Universidad Carlos III de Madrid

Seminario del Instituto Gregorio Millán

Least-Squares Finite Element Models of Flows of Incompressible Fluids

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Abstract

Finite element formulations based on the weak-form Galerkin method in solid and structural mechanics resulted in enormous success. However, extension of these concepts to fluid mechanics and other areas of mechanics where the differential operators are either non-self adjoint or non-linear have met with mixed success. Numerical schemes such as modified weight functions, modified quadrature rule, optimal upwinding etc. have been presented in the literature to alleviate problems encountered with weak form Galerkin procedures in solving non-self adjoint and nonlinear problems outside of solid mechanics.

The lecture presents the formulation and application of the least-squares finite element formulations to the numerical solution of the Navier-Stokes equations governing two-dimensional flows of viscous incompressible fluids. Finite element models of the vorticity-based or velocity gradients-based Navier-Stokes equations are developed using the least-squares technique. The use of least-squares principles leads to a symmetric and positive-definite system of algebraic equations that allow the use of iterative methods for the solution of resulting algebraic equations.

High-order nodal expansions are used to construct the discrete finite element models. The system of equations thus obtained is linearized by Newton's method and solved by the preconditioned conjugate gradient method. Exponentially fast decay of the least-squares functional, which is constructed using the L_2 norms of the residuals in the governing equations, is verified for increasing order of the nodal expansions. Numerical results will be presented for several benchmark flow problems to demonstrate the predictive capability and robustness of the least-squares based finite element models.

Día y hora: Jueves, 2 de julio de 2013 a las 12:30 horas
Lugar: Sala 2.1.17 (Edificio Sabatini), Universidad Carlos III