بسم الله الرحمن الرحيم

شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم

شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الالكتروني والميكروفيلم

قسم

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الاصليـــة تالفـــة

PATCHING METHODS IN FLUID MECHANICS

THESIS
SUBMITTED FOR PH.D. DEGREE IN SCIENCE
(APPLIED MATHEMATICS)

BY

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بسم الله الرحمن الرحيم

سُبحانكَ لاَ علمَ لنَا إلَّا مَاعلَّمتنا إنَّكَ أنتَ
العليمُ الحكيمُ

صدق الله العظيم

سوره البقره (٣٢)

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TO MY PARENTS,

MY WIFE ABIR AND OUR CHILDREN

MOHAMED, AHMED, AND MOATAZ

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SUMMARY

The thesis comprises six chapters. In the thesis a new method has been deduced to solve Navier- Stokes equations for compressible and incompressible fluid flows the results have been compared to those resulted by using Beam and Warming techniques.

In the first chapter exhibits most of the known methods in question such as

1- The Non- Primitive variable Approach

(i)The Velocity- Vorticity Approach

(ii)The Vorticity- Stream function Approach

2- The Primitive variable Approach

(a) The Artificial Compressibility Approach

(b) The Primitive- Variable Approach with Pressure Poisson Equation

(c) Compatibility Condition

(d) The present Approach

In the second chapter the Navier- Stokes equations are derived together with the continuity equation, momentum equation and energy equation.

In the third chapter the author shows the way of deriving a new method in two-dimensional and in three- dimensional(Cartesian and generalized curvilinear coordinate systems), in the following cases:-

1- Incompressible fluid flow

2- Compressible fluid flow

The fourth chapter deals with the accuracy and stability of a new scheme applied to the heat equation(diffusion equation) as an example.

In the fifth chapter the new scheme is applied in a fractional step method. In the last chapter the author introduces applications to incompressible and compressible fluids.

In the incompressible cases:-

(I) The driven cavity in two-dimensional

(II) The driven cavity in three- dimensional

Nevertheless, for the compressible flow the Navier- Stokes equations are solved for the case of flow around a wedge. This new method is also very useful in it presents parallel computing which is in itself a time saving procedure applicable on future parallel computing machines.

It is worthwhile noting that the programs throughout the thesis have been written in FORTRAN 77 language , FORTRAN 90 and run on UNIX system supercomputer[CRAY Y- MP, CRAY X- MP and T-3D] at Columbus and the computer of Aerospace department, faculty of Engineering , University of Cincinnati, Cincinnati, OH, USA 45221-70.

List of Symbols

x, y, z : Cartesian Coordinates.

ξ, η, ζ: Generalized Curvilinear Coordinates.

t : Time parameter

V: Velocity Vector.

u : x- component of Velocity.

v : y- component of Velocity.

w : z- component of Velocity.

p : Static Pressure divided by density.

ρ : Density.

P : Thermodynamic Pressure.

E_t **: Total Energy per Unit Mass.**

e : Internal Energy per Unit Mass.

τ_{ij} **: Stress Tensor.**

q : Heat Transfer.

μ : Coefficient of Viscousity.

k : Coefficient of Conductivity.

Q : Conserved Variables.

E, F, G : Flux Vector.

γ : Ratio of Specfic Heats.

C_p **: Specific Heat at Constant Pressure.**

R : Gas Constant.

Re : Reynolds Number.

Pr. : Prandtl Number.

τ : Computational Time.

Δ : Change in Variables.

∂ : Partial of Variables.

LHS : Left Hand Side.

RHS : Right Hand Side.

$\Delta Q^n : Q^{n+1} - Q^n$

∞ : Free Stream Value.

A, B, C : Flux Jacobians.

O : Higher Order Terms.

I : Identity Matrix.

L : Discrete Laplacian Operator.

D : Discrete Divergence Operator.

G : Discrete Gradient Operator.

H : Discrete Convective Operator.

δ : Discrete Space Derivative Operator.

Δt : Time increment.

Δx : Space increment in x- direction.

Δy : Space increment in y- direction.

Superscripts

n, n+1 : Time level at t and t+Δt.

***, ** : Intermediate time levels.**

Subscripts

i,j : Grid indics in x- direction and y- direction, respectively.

x,y : First order derivatives with respect to x- and y- directions, respectively.

xx,yy : Second order derivatives with respect to x- and y- directions, respectively.