ICCES, 2025, vol.34, no.1

Tech Science Press

DOI: 10.32604/icces.2025.010832

PROCEEDINGS

Three-Dimensional Failure Mechanics Theory and Digital Applications

Pengfei Cui*

Nanjing University of Aeronautics and Astronautics, Nanjing, 211106, China

*Corresponding Author: Pengfei Cui. Email: pfcui@nuaa.edu.cn

ABSTRACT

With the continuous advancement of aerospace equipment, in addition to performance, function, and reliability requirements, durability is playing an increasingly crucial role. For instance, the objective of China's new - generation space transportation system is to achieve a reliability of 0.9999 or higher for manned flights, and a single rocket is expected to be capable of up to 100 flights. In high - temperature load - bearing structures, nickel - based alloys are extensively used because of their outstanding strength, fatigue resistance, and creep properties. In advanced aerospace engines, their mass fraction can reach as high as 50%. Thus, ensuring the safety and reliability of nickel - based high - temperature structures during long - term service is of vital importance for enhancing the reusability of aerospace equipment. To achieve this goal, the ability to accurately design the lifespan of nickel - based high - temperature structures is essential.

Nevertheless, the existing design method based on two - dimensional fracture theory cannot be precisely applied to the lifespan design of actual three - dimensional structures. Moreover, the vast amount of measurement and control operation data has not been fully exploited. In this study, we establish a series of creep, fatigue, and fracture design methods from the perspective of three - dimensional failure mechanics. By leveraging digital technology, these methods can further enhance the structural efficiency and reliability.

Funding Statement: This work was supported by the National Natural Science Foundation of China (12502088), and the Fundamental Research Funds for the Central Universities (NS2025044).

Conflicts of Interest: The author(s) declare(s) no conflicts of interest to report regarding the present study.