Flexible Ablators: Applications and Arcjet Testing

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The concept of flexible ablators was developed as a "technology pull" to meet the need for a thermal protection system (TPS) that could enable large (23 meter diameter) hypersonic inflatable aerodynamic decelerators (HIADs). The initial application was incorporated in system analysis studies [1] which showed that large HIADs can be employed to mass-efficiently place payloads of order 40 metric tons (mT) on the surface of Mars with arrival masses of ~ 80 mT. Follow-on systems analysis studies [2] of potential robotic precursor missions to Mars showed that flexible ablators could also be used on smaller HIADs to efficiently place payloads on Mars in excess of 2.5 mT with an arrival mass of 7.2 mT. This use of flexible ablators enables one approach to enable robotic Mars missions with payloads exceeding that of the Mars Science Laboratory at ~ one mT, the capped mass using Viking-era technology. Recent system studies [3] of deployable heat shields using mechanical erection methods in the transformable entry system technology (TEST) show that flexible ablators are enabling for human Mars missions and for missions to Venus, both involving aerocapture and subsequent out-of orbit entry. Flexible ablators can also be used as TPS for the cover panel system (CPS) to protect un-deployed supersonic inflatable aerodynamic decelerators (SIADs) from hypersonic heating of Mars landers [4]. Flexible ablators can simplify the design and manufacture and reduce cost of TPS for conventional, rigid-body vehicles [5]. This follows since flexible ablators are conformal, eliminating thermal structural design issues. They are manufacture-able from 1.8 meter wide felts so the number of gap/seams in a TPS are greatly reduced as compared to conventional tiled systems such as in the rigid phenolic impregnated carbon ablator (PICA) design for Orion. This presentation will include a brief summary of how flexible ablators are made and have been tested that is covered in more detail elsewhere [6]. This presentation will focus on the range of entry vehicle heating environments where flexible ablators may be applicable, and will also discuss new arcjet testing approaches under consideration for flexible ablators for both conformal and deployable applications.

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References

[1] Dwyer-Ciancolo, Alicia, et. al, "Entry, Descent and Landing System Analysis Study: Phase I Report", NASA/TM-2010-216720, July 2010.
[2] Dwyer-Ciancolo, Alicia, et. al, Entry, Descent and Landing System Analysis Study: Phase II Report, Exploration Feed-Forward", NASA/TM-2011-217055, February 2011.
[3] Venkatapathy, E., et.al, "Transformable Entry Systems Technology", ", 21st AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar 23-26 May 2011, Trinity College, Dublin, Ireland.
[4] James O. Arnold, et.al, "Thermal Protection System for Supersonic Inflatable Aerodynamic Decelerator Cover Protective Shield", 21st AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar 23-26 May 2011, Trinity College, Dublin, Ireland.
[5] James. O. Arnold "Affordable Thermal Protection Systems for Future Entry Vehicles: Lessons Learned from Shuttle, Orion and Ongoing Research and Development", Commercial and Government Responsive Access to Space Technology Exchange. October 25-28, 2010. Moffett Field, CA.
[6] Robin A. Beck, et. al, "Overview of Initial Development of Flexible Ablators for Hypersonic Inflatable Aerodynamic Decelerators" 21st AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar 23-26 May 2011, Trinity College, Dublin, Ireland.