Available online at www.sciencedirect.com
ScienceDirect
Mathematics and Computers in Simulation 82 (2011) 104–117
MATHEMATICS AND COMPUTERS IN SIMULATION
www.elsevier.com/locate/matcom

Original Articles

Optimization of the iteration parameters of the simulation of incompressible flow

A. Arbel, A. Shklyar*

Institute of Agricultural Engineering, Agricultural Research Organization, the Volcani Center, P.O. Box 6, Bet Dagan 50250, Israel

Received 3 May 2009; received in revised form 24 May 2010; accepted 30 November 2010
Available online 16 December 2010

Abstract

In optimizing the iteration parameters of the SIMPLE numerical procedure, a genetic algorithm (GA) that searches for a minimum calculation time in a space of iteration numbers was developed. A methodology has been presented for the numerical solution of natural convection in a squeezed cavity at Rayleigh numbers of 10^6. A double-staggered-grid numerical method which leads to generalization of the SIMPLE-like method for external and internal problems was used to optimize the iteration parameters for a single grid. The momentum equation was treated by the successive overrelaxation and the Gauss-Seidel methods. The pressure correction equation was solved by the conjugate gradient method with an incomplete factorization preconditioner. The temperature equation was solved by the bi-conjugate gradient-stabilized method with incomplete factorization preconditioner.

Keywords: General curvilinear co-ordinates; Incompressible flow; Natural convection; Genetic algorithm; Saddle point problems

1. Introduction

Since 1972, when Patankar [14] successfully developed the SIMPLE method, several variants of SIMPLE have been proposed, to improve the convergence rates. Progress of an effective iterative solution of a linearized momentum-mass-energy system depends heavily on the set of iteration parameters and the iterative procedures of the system of linear equations. In the context of values of iteration parameters of computational methods it is appropriate to refer to the iterative method for solving the unsteady viscous flow equations, according to Fletcher [8], p. 169: "Possibly the delicate point of the method lies in the choice of parameters, since the number of iterations necessary to reach convergence is very sensitive to this choice." The number of iterations, the relaxation factors and the iteration parameters are generally chosen on the light of numerical experiments or published recommendations.

In most studies it is emphasized that the SIMPLE method has a slow convergence rate, even though Cartesian co-ordinates are used. Attempts to enhance the convergence properties of the SIMPLE method in general coordinates may be divided into two parts: enhancement of the approximation of momentum-mass-energy equations, which includes approximation of cross-derivatives and use of enhanced linear algebraic methods; followed by choice of the set of iteration parameters. Lehnhäuser and Schäfer [12] used an approximation of the pressure derivatives based on a multi-dimensional Taylor expansion and they discussed the problem associated with of the pressure-correction equation. Yen

* Corresponding author. Tel.: +972 39683336; fax: +972 39604704.
E-mail address: shklyar@agri.gov.il (A. Shklyar).

0378-4754/$36.00 © 2010 IMACS. Published by Elsevier B.V. All rights reserved.
doi:10.1016/j.matcom.2010.11.010