A multi-field decomposed model order reduction approach for thermo-mechanically coupled gradient-extended damage simulations

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Abstract

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The analysis and prediction of damage onset and propagation within ductile materials under thermomechanical scenarios play an essential role in both research and industry. Many models in the literature concentrate solely on fracture and damage mechanisms while neglecting the influence of temperature. Therefore, simulations based on such models are often suitable only for some special cases that deviate far from true manufacturing conditions. On the other hand, multiphysics damage modeling considering temperature-dependent plastic flow is not only a challenging task, but also usually leads to computationally expensive simulations. This is mainly due to an increased number of degrees of freedom (in the case of nonlocal damage) and the coupling between the damage, plasticity, and temperature. Consequently, incorporating efficient model order reduction techniques into multiphysics models is an interesting and promising field of research, particularly for industries focusing on real-time simulations.

The first objective of this work is to develop a multi-field decomposed model order reduction approach (1) and combine it with the gradient-extended damage-plasticity formulation for finite strains by Brepols et al. (2) and to study its effect on reducing computational costs. In the second step, the multi-field decomposed model order reduction approach is integrated into the thermo-mechanically extended version of the aforementioned model (see Felder et al. (3)) to enable fast multiphysics damage-plasticity simulations. Finally, the new approach is investigated in several numerical benchmark tests to evaluate its advantages and disadvantages.

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References

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