SPACE PROPULSION SYMPOSIUM (C4)
Hypersonic and Combined Cycle Propulsion (5)

Author: Dr. Antonella Ingenito
University of Rome “La Sapienza”, Italy, antonella.ingenito@uniroma1.it

Dr. Claudio Bruno
Sapienza University of Rome, United States, brunoc@utrc.utc.com

SIZING OF A RAMJET POWERED VEHICLE FOR MARS EXPLORATION

Abstract

Surveying and exploring Mars in reasonable times is of critical interest for biological and geological findings and probably also for understanding planetary climate changes. In fact, so far, with current means (rovers) only 1/1000 of a martian meridian length has been explored. Furthermore, the presence of high mountains (e.g., Olympus Mons) and the largest and deepest valleys (e.g., Vallis Marineris) known in the solar system makes imperatives considering other future means of exploration. Since the Martian atmosphere is about 0.953 carbon dioxide, 0.027 nitrogen and 0.016 argon, the CO2 in the Martian atmosphere can be in principle the oxidizer of unconventional fuels. For instance, due to the large heat release of CO2 reacting with silanes (or light metals), Isp of order 3000 s at M=5 are possible (Simone, 2006). Based on these considerations, this paper focuses on sizing of a ramjet-powered vehicle for fast Mars exploration. Compared to a rocket ‘hopper’, ramjets using the Martian atmosphere save on- board propellant and this means saving vehicle mass, a crucial issue, since any such vehicle must either be ferried from Earth, or built in situ.. Preliminary work already done shows that flying at lower speed is, in fact, not advisable or feasible, due to the low Martian atmosphere density. To this purpose a Mach 5 ejector-ramjet configuration has been analyzed in this paper. The approach to size this vehicle is that proposed by Czysz (2000) and that has been validated and then applied also in the current EU project LAPCAT II. By looking at a Mars mission requirements such as range, fuel, payload and Mach number, a set of optimal configurations that allows the convergence of volumes and weights have been defined. A sensitivity analysis of the mass breakdown to thrust, payload and structural index has also been conducted. In particular, assuming as structural index (the ratio between mass and wetted surfaces) 21 kg/m2, and assuming as mission range 5000 km, converged solutions are shown to be realistic and feasible with current technology. The minimum take-off gross mass with 2000 kg payload turns out to be of order 3.8 tons, including the propellants needed to achieve ramjet operation. These figures are indicative of the potential of non-rocket propulsion for exploring Mars in the future.