NASA TECH BRIEF

NASA Pasadena Office

Rocket Plume Properties Measured in Space Simulators

Methods for determining the dynamic properties of rocket plumes emanating from small nozzles in a vacuum are, of course, extremely important because the results make possible an evaluation of the interaction of the plumes with spacecraft surfaces; however, the methods developed for aerospace purposes may also be of importance for terrestrial applications such as the design of diffusion pump jets for multiple stage vacuum pumps.

Characterization of the nature of exhaust plumes from nozzles with relatively large internal boundary layer flow has taken place in a 25-foot space simulator facility and in a molecular sink facility. The molecular sink facility provides means for performing tests at pressures as low as 10^{-5} torr with a continuous flow of about 0.07 mole of gas per second, or an equivalent altitude of 160 km at 0.01 mole of gas per second. Plume density has been measured by an electron beam/photomultiplier system.

Study of rocket nozzle plume flow fields as they would occur in space requires that the plume be undisturbed either by the chamber wall or by the measuring instruments. The first requirement was accomplished by a 20°K wall of the chamber because it captured virtually all of the gas molecules on first encounter. The second was met by means of an electron beam/photomultiplier system and an array of quartz-crystal microbalances located away from the nozzle.

The electron beam system is based on use of a collimated beam of electrons which is projected into the plume, resulting in an illuminated path whose intensity and spectral characteristics are related to gas density, composition, and temperature. The fluorescence of the beam is measured by a photomultiplier whose output is normalized by the electron beam current; the photomultiplier/electron beam system is calibrated against known gas density. Movements of both the beam and the photomultiplier allow determination of the density at any desired point in the plume.

Measurement of the mass-flow per unit area (nitrogen) has been effected by means of twelve 5-MHz quartz-crystal microbalances utilizing quartz crystal sensors mounted in various locations on the walls of the chamber. The quartz crystals are frequency sensitive and can detect changes in mass.

Notes:

1. Quartz-crystal microbalances have also been used in biological studies; see Tech Brief B72-10243.
2. Requests for further information may be directed to:

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