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.
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No patent action is contemplated by NASA.
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