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Session:

Combining ZDES with Immersed Boundary Conditions technique for the treatment of complex geometries

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The present paper focuses on a numerical strategy called ZIBC consisting of the zonal use of the Immersed Boundary Conditions combined with the ability of Zonal Detached Eddy Simulation [1, 2] to simulate high Reynolds number separated flows. The motivation of such a strategy lies in the accurate handling of geometrically complex configurations with validated unsteady tools. Indeed, in the framework of scale-resolving unsteady simulations with a classical body-fitted mesh approach, the grid generation can become dramatically time-consuming or even unfeasible due to strict grid requirements. The aforementioned methodology appears to be a way to circumvent those limitations. In particular, it would be of considerable interest within the framework of space launcher afterbody by adding geometrical complexity to simplified configurations. Thus, we propose here to assess such a methodology on a simplified space launcher afterbody. The configuration consists of a cylinder elongated by another cylinder of smaller diameter (i.e. an extension). Immersed Boundary Conditions are used to handle the introduction of the extension into a pre-existing structured curvilinear grid fitting the ZDES grid requirements to treat the blunt body configuration (Fig. 1). The governing equations are solved using a standard body-fitted finite volume technique over the whole grid. A direct forcing source term, based on the work of [3] is used on the cells inside the emergence to drive the velocity and the turbulence variables to the chosen values. Numerical simulations are performed at a Reynolds number based on the larger diameter of 1.2×10^6 and a free stream Mach number of 0.702. The numerical results are compared with the experimental (respectively numerical) data of [4-5] (respectively [6]), corresponding to the classical body-fitted mesh approach. Fig. 2 and Fig. 3 suggest that the emergence is properly taken into account. Furthermore, the pressure coefficient (see Fig. 4) illustrates a very good agreement between both the available experimental and ZDES numerical data (classical approach without IBC) and the current ZIBC simulation.

In the final version of the paper, the influence of the combination of Immersed Boundary Conditions technique with ZDES on the fluctuating pressure field around the immersed body will be evaluated within the framework of high Reynolds number separated flows.

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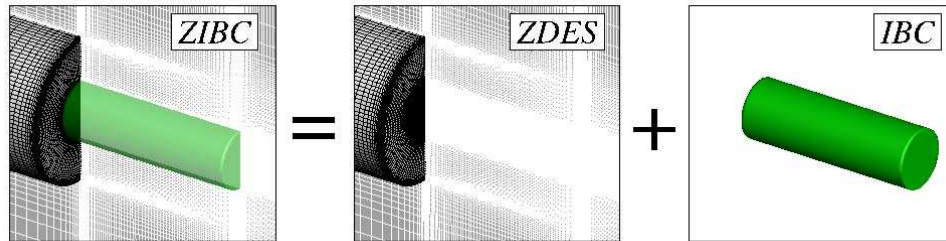


Fig. 1 Principle of ZIBC decomposed into classical primary approaches (i.e. ZDES and IBC)

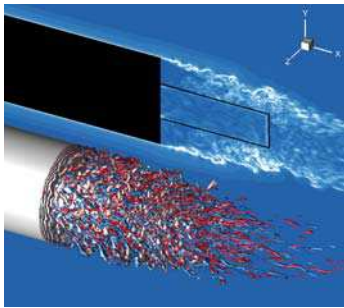


Fig. 2 Qualitative overview of the instantaneous flow field. Foreground: isosurface of Q criterion colored by the sign of streamwise vorticity (red for positive and blue for negative). Background: iso-contours of the density gradient norm in the longitudinal plane

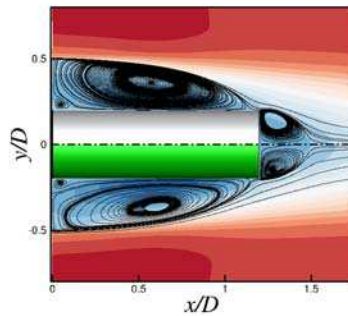


Fig. 3 Streamlines in the mean field with iso-contours of the streamwise velocity plotted on the longitudinal plane. Top: classical body-fitted approach. Bottom: present ZIBC

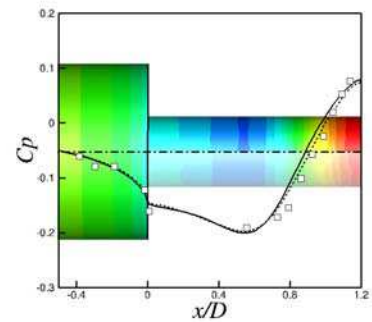


Fig. 4 Streamwise distribution of the mean pressure coefficient with the corresponding isocontours on the skin of the afterbody plotted in the background. Numerical simulations (ZDES): (-) classical approach, (- -) ZIBC. Experiments from [5]: (□)

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