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Title
Demise performance of Composite Overwrapped Pressure Vessels in reentry conditions

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Abstract
During the atmospheric entry, the decommissioning satellite/component is strongly affected by aerodynamic heating due to dissipation of a huge amount of kinetic energy into thermal energy. In these conditions, the vehicle usually breaks up into several parts which are, in turn, degraded by the high enthalpy flow. However, Carbon Fibers Reinforced Polymers (CFRP) materials behave similarly to thermal protection ablators and, hence, show a strong resistance when exposed to high enthalpy flows. For instance, objects made with this type of material like Composite Overwrapped Pressure Vessels (COPV) often survive the re-entry. This component is made of a metallic liner wrapped by CFRP. During the atmospheric entry, the part will be exposed to a high enthalpy flow which will progressively pyrolyze the resin of the CFRP, then erode by thermo-chemical phenomena the remaining carbonaceous residue together with the carbon fibers and finally melt the liner if the heat load is sufficient. High-fidelity models have been developed in the recent years to predict the response of light porous ablative thermal protection materials and there is a growing interest in exploring the possible extension of those models to predict the demisability of space debris composite materials.

The objective of this work is to perform an experimental and numerical campaign reproducing the demise of CFRP tanks. Initially, the Thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) will be applied on the towpreg precursor (a continuous prepreg composite with a particularly high filament count) to investigate the thermal decomposition and specific heat analysis. The wrapped pressurized vessels produced with the same towpreg carbon fiber will then be subjected to reentry conditions in the Plasmaton facility at the von Karman Institute, which reproduces relevant atmospheric entry conditions.

This is followed by the numerical simulations using a unified numerical approach (ARGO), which solves the flow through and around the degrading porous material. Volume averaging theory is used to described macroscopically the flow through the reactive porous medium and derive a single set of equations valid in the whole computational domain. This allows to capture with high accuracy the gas-surface interaction. This methodology has shown its advantages to predict

the response of low-density porous material but its extension to very dense composite materials such as CFRP presents several numerical challenges that will be discussed.

This presentation will focus on the results of the experimental campaign where the interpretation of the experimental results will aid in laying the foundation for a technological use of these procedures in the design phase of components susceptible to re-enter our atmosphere. The numerical results will also be presented as far as available.