NASA TECH BRIEF

Computer Program Provides Steady State Analysis for Liquid Propellant Propulsion Systems

The problem:

To design a computer program that will provide performance analysis in the application of steady state fluid flow theory to determine line pressure drop in a system with six outlets for each of two main storage tanks. It was desired to make a study of the engine performance of the Apollo reaction control system in variable firing modes. When considering the mathematical model setup of the pressure drop relations between each of the six engines under consideration, given by an extension of Bernoulli's formula for pressure drops between two points, a problem was presented in that two unknown variables appeared in each relationship.

The solution:

The application of Bernoulli's formula for pressure drops between two points provides the main aspect of the theory of fluid flow for the solution. The application of a numerical scheme referred to as the Newton–Raphson method presents an iterative solution to Bernoulli's pressure drop relations in a manner which results in fast execution time by the computer. Execution provides computed output of chamber pressures, thrusts, mixture ratios, injector pressures, line pressure drops, flow rates, and characteristic velocities for all engine modes fired. Program flexibility arises in the ease with which changes in the fluid line geometry can be made, i.e., line length, diameter, and shock losses.

How it's done:

The problem of solving for the flow rates of each engine is readily adaptable to solution by numeric methods. A common method of obtaining these solutions is that of starting with an initial approximation to the solution that is desired and employing a recurrence formula to construct a sequence of successive approximations which will converge to the desired solution. The Newton–Raphson method is an iterative scheme which obtains a solution in the manner described.

The equations to be solved are formulated from pressure drop relations found by Bernoulli's formula. The pressure drops are found from the propellant tanks to each of the six engines. Each equation is then set to zero by transposing the pressure drop to the right hand side giving 12 equations in which the unknown variables are the flow rates and chamber pressure.

Notes:

1. This program is written in Fortran IV for an IBM 7094 computer.
2. Inquiries concerning this program may be directed to:

   COSMIC
   Computer Center •
   University of Georgia
   Athens, Georgia 30601
   Reference: B67-10414

Patent status:

No patent action is contemplated by NASA.

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