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AEC-NASA TECH BRIEF

Computer Program MCAP Provides for Steady State Thermal and Flow Analysis of Multiple Parallel Channels in Heat Generating Solid

The problem:

To devise a computer program to calculate the temperature distribution in a heat generating solid complicated by nonuniform power distribution and nonuniform flow distribution between multiple channels. In nuclear rocket reactors it is desirable to produce as high an exit coolant temperature as possible (for high specific impulse) without exceeding material limitations. The channels must be orificed or must have different diameters to account for nonuniform heat generation.

The solution:

The multiple channel analysis program (MCAP) determines the channel diameters or channel orifice coefficients, the effects of tolerances, the pressure drop through a heat exchanger at a given flowrate, or the flowrate for a specific pressure drop. The code is designed to facilitate the use of various parameters such as film heat-transfer correlations, material properties, system configurations, and gas properties.

How it's done:

The MCAP analyzes up to 50 parallel channels contained within a heat generating solid having uniform or nonuniform axial and/or radial variations in internal heat generation. The geometric array of the channels provides input to the program which includes interior adiabatic boundaries encompassing each channel. The temperature along the wall of each channel and the temperature profile of the adiabatic boundaries are computed using unidirectional Fourier conduction and appropriate forced convection heat transfer boundaries. The model to be analyzed can be divided into 40 or less axial increments (no axial heat conduction is considered); the energy and momentum equations for the fluid are expressed in finite difference form to facilitate the iterative calculations. Turbulent gas flow is assumed, with provisions for variable fluid properties, and the capability exists for expressing the Nusselt correlation in various forms with properties evaluated at either bulk, film, or wall temperature. MCAP also contains the option of determining channel diameters and/or orifice sizes for each channel entrance to provide the required pressure drop and/or rates of heat transfer.

Typical solution sequence: (a) the mass flow for each channel is adjusted until the pressure drop for each channel is essentially equal with constant total mass flow; (b) with a specified pressure drop the flowrate for each channel and therefore the total mass flow is determined; and (c) with the mean exit gas temperature and the total flow specified, the total power distribution and/or channel diameters are determined within prescribed tolerances.

Notes:

1. The program has been written in the Fortran II language for use on the IBM 7094 computer.
2. Inquiries concerning this program may be made to:
   COSMIC
   Computer Center
   University of Georgia
   Athens, Georgia 30601
   Reference: B67-10457

Patent status:

No patent action is contemplated by AEC or NASA.

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