized using Q criterion. a) t=T/2 (left); b) t=T (right)

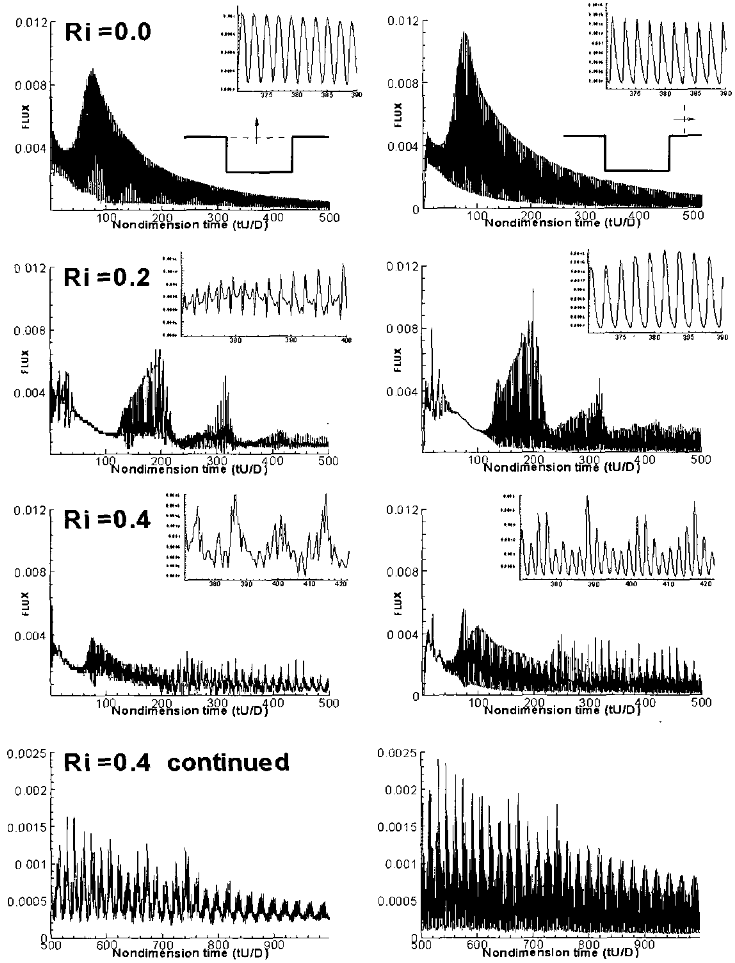

Fig. 2 Contaminant flux dependence on the Richardson number. a) flux through cavity top (left); b) flux through x=2.25D plane downstream the cavity (right).

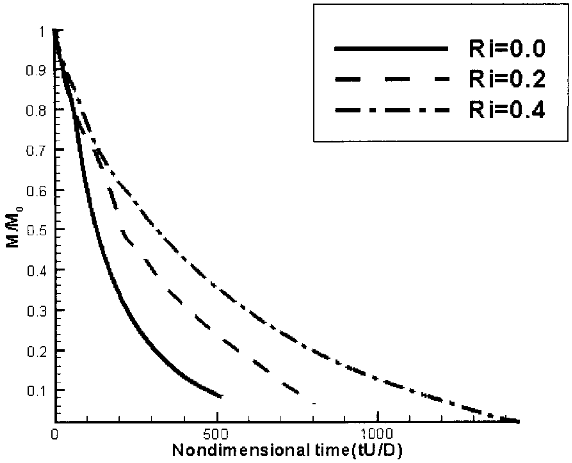

Fig. 3 Variation of contaminant volume in time.