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The multi-field simulation system for hierarchical structure base on non-Fourier heat conduction

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ABSTRACT

Hierarchical structure composed of hard and soft materials, enabling it exhibits a remarkable combination of stiffness, strength and light weight performance. However, the complex external environment will directly affect the stability of the structure. Thermal impact is one of the main environmental conditions that the hierarchical structure might encounter. Until now, Fourier's law is widely used in theoretical and numerical models, which allows the thermal disturbance to spread at an infinite speed. However, the heat flux vector and the gradient of the temperature is not synchronized. In the extreme thermal conditions such as high temperature gradients or near-absolute zero temperature, such desynchronized performance becomes more obvious. To fix this problem, we build a non-Fourier theoretical model for the hierarchical structure and develop a user-defined subroutine based on non-Fourier heat conduction in ABAQUS. Finally, the temperature results of a cracked hierarchical structure obtained by the numerical model are compared with the results of theoretical analysis. In the lifetime of the hierarchical structure, combined physical conditions will inevitably happen simultaneously, such as thermal and mechanical loading. However, the crack performance of the hierarchical structure under extreme multiphysical field is still unknown. Therefore, after obtaining the reliable non-Fourier simulation model, a multi-field system is achieved in ABAQUS. The singular stress field and stress intensity factors are used to discuss the effect of multi-field conditions on the fracture performance of the hierarchical structure.

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