Efficient Preconditioning of Linear Systems Arising from the Enriched Finite Element Discretization of Conduction-Radiation Equations

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Abstract

We investigate the effectiveness of preconditioning techniques for the enriched finite element solution for transient conduction-radiation problems in diffusive grey media. The governing equations consist of a semi-linear transient heat equation for the temperature field and a stationary diffusion approximation to the radiation in grey media. The coupled equations are integrated in time using a semi-implicit method in the finite element framework. We show that for the considered problems, a combination of hyperbolic and exponential enrichment functions based on an approximation of the boundary layer leads to improved accuracy compared to the conventional finite element method. Most of enriched finite element methods use dense direct solvers for the resulting linear systems. This is mainly the case due to the illconditioned linear systems that are associated with these methods. In this study, to solve the resulting linear system we formulate diffusion synthetic acceleration and Krylov subspace methods. We also introduce a fast multilevel algorithm. All these methods can be viewed as preconditioned iterative methods with different preconditioners. Numerical results along with comparisons of effectiveness and efficiency of these solvers are carried out on several test examples for conduction-radiation in diffusive grey and non-grey media.

References

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