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Comparison of SPH and RANSE methods for the evaluation of impact problems in the marine field

*** Brizzolara S. [1], Viviani M. [2] , Savio L. [3]**

Department of Naval Architecture and Marine Engineering
Via Montallegro 1, 16148 Genova, Italy
www.dinav.unige.it
[1] brizzolara@dinav.unige.it [2] viviani@dinav.unige.it [3] savio@dinav.unige.it

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ABSTRACT

Problems involving impact phenomena in the marine field (hull slamming, sloshing in tanks, green water on deck) have been investigated for a long time both theoretically and experimentally. Nevertheless, they are still under investigation, due to the intrinsic difficulties which arise from the high non-linearities involved and to the complex interactions between free-surface, hull sections and air. One of the most important problems related to all impact problems is linked to the strong variations of free surface and to the consequent high non-linearity, which make free surface treatment more difficult with conventional methods, in which a certain mesh is adopted (both potential and RANSE methods). Meshless methods, like SPH, with their Lagrangian approach allow to overcome this problem, with a much faster generation of the input data for the problem and their intrinsic ability to treat free surfaces; on the other hand, these methods present some shortcomings, related to the necessity of a high number of particles in order to capture very localised (and fast) phenomena, to the necessity of a fine tuning of some parameters which are very significant (such as artificial viscosity, sound speed, etc.) and to the large computational times needed in some cases.

This paper relates to the comparison of two different numerical methods applied for the evaluation of slamming and sloshing problems. In particular, a CFD VOF program [1] and Smoothed Particles Hydrodynamics (SPH) currently under development at DINAV [2] have been applied.

Regarding slamming calculations, they have been applied on a typical wedge shaped section and a more complex ship bow section, for which experimental data of previously developed drop tests has been made available within MARSTRUCT thematic network [3]. Experimental tests and calculations have been performed with a free falling rig, resulting in a variable drop speed, which affects significantly results in terms of pressures and global forces on the section. In figure 1, two cases considered are presented.

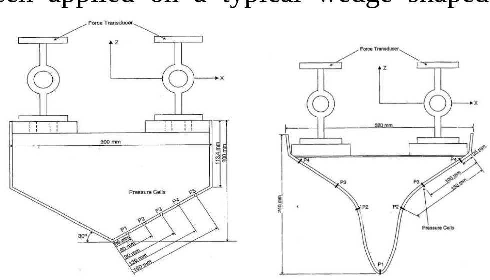

Figure 1: wedge and ship-like section

As an example, calculations for pressure time histories for point P1 in correspondence to a drop speed of 2.40 m/s and a heel angle of 14.7° for the wedge section are reported. As it can be seen, both methods allow to capture pressure time history with a reasonable agreement, even if SPH presents a certain “pressure drift” due to numerical integration problems. Moreover, an example of SPH capability of capturing slamming kinematics is reported.

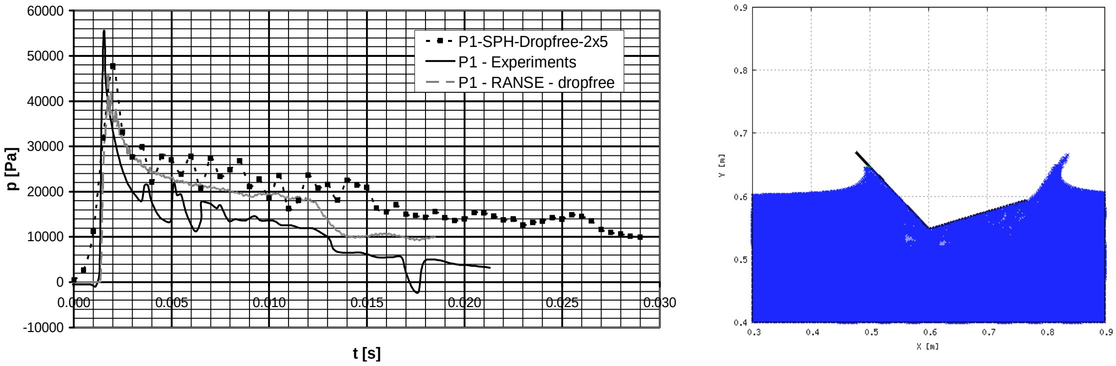

Figure 2: Wedge section, Drop speed 2.40 m/s, Heel Angle 14.7°, P1 time history and kinematics

Regarding sloshing calculations, they have been applied on a two dimensional tank rolling around a horizontal axis with a constant amplitude of 4°, different periods and different water levels, for which experimental data of tests currently under development have been made available by ETSIN [4].

As an example, calculations for pressure time histories for Sensor 1 in correspondence to a water height of 9.3 cm and the resonant period are reported, together with an example of kinematics capturing with SPH.

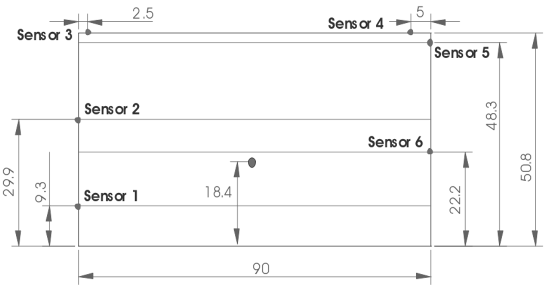

Figure 3: Test set-up for sloshing experiments

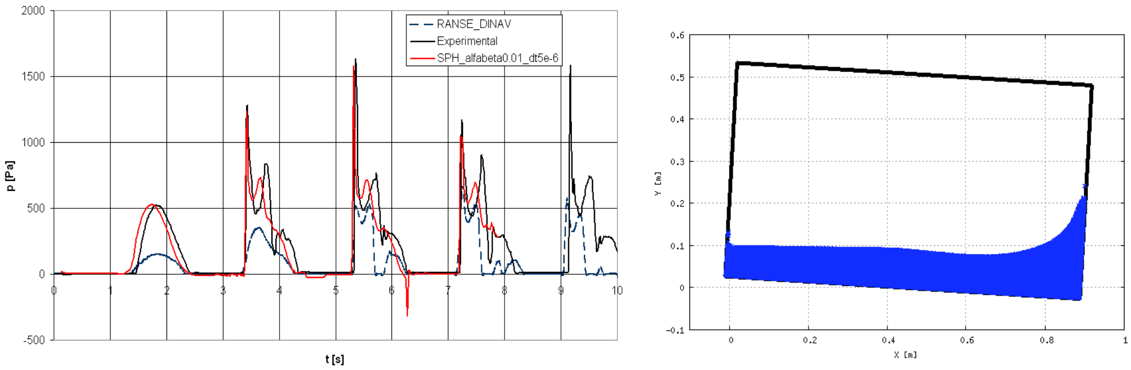

Figure 4: Sloshing case: water height 9.3 cm, T=1.91 s, Sensor 1 time history and kinematics

As it can be seen, once correctly calibrated, SPH is able to correctly predict pressure peaks caused by the sloshing phenomenon, while RANSE seems to be overdamped, slightly overpredicting them.

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