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Finite element methods for one-dimensional combustion problems. (English) Zbl 0705.76057
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Summary: Three adaptive finite element methods based on equidistribution, elliptic grid generation and hybrid techniques are used to study a system of reaction-diffusion equations. It is shown that these techniques must employ sub-equidistributing meshes in order to avoid ill-conditioned matrices and ensure the convergence of the Newton method. It is also shown that elliptic grid generation methods require much longer computer times than hybrid and static rezoning procedures. The paper also includes characteristic, Petrov-Galerkin and flux-corrected transport algorithms which are used to study a linear convection-reaction-diffusion equation that has an analytical solution. The flux-corrected transport technique yields monotonic solutions in good agreement with the analytical solution, whereas the Petrov-Galerkin method with quadratic upstream- weighted functions results in very diffused temperature profiles. The characteristic finite element method which uses a Lagrangian-Eulerian formulation overpredicts the flame front location and exhibits overshoots and undershoots near the temperature discontinuity. These overshoots and undershoots are due to the interpolation of the results of the Lagrangian operator onto the fixed Eulerian grid used to solve the reaction- diffusion operator, and indicate that characteristic finite element methods are not able to eliminate numerical diffusion entirely.

MSC:

76L05 Shock waves and blast waves in fluid mechanics
76M10 Finite element methods applied to problems in fluid mechanics
80A25 Combustion

Keywords:

adaptive finite element methods; equidistribution, elliptic grid generation; hybrid techniques; reaction-diffusion equations; ill- conditioned matrices; convergence of the Newton method; flux-corrected transport algorithms; linear convection-reaction-diffusion equation; analytical solution; flux-corrected transport technique; monotonic solutions; Petrov-Galerkin method; quadratic upstream-weighted functions; Lagrangian-Eulerian formulation; fixed Eulerian grid

Full Text: DOI

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