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The winding road from QNDE to SHM and beyond

Jan D. Achenbach[1]

Summary

A significant limitation of NDE became apparent in the sixties with the advent of fracture mechanics as a major consideration for the determination of structural safety. Fracture mechanics requires quantitative information that has to be obtained from non-destructive testing procedures. The 1970's mark the start of research and development to achieve quantitative capability, and adding the Q to NDE. Since that time significant advances have been made of the methods of quantitative non-destructive evaluation that are the basis of the diagnostics part of structural health management, including sensor development, new techniques such as laser-based ultrasonics, acoustic and x-ray imaging, thermal wave methods, and significant improvements in ultrasonic, electromagnetic and eddy current techniques. Very important contributions to the diagnostics area were also made by the development of measurement models and methods for the probability of detection, which facilitated improved data processing for defect characterization.

The results of diagnostics techniques provide the input to prognostics. Material-science-level modeling of constitutive properties, supported by experimental results, provides damage growth laws, which in turn provide information on damage evolution and remaining life. Depending on its magnitude, the resulting statement of failure probability may either result in a recommendation for repair or replacement of a structural component, or for an additional cycle in the diagnostics/prognostics loop of the structural health management system.

In this presentation, we will devote particular attention to the probabilistic aspects of diagnostics and prognostics. For the case of cyclic loading, we will discuss the probability of crack growth and crack detection, taking into account the probability of detection. We will also consider probabilistic aspects of optimization of the inspection schedule.

Experimental ingenuity, improved hardware, analytical simulation techniques, use of statistical methods and improved signal processing techniques have produced significant progress in QNDE. On the other hand, SHM has not yet broken through in a big way. Among the impediments, SHM systems are not yet affordably maintainable, with near-zero false alarm rates. Huge benefits can, however, be achieved if SHM can justify reduced design margins, longer life spans and reduced service interruptions of structural systems.

[1]Center for Quality Engineering and Failure Prevention, Northwestern University, Evanston, IL 60208, USA