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C3Or4A-01: Energy of Fluid (EOF) simulations of large-scale zero boil-off hydrogen storage systems

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This study evaluates a Computational Fluid Dynamics (CFD) model's ability to predict the flow fields and thermal behavior of liquid hydrogen (LH_2) during zero boil-off (ZBO) operation in the Ground Operations Demonstration Unit for Liquid Hydrogen (GODU-LH_2) tank at NASA's Kennedy Space Center. The model focuses on capturing natural convection and heat transfer effects driven by the Integrated Refrigeration and Storage (IRAS) system within a large-scale cryogenic storage tank. A pressure-based finite volume solver, enhanced with User Defined Functions (UDFs) and an internal energy-based formulation, was employed to achieve computational efficiency while resolving complex thermal and flow fields. Simulations were validated against experimental data, showing strong agreement with measured temperature and pressure profiles. Results highlight the IRAS system's role in generating recirculation patterns that regulate temperature distribution and optimize heat transfer to sustain ZBO conditions. The analysis provides insights into the interaction between the heat exchanger and the bulk fluid, demonstrating the system's effectiveness in maintaining cryogenic stability and minimizing propellant losses. This work establishes a reliable framework for modeling ZBO operations, advancing thermal management strategies, and supporting the development of next-generation cryogenic storage technologies for aerospace and industrial applications.

Author: Dr MAHONY, Colin (Gloyer-Taylor Laboratories)

Co-authors: Mr SWANGER, Adam (NASA-KSC); Dr MARCHETTA, Jeffrey (University of Memphis)

Presenter: Dr MAHONY, Colin (Gloyer-Taylor Laboratories)

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