PARAMETRIC THERMAL SOAK MODEL FOR EARTH ENTRY VEHICLES

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Predict peak payload temperature and provide temperature contours of an Earth Entry Vehicle (EEV) for sample return missions.

Objectives

- Samples from outer space are brought to earth by means of earth entry vehicles (EEV).
- During the re-entry these vehicles are subjected to extremely high heating.
- Science mission requirements for biological samples are very stringent.
- MSR requires to maintain temperature control below 20°C.
- Payload temperature history and peak temperature knowledge is critical for mission success.

Background

- Mars Sample Return EEV
- Time span for thermal soak

- Design elements influenced by MSR geometry
- 2-D axi-symmetric model with 1.05m diameter, 60 deg sphere cone angle and spherical nose
- Sample container protected by crushable foam and C-C structure.
- Marc. Mentat Finite Element (FE) Software
- supports fully transient, non-linear, thermal analysis
- Conduction, external and internal re-radiation as heat-transfer mechanisms
- Adaptive time-temperature
- Spatially and temporally varying heatflux from CFD imposed as surface boundary condition
- Carbon Phenolic and PICA as TPS candidates

Model Development

- High heat load trajectory
- Low heat load trajectory
- Vehicle Geometry
- Finite Element Model

Analysis and Results

- It takes several hours for the payload container and interior foam to heat up.
- Entry heatload and choice of TPS materials significantly affect the payload temperature.
- Lower peak payload temperature with PICA compared to CP.

Conclusions and Outlook

- Parametric thermal soak model can be developed for a representative EEV geometry to predict peak payload temperature for a given heatload, heatflux and vehicle diameter.
- Future work will include different TPS thickness and entry vehicle configurations, and incorporate them into thermal soak model.