NASA TECH BRIEF

Ames Research Center

NASA Tech Briefs announce new technology derived from the U.S. space program. They are issued to encourage commercial application. Tech Briefs are available on a subscription basis from the National Technical Information Service, Springfield, Virginia 22151. Requests for individual copies or questions relating to the Tech Brief program may be directed to the Technology Utilization Office, NASA, Code KT, Washington, D.C. 20546.

Volume-Reflecting Dielectric Heat Shield

Heat shields for planetary entry probes thusfar have been satisfactorily fabricated from carbonaceous materials which dissipate energy largely by emission of radiation to the relatively cool ambient atmosphere. However, when a probe enters the atmosphere of a planet such as that of Jupiter, the amount of energy to be dissipated is so great that conventional heat shields are relatively ineffective. It has been suggested that large amounts of radiant energy might be dissipated by reflection from a heat shield which incorporates reflecting metallic flakes in a basic material of high transmissivity. Unfortunately, metal flakes absorb radiation and suffer from excessive heating under intense radiation.

The results of investigations have indicated that an efficient heat shield which exhibits the property of reflectance in volume can indeed be fabricated from a dielectric material. A white, volume-reflecting dielectric material absorbs essentially none of the incident radiant energy, and continues to reflect even though in a severe environment its surface is melted and is being vaporized. The process of overall reflectance in a dielectric material, involving internal refractions and reflections, is similar to the process of reflection in paints; for example, tiny particles of a pigment such as a metal oxide are colorless and transparent, but when suspended in a colorless and transparent binder or vehicle, they impart a white color to the paint simply because there is a difference in index of refraction between pigment and binder.

Polytetrafluoroethylene (PTFE) was selected to demonstrate the principle of diffuse reflectance by a dielectric body; its ablation performance in convective heating environments is well known. PTFE is a partially crystalline material in which the amphorous and crystalline zones are uniformly distributed, with the degree of crystallinity varying from 50 to 70 percent depending on the manufacturing process. Under normal conditions, it is an opaque white, but when heated above 327°C all crystallites melt and the substance becomes transparent, at least to visible light; below 327°C, the difference in the index of refraction of the adjacent amorphous and crystalline zones enables reflections and refractions to occur at the zone boundaries so that the material appears white.

At first, PTFE was subjected to convective heating only to establish the validity of experimental procedures; the measured surface recession rates were in excellent agreement with rates calculated from ablation expressions. Then, the imposed heating was doubled and tripled by addition of a radiation component, but no additional recession was observed; the reflective property of PTFE (backscattering by the crystalline zones in the absence of absorption) prevents additional radiative heating from further degrading the material. In contrast, a black PTFE (pigmented with graphite), which exhibited the same recession rates in convective heating only, receded at nearly five times the rate of the white PTFE in the combined heating environments.

Although PTFE is only a marginal candidate for a radiation-dominated entry environment because of its very low heat of vaporization, the outstanding potential of volume-reflecting materials has been shown. Materials with higher heats of vaporization or sublimation, such as fused amorphous silica, that demonstrate the basic feature of reflection by scattering would improve the overall ablation performance for reflecting heat shields.

(continued overleaf)

Note:

Requests for further information may be directed to:

Technology Utilization Officer
Ames Research Center
Moffett Field, California 94035
Reference: TSP 74-10074

Patent status:

NASA has decided not to apply for a patent.

Source: Philip R. Nachtsheim,
David L. Peterson, and John T. Howe
Ames Research Center
(ARC-10803)