APPLICATION OF CEV SIZING PROCESS OF PICA TO STARDUST
(IPPW-7)

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ABSTRACT

The Stardust mission is so far the only mission in which the sample return capsule, after undergoing a hypervelocity reentry, was recovered withthout major damage. The capsule heat shield, composed of a PICA (Phenolic Impregnated Carbon Ablator) Thermal Protection System (TPS) and bonded to a composite aeroshell was subjected to a series of post-flight data analysis. One of the actions received by the Stardust postflight analysis team was to assess the differences in the Stardust and CEV TPS design processes by comparing the Stardust heat shield design process with current CEV best practices. The goals were:

1. to validate CEV design process against flight data by comparing the overall thickness, bondline temperature maintenance and recession
2. to assess the conservativeness of the CEV design
3. to potentially make recommendations on possible alternative to CEV design process that could result in mass savings for future missions which employ similar materials.

The Stardust design process was relatively simple and consisted in an unmargined TPS thickness estimate of 1.88 in. This thickness resulted from one FIAT optimization run against a not-to-exceed bondline temperature of 482^0F, corresponding to stagnation point conditions and using a pre-flight PICA material property model. An additional margin of 29% was then applied in terms of added thickness. This number resulted from an RSS calculation of trajectory margin (0%), aerothermal margin (21%) and PICA material margin (20%). A constant thickness heat shield was built with the final thickness of 2.29 in. The current CEV margins process differs from the Stardust design process by the way the various margins are applied: the trajectory and aerothermal margins are applied as multiplying factors on the nominal aerothermal environments while the PICA material margin is applied in terms of bondline temperature reduction (by 108^0F). The thicknesses and recessions predicted in these three branches are RSS-ed to calculate a baseline thickness and an equivalent recession thickness with the final thickness being the maximum of the two (corrected for factor of safety and recession margin).

The present work investigates the influence on the Stardust sizing process of the following trades: bondline temperature requirement, multiple temperature constraints, material stackup, initial temperature. The largest impact on the final thickness originated from the change in the value of the bondline constraint as well as applying multiple constraints. The sizing process proved to be less conservative (45%) in terms of PICA material properties but more conservative (58%) in terms of applied margins.