Wall-modelled LES of the Japan Bulk Carrier in model scale

Mattias Liefvendahl[*†] **and Timofey Mukha**[†]

[†] Department of Mechanics and Maritime Sciences
Chalmers University of Technology
SE-412 96 Gothenburg, Sweden
e-mail: timofey@chalmers.se, web page: http://www.chalmers.se/

[*] Department for Naval Systems
Swedish Defense Research Agency, FOI
SE-164 90 Stockholm, Sweden
e-mail: mattias.liefvendahl@foi.se, web page: http://www.foi.se

ABSTRACT

This work considers the application of wall-modelled large-eddy simulation (WMLES) to the flow around the hull of a Japan Bulk Carrier (JBC) in model scale. The simulated configuration corresponds to a double body, i.e. a symmetry plane to represent the water surface, which is one of the test cases of the Tokyo 2015 Workshop on CFD in Ship Hydrodynamics. A relatively large number of contributions to the workshop employed RANS, and there was one [1] in which wall-resolved LES (WRLES) was used. For the WRLES, $4.8 \cdot 10^9$ grid cells were necessary to have sufficient spatial resolution, the most part of which were situated in the inner part of the turbulent boundary layer (TBL).

The first results for this simulation case with proper WMLES, i.e. with resolved fluctuations in the TBL along the hull, were published in [2]. Since the wall-modelling relaxes the grid resolution requirements in the inner part of the TBL, it sufficed with $136 \cdot 10^6$ grid cells for this case, i.e. a gain of a factor 35 as compared to WRLES. The grid generation was based on an a-priori estimate of the TBL thickness, δ, along the hull, then employing the best-practise guidelines for WMLES previously developed, [2]. The present contribution extends the study [2] with further analysis of the results, as well as additional simulation data. The focus is on assessing the predictive accuracy of the turbulence modelling approach, with respect to the characteristics of the TBL over the hull, and in particular when affected by the adverse pressure gradient over the stern.

Previously [2], the analysis focused on the skin friction coefficient, and the mean velocity profile. Here a more detailed consideration of the obtained flow field will be presented, including unsteady features of the flow and a closer look at the stern flow field, which is very important for propulsion applications. Furthermore, the effect of variations in wall modelling methodology will be discussed. The most important are the wall model, and the grid resolution and grid cell topology within the TBL. An algebraic wall-stress model is employed, an important feature of which is that the velocity sampling can be selected independently of the grid. Based on results from simulations of a flat-plate TBL and turbulent channel flow [2, 3], a judicious use of this feature is expected to improve the WMLES predictions.

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