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GIMNAP-Departamento de Matemática, UBB
Centro de Investigación en Ingeniería Matemática (CI^{2}MA), UDEC

Expositor:

Paulo Zúñiga

Centro de Investigación en Ingeniería Matemática (CI^{2}MA), UDEC

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Analysis of a conforming finite element method for the Boussinesq problem with temperature-dependent parameters

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Resumen

In this paper we analyze a conforming finite element method for the numerical simulation of non-isothermal incompressible fluid flows subject to a heat source modeled by a generalized Boussinesq problem with temperature-dependent parameters. We consider the standard velocity-pressure formulation for the fluid flow equations which is coupled with a primal-mixed scheme for the convection-diffusion equation modeling the temperature. In this way, the unknowns of the resulting formulation are given by the velocity, the pressure, the temperature, and the normal derivative of the latter on the boundary. Hence, assuming standard hypotheses on the discrete spaces, we prove existence and stability of solutions of the associated Galerkin scheme, and derive the corresponding Cea estimate for small and smooth solutions. In particular, any pair of stable Stokes elements, such as Hood-Taylor elements, for the fluid flow variables, continuous piecewise polynomials of degree le k+1 for the temperature, and piecewise polynomials of degree le k for the boundary unknown become feasible choices of finite element subspaces. Finally, we derive optimal a priori error estimates, and provide several numerical results illustrating the performance of the conforming method and confirming the theoretical rates of convergence.