COHERENT STRUCTURES IN PUMP-INTAKE FLOWS: A LARGE EDDY SIMULATION (LES) STUDY

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The presence of unsteady intermittent meandering wall attached and free-surface vortices is a common feature of pump intake flows. These vortices are known to induce high levels of unsteady swirl inside the pump column and negatively affect the performance of the pumps. In the present study we describe the use of a LES model to numerically study the flow and main coherent structures. The numerical engine is a non-dissipative Navier-Stokes massively parallel LES solver that can use hybrid unstructured grids. The model is first validated using the PIV data (Yulin et al., 2000) collected on a scaled model (Fig. 1) of a pressurized (no free surface) pump sump (see Fig. 2). It is found that LES can correctly capture qualitative and quantitative aspects of the flow including the mean flow features observed in the PIV study (Fig. 2) along with the distributions of the mean velocities and especially of t.k.e. Next, the evolution and changes in the structure of the main vortical structures originating at the floor, lateral walls and top wall including phenomena such as intermittency and meandering are analyzed using the instantaneous LES flow fields and spectral analysis. The flow is dominated by large scale interactions among these vortices (e.g., see Fig. 3 which shows the evolution of the main vortex originating at the top wall of the intake in a plane parallel to the floor which cuts through the pump column). For the given flow conditions the main vortex in the flow originates at the floor. The core of the floor attached vortex was found to maintain its coherence not only at the pump bell level but also over the whole extent of the vertical pump column. The decay of the induced swirl inside the pump column was quantified. This study shows that LES can be used to obtain detailed information on the evolution and interactions among the main vortices that is very hard to obtain from scaled model studies. The long time goal of the present work is to use LES as a predictive tool that can be employed in the design or redesign process of pump intakes. As LES directly resolves the most energetic coherent structures, it has build into it much more physics compared to RANS/URANS models and thus a much better chance to accurately capture not only the unsteady dynamics of the vortices but also to more accurately predict the mean flow, in particular the mean swirl distribution inside the pipe.

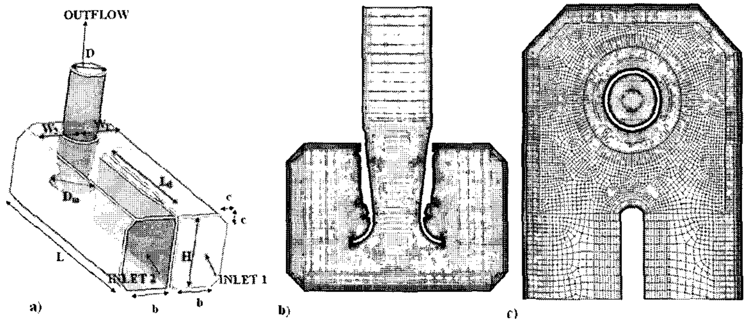

Fig. 1 Pump-intake geometry; a) General sketch of the pump-sump; b) Mesh in a section parallel to the back wall; c) Mesh in a section close to the pump bell level.

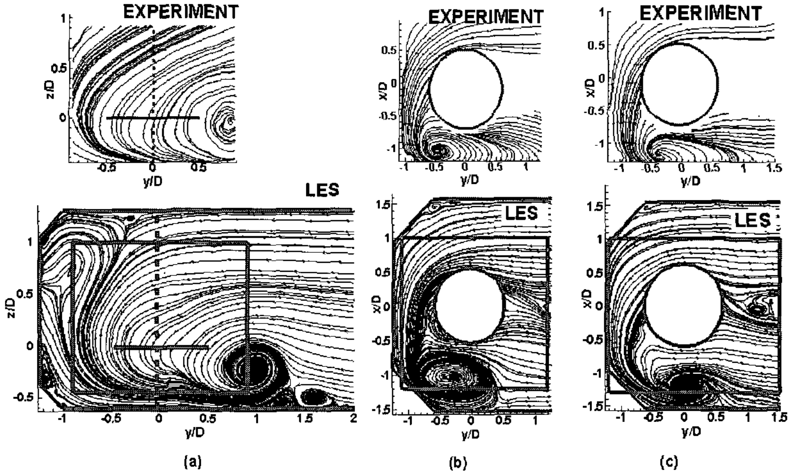

Fig. 2 Comparison between experiment (top) and LES statistics (bottom); a) streamlines in a plane parallel to the backwall; b) streamlines in a plane parallel to the floor; c) streamlines in a plane parallel to the floor closer to the top wall.

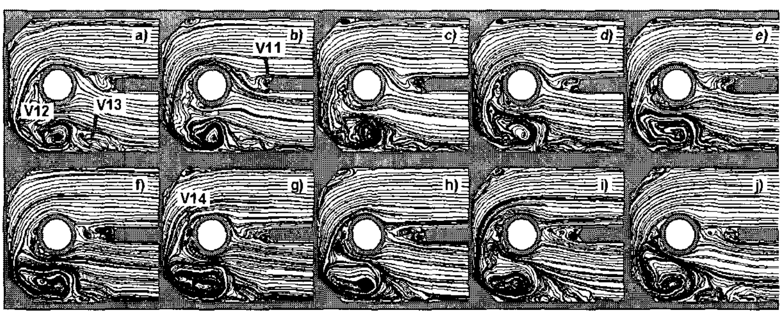

Fig. 3 Instantaneous streamlines of a plane parallel to the channel floor at the level z = 0.53D (1.13D from floor); a) t = 0; b) t = 15D/U; c) t = 30D/U d) t = 45D/U; e) t = 60D/U; f) t = 75D/U; g) t = 90D/U; h) t = 105D/U; i) t = 120D/U; j) t = 140D/U.