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DEVELOPMENT OF PARTIAL CHANNEL FLOW FOR ARBITRARY INPUT VELOCIT--ETC(U)

APR 79 L R HESTER, J F THOMPSON

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) channel flow velocity distribution partial channel flow computational mechanics internal flow problems laminar incompressible flow symmetrical flow		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report summarizes the results of the attempted solution of the class of problems associated with partial channel flows using a numerical technique of boundary-fitted coordinate systems.		

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FINAL REPORT

TITLE: Development of Partial Channel Flow for Arbitrary Input Velocity Distributions Using Boundary-Fitted Coordinate Systems.

GRANT NO.: DAAG29-76-G-0144

PUBLICATIONS: "Development of Partial Channel Flow for Arbitrary Input Velocity Distributions Using Boundary-Fitted Coordinate Systems," D. Kumar, L. R. Hester, and J. F. Thompson, presented at the ASME Symposium on Non-Steady Fluid Dynamics at the ASME Annual Winter Meeting, San Francisco, California, December 10-15, 1978, and published in the ASME Symposium on Non-Steady Fluid Dynamics, BK No. H00718, Pages 53-61, December 1978.

"Recent Developments in the Use of Boundary-Fitted Coordinate Systems for Computational Mechanics," Joe F. Thompson, Z. U. A. Warsi, C. W. Mastin, and L. R. Hester, Eighth U.S. National Congress of Applied Mechanics, Los Angeles, 1978.

SCIENTIFIC PERSONNEL
AND ADVANCED DEGREES:

Leslie R. Hester, Principal Investigator; Joe F. Thompson, Project Director; Dilip Kumar, Graduate Student, awarded the Ph.D. degree December 22, 1978.

STATEMENT OF PROBLEM STUDIED:

The main thrust of the work under this grant was to attempt a solution of the class of problems associated with partial channel flows using a numerical technique of boundary-fitted coordinate systems. Emphasis was placed on those partial channel configurations that are common to laminar flow fluidic devices. Partial channel flows are a special class of internal flow problems in which the main stream of fluid only partially fills the main channel. Additionally, there exists intersecting channels with in and out flows which interact with the main stream flow. Thus it is impossible to obtain an analytical solution because of a mixture of forward and reverse flows associated with the main channel flow and the interaction between the main channel flow and the intersecting channels flow.

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The study was limited to two-dimensional configurations with laminar incompressible flow. The final configuration chosen for this study was a fluidic laminar proportional amplifier that had recently been under experimental study by separate investigators.

SUMMARY OF MOST IMPORTANT RESULTS:

At the beginning of this study the numerical technique of boundary-fitted coordinate systems had been applied only to external flows. For these flows most of the coordinate systems generated have transformed planes that consists of a single rectangle. Thus the initial effort here had to be directed toward generating coordinate systems for the somewhat more complicated internal shapes associated with partial channel flows. It is possible for these configurations to have transformed planes consisting of a single rectangle, however, it was found that having the transformed plane consisting of several rectangles and slits would be more advantageous. From this it became apparent that a general purpose computer code could be developed that would generate coordinate systems on which a wide range of internal flow problems could be solved. This again demonstrated the versatility of the boundary-fitted coordinate system.

Thus the first important result of this study was the development of a general purpose computer code that would generate coordinate systems on which a wide range of internal flow problems could be solved. The program will handle internal flow configurations from a single straight channel to a channel that consists of: a main channel; an input nozzle to the main channel; one control port channel on each side of the main channel; two vent channels on each side of the main channel; and two output channels from the main channel. The configuration can be symmetrical or asymmetrical with straight or curved walls.

Conservative and non-conservative formulations of the time-dependent, two-dimensional compressible Navier-Stokes equations in the primitive variables u , v , and p were derived in the transformed plane. The Poisson equation for pressure, an equation for pressure on solid walls and boundary conditions to evaluate pressure on entrances and exit of flow sections were also derived in the transformed plane. The transformed equations were derived in numerical form using backward time central space differencing.

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The second important result of this study was the development of a computer program that yielded the numerical solution of the time-dependent, two-dimensional incompressible Navier-Stokes equations for several partial channel configurations with various boundary conditions. The initial solutions developed were for simple full channels for which good empirical results were known for verification of the numerical program. This being established, partial channel configurations with various entrance and exit boundary conditions were then considered.

Field solutions for the velocity and pressure were obtained for the symmetrical flow case of the most complicated partial channel configuration studied. This configuration consisted of: a main channel flow; an input nozzle flow; two control ports flow; four vent ports flow; and two output ports flow. Good agreement with available experimental data was obtained. Numerical results for the corresponding asymmetrical flow case showed only partial agreement with experimental results.

The number of computational field points used for the most complicated partial channel configuration was approximately 10,000 which required a large amount of computer time for the solution. Part of the disagreement with experimental results in the asymmetrical flow case can be placed on the need for more field points, in particular, in the solid boundary corner regions and the interacting flow regions.

Thus it would seem desirable at this point to concentrate further basic research into methods that would decrease the computer time necessary to obtain flow solutions for the asymmetrical flow in partial channel configurations.