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Brief 68-10447

NASA TECH BRIEF

Plume Radiation Program

The problem:

To develop an analytical procedure for the prediction of the radiative effects from rocket plumes such as those produced by the Rocketdyne F-1 and J-2 engines.

The solution:

A computer program which determines the radiant flux to the base region of a real gas system with an axisymmetric geometry and any axisymmetric property distribution.

How it's done:

The program provides for the radiation contribution from carbon dioxide, water vapor, and incandescent carbon particles (it is not difficult to extend the program to include other radiating constituents). The radiative flux is determined by simultaneously accounting for the emission, interlayer absorption, and transmission of all of the radiating constituents. Differences in the chemical composition of the plume "core", the afterburning mantle, and the surrounding atmosphere can be accomodated by the program.

The present form of this program incorporates a "frozen equilibrium" chemical composition in the plume core along with a temperature and density distribution which varies as a function of the axial and radial positions. The program further provides for axial variations in temperature, pressure, and chemical composition in the afterburning mantle region, and fixed values of the pressure, temperature, and water vapor mol fraction for the surrounding atmosphere, if any exists. The core and afterburning mantle geometry and the distributions of temperature, density, pressure, and chemical composition must be given as inputs to the computer program along with the nozzle geometry and the spectral absorption coefficients of all radiating constituents (as a function of temperature and wave number).

For an appropriate set of input values, the computer program predicts the local radiative flux to the base region of the vehicle. Further, the program simultaneously computes the configuration factor between the visible plume surface and an infinitesimal area element at the base of the vehicle. The occlusion effect of the nozzle is considered in determining the configuration factor. For cases in which it is valid to assume that the plume radiates as an opaque isothermal diffusely radiating surface, a "shell model" can be used based on this configuration factor.

Notes:

1. The program has been specifically applied to the case of a single rocket engine plume; however, the analytical techniques can be extended to other physical situations, for example, the analysis of radiation from a gas core nuclear reactor, multiple plume rocket engine systems, and more generally, any axisymmetric radiating gas system.
2. The program is written in Fortran IV for use on the IBM 7094 computer.
3. Inquiries concerning this program should be directed to:

   COSMIC
   Computer Center
   University of Georgia
   Athens, Georgia 30601
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Patent status:

No patent action is contemplated by NASA.

Source: S. De Soto and C. A. Vok
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