MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures II - Development and Verification (Deployable and Dimensionally Stable Structures) (2)

Author: Dr. ELCIO JERONIMO DE OLIVEIRA
Institute of Aeronautics and Space (IAE), Brazil, elcioejo@fab.mil.br

Dr. Humberto Araujo Machado
Institute of Aeronautics and Space/ CTA, Brazil, humbertoam@iae.cta.br
Prof. Paolo Gasbarri
Università di Roma "La Sapienza", Italy, paolo.gasbarri@uniroma1.it
Mr. Lucas Cavicchiolo
UNIVAP, Brazil, lucascavicchiolo@hotmail.com
Mr. Felipe Vieira Franciscani
UNIVAP University, Brazil, fvfranciscani@gmail.com

THERMO-STRUCTURAL ANALYSIS DURING ASCENT FLIGHT AND ATMOSPHERIC REENTRY FOR SARA CAPSULE

Abstract

This paper presents the thermal and structural analyzes of the SARA (Atmospheric Re-entry Satellite) capsule during its ascent trajectory and atmospheric re-entry. The main purpose of the SARA mission is to allow the microgravity experiments during the suborbital flight by using a reusable capsule.

In general, during the ascent flight, a fairing protects the space capsule avoiding the dynamic pressure effects over the capsule structure. In a different way, the external structure of the SARA capsule is also the fairing of the rocket and undergoes the aerodynamics and thermal loading during the flight (ascent trajectory and atmospheric reentry). Considering the structural properties changing with the temperature and the partial ablation of the external TPS surface, the evaluation of the heat transfer transient and aerodynamic loads is mandatory in order to maintain the integrity (tightness) of the capsule to be recovered in the ocean after splashdown. The temperature inside the capsule is also a critical point to control in order to preserve the electronic systems.

The aerodynamic forces associated to the cumulative heating over the capsule during the atmospheric flight impinges a modification in the material (or structural) properties, which in turn can affect the capsule structural integrity.

An accurate representation of the thermal and structural parameters of the SARA capsule during atmospheric flight, demands a FEM analysis using a commercial software coupled with specific codes developed to calculate flight dynamic parameters and aerodynamic heating. The aerodynamic heating is estimated through a reliable engineering method, which provides the air recovery temperature and the convection coefficient at any instant of the trajectory. With such parameters, the external surface heat flux is estimated in a coupled process with the surface recession in the ablative parts of the TPS (thermal protection system). These results are used as boundary conditions for the thermal-structural analysis. The resulting temperature profile will allow verify if the internal temperatures are below the prescribed limit.

To deal with this multidisciplinary problem, a specific code was developed to process, in a co-simulation loop, the equations of motion that includes structural parameters, mathematical model for aerodynamics heat transfer and a commercial FEM software to perform heat transfer transient and structural analyzes.

The work will show in details the thermo-structural analysis co-simulation methodology which allows a stable and useful way for preliminary analyzes of the deformation and temperature magnitudes inside

and outside of the SARA fairing. Several numerical results will complete the work.