A fully-nonlinear potential flow model for aircraft ditching applications

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ABSTRACT

A fully nonlinear, potential flow model for the descriptions of the hydrodynamics of water entry is presented. The problem is formulated in terms of boundary-element representation of the velocity potential and the time evolution is described by a mixed Eulerian-Lagrangian approach, originally proposed in [1]: the velocity potential is assigned on the free surface by integrating the unsteady Bernoulli's equation, whereas its normal derivative is assigned on the body contour. In order to reduce the computational effort, a simplified model, based on finite element method, is adopted for the thin jet developing along the body. The model has been deeply validated through comparisons with similarity solution of the wedge impact with constant entry velocity [2, 3] and it is found able to describe the detailed flow evolution and to evaluate the pressure distribution and the total hydrodynamic force acting on the impacting body.
This model is further developed within the H2020-SARAH project with the aim of using it as a lower-fidelity tool for the aircraft ditching problem. With respect to other approach, like Modified Logvinovich Model [4] or the Generalized Wagner [5], both extremely efficient in providing an accurate predictions of sectional forces, the proposed model, being fully nonlinear, provides more accurate estimates of the pressure distribution at the spray root, which can be significant when modelling the fluid-structure interaction. Due to the smoothly curved aircraft sections, a flow separation model based on a kinematic criterion is developed to retrieve the unknown flow separation point. In order to describe the flow generated by the water entry with horizontal velocity of the fuselage, the two-dimensional solver is embedded in a 2D+t aproach [4, 6] where the 3D problem is approximated by a 2D problem in the transverse plane in an earth-fixed frame of reference, with the shape of the impacting body changing in time.
Validation studies will be presented together with preliminary applications to the aircraft ditching.

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