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Thermodynamic Control System for cryogenic propellant storage : experimental and analytical performance assessment[1] SAMUEL MER, JEAN-PAUL THIBAULT, CNRS - UGA - LEGI, CHRISTOPHE CORRE, Ecole Centrale de Lyon - LMFA — Future operations in space exploration require to store cryogens for long duration. Residual heat loads induce cryogenic propellant vaporization and tank self-pressurization (SP), eventually leading to storage failure for large enough mission duration. The present study focuses on the Thermodynamic Venting System (TVS) control strategy : liquid propellant is pumped from the tank, cooled down by a heat exchanger and re-injected, as a jet, inside the tank. The injection is followed by vapor condensation and liquid bath destratification due to mixing. The system cold source is created thanks to a Vented Branch where a liquid fraction is withdrawn from the tank and expanded through a Joule-Thomson valve. The vented branch vaporization permits to cool down the injection loop. Quantitative analyses of SP and TVS control have been experimentally performed using a $110\,L$ tank and a simulant fluid. A database of accurate temperature and pressure dynamics has been gathered and used to validate a homogeneous thermodynamic model which provides a fast prediction of the tank dynamics. The analytical model has been coupled with a multi-objective optimizer to identify system components and regulation strategies that maximize the tank storage duration for various mission types.

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