

Seakeeping Prediction of the ONRT Tumblehome in Head Waves with Unsteady RANS

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ABSTRACT

CFD can be considered as a mature tool now for steady state ship hydrodynamic applications such as resistance in calm water. Accurate enough predictions can be obtained with reasonable resources even for fully appended hulls, both for model and for full scale in a routine design procedure.

Compared with resistance computation, validation for propulsion computation is much more challenging. To author's knowledge, the only approach that is capable to predict ship propulsion with accuracy is to simulate directly the rotating propeller with sliding grid or overset approach. Time accurate simulation is required for such simulation even if time averaged solution is sufficient. Our experience from V&V exercises is that a reliable numerical uncertainty estimation is nearly impossible for such simulation due to high iterative error as well as time discretization error.

A reduced model as a possible cost effective solution is to operate the propeller in a rotating reference frame: in order to model a general rigid-body motion (rotation) of one object, the RANS equations are solved in the moving reference frame but written in terms of absolute or inertial reference frame quantities. In the simplest case of a propeller in open-water, that rotating frame method (RFM) allows the use of steady calculations. Nevertheless, unsteady flows are possible to be modelled with this RFM approach, for instance when the unsteadiness comes from the flow pattern (vortex shedding, cavitation, etc.) or even for some cases of imposed motions (roll-damping).

A third solution for self propulsion simulation is to model the effect of propeller by simple body forces in the RANS solver (Actuator Disk or AD) where propeller thrust is provided by the RANS solver.

The case considered is the ONRT Tumblehome ship, Figure 1, from the Tokyo 2015 Workshop on CFD. It is a very challenging case for computation as it involves 6-DOF free motions with active rudder control in waves to maintain a straight course. In any case the overset technique is used to handle rudder motion and the sliding grid approach for the propeller resolved simulations. Here the use of RFM is justified as soon as the propellers are located far from the hull. Results obtained with our ISIS-CFD flow solver are briefly summarized in Figure 2. It compares the effect of the propeller representation on the predicted ship speed in waves: from propeller resolved, to propeller modelled (AD) and to RFM model. EFD conditions have been fulfilled with CFD simulations initialized from self-propulsion in calm water. If the computational cost goes from 2 to 3 days with the propeller modelled or RFM and until 30 days for the propeller resolved, the time-averaged computed ship speed difference with EFD is about 0.7% with RFM or propeller resolved and only 2.4% with AD approach. However, in any case and for reasons as yet unknown, the amplitude of the signal is always underestimated by a factor of 2.

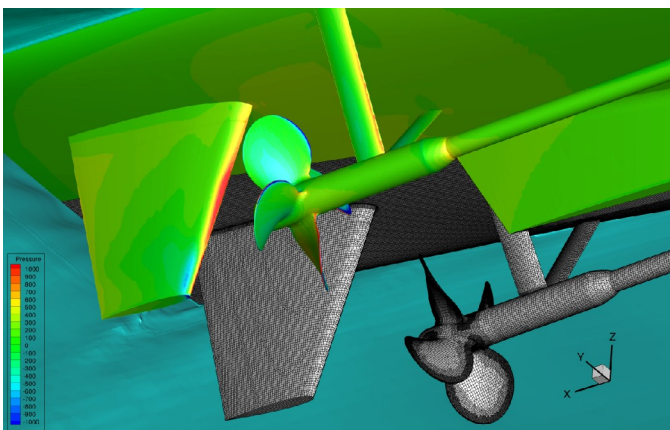


Figure 1: Propulsive system of the ONRT Tumblehome.

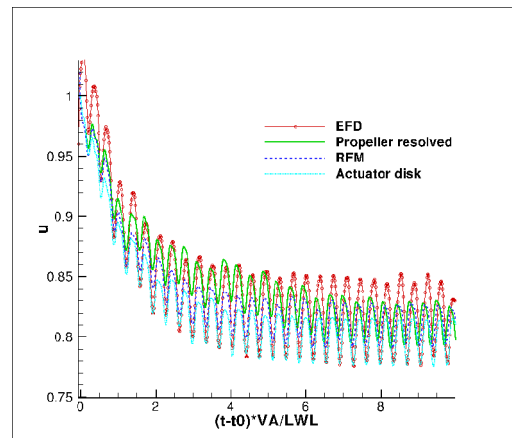


Figure 2: Time history of the normalized ship speed with three CFD approaches for propeller and comparison with EFD.