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Design space exploration through Liquid H2 tank preliminary sizing and Design of Experiments analysis

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Abstract

Introduction:
Climate changes have been the reason of increasing interest in alternative solutions to the use of fossil fuels during the last decade. In addition, the efforts towards this direction have been recently and rapidly increasing due to the energetic crisis highlighting the need for alternative and sustainable energy sources for both environmental and geopolitical reasons. Complying with the needs for energy arising from different industrial sectors is a great challenge and there is not a unique answer. In this context hydrogen has the potential to become the solution able to fulfill even the most diverging requirements. As an energy carrier hydrogen can enable the creation of an energy network including different energy sources, as renewables or nuclear, transportation systems, through pipelines, trains or trucks, and final users, like production plants, especially those classified under the so called hard-to-abate sector, or vehicles.
Among the many players involved in this challenging hydrogen revolution, the transports sector also saw an increasing interest in new technologies. Automotive, especially heavy-duty vehicles, maritime and aviation sectors are facing hard technical issues that are transforming the design approaches applied up to now.

Objectives:

The aim of the present work is to explore the design space related to the hydrogen storage in the aeronautic sector.

Material and methods:

The analysis is then carried out through a model of a liquid hydrogen tank, whose objective is to quantitively evaluate the outcomes of different solutions. As it can be seen from the following figure the analysis has been divided into three steps: geometric, mechanical, and thermal design. The hydrogen tank sizing has been carried out by considering the requirements coming from each one of the three design phases, their mutual influences, and the very stringent constraints, commonly known in the aeronautic sector, imposed at the higher system level, like a precisely calibrated quantity of stored fuel to comply with the minimum weight restrictions.

To clearly understand the influence of the many design parameters and to prioritize them a further Design of Experiments (DoE) analysis has been applied.

Results:

The design of the hydrogen storage tank is performed aiming at satisfying various requirements. The information that can be depicted from the results and the charts resulting from the preliminary analysis are crucial to avoid certain solutions and focus on the most promising ones. The flexible model shown in the present work revealed to be essential in efficiently exploring the design space.

Conclusions:

The investigation of the outputs coming from the tank sizing model and the DoE analysis revealed to be fundamental in the exploration of the design space and in the definition of a roadmap for the following design phases.

Acknowledgment

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