IMPROVING NDE THROUGH MULTIPLE INSPECTIONS

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INTRODUCTION

Current nondestructive evaluation techniques generally do not produce identical indications when applied to flaws of the same length. The chance of detecting a given crack length depends on many factors, such as the location, orientation and shape of the flaw, materials, inspectors, inspection environments, etc. As a result, the probability of detection (POD) for all cracks of a given length has been used in the literature to define the capability of a particular NDE system in a given environment. Some POD curves are shown in Fig. 1 for various laboratory inspection techniques. Many other POD curves can be found, for instance, in Refs. 1-3.

In practical applications, a nondestructive inspection limit, \(a_{NDE}\), is chosen, which is a crack length that usually corresponds to a high detection probability and a high confidence level. For instance, the damage tolerant specification [4, 5] requires that \(a_{NDE}\) should be the crack length associated with a 90% detection probability and 95% confidence level. The fracture mechanics residual

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life, \( N_f \), is the life for the crack length \( a_{\text{NDE}} \) to propagate to the critical crack length \( a_c \) under expected usage environments as shown in Fig. 2(a). The return to service interval, denoted by \( N_R \) is equal to \( N_f \) divided by a safety factor \( S_f \), i.e., \( N_R = N_f / S_f \). If no crack is detected during inspection, the component is returned to service and the crack length in that component is reset to be equal to \( a_{\text{NDE}} \) as shown in Fig. 2(b). Hence the inspection limit \( a_{\text{NDE}} \) is also referred to as the reset crack length. In the damage tolerant analysis, a safety factor of 2.0 has been used.

It follows from Fig. 1 that the NDE reliability consists of two types of wrong indications; (i) failure to give a positive indication in the presence of a crack whose length is greater than \( a_{\text{NDE}} \), referred to as Type I error, and (ii) given a positive indication when the crack length is smaller than \( a_{\text{NDE}} \), referred to as Type II error. For safety critical components in airframe structures, Type I error is of primary concern. In the Retirement-For-Cause (RFC) analysis of gas turbine engine components, however, both Type I and Type II errors are important, because the criterion used in RFC analyses is the minimization of the life cycle cost (LCC) for engine components [e.g., 6-7]. As a result, the reduction for both types of error is one of the main objectives of the present study.

The Type I error allows the components containing a crack length longer than \( a_{\text{NDE}} \) to return to service, thus greatly increasing the potential safety hazard. For a given NDE system the Type I error can be made as small as possible by choosing a large value for the inspection limit \( a_{\text{NDE}} \). However, as the value of \( a_{\text{NDE}} \) increases the return to service interval \( N_R \) reduces thus increasing the frequency

![Fig. 1. POD curves for various NDE systems.](image-url)