Numerical prediction of ship resistance and squat in confined waters

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ABSTRACT

Accurate prediction of hydrodynamic forces opposing ship displacement in restricted waterways is necessary in order to improve energy efficiency of inland transport. When a ship moves in restricted waterways, a significant increase in ship squat (combination of sinkage and trim) and resistance occurs compared to open waters. In this paper, a 3D numerical model based on fluid-structure coupling is presented and used to investigate the effect of limited water depth and channel width on ship resistance and squat.

The numerical model is based on the resolution of RANS (Reynolds Average Navier Stokes) equations closed with SST κ-ω turbulence model. The free surface capture (see fig. 2) is accomplished by using the VOF (Volume of Fluid) method and the ship position is updated by using the dynamic mesh technique.

In this work we study the case of a ship sailing at constant speed and in dynamic equilibrium. The equilibrium position is defined as the position where the resultant of vertical forces along sinkage axis z and momentum along trim axis y calculated at the gravity centre are equal to 0. Instead of solving the classical rigid body motion equation (6 DOF model), a Newton method is used in order find the equilibrium position, thus allowing to skip the transient state. This method is implemented through User Defined Function (UDF) in the Computational Fluid Dynamics software Fluent.

The numerical results are compared to experimental results (see fig. 1) deriving from towing tank test carried out at the University of Liege (ANAST). In these experiments a 135 m (full size) boat was used at 1/25 scale. A wide range of parameters were tested such as channel width (W), channel depth (H) and ship draft (T). The boat was free to sink and trim and forces and moments acting on the ship as well as sinkage and trim were recorded.

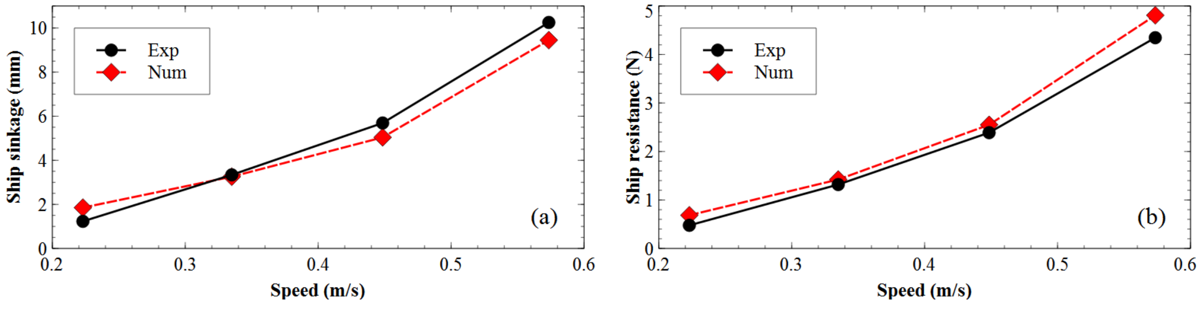

Figure 1: Comparison between experimental and numerical results for ship sinkage (a) and resistance (b) (W=1.44m, H=0.18 m and T=0.1 m)

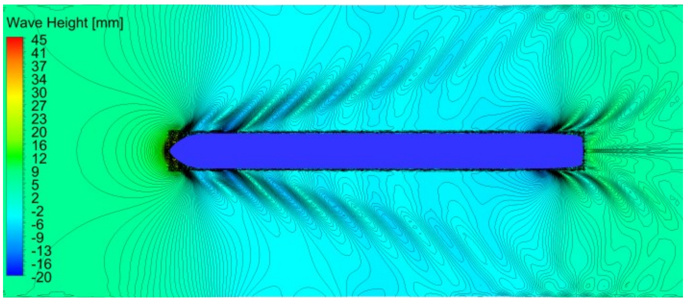

Figure 2: Iso-contours of wave height (W=2.88m, H=2.4m, T=0.1m and V=0.89 m/s)