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Investigations on fretting fatigue in aircraft engine compressor blade

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ABSTRACT

An investigation of several cracked blade tangs in the military aircraft engine compressor was conducted to identify the root cause of the failure. These cracks were found during the scheduled maintenance with fluorescent penetration inspection. The engine compressor blade made of Ti–6Al–4V is attached to compressor rotor by means of inserting retaining pin through rotor and blade tang. By analyzing the fracture surface of the failed blade tang, it is found that the crack in the blade tang was initiated by fretting fatigue and propagated under low cycle fatigue. Stress analysis of the blade using a non-linear finite element method is coincident with the results of fractography. The clearance between retaining pin and tang hole caused small amplitude of sliding motion leading to fretting wear during engine operation. Consequently, the damaged area due to fretting wear acts as a stress raiser inside tang hole and contributes to accelerate fretting fatigue.

1. Introduction

Compressor blade failures in gas turbine engine may have serious consequences for the safety of the engine. Comprehensive investigation on the root cause of the failure is essential for users to prevent similar problems leading to engine malfunction. Generally blade failures can be caused by a lot of mechanisms under high rotational speed and vibration at elevated temperature. In this study, the fracture of Ti–6Al–4V blades was investigated by both experimental observations and finite element analysis. The first stage compressor blades of J85 engine are attached to the rotating disk by means of inserting retainer pins through tang type root of the blades. The interface damages occurred among tangs, a retaining pin, and a rotating disk may have a detrimental effect on the durability of the compressor rotor assembly. Especially fretting is one of the common failure mechanisms of blade-disk assemblies. In a majority of failure analysis of blade-disk assemblies, surface damages on the contacting areas were analyzed by making use of experimental methods [1–4] and contact conditions were evaluated by analytical and numerical approaches [5–8]. Especially, the fretting damage of the dovetail joint in blade-disk assemblies has been thoroughly investigated to reveal the root cause of failure while there have been few studies on the failure of the tang type blade-disk attachment. This study is mainly focused on identifying the root causes of the cracked tangs found during the periodic non-destructive inspection (NDI) in-service. Several factors leading to blade failure were revealed by visual inspection, quantitative fractography, and finite element analysis.

2. Analysis

2.1. Macroscopic examination of failed blades

After emergency landing due to engine malfunction during in-flight, the removed engine was inspected by investigators. As shown in Fig. 1a, a blade and a retainer pin in the first stage compressor assembly were missed. Consequently, other

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