

**Structural Health Monitoring (SHM)**  
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**Lecture – 06**  
**Components of Structural Health Monitoring - Part 2**

74. Let us see what are the common tools, which can be used for removing the anomalies in aircraft design or a vision industry based upon health monitoring.

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Tools of SHM (for aviation industry)

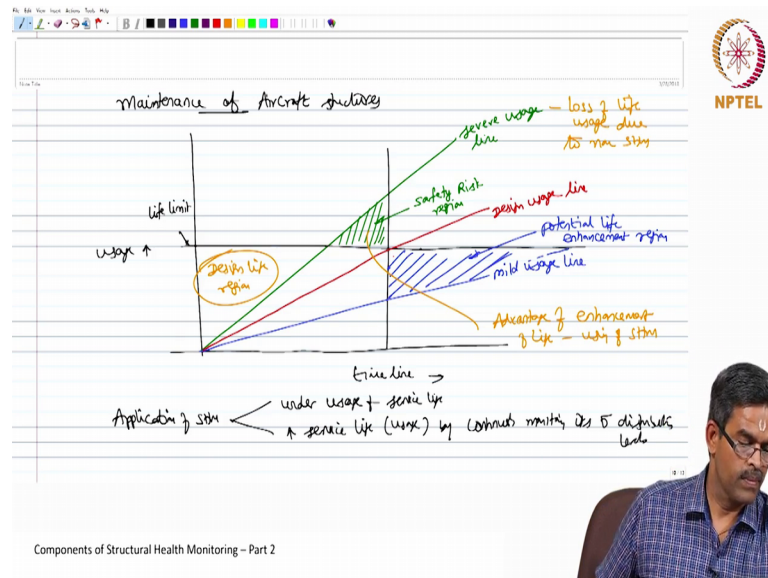
- (1) fuzzy pattern recognition
- (2) neural networks
- (3) diffused ultrasonic waves technique to detect the structural damage present in the unmeasured temporary members
- (4) vibration-based technique
- (5) intelligent parameter varying technique for location of damage
- (6) use novel sensor layout in SHM.

NPTEL

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One can use fuzzy pattern recognition, one can also use neural networks, one can use diffused ultrasonic waves technique to detect the structural damage present in the unmeasured temporary members. One can also use vibration-based technique for SHM of aviation. One can use intelligent parameter varying technique for location of damage. One can use a novel sensor layout in SHM.

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Interestingly friends, if you look at the maintenance of aircraft structures, one can see then the use of health monitoring playing a very major role in successful maintenance of them. Look at this curve which discusses parameters which are contributing to the maintenance of aircrafts. Let us say the time line is on the x axis and usage in on the y axis.

Let us say there is a severe usage pattern compared with design usage pattern, which is further compared with mild usage pattern. Somewhere down the line if you look at the time scale and if you look at the life limit, then this portion clearly shows safety risk region. This line should pass through then this region clearly shows potential life enhancement region. This area shows the design life region.

So, this curve shows that severe usage represents loss of life usage due to non SH, which represents this area whereas, the green region clearly shows the advantage of enhancement of life due to usage of SHM. So, application of SHM can help in checking the under usage of service life of an aircraft, and it can enhance the service life or usage value of an aircraft by continuously monitoring it is stress distribution levels. In this context people also recommend passive SHM and active SHM.

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passive shm: means that . observing a structure as it evolves

- a physical parameter and its state evolve as a result of interaction with the environment

ex: Acoustic Emission (AE),

Active shm - structure is equipped both with sensors & actuators

- structures which are unmanned (petroleum production platform - unmanned)
- actuators prompt forces, opposite to the structural motion and impart a recentering capability of the platform under environmental loads
- SMART STRUCTURES

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Let us quickly see what is a passive SHM; it means that observing a structure as it evolves. Basically, a physical parameter and its state of evolution as a result of interacting with the environment, tools used could be acoustic emission. Active SHM deals with a system where the structure is equipped both with sensors and actuators. This is very highly suitable for structures which are unmanned.

There are many petroleum production platforms in offshore gulf which are unmanned. In such cases, the actuators provide forces opposite to the structural motion and impart a recentering capability of the platform or the system under environmental loads. What we call other ways as smart structures. There are many examples of aircrafts which are embedded with structural health monitoring systems.

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The image shows a whiteboard with handwritten notes in green and red ink. The notes are organized into sections: 'Example' and 'Location'. The 'Example' section lists 'Boeing 787 Dreamliner' and notes it is 'equipped with embedded sensors for continuous health monitoring'. The 'Location' section lists 'shell fuselage', 'lower wing skin', and 'door shuttles'. A red note states 'probability of damage is relatively high during loading'. The NPTEL logo is visible in the top right corner, and a man's head is visible in the bottom right corner. The text 'Components of Structural Health Monitoring - Part 2' is at the bottom.

Example  
Boeing 787 Dreamliner  
- equipped with embedded sensors for continuous health monitoring

Location  
- shell fuselage  
- lower wing skin  
- door shuttles

probability of damage is relatively high during loading

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One of the famous example is a very common practice in aircraft industry is that Boeing 787. Dreamliner is an aircraft which is equipped with embedded sensors for continuous health monitoring. Location of the sensors are very important, generally they are located in shell fuselage, lower wing skin and door shuttles. These are the common locations where these sensors are kept; because these are the places where the probability of damage is relatively high during loading.

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The image shows a whiteboard with handwritten notes in green and black ink. The notes describe 'Common types of sensors - used in SHM'. The first type listed is 'Fibre Bragg Diffraction Grating sensors'. It notes they are 'embedded in structures', 'laser marked with optical-interference parameter', and 'any local strain caused by the deformation results in sensor measurement'. A final note states 'will transmit wavelengths' with a bracket indicating 'This can be detected'. The NPTEL logo is visible in the top right corner, and a man's head is visible in the bottom right corner. The text 'Components of Structural Health Monitoring - Part 2' is at the bottom.

Common types of sensors - used in SHM

(1) Fibre Bragg Diffraction Grating sensors  
- embedded in structures  
- they are laser marked with optical-interference parameter  
- any local strain caused by the deformation  
- results in sensor measurement  
- will transmit wavelengths

This can be detected

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Let us now look into common types of sensors, which are used in health monitoring. The foremost in the list is Fibre Bragg diffraction grating sensors. They are actually embedded in structures; they are laser marked with optical interference parameter. They measure any local strain caused by the deformation, which results in sensor measurement. This will transmit a different wavelength based on which this can be detected.

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(2) Acoustic emission sensors

- Acoustic signals generated by presence of cracks, delamination of fibre or breakage
- measurable

(3) Smart sensors - sensor coatings

- paints (or) coatings, applied on the surface
- integrated with piezo or ferro. electric elements
  - Carbon nano-tubes
- They are useful to detect variation in strain
- A detailed spectroscopic analysis is required to process the strain variations caused by the damages in local scale - detected on the coating

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The second type of sensor is acoustic emission sensor. In this type of sensors acoustic signals which are generated by presence of cracks or local faults, delamination of fibres or even breakage, they are measurable. One can also use smart sensors, which are otherwise nothing but sensor coatings. There are paints or coatings which are applied on the surface; they remain integrated with the piezo or ferroelectric elements. Sometimes even carbon nano tubes also being used to detect variation in strain. So, a detailed spectroscopic analysis is required to process, the strain variation caused by the damages in local scale. They will be the damages detected on the coatings, which actually indicate the strain variations.

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(4) Microwave sensors

- useful to indicate moisture ingress, when embedded
- very useful/efficient in composite structures

(5) Imaging ultrasonic sensors

These sensors contain a small, ultra-sonic wave transducer, which generates signal, that pass through the material

- change in reflection indicate flaws, cracks or local damage

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One can also use microwave sensors, they are actually useful to indicate moisture ingress, when embedded in structures. They are very useful and efficient in composite structures. One can also use imaging ultrasonic sensors; these sensors contain a small ultrasonic wave transducer, which generates signal that passes through the material. So, change in reflection actually indicate the flaws presence of cracks or any other local damage. So, friends in this lecture we discussed about various components of structural health monitoring processes.

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Summary

- (1) Components of SHM process
- (2) Aviation Industry
  - semia-life (fatigue) ↑
- (3) Variety of sensors - SHM in civil infrastructure

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We started looking into application of SHM in aviation industry. We understood that how the service life of an aircraft can be enhanced, what we say as flight hours can be enhanced by continuously monitoring the strain variations on the skin membrane of the aircraft. We have been also identifying a variety of sensors that are commonly used for SHM in civil infrastructure.

Thank you very much and bye.