Abstract submission for EUCASS 2013 in Munich

!!! In case of the acceptance of both contributions, the closely related presentation "Modeling and experimental validation of the heat accumulator in a Low Trust Cryogenic Propulsion (LTCP) system" by UPC and DLR should be placed immediately after this presentation !!!

Hot run test results of a validation optimized water-ice phase change heat accumulator and comparison to numerical analysis

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Heat accumulators for cryogenic in-space propulsion were investigated in the framework of the "In Space Propulsion - 1" (ISP-1) project [1][2]. In general ISP-1 focused on studies of low thrust and low cost cryogenic propulsion (LCCP) with liquid oxygen, liquid hydrogen, and liquid methane propellants. LCCP is intended to be designed for orbital transfer missions. Besides the thermal management and the corresponding heat accumulators, ISP-1 investigated LOX/CH4 combustion, the corresponding material compatibility and tribology, hydrogen embrittlement, and electrical pumps [3] for the propellants.

The main purpose of the heat accumulators are a well-controlled and energy efficient pressurization of the propellant tanks during the hot run of the rocket engine. Two heat accumulators are intended to be used: the High Temperature Accumulator (HTA) for the hydrogen tank self-pressurization and the Low Temperature Accumulator (LTA) for the oxygen tank self-pressurization. The LTA being based on water-ice as heat accumulator material is of particular interest for experimental investigation. The LTA must be able to both:

- transfer enough heat to the vaporization cycle of the LOX tank so that the tank pressure can be controlled exactly
- cool the fuel cells, which produce (due to their electrical efficiency of approximately 50%) about the same amount of thermal as electrical energy

A particular scientific interest of the investigation of the LTA concept is the analysis of the phase change behavior of the heat storage material. The single heat transfer tube LTA set up by DLR [4][5] is mainly designed for validation purposes of numerical models which were developed by another ISP1 member (UPC) [6][7][8] for the LTA concept. The main parts of the EUCASS 2013 paper / presentation will be

- description of the validation optimized LTA design developed by DLR including a temperature measurement system for the inner heat transfer tube, the phase change material as well as for the outer vessel wall
- detailed measurement results of the experimental investigation of the phase change behavior of the water / ice PCM during a hot run operation of the LTA (heating up from frozen PCM condition)
- comparison of selected numerical results obtained by UPC to the experimental results obtained by DLR

The results provide the theoretical understanding as well as validated tools for designing and dimensioning both (the LTA and the HTA) heat accumulators for future in-space propulsion systems.

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