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Brief 66-10633

NASA TECH BRIEF

Predicting Surface Heating Rates and Pressures Resulting from Hot Exhaust Gases

The reaction control system (RCS) rocket engines on the Apollo spacecraft are placed on the service module in such a manner that the effects of engine exhaust plume impingement on the vehicle (surface heating and surface pressure) are important to structural integrity. To determine experimentally the amount of thermal protection required on the service module because of plume impingement heating a series of tests was performed, and sufficient parametric data were obtained to allow a theoretical correlation of the results.

A report, "High Vacuum Plume Impingement Test Correlation," by E. T. Piesik, SID 64-1563, August 1964, was prepared which presents analytical methods (backed up by experimental data) for predicting the heating rates and surface pressures which result from an exhaust plume impinging on a flat plate in space. These methods have been used to design the service module plume heat shields for the roll, pitch, and yaw reaction control system engines.

The method of characteristics, described in the report, is capable of solving the complex problems involved. Individual computer programs exist throughout industry which calculate various parts of the problem: chemical composition and engine performance parameters at various nozzle area ratios, three-dimensional nozzle characteristic flow field properties with variable specific heat ratio for performance loss calculations, and exhaust plume flow field characteristics based on the nozzle exit Mach number and exit pressure. However, a computer program which currently accounts for all physical phenomena which make up the exhaust flow field of a contoured nozzle rocket engine is not known. Because of the complexity of calculating plume flow field for other than relatively simple nozzle exit conditions, the requirements for an exact flow field calculation must usually be relaxed. The report shows, at least for the engine tested, that a very simple analysis of the exhaust flow field will result in good correlation with the experimental data on heating rate and surface pressure for a flat plate impinged upon by an exhaust plume in a near-perfect vacuum.

Note:

The report is available from:

Technology Utilization Officer
Manned Spacecraft Center
Houston, Texas 77058
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Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: D. J. Simkin and E. T. Pieski
of North American Aviation, Inc.
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Manned Spacecraft Center
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Category 05