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Analysis of failure behaviors of dovetail assemblies due to high gradient stress under contact loading

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ABSTRACT

Two key questions of fretting fatigue of dovetail assemblies should be still investigated to meet the engineering requirement. One is describing the high gradient stress at the edges of contact in blade/disc assembly exactly, especially introducing the plasticity. The other is finding the suitable parameters to correlate the fretting failure under contact loading. Finite element (FE) models of one dovetail assembly with different mesh sizes are used to calculate the plastic contact stresses near the edges of the contact zone, and then a failure model is established to predict the initiation of a crack.

1. Introduction

Dovetails are usually applied in fan or compressor blade/disc assembly, and fretting failure becomes more and more noteworthy under long-time service. Many studies focusing on fretting behavior of engineering materials, which mostly tended to Ti-alloy (Ti–6Al–4V [1]), also including single crystal (PWA1422 [2]), high-strength steel (AISI 52100 [3], Ni–Cr–Mo–V [4]), and Al-alloy (2024-T351 [5], 7075 [6]). In experiment, the conventional fretting fixtures [7] have changed into dovetail attachment [8].

Firstly, calculation of the contact stress is the basis of a fretting analysis, and solving difficulties arise from nonlinearities, such as geometry, material, and boundary conditions. It is difficult to explore the effect of these coupling factors simultaneously, so plasticity is chosen as the emphases. Comparing with previous results [9], studies [10,11] revealed that there occurs a high gradient stress near the edges of the contact zone of the dovetail attachment by means of FE method, but the constitutive model is still linear elastic. Secondly, failure analysis method of dovetail is still far from perfection. Though some crack initiation parameters are used widely in engineering analysis of fretting fatigue, such as strain based, critical plane based, even parameters of fracture mechanics, new appropriate parameters correlating with structural characteristic should be established. So based on the elastic–plastic stress of the dovetail attachment, a fracture model for high gradient stress of dovetail is established based on fracture mechanics, which can be used to judge the direction of crack initiation and propagation, further to use in the predication of propagation.

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