Probabilistic integrity assessment of turbine disks in presence of potential defects

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Abstract. Rotor disks for gas turbines are heavy components and are usually designed following a safe-life approach, where the low-cycle fatigue analysis is carried out referring to design life curves with suitable probabilistic margins. However, in the case of such a heavy component there is the possibility of rare occurrence of undetected defects or, better, the need to identify the defect acceptability for the different rotor regions (considering stress, temperature, mission profile). In order to carry out such calculations for a turbine rotor disk a software named {AStrID} (Assessment of the **Str**uctural **I**ntegrity of **D**isks) has been developed in close cooperation between Politecnico di Milano and Ansaldo Energia (AEN). This paper summarizes its background and some of the relevant features.

1. Introduction

Accidents involving rotating equipment such as steam and gas turbines can result also in damage of other components in plants and loss of human lives. In order to minimize accidents it is very important to understand and prevent failures. The type of failure giving the highest contribution to the number of losses is represented by the burst of disks due to accidental overspeeds [1]. There are several approaches and methodologies in the literature which allow to carry out a probabilistic structural integrity assessment specifically for rotating components [2, 3].

The software *AStrID* has been developed with the goal to have a reliable tool for the thorough and automatic assessment of turbine disks, consider the prospective occurrence of an overspeed at the end of the prospective service life N_{life} of the order of 3000–5000 cycles. Among the features of the software, the three most important capabilities are the following: i) residual lifetime after a prospective defect with size a_o has been detected; ii) calculation of the maximum permissible defect a_p given a target residual life N_{life}. The CDF (Crack Driving Force) approach has been implemented in the software for calculating failure probability at overspeed, according to SINTAP/FITNET [4]. CDF is typically expressed in terms of a plastic-corrected stress intensity factor K_J, and failure occurs in the critical

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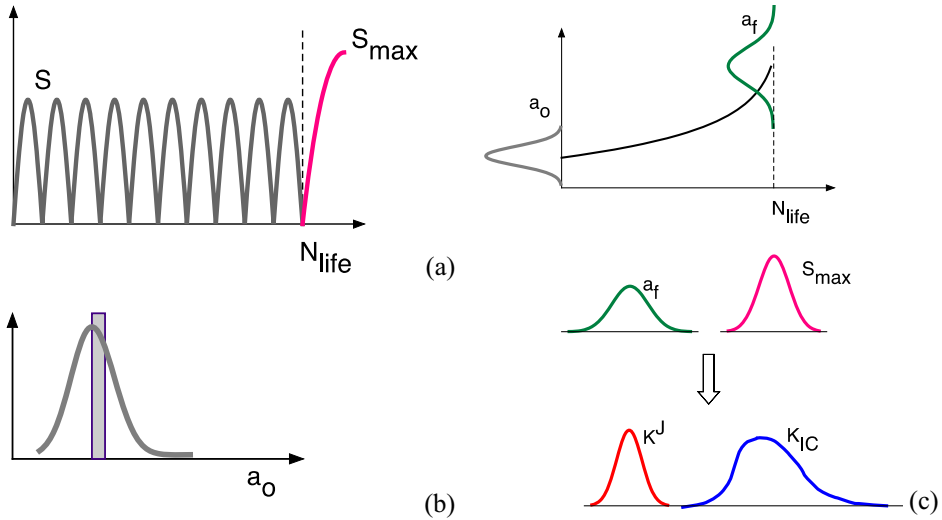a Corresponding author: stefano.beretta@polimi.it

Figure 1. Scheme of the calculations: a) service of a turbine and assessment against a prospective overspeed; b) sizing error related to a prospective NDT; c) scheme of calculation of failure probability.
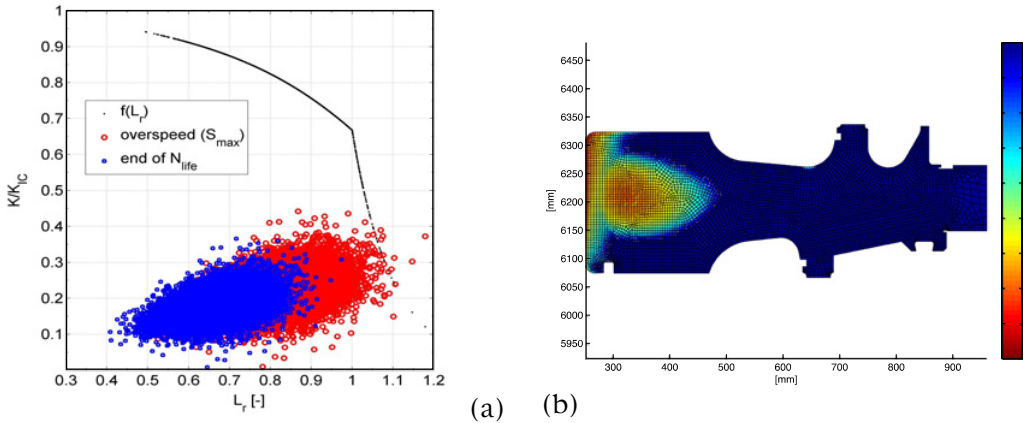

Figure 2. Probabilistic calculations in *ASTRID*: a) Montecarlo simulation according to Fig. 1.c; b) map of the permissible defect in a disk for obtaining a failure probability of 5×10^{-5} considering N_{life} turbine start-ups.

condition for the component when:

$$K^J \geq K_{mat}(T). \tag{1}$$

2. Probabilistic assessment

The probabilistic asseesment onto a FAD diagram is shown in Fig. 2. The nature of the software *AStrID* is semi-probabilistic in the sense that the structural integrity assessment is carried out with deterministic values adopting *Partial Safety Factors–PSF–* which have been tuned with Montecarlo simulations in order to achieve a target failure probability of 5×10^{-5} at the end of the prospective life.

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