

AUTOMATED STRUCTURAL DESIGN OPTIMIZATION OF DOUBLE WALLED LIQUID HYDROGEN TANKS AND SUBSEQUENT COMPARISON OF CFRP WITH ALUMINIUM ON AIRCRAFT LEVEL

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Abstract

The design of hydrogen fuel storages in future aircraft configurations is one key enabler for drastic reduction in climate impact of aviation. For aerospace applications, the storage of hydrogen in liquid state (LH2) is the most promising solution due to its higher gravimetric energy density compared to kerosene and its higher volumetric energy density compared to gaseous high pressure vessels. Since no empirical data for such aircraft is available, physical simulation models must be established that facilitate an efficient assessment of a multitude of configurations.

This study presents an automated design optimization process for carbon fiber reinforced plastics (CFRP) and metal tank structures. The CFRP simulation employs a detailed winding simulation for the inner and outer vessel's skin, a thermomechanical stress analysis and an additional stability assessment for the outer vessel. An optimization procedure is presented for the CFRP layup, that accounts for winding specific manufacturing constraints. The metal methods comprise of analytical formulations for the vessels skin, a fatigue analysis and a stability assessment for the outer vessel as well. All proposed methods calculate structural masses comprising of the thickness and layup for skin and stiffeners of the vessel. These masses are extended with design factors for components not under physics based consideration.

The proposed methods are applied to a short-range aircraft configuration containing a rear fuselage hydrogen storage with approximately 3.5m tank diameter, which is depicted in Fig 1. Firstly, the set of governing loads is discussed and their magnitude is compared. The vessels designed with the given methods are compared for their main characteristics on aircraft level including resizing effects due to their interdependencies. This approach allows the identification of key factors influencing structural design of the liquid hydrogen vessel and provides insight into their impact on aircraft performance.

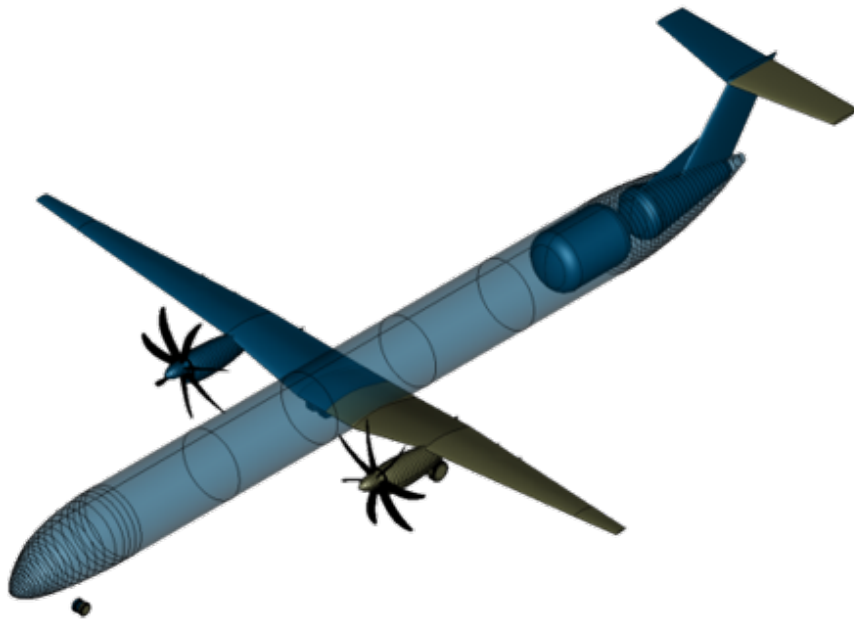


FIG 1. Turboprop aircraft configuration with rear fuselage CFRP tanks