Nondestructive Evaluation Technology and Reliability of Products

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(Abstract)

It is well known that the reliability of materials of mechanical products is becoming more and more important not only for assurance of quality, but for international competition of products. In order to assure the reliability of materials or mechanical products nondestructive evaluation (NDE) techniques are playing more important roles. The existence of internal defects in materials or mechanical parts is served as crack initiation site during the various loading condition. Historically, nondestructive evaluation (NDE) technique has been used almost exclusively for detecting microscopic discontinuities in materials or mechanical parts after they have been in service to expand the role of the NDE to include all aspects of materials production and application. Research efforts are being directed at developing and perfecting NDE techniques capable of monitoring (1) materials production processes (2) material integrity following transport, storage and fabrication and (3) the amount and rate of degradation during service. In addition, efforts are underway to develop technique capable of quantitative discontinuity sizing, permitting determination of response using fracture mechanics analysis, as well as techniques for quantitative materials characterization to replace the qualitative techniques used in the past.
In this paper, the important role of NDE technology for reliability assurance of materials/mechanical parts is introduced.

How is NDE technology related to structural performance and reliability assurance?

As interdisciplinary approach to integrity and reliability assurance of materials or mechanical parts, some core technologies including NDE technology, flaw sensitivity analysis, fracture mechanics, and structural mechanics are absolutely needed as shown in Fig. 1. In order to predict residual life of materials/mechanical parts, some flaws initiated in materials/mechanical parts during in-service time should be first evaluated by appropriate NDE technique. Based on this inspected result, flaw sensitivity analysis is perfumed along with the concept of fracture mechanics.

The important elements of full spectrum of NDE for reliability assurance is also illustrated in Fig. 2. In this Fig. 2, NDE can provide material characterization, process sensing and in-service characterization. For the successful accomplishment of NDE tool for these purposes, sensor development, signal acquisition and analysis and handoff for processing decisions etc., are also needed.

Improved Methodology for Predicting POD of Detecting Flaws in Materials/Mechanical Parts

In this presentation, the concept of Probability of Detection(POD) which is one of the physical/statistical models to estimate NDE capability will be also introduced. Physical models based on the theory of ultrasonic wave scattering provide predictions for typical measurements from the flaw signal distributions. A statistical model is used to quantify deviations between the physical model predictions and actual NDE measurements. This model for the deviations provides a framework for statistical estimation of POD.

Based on the concept of POD, elements of the cost/reliability estimation process for in-service inspection of materials/mechanical parts are shown in Fig. 3. Probability distribution of pre-inspection crack size, Probability of detection versus flaw size are used to determine post-inspection distribution which is directly input for decision of failure probability with the aid of stress history and crack growth characteristics. The figures of merit for this procedure are cost-saving, reliability assurance and inspectability.

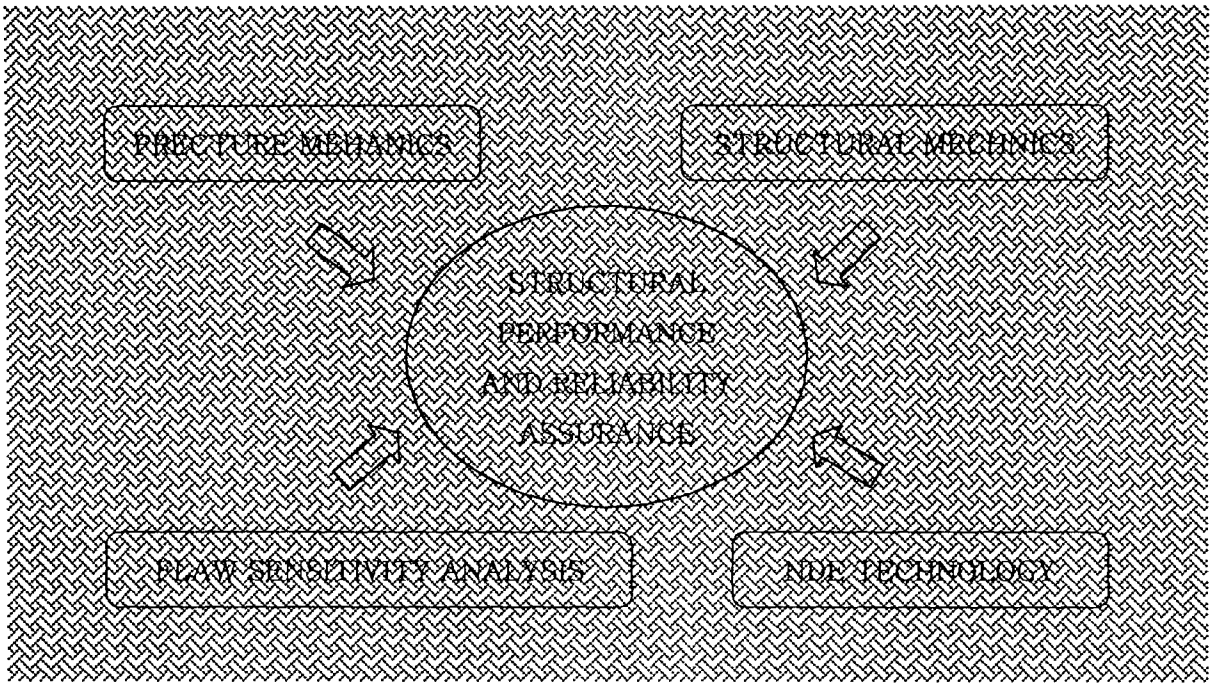

Fig. 1 As interdisciplinary approach to integrity and reliability of mechanical parts

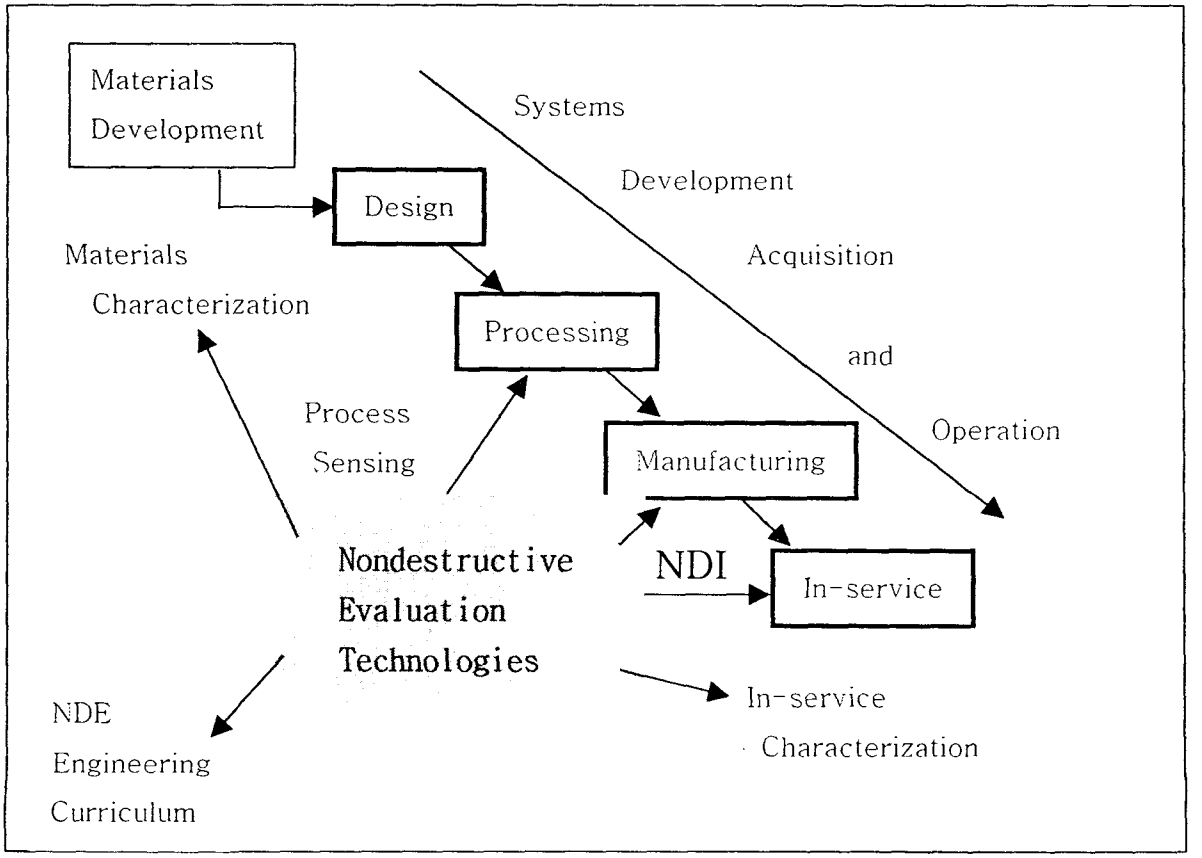

Fig. 2 Full spectrum NDE.

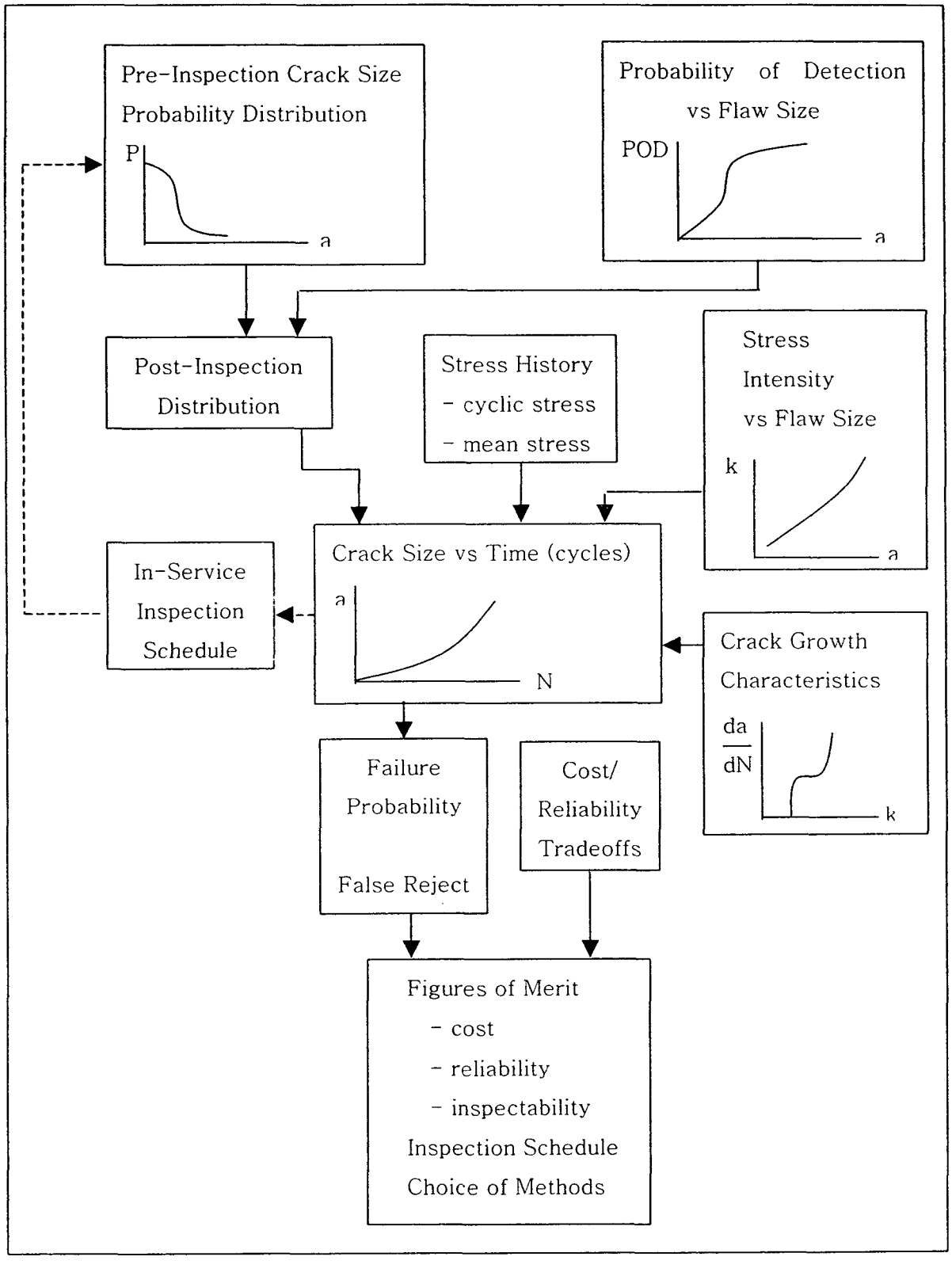

Fig. 3 ELEMENTS OF THE COST/RELIABILITY ESTIMATION PROCESS FOR IN-SERVICE INSPECTION