Aliabadi, S.; **Abatan, A.**; **Johnson, A.**; **Abedi, J.**; **Yeboah, Y.**; **Bota, K.**

Stabilized finite element formulation of buoyancy-driven incompressible flows. (English)

Zbl 1001.76052
Commun. Numer. Methods Eng. 18, No. 5, 315-324 (2002).

Summary: We develop a streamline-upwind/Petrov-Galerkin finite element method for buoyancy-driven incompressible flows with heat and mass transfer. The stabilized finite element formulations are implemented in parallel, using message passing interface libraries. To measure the accuracy of the method, we solve a two-dimensional numerical example of natural convection flows at moderate to high Rayleigh numbers. The three-dimensional applications include the dispersion of smoke from a chimney and within a stadium.

MSC:

76M10 Finite element methods applied to problems in fluid mechanics
76D05 Navier-Stokes equations for incompressible viscous fluids
76R10 Free convection
80A20 Heat and mass transfer, heat flow (MSC2010)
65Y05 Parallel numerical computation

Keywords:

heat transfer; streamline-upwind/Petrov-Galerkin finite element method; buoyancy-driven incompressible flows; mass transfer; stabilized finite element formulations; message passing interface libraries; natural convection; dispersion of smoke; chimney

Full Text: DOI

References:

[1] Barakat ZH Clark AJ Analytical and experimental study of transient laminar natural convection flows in partially filled liquid containers 1966 152 162

[2] Formm, The time dependent flow of an incompressible viscous fluid, Methods in Computational Physics 3 pp 345– (1964)

[3] Roache JP Computational fluid dynamics Hermosa Publishers Albuquerque, NM

[4] Aliabadi, Space-time finite element computation of compressible flows involving moving boundaries and interfaces, Computer Methods in Applied Mechanics and Engineering 107 pp 209– (1993) · Zbl 0798.76037 · doi:10.1016/0045-7825(93)90176-X

[5] Aliabadi, SUPG finite element computation of viscous compressible flows based on the conservation and entropy variables formulations, Computational Mechanics 11 pp 300– (1993) · Zbl 0772.76032 · doi:10.1007/BF00350089

[6] Aliabadi, Parallel fluid dynamics computations in aerospace applications, International Journal for Numerical Methods in Fluids 21 pp 783– (1995) · Zbl 0862.76033 · doi:10.1002/fld.1650211003

[7] Saad, GMRES: generalized minimal residual algorithm for solving nonsymmetic linear systems, SIAM Journal of Scientific and Statistical Computing 7 pp 856– (1986) · Zbl 0599.65018 · doi:10.1137/0907058

[8] Tezduyar, Flow simulation and high performance computing, Computational Mechanics 18 pp 397– (1996) · Zbl 0893.76046 · doi:10.1007/BF00350249

[9] Aliabadi S Olatidoye O Tezduyar T Finite element simulation of air pollution around high-rise buildings 1998

[10] Aliabadi, Stabilized-finite-element/interface-capturing technique for parallel computation of un-steady flows with interfaces, Computer Methods in Applied Mechanics and Engineering 190 pp 243– (2000) · Zbl 0994.76050 · doi:10.1016/S0045-7825(00)00200-0

[11] Aliabadi, Two-fluid flow simulations using parallel finite element method, Simulation 75 (5) pp 256– (2001)

[12] Tezduyar, Enhanced-discretization interface-capturing technique (EDICT) for computation of unsteady flows with interfaces, Computer Methods in Applied Mechanics and Engineering 155 pp 235– (1998) · Zbl 0961.76046 · doi:10.1016/S0045-7825(97)00194-1

[13] Mittal, Parallel computation of unsteady compressible flows with the EDICT, Computational Mechanics 23 pp 151– (1999) · Zbl 0951.76045 · doi:10.1007/s004660050395

[14] Tezduyar, EDICT for 3D computation of two-fluid interfaces, Computer Methods in Applied Mechanics and Engineering 190 pp 403– (2000) · Zbl 0995.76052 · doi:10.1016/S0045-7825(00)00210-3

[15] Johnson A Aliabadi S Application of automatic mesh generation and mesh multiplication techniques to very large scale free-surface flow simulations 2000

[16] Aliabadi S Johnson A Large-scale parallel simulation of free-surface flow applications 2000

[17] Aliabadi S Johnson A Berger C Smith J Zellars B Abatan A High performance computing in coastal and hydraulic applications 2001

[18] Keyhani, Experiments on transient thermal convection with internal heating-large time results, ASME Journal of Heat Transfer 5 (5) pp 261– (1988)

[19] Kulacki, Steady and transient thermal convection in a fluid layer with uniform volumetric energy sources, Journal of Fluid Mechanics 55 (2) pp 271– (1977)· doi:10.1017/S0022112072001855