

Module 2

Lecture 4: Non-Destructive Evaluation - II

Based on the incidence of the transducer, with respect to the surface, waves may be created.

- It may be P waves, S waves and their combination
- These waves detect anomalies around the sound path, they travel

In pulse-echo method, defects are detected in the form of echos.

In pitch-catch method, flaws are detected by wave dispersion and attenuation due to damage.

Pitch-catch method

- Suitable for embedded Non-deceptive Evaluation.
- This method can be used to detect the structural changes that take place b/w the Transducers
 - one transducer will be placed as a receiver
 - another transducer will be working as a Transmitter
- Pitch-catch method can detect changes that are created by guided wave amplitude phase difference and wave dispersion.

Applications of Embedded NDE with Pith-Catch method

- Corrosion detection in metallic structures
- damage detection in composite materials
- detection of delamination in adhesive joints
- detection of delamination in layered composites.

In the Embedded method of NDE, transducers are permanently inserted

- either between the layers of the composites
- on the structure (attached to the structure, permanently)

Advantages of crack detection in metallic structures :-

cracks, in metallic structures generally form/propagate perpendicular

to the surface

- It covers the whole thickness

- In such case, crack is through-thickness crack

- consequence of such crack is that it can tear the metallic structure

In conventional NDE, cracks in metallic structures are generally detected with ultrasonic or eddy-current probes

- one of the limitations of this method is they can detect cracks/flaws only @ particular points.

- If we need to examine crack presence of the whole surface, we should have to manually scan over the complete surface to detect cracks

- This is very tedious exercise
- possibility of overlooking a few crack locations

This problem can be corrected by pitch-catch method

Guided waves are transmitted from one location and received in another location

Thus, the whole member/material is analysed for

That will help to detect presence of cracks

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- (i) Guided-wave steps & its amplitude
- (ii) peak-log created b/w the end signals
- (iii) change in amplitude

without manually scanning the complete surface

pitch-catch method can detect presence of cracks and also their extension, without scanning (manually) the whole surface

- Probability of crack detection by pitch-catch method is higher than other methods. This is given by the following relationship:

$$P(\text{crack detection}) = \frac{\sum \text{cracks recorded by pitch-catch method}}{(M - N) + 1}$$

where M = # of crack events recorded by NDE method
 N = # of general events.

Pitch-catch method is also effective in detecting fatigue crack propagation

Additional reading can be seen:

Nick Gungl, Adrian Cuc. 2005.

Embedded Non-destructive Evaluation for Structural Health Monitoring, damage detection and failure prevention, Shock & Vib digest, 31(2): 83-105.

Crack detection in composites

- Composites generally resist the loads by the layered structure
- In case of formation of through-thickness cracks, load propagation is impeded by the presence of reinforcement fibres.
- Hence, cracks grow ill to the surface
 - @ the interface between the layers
- They are generally initiated by
 - i) fabrication imperfections
 - ii) unable to resist fatigue loads

In the conventional NDT, ultrasonic probes are used to generate the additional echoes to capture the surface if crack

- P waves will be reflected by delamination of layers
- This will be an indication of crack development, if to the surface, which causes delamination in composites.

Pulse-echo method can also be used for crack detection in composites

In such case, an appropriate guided wave (Lamb wave) must be chosen to detect the crack

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It is seen that

- Lamb waves show better reflection from the through-thickness cracks
- They should be less dispersive

Advantages

- (1) better reflection ensures a strong signal for crack detection
- (2) less dispersion ensures compactness and convenience to interpret

wide application of pipe-cable method as seen is

{ Pipe line
short conduits (tunnels)
cables etc

NDE - Embedded phase arrays

- In this technique, real-time phased array systems are used
- Transducers to inspect very thick specimens
 - Reinforced concrete slabs, deck & bridge
 - with β -waves

NDE - Time-reversed method

- Signal sent by a transmitter arrives at the receiver, while it gets modified in the medium through which it travels
- If the received signal is reversed and sent back from the receiver to the transmitter, then after it the medium through which the signal travels is also reversed
- This technique is called Time-reversed method

This is very useful when dispersive Lamb waves are employed for damage detection

- one of exclusion application of this method is usefulness is ultrasonic imaging of difficult media
- By comparing the discrepancies b/w the original input signal and the reconstructed signal, damage can be detected

Summary

NDE methods

- pipe-girth method
 - advantages
 - application procedure
- embedded phase arrays
 - thick specimens
- method to crack detection in composites (delamination)
- Time-reversed method - complex medium