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NASA TECH BRIEF

Computer Program Performs Flow Analysis Through Turbines

The problem:

To devise a method of analyzing flow through a turbomachine (turbine, compressor, or pump) that is readily adaptable to computer programming. Previous methods obtained a two-dimensional solution based on an equation for the velocity gradient along the normal to the projection of the streamlines on a plane containing the axis of rotation (the meridional plane). The meridional streamlines and their normals are used to establish a grid for a meridional-plane solution. In cases where the distance between the hub and shroud is great and there is a large change in flow direction within the rotor, the normals vary considerably in length and in direction during the course of the calculations. Therefore, it is difficult to obtain a direct solution on the computer without resorting to intermediate graphical steps.

The solution:

A new method and computer program based on an equation for the velocity gradient along an arbitrary quasi-orthogonal rather than the normal to the streamline as used in previous methods. The program (in the Fortran programming language) obtains meridional solutions for a hub-to-shroud analysis and blade-to-blade analysis at the hub, mean, and shroud surfaces in a single computer run.

How it's done:

This method obtains a direct solution by the use of arbitrary curves (called quasi-orthogonals) from hub to shroud instead of streamline normals. The quasi-orthogonals are not necessarily orthogonal to each streamline but intersect every streamline once across the width of the passage. The quasi-orthogonals remain fixed regardless of any change in streamlines. Using this technique, a computer program is developed that calculates a streamline solution in the meridional plane without any intermediate graphical procedures, even for turbomachines with wide passages and a change in direction from radial to axial within the rotor blade.

From the meridional solution, it is possible to obtain blade-surface velocities by several methods. However, the basic concept used to obtain the meridional solution can also be applied to obtain a blade-to-blade solution. In this case, the quasi-orthogonals run from blade to blade on a stream surface determined by the meridional solution. By extending the solution upstream and downstream, a good solution throughout the rotor is obtained.

Notes:

1. This program will be useful in the design of any type of turbomachines (turbines, compressors, or pumps) and for either compressible or incompressible fluids.
2. Further information concerning this innovation is presented in NASA TN D-2546, "Use of Arbitrary Quasi-Orthogonals for Calculating Flow Distribution in the Meridional Plane of a Turbomachine" by Theodore Katsanis, December 1964; and in TN D-2809, "Use of Arbitrary Quasi-Orthogonals for Calculating Flow Distribution on a Blade-to-Blade Surface in a Turbomachine" by Theodore Katsanis, May 1965, available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151. Inquiries may also be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B66-10496

(continued overleaf)

Patent status:

No patent action is contemplated by NASA.

Source: Theodore Katsanis
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