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PROCEEDINGS

Investigation of Multiaxial Creep Rupture Mechanisms and Life Prediction in High-Temperature Alloys Under Complex Environments

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ABSTRACT

Modern advanced equipment is often in high-temperature and high-load service environment for a long time, in which multiaxial creep rupture is one of the important failure modes of key components. For example, typical structures under multiaxial stresses state, such as aero-engine turbine blades film cooling holes and turbine disk groove connection structures, are usually prioritized for creep rupture failure in high-temperature, high-pressure and high-speed loading environments. At present, the coupling mechanism between temperature and stress fields in complex environments, as well as the rupture mechanisms and life characteristics of structures with multiaxial stresses in service are still unclear, and effective life prediction methods are even more lacking. In this study, the multiaxial creep behavior of high-temperature alloys in complex environments has been considered, and creep damage and life characteristics studies have been carried out for the film cooling hole structure and a variety of typical notched structures, based on conjugate heat transfer simulations, crystal plasticity finite-element method and experiments. The effect rules of flow parameters and aerodynamic parameters on macroscopic properties have been investigated, the thermal-force coupling mechanism of different multiaxial stress structures has been revealed, and the mechanism of temperature-stress fields interference on high-temperature alloy damage rupture under multiaxial stress state has been clarified. A neural network fusion of physical mechanisms for multiaxial creep life prediction has been established based on the optimization of traditional methods.

KEYWORDS

Multiaxial creep; high-temperature alloys; complex environments; life prediction; rupture mechanism

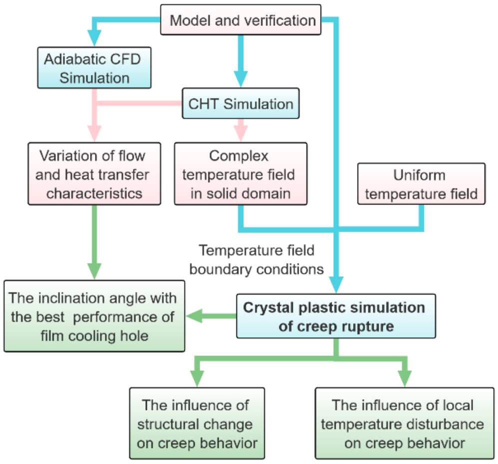

Fig. 1. The flowchart of the numerical simulation.

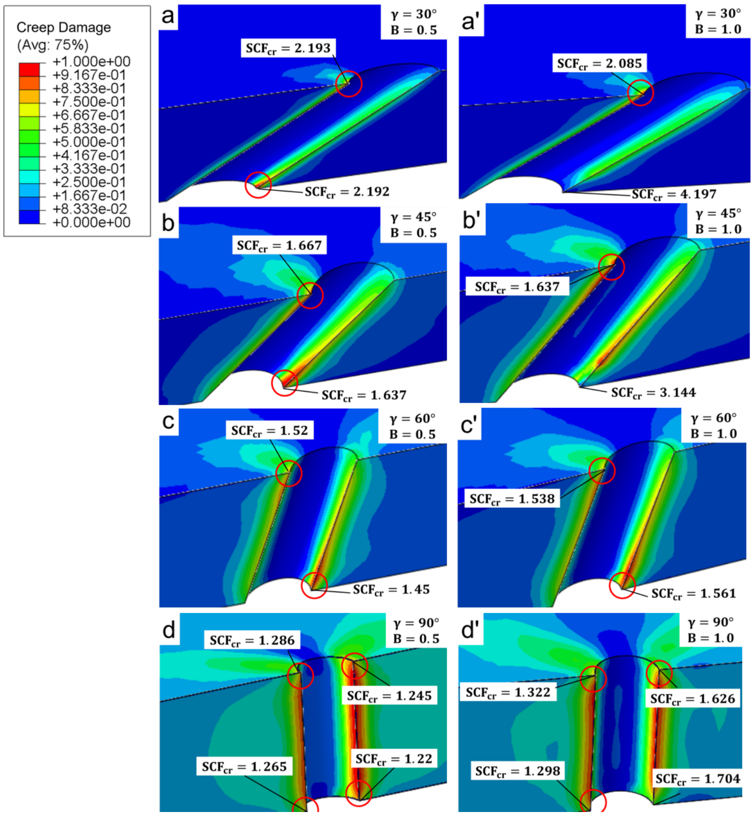

Fig. 2. Creep damage and the Max SCFcr distribution around the film cooling holes with different inclination angles in complex environments.

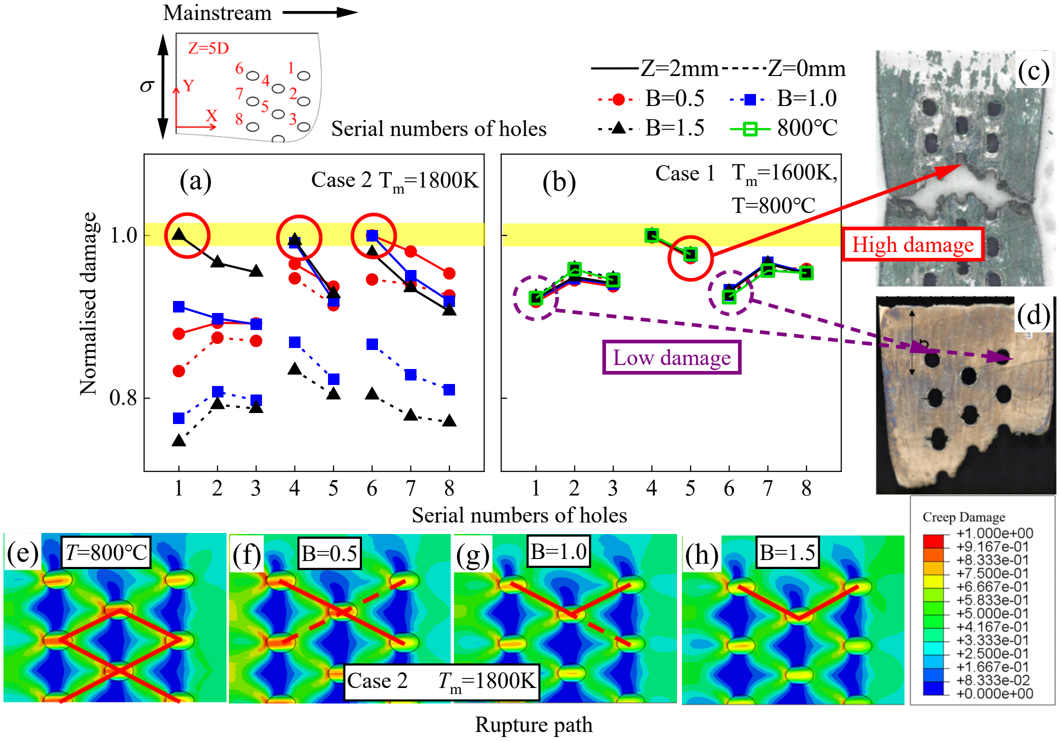

Fig. 3. Inter-hole interference of inclined film cooling holes in complex environments.

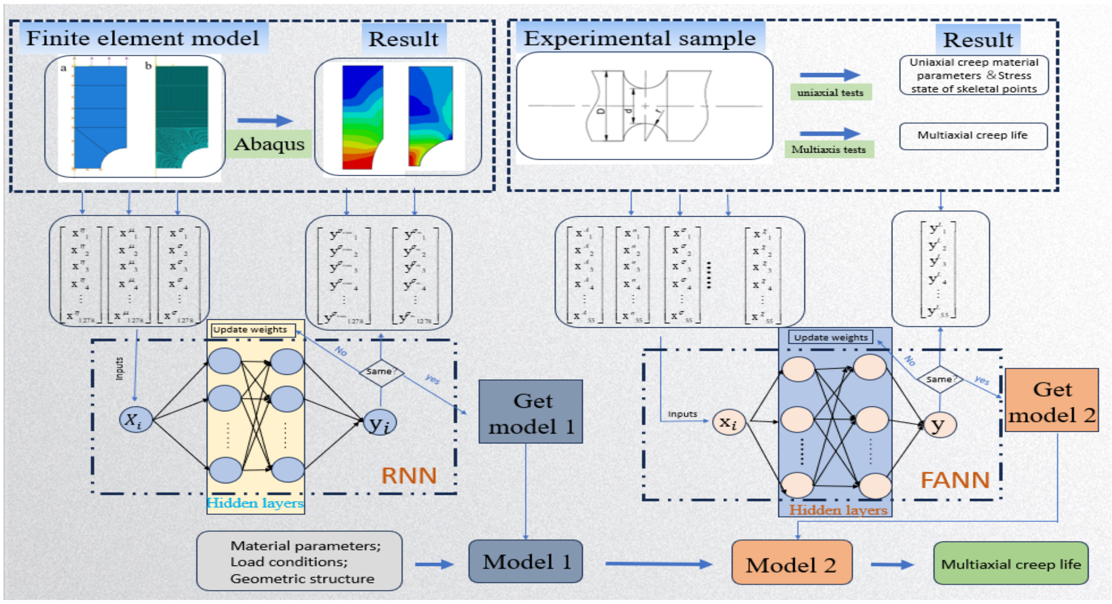

Fig. 4. The neural network fusion of physical mechanisms for multiaxial creep life prediction method.

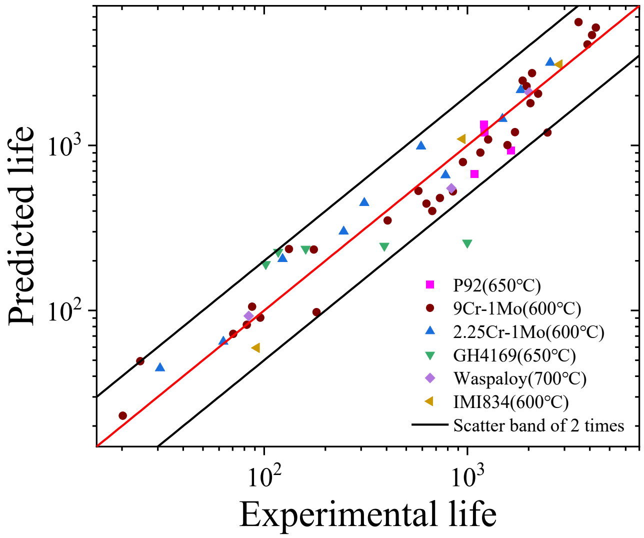

Fig. 5. Results of multiaxial creep life prediction.

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