

Session:

Assessment of turbulence models for flow around three-dimensional geometries

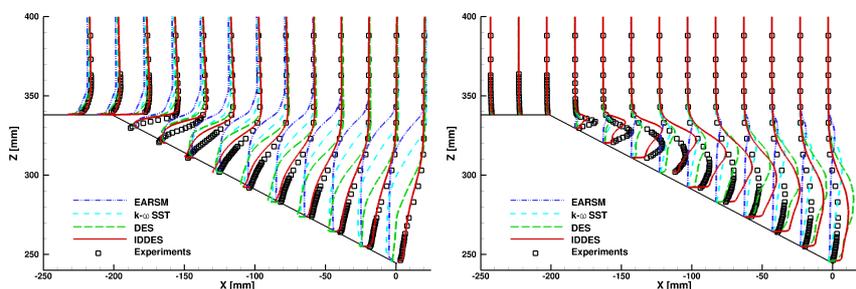
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This paper presents a computational study of flow around three-dimensional geometries as the Ahmed body, which is a classical test case for automotive flow, but also as the JBC (Japan Bulk Carrier) which was firstly investigated in the framework of the Tokyo 2015 Workshop on Numerical Ship Hydrodynamics. For both test cases, an investigation of RANS ($k-\omega$ SST [1] and EARSM [2]) and hybrid RANS-LES models (DES [3] and IDDES [4]) is conducted. All simulations have been performed with the ISIS-CFD flow solver, which is developed by Ecole Centrale de Nantes and CNRS.

The first geometry is the Ahmed body. The Reynolds number, based on the length of the model and the upstream velocity is $Re = 2.78 \cdot 10^6$. The computational grid contains 23.6 million nodes for the slant angle 25° .

Figure 1 presents a comparison of the upstream velocity, U component, and turbulent kinetic energy, TKE, on the rear window in the symmetry plane of the Ahmed body. The agreement with the experimental data is not good for the results obtained with a RANS turbulence model. With this turbulence model, a massive separation is predicted on the rear window. With a hybrid RANS-LES model, the agreement with the experimental data is better. A recirculation bubble is predicted on the slanted rear. However, with the DES model, this bubble covers the whole



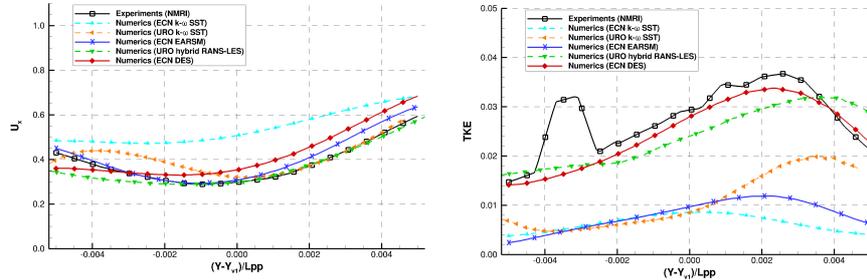
a) Upstream velocity b) Turbulent kinetic energy
Fig. 1 Comparison of U component and TKE in th symmetry plane

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window while with the IDDES model, a reattachment point is located at 75% on the rear window. With both hybrid RANS-LES models, TKE is overestimated at the end of the rear window.

The second geometry is the Japan Bulk Carrier (JBC). Its length between perpendiculars at model scale is $L_{pp} = 7$ m, its speed is $U = 1.179$ m/s, and then the Reynolds number is $7.46 \cdot 10^6$. The mesh comprises of 66 million nodes. Comparisons with experimental data are carried out in a plane $X/L_{pp} = 0.9843$, $X = 0$ being the front of the ship. In this plane, the main vortex center is relied on the local maximum of the longitudinal vorticity, which is satisfactory if the axis of the vortex is aligned with the X longitudinal direction.

Figure 2 shows the comparison for the longitudinal component of the velocity and TKE. Y_{v1} and Z_{v1} stand for the coordinates of the mean vortex center. A satisfactory agreement is observed for the mean longitudinal component of the velocity in the core of the vortex while a very large difference between experiments and computations for TKE distributions is noticed. The level of TKE computed with hybrid RANS-LES formulations, in very good agreement with experiments, is three to ten times higher than what is simulated by the isotropic or anisotropic RANS models.



This paper shows the superiority of the hybrid RANS-LES models against RANS models to predict all quantities for three dimensional flows.

References

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