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MINIMUM-MASS HEAT SHIELD FOR A NEPTUNE AEROCAPTURE MISSION

Abstract

This paper discusses the sizing of the heat shield of a lifting-body spacecraft protected by a rigid aeroshell, to minimize its mass for a future aerocapture mission to Neptune. The savings on the heat shield mass is a primary requirement for the mission design because the high expected heat loads can raise the value of its mass fraction to unacceptable levels for a successful execution of the mission. The heat shield is divided into several regions, each characterized by different levels of the entering heat flux. The minimization of its mass is carried out through the identification of the most suitable materials to be used in the different zones and through the determination of their minimum thicknesses. To accomplish this, it has been assumed a mapping established a priori based on a common case treated in the literature. The analysis has shown that to obtain the maximum savings in mass for this vehicle, it is necessary to adopt a heat shield composed of different ablative materials that vary depending on the area to be protected. The front part of the spacecraft, near the stagnation point, should be protected exclusively by carbon phenolic, a high-density material, using substantial thicknesses, whereas ablative materials having lower density and using smaller thicknesses should carry out the protection for the ventral and dorsal regions. The frontal area alone constitutes approximately half of the entire mass of the heat shield, while covering less than 10% the total surface.