Scale effects on self-propulsion characteristics of Japan Bulk Carrier

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ABSTRACT

The ship propulsion characteristics are commonly obtained by means of towing tank tests. The experimentally obtained results need to be extrapolated to full-scale using extrapolation procedures, which may introduce numerous sources of errors. Alternatively, Computational Fluid Dynamics (CFD) can be used to assess the ship hydrodynamic performance. Nowadays, with increased computational power it is possible to conduct full-scale numerical simulations [1], which allow the prediction of scale effects. In this study, the scale effects on the propulsion characteristics are investigated by performing numerical simulations of the self-propulsion and resistance tests using the commercial software package STAR-CCM+. The Japan Bulk Carrier (JBC) is selected for the case study since experimental results are available online [2]. The mathematical model used within the numerical simulations is based on Reynolds-Averaged Navier Stokes (RANS) equations which are discretized using the Finite Volume Method (FVM). The Volume of Fluid (VOF) method is used to locate and track the free surface with the High-Resolution Interface Capturing scheme applied to maintain a sharp interface between the fluids. Within STAR-CCM+ the motion of the ship is modelled using the Dynamic Fluid Body Interaction (DFBI) method, which enables six degrees of freedom. The body force propeller method, which is based on a uniform distribution of volume force over the cylindrical virtual disk, is used to model the effects of the propeller. The rotation rate and delivered power are determined using the numerical simulations of the self-propulsion test. The scale effects on the thrust deduction fraction and effective wake are investigated. The nominal wake of the ship is obtained using the International Towing Tank Conference (ITTC) procedure [3] within numerical simulations of the resistance test. A verification study is conducted to assess the simulation numerical uncertainty and the validation study is carried out using the available experimental results to confirm the validity of the numerical model. The obtained numerical results present the scale effects on the ship propulsion characteristics. As noticed in [4], significant scale effects are obtained for both the integral value of nominal wake and circumferential averaged non-dimensional axial velocity distribution.

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