STAGNATION-POINT RADIATIVE HEAT FLUXES IN NEPTUNE AEROBRAKING

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ABSTRACT

In [1], the flow environment occurring during the aerobraking flight of a spacecraft into Neptune was calculated. The aerobraking maneuver was to be carried out for the purpose of inserting the spacecraft arriving from Earth into an orbit around Neptune. The apogee of the orbit was to be the distance to Triton so that the spacecraft could observe Triton. Because Triton rotates around Neptune in the retrograde direction, the entry flight was to be also in the retrograde direction. The spacecraft was to have a mass of 600 kg, base diameter of 0.5 m, and a nose radius of 0.2 m. The entry velocity was to be 29 km/s, considerably higher than the parabolic value of 26.5 km/s. In that work, the convective and radiative heat fluxes were calculated at the stagnation point.

In the calculation of convective heat flux, the effect of blowing due to ablation was ignored, leading to an overestimation. On the other hand, radiative heating rate was calculated ignoring the possible nonequilibrium radiation overshoot phenomenon. The calculation lead to the conclusion that the convective heating was dominant, and that the sum of two heating rates are below that experienced during the entry flight into Jupiter.

In [2], a method was developed to calculate the radiative heating rate in a hydrogen-helium mixture similar to that which constitutes the atmosphere of Neptune, accounting for the nonequilibrium phenomena occurring behind a shock wave. The work was based on the experiments conducted in the 1970s, and concluded that the nonequilibrium radiation phenomenon increased the radiative heating rate. The radiative heat load at the stagnation point was to be 1.5 MJ/cm^2, which is four times that to the Galileo Probe vehicle which entered into Jupiter and is beyond the present capability for thermal protection.

In the present work, this method was used in calculating the radiative heating rates to the stagnation point of the Neptune aerocapture vehicle at different entry velocities. For the vehicle considered in [1], radiative heat load to the stagnation point becomes 0.79 MJ/cm^2 at the entry velocity of 27 km/s, and 0.28 MJ/cm^2 at 25 MJ/cm^2. These values are presently manageable.

References

[1] Jits, R., Wright, M., and Chen, Y-K., “Closed-Loop Trajectory Simulation for Thermal Protection System Design for Neptune Aerocapture," *Journal of Spacecraft and Rcoekts,* Vol. 42, No. 6, November-December 2005, pp. 1025-1034.
[2] Park, C., “Nonequilibrium Ionization and Radiation in Hydrogen-Helium Mixtures’, AIAA paper 2010-814.