CONTRIBUTION TO THE STUDY OF SOLID PARTICLES BEHAVIOR IN CONFINED TURBULENT FLOW BY DIRECT NUMERICAL SIMULATION

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This subject is the combination of two research activities at VKI. On one hand, it is a fundamental work done to improve the knowledge on turbulence mechanisms and on the other hand, it concerns the description of the interactions occurring in multiphase flows.

Considering the first part, the increasing power of computers has made possible the direct resolution of Navier-Stokes equations (DNS). In our channel case, the Reynolds number is the same than the benchmark case of Kim & al. (1987). The numerical techniques involved are the one of Orlandi (2000) with the adjunction of a constant mass flow rate to sustain a stationary turbulent state. Very good statistical, spectral and structural results are obtained. Even if for the latter analysis, it appears that there is no equivalence in between the well known detection criteria λ_2 , Q & D in the channel.

In the second part, a Lagrangian formulation is used to track solid or fluid particles. The solid particles description uses the point materiel hypothesis and involves forces such as; the non-linear drag, the shear-induced lift (both corrected for wall proximity) and/or potential forces (as the one from a gravity or an electrostatic field). These forces use a fully 3d Hermitian interpolation when the fluid velocity at the solid or fluid particle location is necessary. Part of this year as been spend on the description of the turbulence “seen” by solid particles in diluted flow. It has been shown that in weightlessness condition the correlation of Wang & Stock (1993) used to assess the dispersion of solid particles by Lagrangian models (stochastic or Langevin type) was giving good estimation in the spanwise & wall normal direction but not in the direction of the flow. This correlation established in isotropic and homogeneous turbulence was never checked (but used) in non-isotropic and non-homogeneous turbulence. To reach this conclusion Eulerian integral time in a fix and moving reference frame and Lagrangian integral time of the fluid or of the fluid seen by different particles were obtained on all the channel width for the first time and has been shown in a paper in the International Conference of Multiphase Flows in New Orleans (June 2001). Another aspect of this work has been spend in more concentrated flow where the turbulence is attenuated by the solid phase. Diminution of turbulence, augmentation of wall shear stress and displacement of the turbulent energy contents toward high wave number were noticed in weightlessness state. These studies have lead to the final Ph.D. defense in November 2001 and accepted under a French version of the present title.

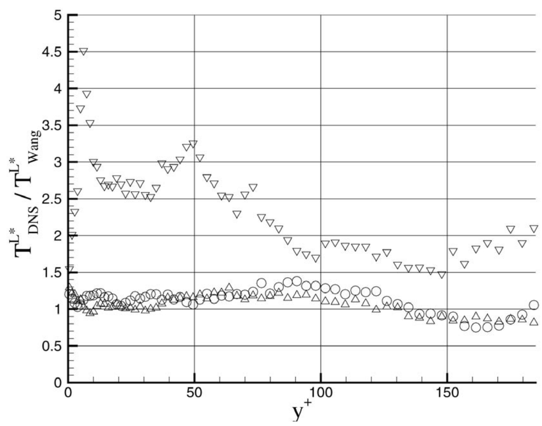

Figure 1: Comparison between the turbulent integral time scales seen by the solid particles predicted by the code and the prediction of Wang & Stock (1993). $\nabla\, u, \mathrm{O}\, v, \Delta\, w$

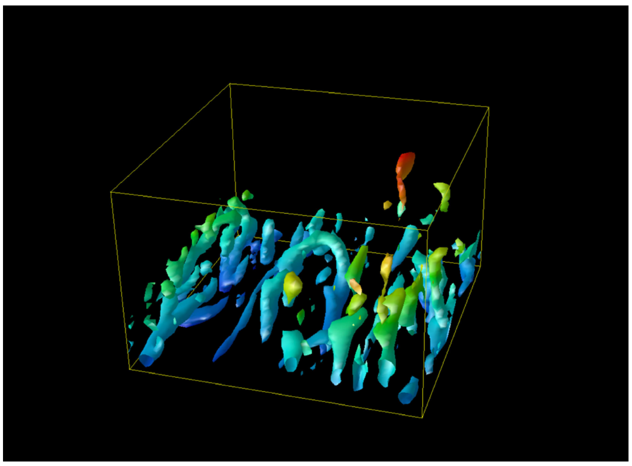

Figure 2: Arch-shoe type vortex detected by Q criterion (colour: from blue to red depending of the distance to the wall).