IAF SPACE PROPULSION SYMPOSIUM (C4)
Propulsion Technology (1) (3)

Author: Dr. Samuel Webster
ArianeGroup, Germany, samuel.webster@ariane.group

COMPARISON OF SIMULATION AND EXPERIMENTAL RESULTS FOR FUNCTIONAL VERIFICATION OF A PROPELLANT MASS-FLOW REGULATION DEVICE

Abstract

Reliable propellant flow management, in rocket propulsion systems, is critical to the safe functionality of a liquid rocket propulsion system (LRPS). Driving down costs with all parts of a rocket system is an important aspect of a modern development program. Combined with the extreme conditions experienced in rocket supply systems, commonality, which is used to drive down costs, extends requirements so that fluid control equipment (FCE) needs to be functional for a wide range of operating conditions. Specifically, four operational variables are primarily considered in the design; pressure, temperature, mass-flow rate and fluid.

The European launcher the Arinae 6, which is currently in development at Ariane Group Ottobrunn uses the combination of oxygen and hydrogen for its propulsion systems. Oxygen is a popular propellant choice for use in liquid propulsion engines. A high density, low relative cost and high specific impulse (ISP) when combined with a number of fuel types provide a strong argument for its use despite the associated risks [1]. A mass-flow regulator that is to be used in both oxygen and hydrogen environments must be able to withstand both flammability in oxygen atmospheres and be resistant to embrittlement in hydrogen atmospheres. The risks associated with each become more acute in mass flow regulation devices due to moving parts which can easily trigger an ignition event if material selection is not correctly made. Mass flow regulation is typically made through the use of a pressure driven (pneumatic) or, alternatively, an electro-magnetic valve [3]. Electro-magnetic valves provide an advantage over pressure driven valves as they do not require an additional pressure supply which adds weight and therefore cost to the system. However, electro-magnetic valves typically have much lower power levels, which influence the opening forces and through them the pressure ranges where they can be reliably operated. These points highlight some of the many aspects must be considered for a valve development program to be successful, especially in the rocket environment.

An overview of the mass-flow regulator development program, which currently underway, as well as a description of proposed valve functional concept was recently presented at EUCASS 2017 [3].This paper considers, in more detail, simulation and experimental results and their role in the early verification of valve functionality. The particular importance of understanding internal forces and movements in a complex, electro-magnetic, pressure balanced, valve will also be highlighted.