

## 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 wave, S waves and their combinations
- 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-destructive Evaluation.
- This method can be used to detect the structural changes that take place by 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 using pitch-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
- or the shims (attached to the shims, permanently)

## Advantages of crack detection in metallic structures :-

cracks, in metallic structures generally form/ propagate perpendicular

to the surface

- It cover 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 the method is they can detect crack / flaws at particular points.
  - If we need to examine crack presence to the whole surface, we should have to manually scan over the complete surface to detect cracks
    - This is very tedious exercise
    - possibly if overnight a few crack forming
- 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 analyzed for

that will help to detect presence of crack

Guided-wave shape & its amplitude change creates by the end points

change in amplitude

vibration manually scanning the complete surface

Pitch-Catch method can detect presence of cracks and also their extension, without scanning (manually) the whole surfaces.

- Probability of crack detection by Pitch-Catch method is higher than other methods. They is given by the following relationship:

$$P(\text{Crack detection}) = \frac{\sum \text{Crack recorded by Pitch-Catch method}}{(M - N) + 1}$$

Where  $M$  # of crack events recorded by NDE method

$N$  # of serial events.

Pitch-Catch method is also effective in detecting fatigue crack propagation.

Additional reading can be seen:

Nicușor Giurgiuțiu, Adrian Cuc. 2005.

fonkreddet Non-destructive Evaluation for structural health

monitoring, damage detection and failure prevention,

Shock & vib digest - 37(2) : 83 - 105 .

## Crack detection in Composites

- Composites generally resist the loads by the layered structure
- In case of formation of through-thickness cracks, their propagation is resisted by the presence of reinforcement fibres.
- Hence, cracks grow till to the surface
- ↗ in interface between the layers
- They are generally initiated by
  - i) fabrication imperfections
  - ii) unable to resist failure loads

In the conventional NDE, ultrasonic probes are used to sense the additional echoes to capture the surface of the crack

- P wave will be reflected by delamination of layers
- This will be an indicator of crack development, in the surface, which causes delamination in composite.

Pulse-echo method can also be used for crack detection

in composite

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

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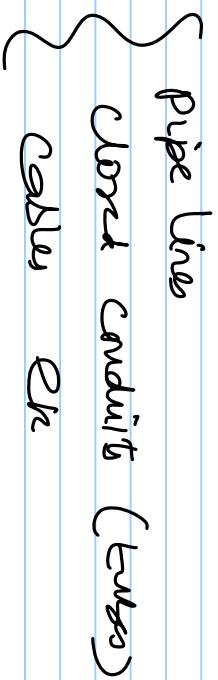
It is seen that

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

### Advantages

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

Wide application of pitch-catch method as seen is



## NDE - Embedded Phased Arrays

In this technique, real-time phased array systems are used

- Transducers to inspect very thick specimens
- Reinforced concrete slabs by decks a bridge
- uses P-waves

## NDE - Time-reversed method

- Signal sent by a transmitter arrive 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 effect of 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 exclusive application of this method 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

- Pitch-Catch method
- advantages
- application procedure
- Embedded fiber arrays
- thick specimens
- methods to crack detection in composite (delamination)
- Time-reversal method - complex medium