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EVALUATION OF AEROTHERMAL MODELING COMPUTER PROGRAMS

K.C. Hsieh and S.T. Yu
Sverdrup Technology, Inc.
Lewis Research Center
Cleveland, Ohio

In the present research, various computer programs based upon the SIMPLE or SIMPLER (ref. 1) algorithm have been studied and compared for numerical accuracy, efficiency, and grid dependency. Four two-dimensional codes and one three-dimensional code originally developed by a number of research groups were considered. In general, the accuracy and the computational efficiency of these TEACH typed programs have been improved by modifying the differencing schemes and their solvers. A brief description of each program follows:

(a) Error Reduction Programs (ref. 2): a two-dimensional program and a three-dimensional program were developed by Pratt & Whitney and modified by Advanced Scientific Computing LTD. The modifications include (1) Stone's Strongly Implicit Procedure (SIP) for the solution of the pressure correction equation, (2) Incomplete Choleski (IC) for the solution of the pressure correction equation, (3) Additive Correction Multigrid (ACM) to accelerate the convergence of SIP and IC, (4) Block Correction (BC) to accelerate the convergence of IC with the option of further accelerating convergence by using ACM, and (5) incorporation of Linear Profile (LP) and Mass Weighted (MW) Skewed Upstream Differencing Schemes (SUDS).

(b) Two-Dimensional Flux Spline Programs (ref. 3): Two two-dimensional programs based on the flux spline method were developed by K.C. Karki in Allison Gas Turbine Corporation. The flux spline method assumes that the total flux across the boundaries of each numerical control volume varies in a piecewise linear manner as opposed to the lower-order methods, such as the hybrid scheme, which assumes that the total flux is uniform between two adjacent grid points. Thus, a more accurate solution can be obtained through the flux spline method. In this research, two versions of the flux spline programs were examined. The first program uses a traditional, line-by-line sequential solver. In the second version of the program, a sparse matrix package developed at Yale University was employed. The momentum equations and the pressure correction equation were solved simultaneously by this direct solver, and computational efficiency has been improved.

(c) Second Order Upwind Differencing Program (ref. 4): A computer program using Price's second order upwind difference scheme originally developed by S.P. Vanka was studied. The solution algorithm employed is based upon a coupled solution of nonlinear finite-difference equations using the multigrid technique.

The model problem for examining the three-dimensional program has been adopted as the subsonic jet in crossflow configuration. The code is efficient and the calculated results are compared with experimental data.

The test case for the four two-dimensional codes was chosen to be the developing entrance flow in a two-dimensional flat channel since the analytic solution is available (ref. 5). All the programs will be examined based upon this configuration. The accuracy and computational efficiency of these programs are compared. The grid dependency of each code is also studied.

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