

TOWARDS LARGE-EDDY SIMULATION OF COMPLEX FLOWS IN MARITIME APPLICATIONS

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Turbulent flows in maritime applications usually contain a wide range of length and time scales, especially for high Reynolds numbers. Therefore, it is not feasible to solve such flows with direct numerical simulation. To reduce CPU-times, a model is proposed. This model is a blend between an LES model based on regularization [3] and an eddy-viscosity model [4]. The non-linear convection term produces small scales of motion. At the smallest scale the diffusion should dissipate these small scales. But on an LES grid, these smallest scales are not resolved. Therefore, an eddy viscosity will be computed such that the diffusion counteracts the production term. In order to prevent the transfer of energy from unresolved scales to resolved scales (backscatter), the convection term will be regularized.

This regularization model is constructed in such a way that it filters the convective terms in the Navier-Stokes equations without adding any artificial dissipation. The spatial discretization preserves the energy too [2]. By this construction, the LES model does not contain any artificial dissipation. This is quite important, since artificial dissipation can interfere with the subtle interplay between inertia and dissipation of the flow.

This blended model is built into MARIN's in-house CFD solver ReFRESKO [1]. An important difference with the methods mentioned in [3, 4] is that ReFRESKO uses unstructured grids. For complex maritime applications unstructured meshes are needed. Unstructured grids are also preferable since local grid refinement can be applied to solve the flow accurately. While at the same time the grid can be coarser in the regions where details of the flow are less important, resulting in a strong reduction of grid cells. Furthermore, the unsteady Navier-Stokes equations in ReFRESKO are solved implicitly in time. Filtering increases the complexity of the nonlinear system of equations, but by us-

ing a defect correction approach the filtering does not enter into the matrix of the linear system. DNS and LES results will be shown for a flow around a 3D circular cylinder at $Re = 3,900$ and compared to the numerical results from [5] and experimental data from [6].

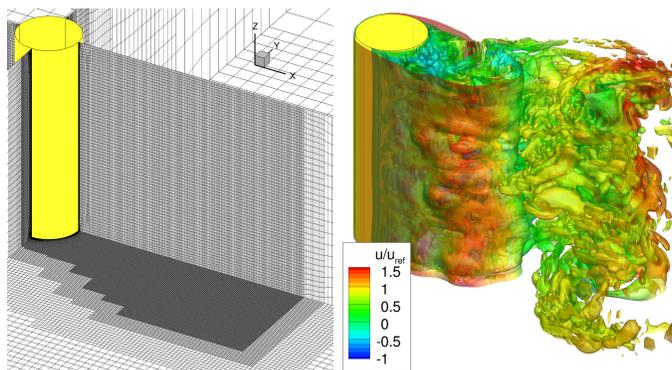


Figure 1: *Left:* Detail of the 3D DNS mesh for circular cylinder, which contains 4.08M grid cells. *Right:* Velocity u plotted on iso-surfaces, which are based on vorticity in z .

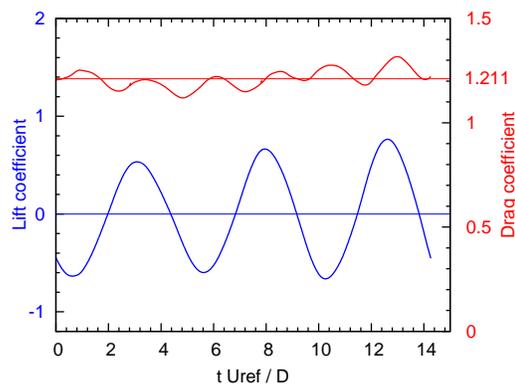


Figure 2: Drag and lift coefficient for 3 shedding cycles for circular cylinder flow at $Re = 3,900$, with $\frac{u_{ref}\Delta t}{D} = 1/64$. $\overline{C_D} = 1.211$, $\overline{C_L} = 0.000$ and Strouhal number is 0.210.

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