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An Acceleration Scheme for the Phase Field Fatigue Fracture Simulation with a Concurrent Temporal Homogenization Method

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ABSTRACT

Fatigue refers to repeated cyclic loading well below the ultimate failure stress of the structure. It accounts for most mechanical failures, and thus deserves serious consideration in engineering practice. Phase field approach is a powerful tool for fracture simulation, which tracks arbitrary and complicated crack paths without extra criterion. This approach has been widely applied to various cracking problems, such as shell fracture, beam fracture , etc. The phase field approach for fracture has been adapted for fatigue fracture in recent years. Due to the mesh requirement of the phase field approach and the large amount of load steps of the fatigue problem, such simulations are time-consuming. Therefore, the acceleration for fatigue simulation with phase field approach is a developing research area.

In this work, we propose an efficient acceleration scheme for this approach based on a time-scale homogenization theory. In this scheme, the original fatigue fracture problem is decomposed into a macrochronological problem and a microchronological problem, and is accelerated with the time steps adaptively skipped. The properties, such as efficiency and accuracy, of this scheme are showcased. This scheme is able to successfully improve the efficiency of fatigue fracture simulations without sacrificing much accuracy, and can be up to 16 times faster than direct numerical simulations in some cases, which is demonstrated by numerical examples.

KEYWORDS

Fatigue fracture; phase field approach; time scale homogenization method; predictor-corrector

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