NASA TECH BRIEF

Lewis Research Center

Computer Programs for Calculating Potential Flow in Propulsion System Inlets

In the process of designing inlets, particularly for VTOL and STOL propulsion systems, a calculational procedure utilizing three computer programs evolved. The chief program is a Douglas axisymmetric potential flow program called EOD which calculates the incompressible potential flow about arbitrary axisymmetric bodies. The other two programs are called SCIRCL and COMBYN. Program SCIRCL generates input for EOD from various specified analytic shapes for the inlet components. Program COMBYN takes basic solutions output by EOD and combines them into solutions of interest and applies a compressibility correction.

The purpose of the SCIRCL program is to supply accurate input to the potential flow program. To this end, the inlet surfaces (e.g., hub and shroud) are divided into segments each of which is a portion of an analytical curve. The curves available are superellipse, ellipse, cubic, lemniscate, and straight line. SCIRCL distributes points along the inlet surfaces in such a way as to meet the requirements of program EOD. The coordinates of these points are punched on cards for direct input to EOD along with other information required by EOD. In addition, SCIRCL outputs printed information about the inlet surfaces (coordinates, curvature, slope, etc.).

In addition to the surface points, sets of points spanning the passage, like flow measuring rakes, are needed at axial locations where velocity profiles or streamlines are desired. At least one "rake" must be specified for use as a control station. Program SCIRCL generates the coordinates of the rake points and punches them on cards for input to EOD.

The EOD is an incompressible potential flow computer program for axisymmetric bodies. Only the bodies must be axisymmetric; the flow itself need not be. The main elements of the program are:

1. Bodies are represented by a distribution of sources and sinks of initially unknown strengths.
2. An integral equation in the unknown source strength is derived from the potential flow equations and boundary conditions.
3. The integral equation is approximated by a set of linear algebraic equations corresponding to discrete points on the bodies.
4. These equations are solved for the source strength by matrix methods.
5. Velocities are calculated on the surface and at other points of interest (such as rake points) in the flow field from the source distribution obtained in step 4.

The program was originally written for closed bodies in a free stream. To apply the method to inlets, the inlets are idealized by adding artificial extensions to the inlet surfaces. The program is used to obtain three basic solutions for the idealized inlet profile and certain free-stream conditions. The basic solutions are ones that provide a convenient basis for generating the combined solutions that represent flow conditions of interest. Program EOD has been modified to output the basic solutions on punched cards for input to program COMBYN.

The COMBYN program combines the basic solutions from EOD into any number of solutions of interest (a solution of interest or combined solution is one having specified values of free stream velocity and direction and control station velocity or weight flow).

One of the "rakes" mentioned under SCIRCL is used as a control station by COMBYN. The control station is the rake at which the average inlet axial velocity of the combined solution is specified. If there are several rakes, any one may be used as the control station.

Notes:

1. These programs are written in FORTRAN IV for use on an IBM 7094 DCS computer system.
2. Inquiries concerning these programs should be directed to:

   COSMIC
   Information Services
   112 Barrow Hall
   University of Georgia
   Athens, Georgia 30602
   Reference: LEW-12152

Source: N.O. Stockman and S.L. Button
Lewis Research Center
(LEW-12152)

Category 09