Energy Efficient Safe SHip OPERAtion

Development and refinement of numerical hydrodynamic tools

WP2

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To perform further development and refinement of various numerical hydrodynamic tools available to the participants.

The codes to be improved differ by their computational speed, complexity and accuracy, some are of universal nature, others focusing at specific situations such as loss of stability in waves, manoeuvring in waves, aerodynamic loads, and hydrodynamic interaction in confined waters.

The models will be used to analyse the experimental results produced in WP3 and in the validation studies in WP 4.

WP2 - Tasks

- Task 2.0. Technical Management (IST)
- Task 2.1. Potential flow methods for seakeeping and loss of stability in extreme seas (IST, UU, NTUA, LR)
- Task 2.2. Potential flow methods for manoeuvring in waves (DNV, GL, IST, NTUA, RINA, LR, DTU)
- Task 2.3. Potential flow methods for manoeuvring in confined waters (IST, SU, LR)
- Task 2.4. Field methods to determine ship hydrodynamic characteristics (TUB, VTT, IST, SU, UDE, LR)
- Task 2.5. Field methods for direct predictions of ship motions (UDE, IST, LR)

Task 2.1. Potential flow methods for seakeeping and loss of stability in extreme seas

- IST and UR will extend a code for assessing the added resistance in waves and the associated emissions.
- IST and UR will work on an existing time domain code that predicts parametric rolling of ships to improve the accuracy of the computation of hydrodynamic loads on the hull and to extend it to include the effect of devices aimed at controlling the effect of parametric roll.
- NTUA will study parametric rolling. The codes will be used in Tasks 4.2, 4.3, 4.6 and WP 6.
2. Speed loss calculation

- Strip theory (Salvesen et al., 1970).
- Added resistance in waves (Faltinsen et al., 1980).
- Wind resistance (Isherwood or Blendermann model).

3. Numerical results

- To carry out improvement and refinement of two fast codes for manoeuvring in waves:
  - the strip-method semi-linear code dedicated to the wave manoeuvring (IST) and
  - the 3D nonlinear potential seakeeping code (GL). In the latter case the code will be fused to some database manoeuvring code.
- DNV also will improve its seakeeping-and-manoeuvring code with better modelling of diffraction-radiation forces and second-order wave loads and better model for propeller and rudder forces.
- NTUA will use the seakeeping code HYBRID with some manoeuvring model.
- RINA will also integrate its 3D potential seakeeping code with a proper manoeuvring model.
- DTU will further develop their OceanWave3D code for computing the seakeeping and added resistance of ships in waves.

The codes will be used in Tasks 4.2, 4.3, 4.5 and WP 6.
DTU

- Code: OceanWave3D
- Steady wave computation on the KCS tanker hull using the immersed boundary code

Task 2.3. Potential flow methods for manoeuvring in confined waters

- A code for deep water existing at SU, will be extended to shallow water in order to study the stability and manoeuvring of vessels in waves in shallow water and the interaction between two vessels either overtaking or crossing in restricted waters.
- The hydrodynamic interaction code developed by IST will be improved by better approximation of the hull surface and better fulfilment of the body boundary condition. The code will be also augmented with dynamic account for the sinkage and trim of the ship.
- The codes will be used in Tasks 4.2, 4.3 and WP 6.

Mirror image vs Panelled moving patch

- Ship-ship hydrodynamic interaction over horizontal flat seabed (overtaking, passing by, encountering, etc.)
- Interaction involving Arbitrary bathymetry
- Bank effect
- Approach Channel

Panelled Moving Patch
Results: Two ships travelling with the same speed in shallow water

Two ships travelling with same speed at different longitudinal distances

Scale: 1/75
$U = 0.238 \text{ m/s}$

Task 2.4. Field methods to determine ship hydrodynamic characteristics

- UDE will use the in-house RANS solver to obtain off-line data bases for describing second-order wave forces, approximations of manoeuvring hull forces in shallow water, rudder forces behind the propeller in waves, simplified unsteady model for a screw propeller and peculiarities of hull-propeller interaction coefficients in waves.
- IST will use STAR CCM+ and OpenFoam codes to predict the hydrodynamic interaction in confined waters as well as the aerodynamic loads on the superstructure and proper hull hydrodynamic forces for specific vessels.
- SU will be using the ANSYS FLUENT CFD software to generate manoeuvring coefficients to be used for special vessel types.
- TUB will refine the in-house or OpenFoam codes to apply them to the following problems:
  1. carrying out virtual 40DF captive model tests with account for the free-surface effects;
  2. development of a suitable body-force propeller model providing also correct rudder inflow data;
  3. determination of the propeller torque in curvilinear motion;
  4. estimation of forces and torque on a rotating propeller in oblique flow;
  5. estimation of hull forces in regular and irregular waves;
  6. estimation of aerodynamic loads with account for the actual true wind profile;
  7. estimation of the influence of a current on hull forces.

VTT will evaluate the hull-propeller-rudder (+all other appendices) interaction by field method (URANSE) in restricted waters.

The free surface effects will be determined either with the field method or with the potential flow method. Special attention will be set on the determination of static surge, sway and yawing manoeuvring forces.

The codes will be used in Tasks 2.2, 4.2, 4.3, 4.5 and WP 6.
Task 2.4: Field Methods

Waves with different encountering angles

RANS calculations:
- Encountering angle variation 0° - 180° in suitable steps
- Grid with 4.4 mio cells
- Calculations on one core
- Calculation time: one week

Dependence on wave length
- Dependence on $\alpha$ (180°-μ) modelled with Fourier coefficients
- Dependence on $\omega$ by polynomial approach of Fourier coefficients

Rotating propeller in oblique flow

RANS calculations performed for body force database:
- Isolated stock propeller
- Variation of incident angle
- Variation of advance ratio

Pressure distribution on blades $\beta=30^\circ$ and $\lambda=0.7$

UDE will extend the in-house RANS solver coupled with the 6DOF ship motion simulator in the following respects:
1. modelling of irregular sea waves;
2. implementation of engine dynamics and automatic controllers;
3. coupling with a simplified propeller model;
4. implementation of a morphing algorithm.

IST will extend the capability to predict hydrodynamic loads on the ship hull due to waves using the OpenFoam code coupled with his own ship motions code.

The codes will be used in Tasks 4.2, 4.3, 4.4 and WP 6.
Irregular Waves

- Modeling of irregular waves
- Implicit coupling of the volume fraction transport equation with the RANS Equations
- Refinement of existing implementation (No. of components, Boundary conditions, Discretization)
- Different wave theories

Source: J. Ley, J. Oberhagemann, O. el Moctar, J. Ship Technology Research, to be published

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