Paper ID: 41887
oral

SPACE PROPULSION SYMPOSIUM (C4)
Hypersonic Air-breathing and Combined Cycle Propulsion (9)

Author: Mr. Lazar T. Chitilappilly
Vikram Sarabhai Space Centre (VSSC), *(country is not specified)*, lt_chitilappilly@vssc.gov.in

Mr. Sivarama Panicker VK
Vikram Sarabhai Space Centre (VSSC), India, vks_panicker@vscc.gov.in
Mr. Jacob Panicker PC
Liquid Propulsion System centre, India, pc_jacobpanicker@lpsc.gov.in
Dr. K. Sivan
Indian Space Research Organization (ISRO), India, k_sivan@vssc.gov.in

SUCCESSFUL FLIGHT TESTING OF SCRAMJET ENGINE OVER WIDE RANGE OF TEST CONDITIONS

Abstract

Flight testing of hypersonic air breathing scramjet engine is successfully carried out by Indian Space Research Organisation achieving supersonic ignition and stable flame right in the first attempt at flight Mach number of 6.0. During the test lasting up to 18s, two similar scramjet engines are operated providing valuable data on various aspects of scramjet operation. The trajectory of the test vehicle, a newly developed two stage sounding rocket, varied down to a flight Mach number of 5 by end of the test.

During the flight testing, all systems related to scramjet engines and test vehicle functioned flawless and as intended. Gaseous hydrogen is carried at very high pressure as fuel and fed into engines as per sequence planned. It is preceded by opening of air intake cowls upon reaching required flight test condition letting air from atmosphere into engines. The aerodynamic "starting" process also occur and internal shock structure gets established. All this and the combustion process that follow fuel injection are well captured through comprehensive pressure measurements carried out within both engines and is detailed in the full paper. Auto-ignition is achieved between fuel and air coming at supersonic speeds into combustion chamber though igniters as fall back are incorporated that are operated with an intentional delay to enable capture this phenomenon. Both engines got ignited near simultaneously and change in test vehicle longitudinal acceleration is captured by a special measurement package developed for the purpose.

The scramjet test started at a flight dynamic pressure of about 140kPa and fuel equivalence ratio of about 0.4. Flight dynamic pressure, Mach number and angle of attack of the test vehicle are monitored by an Air Data System developed. The experiment has been planned for a regulated fuel flow of about 6s. With flight dynamic pressure reducing to 60kPa meanwhile, fuel equivalence ratio increases to as high as 1.1 (due to dependence of air flow rate on flight dynamic pressure). Very useful data is also obtained during blow down mode of fuel supply that followed the regulated supply, for about 12s. With fuel equivalence ratio going down to about 0.3 at flight dynamic pressure of 10-15kPa, due to much faster drop in fuel flow than that of air, the useful range of fuel equivalence ratio is covered both for high and low flight dynamic pressures of interest.