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# Crack propagation analysis of mechanically damaged compressor blades subjected to high cycle fatigue

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ABSTRACT

This paper presents results of experimental crack propagation analysis of damaged compressor blades of the helicopter engine, subjected to high cycle fatigue. The blades used in investigations were preliminary defected to simulate the foreign object damage. The blades during experiment were entered into transverse vibration. The crack propagation process was conducted in resonance condition. During fatigue investigations the crack length and amplitude of the blade tip displacement were monitored. The fatigue beach marks were not well visible on the fracture. For better determine of crack front shape in the early stage of fatigue fracture, a few blades were vibrated only to the first crack detection. Next the blades were statically tensioned and ruptured with use the testing machine. During performing of an experiment, different schemes of fatigue fracture of the blades were observed. The main result of presented investigation is the crack growth plot obtained for the blade including defects similar to foreign object damage. The attention of this work is also devoted to methodical side of experimental crack propagation analysis of the blade subjected to high cycle fatigue.



## 1. Introduction

The ingestion of foreign objects into aircraft jet engines can lead to severe structural damage of the fan or compressor airfoils. The high airflow required to operate such engines creates a powerful suction effect which tends to draw in small objects from area around the aircraft. Damage of the compressor blades of engine is normally caused when a particle is hit by the rotating blade. There is high relative velocity due to the motion of the blade and acceleration of the particle causes high forces and local damage to the blade. Often this damage is located along the leading (attack) edge of the compressor blade (Fig. 1a) and takes the form of a dent or notch (Fig. 1b and c). Foreign object damage (FOD) is a prime reason for maintenance and reparation of military jet engines which operate on landing grounds. The damage induced by small hard objects of millimeter size in conjunction with the typical load spectra experienced by airfoils can lead to non-conservative life prediction and unexpected fatigue failures. Typical loading spectra of an aero-engine consist of low cycle fatigue (LCF) cycling, due to start, flight and landing cycles (i.e. pulsation of centrifugal forces during compressor rotation), with superimposed high cycle fatigue (HCF) cycles due to vibrations, resonant loading, etc. in the airfoils. The LCF could be easily modeled because the profile of the engine speed rotation is simple to measure. The estimation of the blade deformation resulting from vibration is much more complicated. Thus it is difficult to determine which type of fatigue (LCF or HCF) has more impact on the fatigue life of the compressor blade.

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