SPACE PROPULSION SYMPOSIUM (C4)
Interactive Presentations (IP)

Author: Prof. Sterian Danaila
University POLITEHNICA of Bucharest - Research Center for Aeronautics and Space, Romania,
sterian.danaila@upb.ro

Dr. Dragos Isvoranu
University POLITEHNICA of Bucharest - Research Center for Aeronautics and Space, Romania,
ddisvoranu@gmail.com

TURBINE REHEATER: A NEW PARADIGM FOR HYPERSONIC FLIGHT PROPULSION

Abstract

Currently there are a lot of endeavors for achieving hypersonic atmospheric flights. A challenge for this pursuit is assuring the effectiveness of the propulsion in the whole flight envelope. Improvements in component efficiencies will undoubtedly result in some thermal efficiency increase; however, these improvements are small given the asymptotic trend of current technological level. Our investigation follows the footsteps initiated by Sirignano in 1997 who introduced for the first time the idea of isothermal expansion within a Brayton cycle leading to substantial benefits in terms of cycle thermal efficiency. Besides the obvious increase of the thermodynamic efficiency, the present concept can be very well suited for a combined plant approach in order to maintain the efficiency of the turbo-engine at high levels over a large range of flight conditions. For example, the pre-cooled turbojet concept with reheating has been demonstrated to achieve superior performances in terms of Mach number (up to 4-6). In our specific case, reheating is performed in the turbine stage. Liquid methane can serve very well as cooling agent. During the last 20 years, there were several attempts, mostly numerical, trying to simulate the injection of fuel in the vane of a turbine stage to mimic an isothermal expansion. Apart from the already known injection concepts (trailing edge, stator casing, leading edge), our contribution relies on a network of perforated injection pipes embedded mid-pitch in the vane passages. This paper presents the preliminary results of the numerical simulation of flow and combustion in a one stage turbine reheater (turbine stage in situ combustion). The main purpose of the simulation is to assess the stability of the in situ combustion with respect to the unsteadiness induced by the rotor-stator interaction. The flow and combustion are modeled by the Reynolds-averaged Navier-Stokes equations coupled with the species transport equations. The chemistry model used herein is a two-step, global, finite rate combustion model while the turbulence model is the SAS/DES model. The chemistry turbulence interaction is described in terms of finite rate-eddy dissipation concept.