SPACE PROPULSION SYMPOSIUM (C4)
Propulsion Technology (3)

Author: Mr. Sathis kumar B
Indian Space Research Organization (ISRO), India, bhaskaransathiskumar@gmail.com

Mr. Manimaran A
Indian Space Research Organization (ISRO), India, maranavanamuthu@yahoo.com
Mr. Radhakrishnan M
Indian Space Research Organization (ISRO), India, radhashnan@gmail.com

CRYOGENIC PROPELLANT TANK PRESSURISATION SYSTEMS FOR CRYOGENIC UPPER STAGE OF GEO SYNCHRONOUS SATELLITE LAUNCH VEHICLE

Abstract

Indian Space Research Organisation (ISRO) is currently developing indigenous cryogenic propulsion stage named as Cryogenic Upper Stage (CUS) for its Geo Synchronous satellite Launch Vehicle (GSLV Mk2). Fluid systems of CUS stage facilitates supply of rated flow of propellant to cryogenic engine and maintain pressure in both LOX LH2 propellant tanks. During flight regime propellant mass flow rate during engine operation is 14.14kg/s of LOX and 2.68kg/s of LH2 for a nominal engine thrust of 75kN which is achieved using a combination of booster pump main pump. In order to meet the net positive suction head requirement of booster pumps located inside the propellant tanks, and also to meet the tank ullege pressure requirements, tank pressurisation systems are used. A regulated tank pressurisation system is preferred over an orifice with ON-OFF pressurisation mode system which depends on Vent Relief Valves to vent/relieve excess pressurant, In flight pressurisation system for LOX Propellant tank is by high pressure (220 bar) helium gas (GHe) stored at 80K in two numbers of titanium alloy gas bottle kept in inside LOX tank and regulated to a constant pressure of 1.7 bar(a) by two stage regulation using cryogenic pressure regulators. LH2 propellant tank in flight pressurisation is with 240K gaseous hydrogen (GHe) tapped from engine manifold and regulated to 1.9 bar (a) using cryogenic hydrogen pressure regulator. Cryogenic pressure regulators were indigenously designed and developed for the above application. Pressurisation system fluid control components like high pressure pneumatic isolation valve, cryogenic pressure regulators, cryogenic safety valves etc were integrated to modular form. Modules are named as LOX Tank Pressurisation Module (LTPM) and Hydrogen Tank Pressurisation Module (HTPM). Determination of pressurant gas mass for cryogenic propellant tank complex completed because of inter dependent transient phenomenon of heat and mass transfer that occurs simultaneously. To provide reliable method for determination of pressurant gas requirements, experimental evaluations by the way of extensive testing of modules at ambient and cryogenic temperature were done. In addition to the above, propellant expulsion test, engine cold start tests, hot firing tests, fluid mock up tests etc were done to evaluate the adequacy of pressurisation system. This paper presents the design challenges of indigenously designed and developed Cryogenic Propellant Tank Pressurisation System, its elements, development experience, pre-test predictions and test results.

Key words: Cryogenic, propellant, pressurisation, regulator, module, LOX, LH2, helium, gaseous hydrogen.