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PLASMA SHEATH ANALYSIS OF SWERVE/EPW FOR RANGE EXTENSION TRAJECTORY (U)

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Abstract [redacted]

Another objective was to estimate resulting plasma attenuation and reflected EM signal loss for post-reentry phased array radar altimeter terminal fix sensor (TFS). In addition, turbulent boundary layer flow velocity, temperature, density and species concentration distributions were calculated for analysis of a laser altimeter TFS.

Calculations indicate peak temperature, peak electron density, gas density and collision frequency in the plasma sheath increase with increasing V and α due to flow compression on windward body surface.

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Configuration and Flight Conditions

The proposed SWERVE/EPW conical body configuration[1] has a carbon-carbon nosetip (R_N = 0.7376 in) with a carbon-phenolic aft heatshield (θ_c = 5.25 deg) and is assumed sodium contaminated with 45 ppm Na.

Surface Pressure and Edge Conditions

Body surface pressure distribution and boundary layer edge conditions were calculated with an approximate equivalent cone (θ_e) method assuming $\theta_e = \theta_c + \alpha$ for the windward conical body at α.

Surface pressure increases with both increasing cruise velocity and α.

The boundary layer flow edge conditions were computed assuming an isentropic expansion from behind the bow shock to local cone surface pressure while matching the entropy gradient from the curved bow shock.

Boundary Layer Flow Field

The boundary layer flow field program BLIMP was used to calculate turbulent chemically-reacting flow over the SWERVE/EPW surface while allowing carbon-phenolic heatshield surface ablation. Carbon surface char is assumed in heterogeneous equilibrium with flow and pyrolysis gas (C_6H_6O) injection at the surface from indepth phenolic resin decomposition. Curve fitted JANAF thermochemical data is used in BLIMP to calculate species thermodynamic and transport properties. The equilibrium chemistry model consisted of 40 neutral and 18 ionized species.

C-P surface temperature and ablation rates were predicted assuming local steady state surface recession and are given in Figures 3 and 4.

Results indicate both T_w and $\dot{m}_w$ increase with increasing cruise velocity and α. The heat transfer rate to the windward body surface was calculated considering hot wall temperature, surface ablation effects and equal diffusion coefficients for all boundary layer flow species and is presented in Figure 5.

Plasma Analysis

BLIMP calculates equilibrium chemically reacting species concentrations for neutral, positive and negatively charged ions and electrons in gas assuming neutral plasma sheath. An example of predicted neutral species concentrations in the flow at S = 4.0 ft station is presented in Figure 9. Figure 9 shows the species concentrations in mole fraction percent as a function of distance from the C-P surface.

considered in Figure 1 and give the lowest and highest peak T for this matrix (Figure 3). As shown, the species concentration distributions are basically similar for both flight conditions. Near the surface the dominant species are N_2, CO, H_2 and H, where as near edge the dominant species are N_2, O_2, CO_2 and H_2O. The specific neutral species concentrations at surface are given in the following Table.

Table 1

In addition to these species there are trace amounts of other hydrocarbons formed from C H O N elements in the chemical system. As may be seen in Table 1 and Figure 9, at and near the surface almost all of available carbon produced by carbonaceous surface ablation and pyrolysis gas injection is oxidized to CO. In this region there is almost no O or O_2 available for further oxidation reactions.

Therefore, the surface ablation rate is controlled by diffusion of O and O_2 toward the surface. In the central region of the boundary layer the CO further reacts with oxygen forming CO_2.

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2. Memorandum, S. G. Beard and G. F. Polansky, dtd 10/22/85 subject: "Thermal Analysis for Three SWERVE/EPW Trajectories with a Low Flight Path Angle (U), SFRD, RS1633/85/69.

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