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Failure risk control for aeroengine turbine disks based on active thermal management

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Abstract

Turbine system cooling is essentially a process of thermal management. Active thermal management based on thermal load redistribution has been proposed to overcome the limits of passive thermal management based on thermal protection. This research uses this proposition to study the effect of active thermal management on the failure risk of disks and explores possible means for risk control. Active thermal management is conducted by imposing additional heating energy on the disk hub, which is represented by the coefficient of additional heat flow $\eta$. Results show that the disk hub is the most risky part of the disk and that the failure risk of the disk can be effectively controlled by actively adjusting the thermal load distribution. The probability of disk failure declines by 76.1% under the active thermal management load ($\eta = 0.1$) compared with the passive condition ($\eta = 0$). The reason may be that as the temperature distribution of the disk turns into an artificial V-shape, the resulting thermal stresses induced by the negative temperature gradients counteract parts of the stress from rotating, and the failure risk decreases because of the reduced stress.

Keywords

Aeroengine turbine disks; Active thermal management; Failure risk control

1 Introduction

Turbine disks are crucial parts of aeroengines. Turbine disk fractures can directly induce the non-containment of high-energy debris, resulting in catastrophic events such as the destruction of aircrafts and human fatalities [1,2]. Therefore, studying and predicting the failure risk of turbine disks and exploring possible means of risk control are essential to aeroengine safety.

Considerable literature on disk safety exists, and various analysis methods to assess the failure risk of disks are available, such as the finite element (FE) probabilistic analysis of turbine disk life and reliability [3], and the design assessment of reliability with inspection [4-6]. The sensitivity of the failure risk with respect to various geometries, materials [7,8], and flow parameters of rotating cavity [9] is
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