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TESTING COMBINED CRYOGENIC INSULATION AND THERMAL PROTECTION SYSTEMS FOR REUSABLE STAGES

Abstract

Reusable launch vehicles experience a large range of thermal and mechanical stresses during their mission, ranging from the temperatures of the propellant, the heat loads encountered during reentry, to the vacuum of space during ballistic phases. This range of temperature is extended substantially when using cryogenic propellants, especially hydrogen.

The number of operational reusable launch vehicles (RLV) in the history of spaceflight is limited. None of them have made use of a cryogenic tank insulation on their reusable stages. The Space Shuttle and the Soviet Buran were orbital stages without any large cryogenic tanks. The Falcon 9 is a booster stage with integral tanks but without cryogenic insulation. Therefore, no practical experience with an operational RLV implementing reusable cryogenic tank insulation exists. For future RLV's however, the use of cryogenic fuels has large benefits with regard to vehicle size, mass and environmental impact. For a winged system the cryogenic insulation has to be integrated with the thermal protection system, imposing new requirements on both.

Within the DLR this topic was first explored within the AKIRA project, which investigated selected technologies that were deemed critical for operational reusable booster stages but are not being covered within the demonstrator projects of the DLR. This paper will focus on TRANSIENT project, started in 2020 to further investigate the reusable combination of cryogenic insulation and thermal protection system. This represents a continuation of the work presented at the IAC 2019 [1].

The design derived within AKIRA is further refined and applied to other reference vehicles. Segments meant to represent a slice of an RLV tank will be manufactured and equipped with the cryogenic insulation and thermal protection system.

The core of the further development of the combined cryogenic insulation and thermal protection system are experiments with these test objects under representative cyclical mechanical and thermal loads in order to assess the performance after up to 50 missions. In addition to the baseline system assuming a metallic main structure, designs for a carbon-fiber main structure will also be investigated and tested under equivalent loads.

The final paper will include the current status of the project which is planned to go from 2020 – 2022, as well as an outlook on the planned experiments and the hardware being prepared for these.

References

[1] Sippel, M. et al: Enhancing Critical RLV-technologies: Testing Reusable Cryo-Tank Insulations, 70th International Astronautical Congress, Washington 2019