SPACE PROPULSION SYMPOSIUM (C4)
Propulsion Technology (3)

Author: Mr. Juan Merino
MT Aerospace AG, Germany

Mr. Stefan Weiland
MT Aerospace AG, Germany
Mr. Ulrich Glaser
MT Aerospace AG, Germany
Dr. Hans-Dieter SPECKMANN
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany

CFD MULTIPHASE SIMULATIONS OF CRYOGENIC TANK PHENOMENA AND THEIR VERIFICATION BY TESTS

Abstract

In view of improving the design and the performance of cryogenic upper stage tanks, a strong need for reliable methods exists that allows accurate simulation and prediction of relevant thermodynamic phenomena taking place during various mission phases. As a state-of-the-art tool, computational fluid dynamics (CFD) is widely used for such tasks – however, the reliability of results obtained by those methods still needs to be validated either by existing reference solutions or by results obtained in dedicated tests. For that reason, ongoing activities at MT Aerospace in CFD model development for simulating the thermodynamic phenomena of phase change and the transport of heat and matter inside cryogenic upper stage tanks are accompanied by an experiment series. The tests, performed at the Centre of Applied Space Technology and Microgravity, ZARM, are designed to deliver comprehensive data for model correlation and validation. The particular test sequences hereby resemble important operation phases of a cryogenic tank, which are chill-down and filling, self-pressurization, pressure relieve and artificial pressurization with a non-condensable gas. Liquid nitrogen is used as a substitute cryogen because of handling difficulties that would come along when liquid hydrogen or liquid oxygen is used. The test is described in terms of conception, test conduction and in terms of measurement results. Apart from the experimental side, the numerical model for simulating the tests is described, which involves FLUENT as a CFD tool. Most significant results such as temperature and pressure histories or mass flow figures obtained by simulation are compared to corresponding experiment measurements. Occurring deviations are discussed in terms of choice of model parameters, applicability of used modeling approach and its embedding in the FLUENT simulation environment.