Simplified numerical data-driven methodology for the prediction of ditching loads

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INTRODUCTION

Ditching certification is a critical requirement for many aircrafts and helicopters, due to the peculiar loading conditions, drastically different from other types of collisions. In fact, energy absorbing subfloors designed for hard landing on ground may not work properly for water impact, because in this case the load is not transmitted to the frame, but the pressure is distributed on the external skin panels, which are generally thin, and in case of rupture or large deformation, the flotation of the aircraft may be impaired after landing and hence the survivability of the event would drastically decrease [1].

Usually ditching certification is performed by model scale testing [2], however this method allows to assess only the kinematics of the aircraft during water landing, but is not able to take into account structural deformations, which have been confirmed to be essential for the evaluation of ditching loads, or cavitation effects, which depend on the actual dimensions of the structure [3]. Other certification methodologies include comparison with previous design already certified, which, however, is not feasible for novel aircraft configurations or full scale testing, which is largely expensive and, for this reason, can be used only in the last phases of design or for validation purposes [4].

Finite element (FE) methods allow to compute precisely fluid structure interactions during ditching of aeronautical structures, taking into account both structural deformation and fluid dynamics [5]. However, due to the complexity of the problem, it usually requires high computational power [6], especially if considering whole aircraft structures, and, for this reason, it is not feasible for the early stages of development of novel aircrafts.

METHODOLOGY

The present work is part of a larger project investigating the first steps for the development of a simplified numerical tool for an efficient and effective computation of ditching loads on whole airborne structures, given the external shape, internal structure, materials and impact configuration, able to be used in the first design phases for novel concepts of aircrafts.

This numerical tool will take into account both the aircraft dynamics during water landing and the ditching loads distribution, which will be given by a large database of accurate FE numerical simulations of single skin panels or fuselage portions impacting water at different conditions.

For this section of the project, nonlinear finite element software LS-DYNA by Ansys will be used, given its proven efficacy in impact conditions, with Arbitrary Lagrangian-Eulerian (ALE) formulation to model the fluid dynamics [5].

In the figure 1 is illustrated an example of numerical simulation performed.

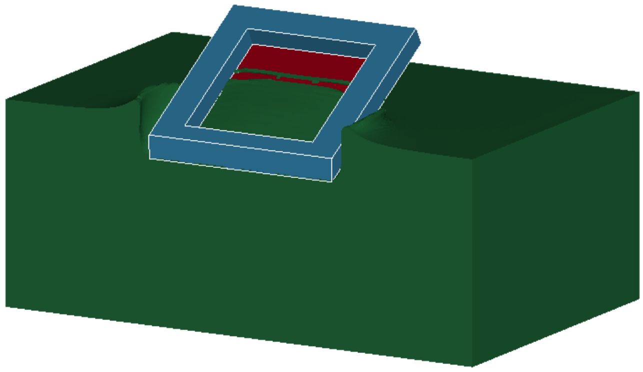

Figure 1: Numerical simulation of tilted thin aluminum panel impacting water in free fall, with ALE method in LS-DYNA

Specific effort was dedicated to the mesh sensitivity analyses and modelling of fluid structure interaction, which followed a penalty formulation. In fact, since some parameters necessary for the contact were not physics-based properties, they needed to be calibrated through ad hoc experimental tests, which were performed on thin aluminum panels, impacting water in free fall, attached to a square frame. This configuration allowed to take into account also structural deformation during the impact. The response of the panels during the impact was evaluated through accelerometers attached to the mounting structure.

CONCLUSION

In conclusion, the present work may provide methodological basis for a numerical tool which will fill a gap in aircraft structural design, being able to predict ditching loads of novel structures efficiently and effectively in order to be used also in the early design phases and for optimization purposes.

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