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Lewis Research Center

Computer Program for the Prediction of Reorientation Flow Dynamics

A computer program, HOPI, has been developed which can be used to predict reorientation flow dynamics, wherein liquid moves from one end of a closed, partially filled, rigid container to the other end under the influence of container acceleration.

This program was written to predict the reorientation flow dynamics of liquids contained in spacecraft which are subject to the effects of acceleration and deceleration in a reduced gravity environment. Initial destabilization and ensuring flow dynamics have been studied analytically, but reorientation time estimates have previously been derived almost entirely from empirical results based on scale-model experiments.

HOPI uses the Navier-Stokes and the continuity equations for incompressible, viscous fluid as the basic equations governing the reorientation flow dynamics. The equations were programmed using explicit finite differencing for two-dimensional planer and three-dimensional axisymmetric problems. The Simplified Marker and Cell (SMAC) numerical technique was used to determine liquid-vapor interface positions.

HOPI can simulate curved as well as straight-walled boundaries. It has the ability to calculate both free-surface and confined flows. It can be used in either cylindrical or plane geometry. The size of the computing mesh is easily changed from problem to problem. The grid dimension in each direction must be constant through the grid mesh, although the grid dimensions in the radial and axial directions may differ. Gravitational effects may be included in any orientation, however, for any given time interval, the gravitational acceleration must be constant and only axisymmetric flow can be calculated. HOPI has a surface pressure interpolation scheme that prevents unrealistic breakup of the surface.

Notes:

1. The HOPI code expands the state of the art in Marker and Cell Code development in incorporating the following four options into one program:
   a. Curved as well as straight-walled boundaries may be input. This allows actual container shapes to be more accurately considered.
   b. The effect of turbulence can be simulated. Test data has shown that the turbulent viscosity can be orders of magnitude greater than the molecular viscosity of the fluid. When this occurs, turbulence must be simulated to accurately predict the fluid motion.
   c. A surface pressure interpolation scheme exists which calculates the pressure in a fluid cell based on the pressure at the fluid surface. This option avoids surface instabilities.
   d. Marker particles can be added at any time during a run. This feature is useful when the acceleration of the fluid causes the marker particles in a given region of the fluid to become too rarified.
2. The program is written in FORTRAN IV for use on a CDC 6400 unit.
3. Inquiries concerning this program should be directed to:

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