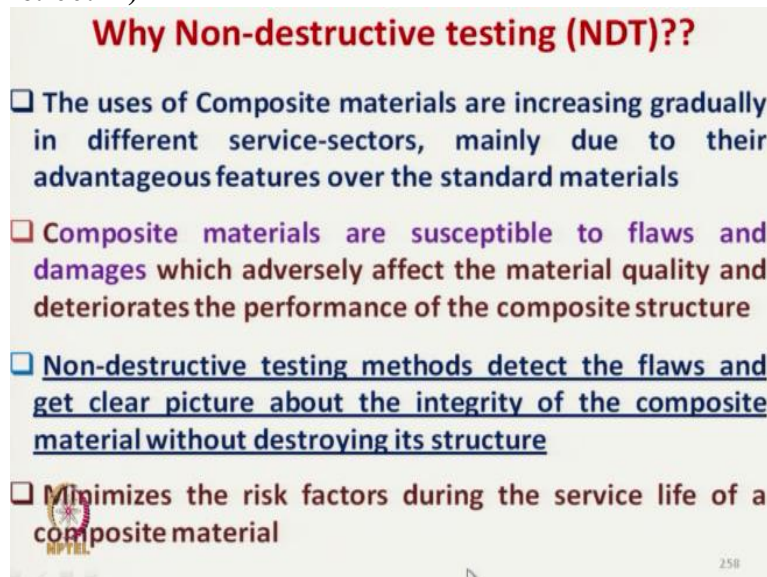


Lecture - 12
Textile Reinforced Composites (Contd.,)

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Why Non-destructive testing (NDT)??

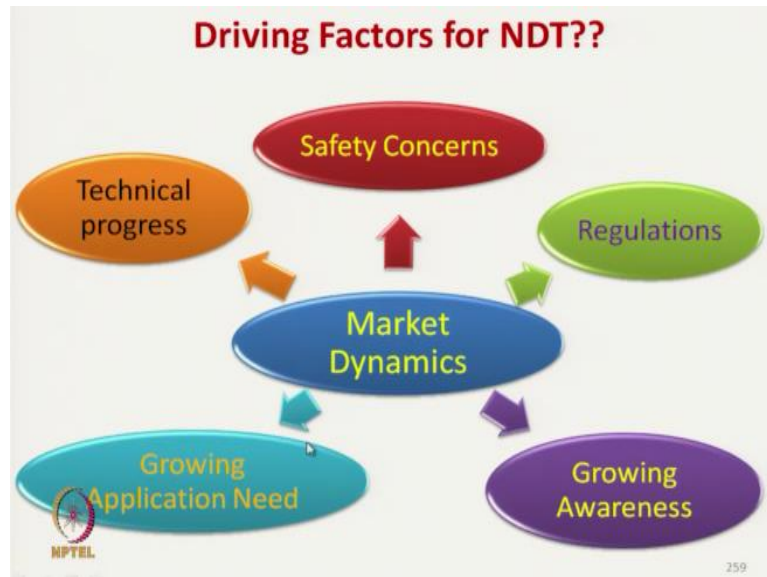
- The uses of Composite materials are increasing gradually in different service-sectors, mainly due to their advantageous features over the standard materials
- Composite materials are susceptible to flaws and damages which adversely affect the material quality and deteriorates the performance of the composite structure
- Non-destructive testing methods detect the flaws and get clear picture about the integrity of the composite material without destroying its structure
- Minimizes the risk factors during the service life of a composite material

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Hello everyone, so, we will now discuss the non-destructive testing of composites. So, first we must understand why do need to test composite in non destructive manner. So, the uses of composite materials are increasing gradually in different service sectors. So, mainly due to their obvious advantages, but the composite materials are susceptible to flaws and damages which adversely affect the material quality and deteriorates the performance of composite structure.

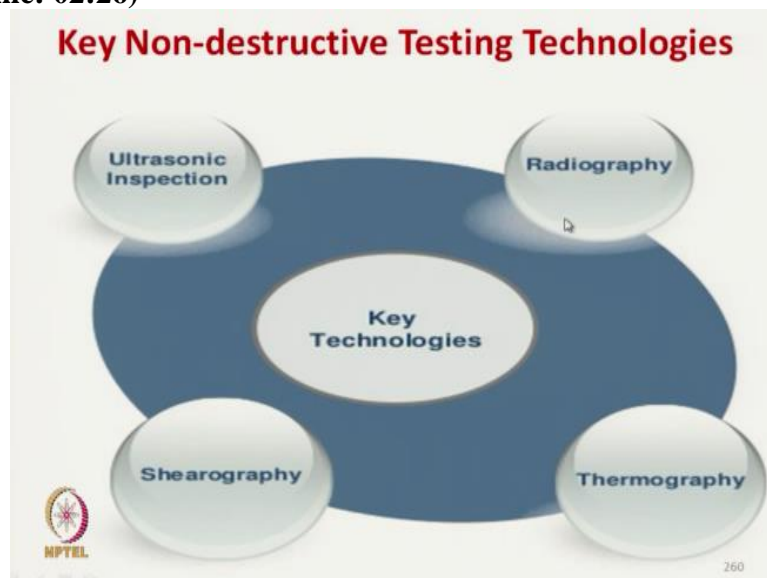
Non destructive testing methods detect the flaws and get clear picture about the integrity of the composite materials without destroying it is structure. So, it is very important, we cannot destroy the structure once it has been erected, it is very important to know the characteristics of composite without removing the component. So, it minimizes the risk factors during the service life of composite material.

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The driving factors for non destructive tests are the market dynamics, safety concern, regulations, safety concerns means we have to test intermittently the condition of the composite materials, so we cannot take out or we cannot destroy that component. So, we have to test the composite insitu, so regulation, growing awareness, growing application need, technical progress these are the market dynamics which actually driving the interest towards the non destructive testing.

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The technology which is used for non destructive testing of composites are radiography, thermography, shearography and ultrasonic inspection. Shearography here we will not discuss here that this is another technique. So, we will discuss mainly radiography, thermography, ultrasonic inspection.

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Ultrasonic Inspections

- It works based on the propagation of ultrasonic waves (ranging from 0.1 MHz and 50 MHz) through the material tested
- During testing the sample is immersed in some liquid to separate the transducer (which generates ultrasound) and the test object
- The transducer is connected to a diagnostic machine and is passed over the object during tested
- Ultrasound inspection works on two principle:

Reflection and Attenuation



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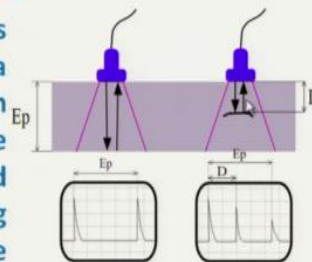
So, ultrasonic inspection here it works based on propagation of ultrasonic waves. So, ultrasonic wave is being propagated through the composite material. So during testing, the sample is immersed in some liquid to separate the transducer and the test object, the transducer is connected to the diagnostic machine and passed over the object during test. So, that transducer is moved through the objects. Ultrasound inspection works on 2 principles, one is reflection principle another is attenuation principles.

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Ultrasonic Inspections ... Cont

Reflection Mode

- The transducer performs both the sending and the receiving of the ultrasound pulsed waves
- After sending, the reflected ultrasound comes from an interface such as the back wall of the object or from an imperfection within the object.
- The diagnostic machine displays the results in the form of a signal with an amplitude representing the intensity of the reflection and the distance, representing the arrival time of the reflection.



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In reflection mode, if we see here, this is a composite material, this portion is without any damage, here damage is present. Now, if you see this is the ultra sound generator and this wave is transmitted through the uniform composite and from other surface it is getting reflected. So, we get the peaks at a certain distance. After every receipt of this reflected ray, we get P.

But once there is a damage inside the composite, the ultrasound wave will get reflected earlier than the previous one and we will get different peaks depending on the shape and size of the damage and we will get an idea about the damage present inside the structure. So, the transducer here performs both the sending and receiving of the ultrasound pulse wave.

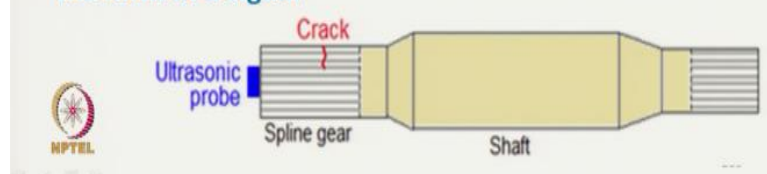
So, it sends an ultrasound pulse and receives, after sending the reflected ultrasound comes from an interface such as the back wall or from an imperfection within the object. So, this can come out reflected from the back wall or from this imperfection and then we get a plot and looking at the distance between these peaks, we can get an idea about the presence and even location of the damage. Suppose the location is close to the surface, one surface, then we will get the distance will be smaller. If it is farther from this generator then we will get at the higher distance.

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Ultrasonic Inspections ... Cont

Attenuation Mode

- A transmitter sends ultrasound through one surface, and a separate receiver detects the amount that has reached it on another surface after traveling through the medium
- Imperfections reduce the amount of ultrasound transmitted, thus revealing their presence
- Finally, the diagnostic machine displays the results in the form of a signal

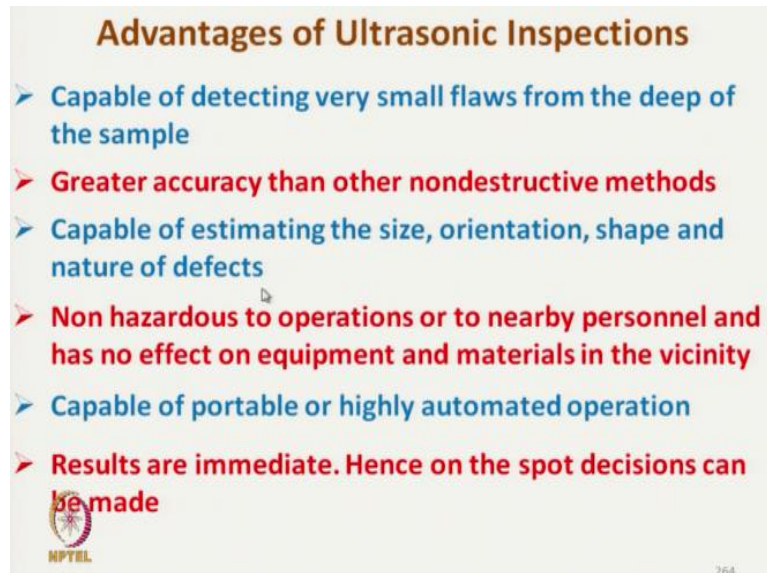


The diagram shows a yellow shaft with a 'Spline gear' on the left and a 'Shaft' section in the middle. A blue 'Ultrasonic probe' is positioned on the left surface of the spline gear. A red crack is shown on the top surface of the shaft. The diagram illustrates the path of an ultrasound wave from the probe, through the shaft, and back to the probe, with the crack acting as an imperfection that reduces the amount of ultrasound transmitted.

In attenuation mode, we will get that we have got 2 probes. One is this is the generator here and this is generator, this is the probe which receives, the transmitter sends ultrasound through one surface and a separate receiver. This is the receiver detects the amount that has reached it on another surface, so here we know the amount of wave, amount of energy it is transmitting and here it is receiving.

If there are cracks or any other imperfections, that means amount from that portion, the ultrasound will get reflected. So the amount of energy it is coming here will be less. The imperfection reduced the amount of ultrasound transmitted, thus revealing their presence.

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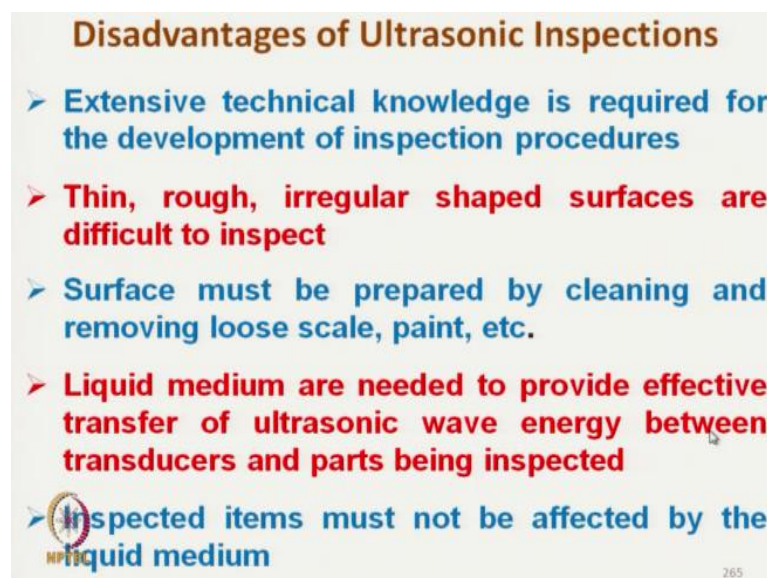
Advantages of Ultrasonic Inspections

- Capable of detecting very small flaws from the deep of the sample
- **Greater accuracy than other nondestructive methods**
- Capable of estimating the size, orientation, shape and nature of defects
- **Non hazardous to operations or to nearby personnel and has no effect on equipment and materials in the vicinity**
- Capable of portable or highly automated operation
- **Results are immediate. Hence on the spot decisions can be made**

NPTEL 264

The advantage, there are many advantages. So capable of detecting various small flaws from deep of the sample, generate accuracy, it is a greater accuracy than other non destructive techniques capable of establishing the size, orientations, shape and nature of defect. It is non hazardous, capable of portability. So we can move that take that instrument to the actual site and we get the result immediately.

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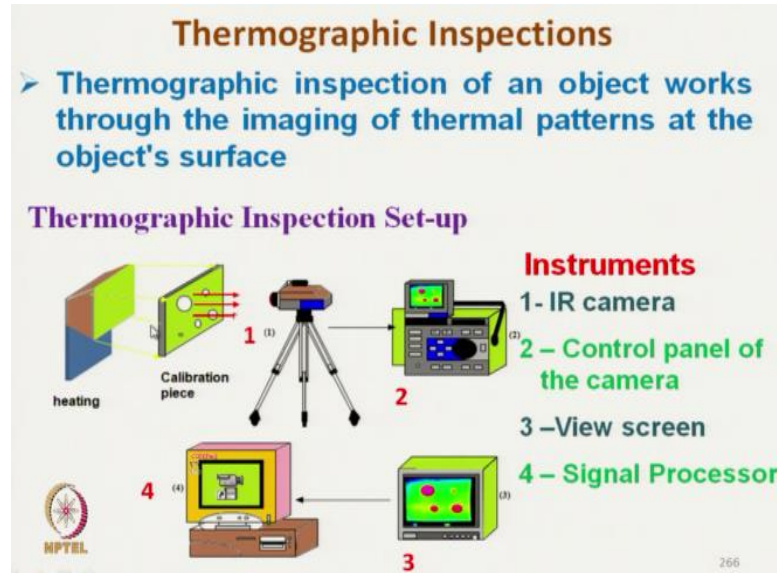
Disadvantages of Ultrasonic Inspections

- Extensive technical knowledge is required for the development of inspection procedures
- **Thin, rough, irregular shaped surfaces are difficult to inspect**
- Surface must be prepared by cleaning and removing loose scale, paint, etc.
- **Liquid medium are needed to provide effective transfer of ultrasonic wave energy between transducers and parts being inspected**
- Inspected items must not be affected by the liquid medium

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So, it is actually technical extensive technical knowledge is required that those are the disadvantages. Thin, rough surface, it is difficult to measure. It should be clean surface, liquid medium is required and the liquid medium should not react to it the composite surface.

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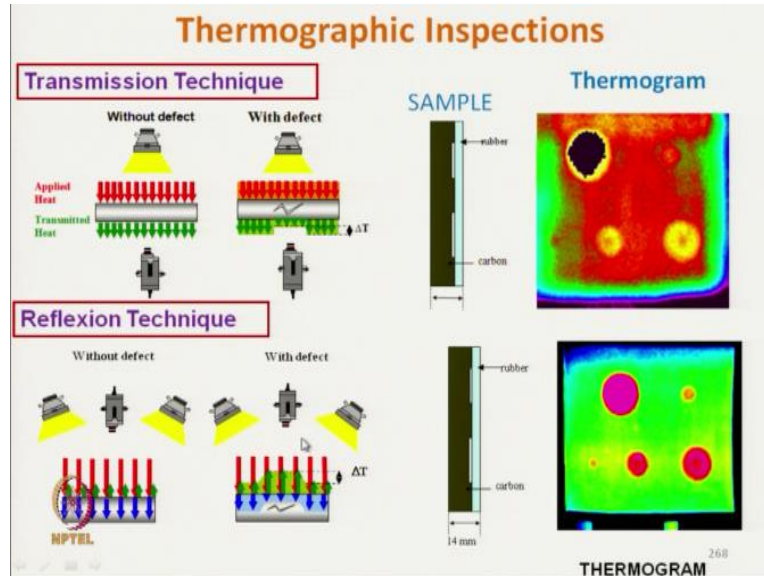
Thermographic inspection, where this is the heater and from other surface we get the image through thermal imaging camera. Depending, this is the IR camera and then here it is a viewing screen, signal processing. So, that we are getting signal processed here viewing the screen is here, so control panel. So, depending on the type of defect we get the image on other side.

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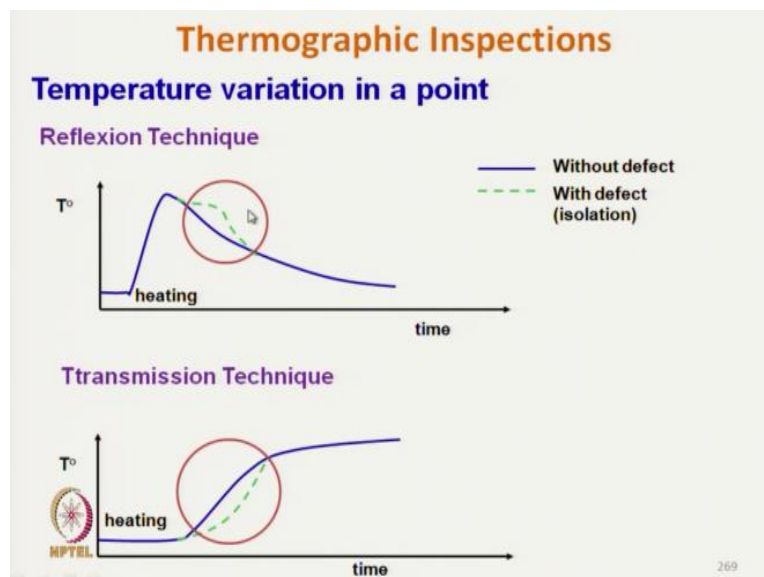
So, there are different types of defects we can get delamination, defects on surface coating, so, different types of defects, inclusion of foreign particles. So, this also works on transmission and reflection mode.

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So, this is the transmission mode here, we can see that the heat this is the heater, without defect that heat is applied here if there is no defect, the heat will be uniformly transmitted. So, we can get image, but in case of any defects like void content, any other defect, the heat will not get transmitted evenly on the other side and we get image here. So, these are the image from there we can get idea about the defects present inside the structure, specimen. And in reflexion mode also we get so, this is the reflexion mode this is heater here and camera we get the reflexion mode.

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So, here we can see in reflexion mode from the defective area we get more heat, because extra heat is being reflected here. But on the other hand in transmission mode, the heat is being blocked in that heat transmission is being blocked at the defective zone. So, the effective heating temperature we are getting it is less. From there these are the 2, the difference between reflexion and transmission, but for same type of defect we get these 2 different curves. So, we must know whether it is working in transmission mode or reflexion mode.

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Thermographic Inspections

Advantages of the method :

- Global examination of part
- **Only ONE SIDE access is required for the examination**
- Real Time inspection
- **Apply for all composite structure and materials**
- Well suited for large surfaces

Disadvantages :

- **Sensitive to heating mode (type, duration, position)**
- Response time must be studied
- **Exact composition of the pieces and the thicknesses must be known**

Inhomogeneous heating on complex part

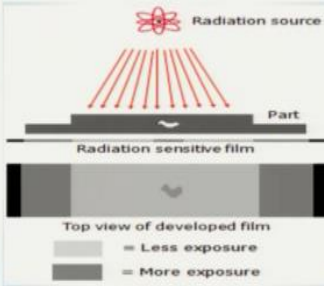
NPTEL 270

So, the advantage is global examination is possible for different parts. But only one side here is required for examination, real time inspection, apply for all composites structures. And main disadvantage is that it is sensitive to heating mode. So, if the duration or type of heating changes, its result may get changed, inhomogeneous heating is there in complex type of part, it is actually it can be used easily for very uniform or straight part, but for complex type of composite, this method it gives wrong results.

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Radiographic Inspections

- Detects hidden flaws of the materials by using the ability of short wavelength electromagnetic radiation to penetrate into various materials
- Types of Radiation used
 - i) X-Ray Radiation ii) Gamma-Ray Radiation iii) Neutron radiation
- The part to be inspected is place between the radiation source and the radiation sensitive film
- Radiation that passes through the part will expose the film and forms a shadowgraph of the part



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Radiographic inspection where different types of radioactive electromagnetic waves are passed through the composite like X ray, gamma ray, neutron radiation. In case of other side there is a, there will be plate, photographic plate will be there, in case of any defect present or any void content present. So that there will be more and more rays will pass through that and that will show up by darker, more exposed portion and that will give us idea about any presence of any defect there.

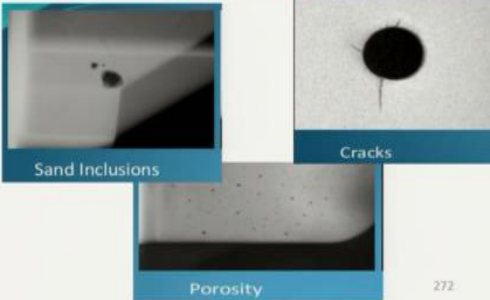
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Radiographic Inspections

- Film darkness will vary with the amount of radiation reaching the film through the test object
- Darker areas indicate more exposure, lighter areas indicate less exposure
- The variation in image darkness is used to determine the flaws or imperfections of the material

Defects Inspected

- Sand inclusion
- Shrinkage
- Cracks
- Blow holes



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So, these are the defects inspection. So, here if there is any crack or sand particles, so these are the different or porosity, we can get an idea about internal defect present in the composite through radiographic inspection.

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Radiographic Inspections

Advantages:

- **Both surface and internal discontinuities can be detected**
- **Variation in composition can be detected**
- **Very few material limitations**
- **Can be used for inspecting hidden areas**
- **Very minimal or no part preparation is required**
- **Permanent test record is obtained**



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So, main advantages here is both surface and internal discontinuities can be detected, variation in composition can be detected, very few material limitations, so, we can use for different types of material, can be used for inspecting hidden area, very minimal to no part preparation is required, we can use directly permanent test record is can be maintained.

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Radiographic Inspections

Disadvantages:

- **Hazardous to the operators and for near by personals**
- **High degree of skilled and experienced person is required**
- **Equipment is relatively expensive**
- **Depth of discontinuity is not indicated**
- **It need two side access to the component**



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Main drawback, these drawbacks are its hazardous. So, all this X ray, gamma ray these are for human health hazard risk are there, skill of the person who will be testing is required high skilled person, expensive testing and it needs 2 side access to the component. So we need to have 2 side access so it is not reflective does not work on reflective mode only in transmission mode. So we need to have access in both surfaces. So this is all about composite. So, next class will start with new topic. Till then thank you.