

Mining Machinery
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Module - 11
Lecture - 60
Non Destructive Testing

Welcome boys. Today, it is our last class of this course on Mining Machinery which we designed for different machines as well as through certain extent introduction of the maintenance and today, this concluding class I will be talking about some advanced technique which are being used in maintenance of machinery.

So, you know that is a Non Destructive Testing this is an area which is, which has got lot of scopes in enhancing the safety and productivity of our machines. So, this today this slides I will be showing here are all taken from this National Science Foundation of Iowa state, where they have got a this nondestructive testing the educations forum they have produced a lot of materials which are of use, you can also see they are available in the public domain.

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Non Destructive Testing

Objectives:
Introduction to Non-Destructive Testing
for Condition Monitoring of Machinery

Destructive tests are often used to determine the physical properties of materials such as **impact resistance, ductility, yield and ultimate tensile strength, fracture toughness and fatigue strength**, but *discontinuities and differences in material characteristics* are more effectively found by NDT

Nondestructive testing (NDT) is the process of **inspecting, testing, or evaluating materials, components or assemblies for discontinuities, or differences in characteristics** *without destroying the serviceability of the part or system*.
Inspection or test is completed the part can still be used.

NPTEL

Now, this objectives of today is to introduce this nondestructive testing and so that you can think of how such type of systems, such type of testing can be incorporated in our condition monitoring of machinery and then how the maintenance can be improved so that the overall capacity utilization and performance of the machines are improved.

Now, as we know that this machinery problems come because of the failure of certain components. So, those components there what is the their internal of this structure how their exactly the capacity of that is how their breaking strength or compressive strength whether those are remaining same or not.

It cannot be normally done by nondestructive testing. Normally, what is done? A lot of destructive testings are taken. This destructive testing which is for impact on the resistance their ductility yield their ultimate tensile strength, fracture, toughness, fatigue strength these

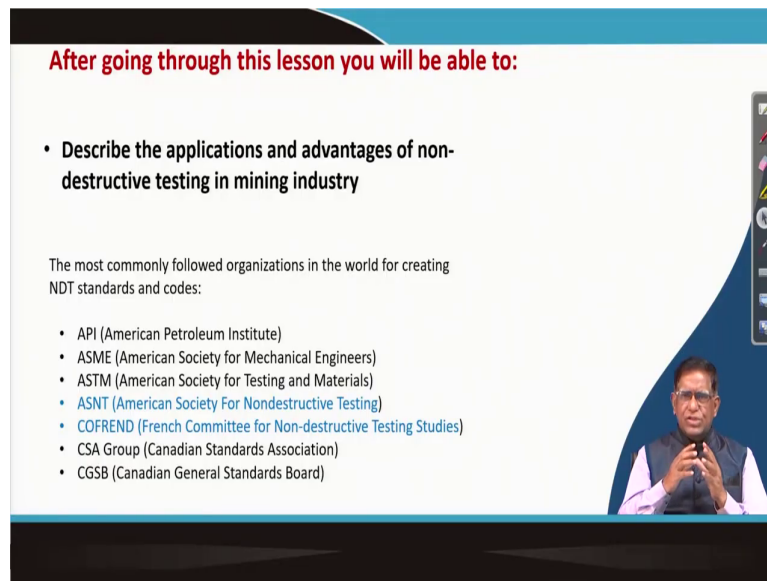
are very very important property. So, then while these parts are used at that time you cannot test it you might have studied in the strength of materials or in mechanics of solids.

If there were some practical classes in your second year level normally you have done how you do this either tests and different test of specimen there was defined specimens are there, they are under impact and all their crust and then once it is tested, the test specimen is no longer it is used because that is a destructive tests.

But, while doing this test, how exactly there is any discontinuity within the structure or how exactly internal things are there in that particular material or member that cannot be done. That is why this nondestructive testing it came and which is a process by which you can inspect tests or evaluate the materials and their components and particular assemblies if there is any discontinuity or there is a change in the characteristics of the material which may lead to a premature failure which may cause to an accident.

So, that is why this then what is there? When you are doing the tests while the item is in use that is the principle or philosophy behind this non-destructive testing or it is sometimes it is called also nondestructive evaluation.

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After going through this lesson you will be able to:

- Describe the applications and advantages of non-destructive testing in mining industry

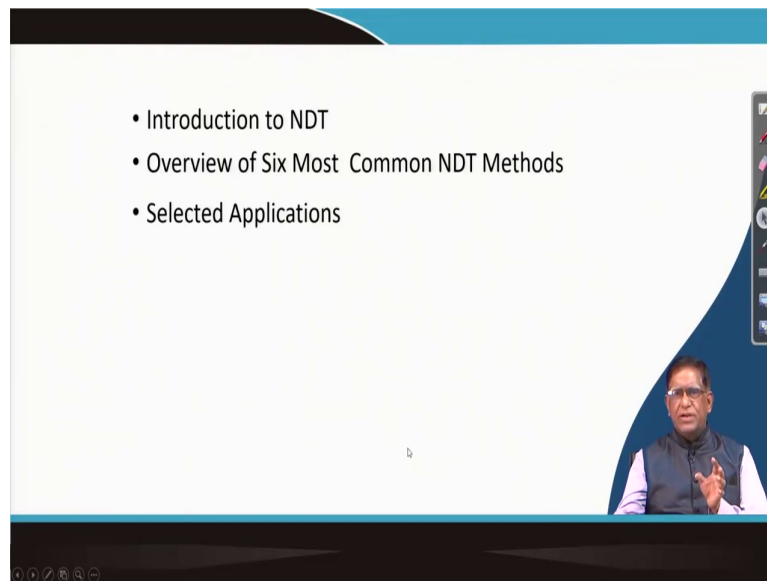
The most commonly followed organizations in the world for creating NDT standards and codes:

- API (American Petroleum Institute)
- ASME (American Society for Mechanical Engineers)
- ASTM (American Society for Testing and Materials)
- ASNT (American Society For Nondestructive Testing)
- COFREND (French Committee for Non-destructive Testing Studies)
- CSA Group (Canadian Standards Association)
- CGSB (Canadian General Standards Board)

So, today we will be just giving a brief that is a bird's eye view on this subject and we will be describing few applications under advantages in the mining industry how we can take it up, but you should note it down that there are many organizations in the world where they are creating a standards and code of practice how those things will have to be done. So, those standards are basically from the American Petroleum Institute, American Society of Mechanical Engineers, then American Society for Nondestructive Testing.

This society they have exactly standardized many of the this nondestructive techniques. So, in France also is there, then Canada also there I think Indian Bureau of Standards they have also certain standards certain testings have been standardized.

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So, one thing if you are when you will be going to field as an engineer you will have to be aware of these standards so that in the industry you can do a very that is your in a better way the work can be carried out. So, now, we have got this introductions that in nondestructive testing NDT is nothing, but having the internal characteristics of the materials are known while the member is in service or you are not destroying it, it is still in use.

So, there are many methods. Some 6 or 8 methods we may be talking today. There are many new methods and there are many new things will be coming up. It is basically the physics and the chemistry and material science – metallurgy, from those sections these knowledge are being developed a new creative innovative ideas are coming and those things are to be used. As a mining engineer, as a mine manager you need to get those development and innovations of different fields to be used over here.


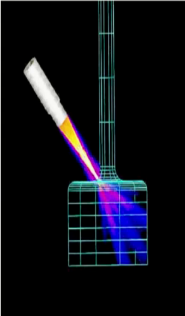
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Definition of NDT

The use of noninvasive techniques to determine the integrity of a material, component or structure
or
quantitatively measure some characteristic of an object.

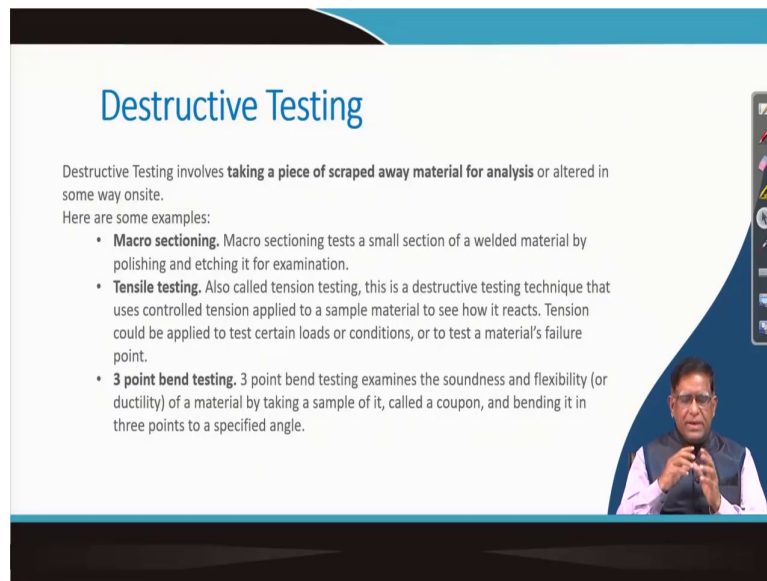
i.e. Inspect or measure without doing harm.

NDT may also be called: **NDE** (non-destructive examination or evaluation) **NDI** (non-destructive inspection)



So, it is clear to you now that the nondestructive testing is nothing, but use of non-invasive techniques which do not destroy the material, but it can you can reveal what is there and it is also called nondestructive evaluation or nondestructive inspection.

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Destructive Testing

Destructive Testing involves **taking a piece of scraped away material for analysis** or altered in some way onsite.

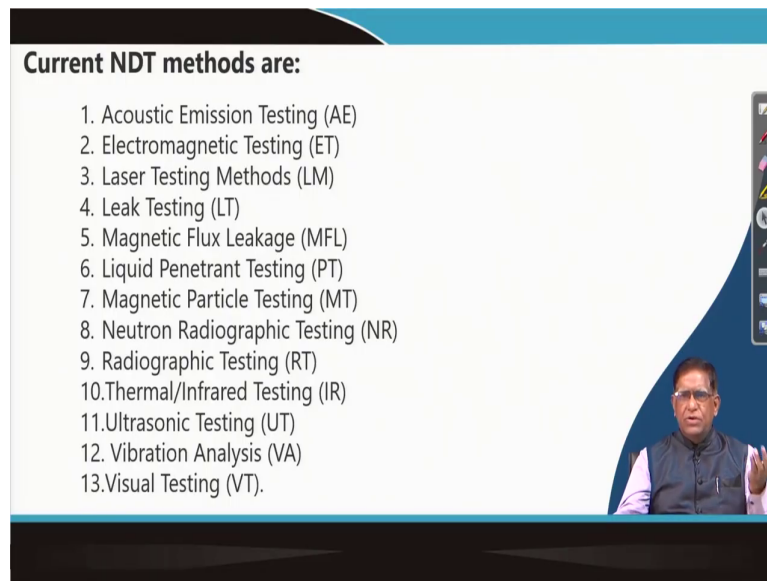
Here are some examples:

- **Macro sectioning.** Macro sectioning tests a small section of a welded material by polishing and etching it for examination.
- **Tensile testing.** Also called tension testing, this is a destructive testing technique that uses controlled tension applied to a sample material to see how it reacts. Tension could be applied to test certain loads or conditions, or to test a material's failure point.
- **3 point bend testing.** 3 point bend testing examines the soundness and flexibility (or ductility) of a material by taking a sample of it, called a coupon, and bending it in three points to a specified angle.

Now, in the destructive testing you may be knowing that what need to be done. If suppose you have done a welding, after that welding things are correct or not you need to do a micro sectioning test. A small section or portions are cut and taken it out and then they will be doing over there some testings are done.

Tensile testing you know that is a tensile test is there that is a particular specimen is created and then it is broken in a particular test rig. And, then there are also for bend 3 point bend testings these are standardized tests by which that is your the whether the material is really working or not how it will be behaving in bend, those things are done by bending the material properly.

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Current NDT methods are:

1. Acoustic Emission Testing (AE)
2. Electromagnetic Testing (ET)
3. Laser Testing Methods (LM)
4. Leak Testing (LT)
5. Magnetic Flux Leakage (MFL)
6. Liquid Penetrant Testing (PT)
7. Magnetic Particle Testing (MT)
8. Neutron Radiographic Testing (NR)
9. Radiographic Testing (RT)
10. Thermal/Infrared Testing (IR)
11. Ultrasonic Testing (UT)
12. Vibration Analysis (VA)
13. Visual Testing (VT).

So, those things are done, but in nondestructive testings you do not bend or you do not destroy the sample or the piece of material they are done differently using the advance scientific knowledge. In this, that what are the some of the techniques like acoustic emission technique that is your exactly very high frequency, this your sound wave they are used for doing this testing. Electromagnetic testing is another way, then laser testing, leak testing, magnetic flux testing.

That is magnetic flux leakage for our winder wire rope also it is used, then your liquid penetrant testing which can be used for our winder drum gear whether the gear teeth are proper or not there we can test it, even sometimes on a boom or in a pipe if there is any crack coming up that can be done by this liquid penetrant testing or magnetic particle testing can be

used for that. Then neutron radiographic testing – this radiographic testing is also if there is any flaws inside the particular piece of item can be found out.

This radiographic testing, thermal infrared testing, ultrasonic testing, vibration analysis, visual testing like that infrared testing means you are taking an infrared photograph that is another method which is very much used called tomography. Those are the terminologies which are coming up these days need to be at least you should be aware of how it is done and then the instruments which are being manufactured and then this testing feature done by others you need to understand.

And then find out in mining industry where you can use these tests.

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Uses of NDE Methods?

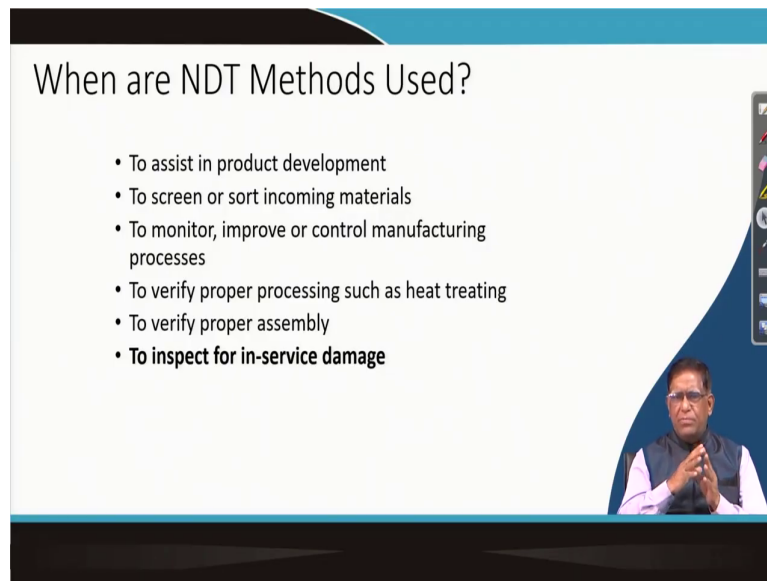
- Flaw Detection and Evaluation
- Leak Detection
- Location Determination
- Dimensional Measurements
- Structure and Microstructure Characterization
- Estimation of Mechanical and Physical Properties
- Stress (Strain) and Dynamic Response Measurements
- Material Sorting and Chemical Composition Determination

So, for example, this is our nondestructive evaluations it is done for flaw detections. If any piece of member anything there is inside a crack or things like that how will you do it? So, these flaw detections your the particularly this nondestructive testing will be used for leak detections if any pipe or anywhere from that there is a leak is coming.

Where is the location determination where from that exactly problem is coming. Say for example, sometimes you get some vibrations from a particular this say bearings or gearing gear box then where exactly that is located can also be done by some of the nondestructive testing; then structure and micro structure characterizations can be done.

Then particularly that particular member after use as the aging is done that how the aging effect is coming if any creep developed is any weakening of the material or weakening of the particular member is taking place, that thing also can be evaluated by estimating the physical property or the behavior how it will be doing in pressure. So, basically the stress and dynamic response measurements can be done by doing this and this non-destructive testing.

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When are NDT Methods Used?

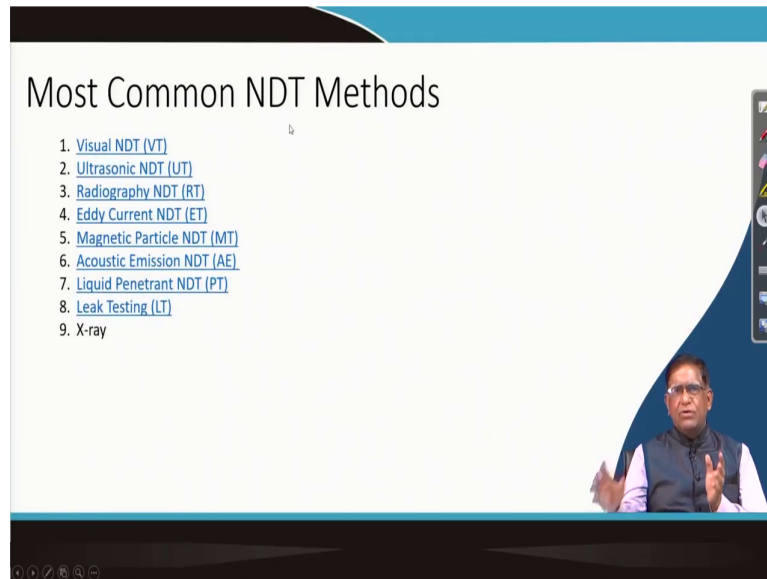
- To assist in product development
- To screen or sort incoming materials
- To monitor, improve or control manufacturing processes
- To verify proper processing such as heat treating
- To verify proper assembly
- **To inspect for in-service damage**

Now, where and why you will use in the mining industry? It is to assist the product development if exactly you can when a particular item is being purchased at that time you can demand that you send the nondestructive testing report while you are manufacturing a part so that you can be sure that it will be serving your purpose.

To screen shot of the some incoming materials. To monitor, improve and control manufacturing process that is if you are using you are having a good workshop where you are of say the making some critical parts which will be used for say for your some of these roof bolts and all that is exactly when you are making those bolts whether they are coming with the proper property or not after this you can test it and then you can let it go.

Similarly, you can verify proper procession such as the heat treatment you do in many parts, whether the heat treatment is done properly or not can be tested. So, but basically it is whether there will be any in service damage have taken place that also can be tested.

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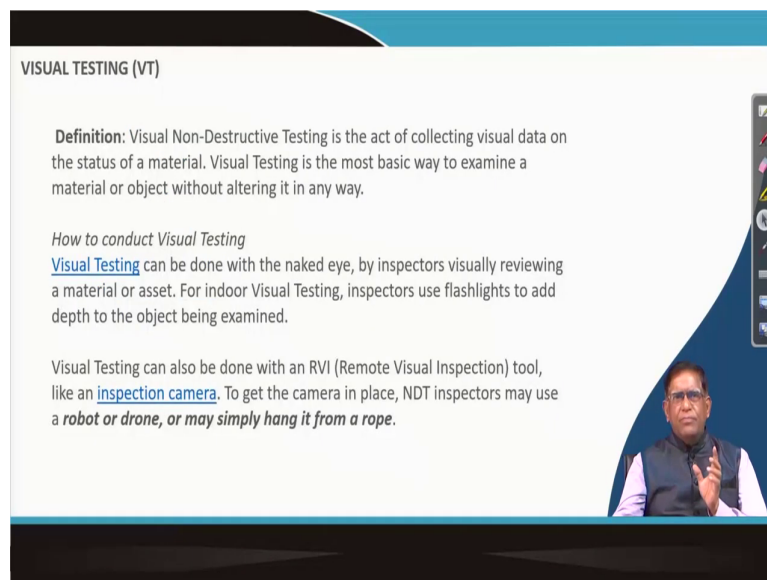


The image shows a presentation slide titled "Most Common NDT Methods". The slide lists nine methods in a numbered list, each with a blue underlined link: 1. [Visual NDT \(VT\)](#), 2. [Ultrasonic NDT \(UT\)](#), 3. [Radiography NDT \(RT\)](#), 4. [Eddy Current NDT \(ET\)](#), 5. [Magnetic Particle NDT \(MT\)](#), 6. [Acoustic Emission NDT \(AE\)](#), 7. [Liquid Penetrant NDT \(PT\)](#), 8. [Leak Testing \(LT\)](#), and 9. X-ray. In the bottom right corner of the slide, there is a small video inset showing a man with glasses and a dark vest over a light shirt, gesturing with his hands as if speaking. The slide has a white background with a blue header and footer. A vertical toolbar with various icons is visible on the right side of the slide.

So, these are the most commonly used methods. These methods you can make a your own drossier about what is the latest devices available, who are the manufacturer, whether such type of manufacture are there in Indian or not, if not that is exactly what it makes to manufacture such type of things, whether this the principle can be adopted and can we locally manufacture some of this that in that system or instruments, then in manufacturing those things then how that what type of market will be there.

So, that type of study you should do those particularly who are looking for our entrepreneurship and some Make in India movement if you want to join.

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VISUAL TESTING (VT)

Definition: Visual Non-Destructive Testing is the act of collecting visual data on the status of a material. Visual Testing is the most basic way to examine a material or object without altering it in any way.

How to conduct Visual Testing

[Visual Testing](#) can be done with the naked eye, by inspectors visually reviewing a material or asset. For indoor Visual Testing, inspectors use flashlights to add depth to the object being examined.

Visual Testing can also be done with an RVI (Remote Visual Inspection) tool, like an [inspection camera](#). To get the camera in place, NDT inspectors may use a *robot or drone, or may simply hang it from a rope.*

So, now let us see this what is this visual testing. Exactly in any maintenance job you do and see the things and find out whether they are we use that seeing means by without any instruments, by we can hear, we can see, we can this like that when you go to see over there then you find out whether there is a cracks and all.

But, by looking it you may not see the crack then you will have to take it for other devices. And, some equipment say for example, you are going to see the shaft in a mine shaft there are the liners there, there are the guide ropes are there, now, these guide rails are there.

Now, if those things are for a long time you are using under a corrosive environment if the corrosion has taken place whether they are exactly in any places there is a corrosion or some this rusting is there or not, to see that you will have to you cannot go in between. So, you can think of easily if you take a drone and then you have some good light emitting and then a photography taking arrangements in the drone, it can go down the shaft and take the things and it can do the inspection.

So, that type of inspection comes under visual inspection.

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Visual Inspection

Inspection of equipment and structures using any or all of our raw human senses such as vision, hearing, touch, and smell and/or any non-specialized inspection equipment.

Most basic and common inspection method.

Tools include fiberscopes, borescopes, magnifying glasses and mirrors.

Robotic crawlers permit observation in hazardous or tight areas, such as air ducts, reactors, pipelines.

Portable video inspection unit with zoom allows inspection of large tanks and vessels, railroad tank cars, sewer lines.

The slide features three images: a person using a borescope, a person in a hard hat and safety gear holding a video inspection unit, and a small red and black robotic crawler. A small inset video of a man speaking is visible in the bottom right corner of the slide.

So, for example, while just at the time of your blasting, then this lot of fumes and other things are coming at that time you cannot go there. It is dangerous, even in underground blasting you

cannot go up to that much because there may be noxious gases coming up. At that time also you can keep certain things that it will visually take up.

What happened exactly at that moment of blasting and it can be brought in and you can take decisions. Like that this is not only with the machinery with the other operations also this visual inspections help. Now, it is a for looking into there are different devices say for example, in a gear box. How the gearbox inside the teeth are there, there are instrument like your borescopes and all just like your stethoscope hear sound like that our with a microscope you can see a piece.

Now, there is a borescope in which there will be a microscope inside a tube and that tube can be inserted into the gearbox and you can take a image and that you can visually see what is happening there inside. So, that type of visual inspections can be carried out. Similarly, that is your inspections you can do it by making those camera or other sensors mounted into the other device and then you can put it over there and do it. For example, in your crushing plant in that your crusher in iron ore mines.

If you go there this is a run of material is going to a jaw crusher first. In the jaw crusher when the jaw are that exactly making at that time there will be the say the liners whether they are varying or not, you cannot go there to see because when it is coming when the things are in operations you cannot do.


But, there you can have a visual inspections through camera can be installed over there and you can see the exactly that how the they are interacting with the rock and what is happening there. So, that type of things are there. By using robotic crawler that type of things are also it can go and climb different ducts or reactors pipelines there it can go.

Similarly, such type of camera can go even in your underwater. Say in a mine sump and in the sump exactly below there could be a lot of this mud and pit and there if something your machine say you are having a pump installed if that is going wrong you cannot do it. Then you can send a underwater robot with a camera and then it can see.

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Remote Visual Inspection (RVI)

Walking into a mine shortly after a blast is so dangerous that it simply isn't done. But a drone can be used to survey the area remotely, collecting visual data on its condition so that mining personnel can make a determination about whether it's safe enough to enter.



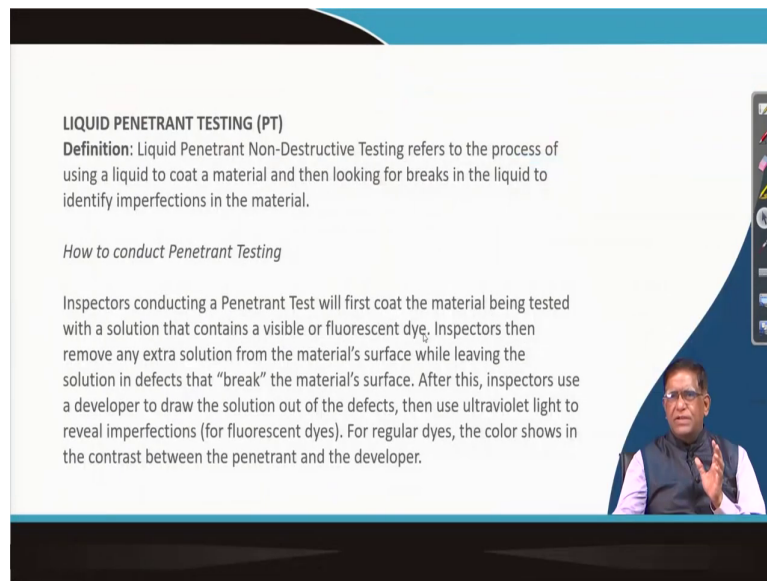
Inspecting a mine shaft

Drones Can Help with Visual Inspections



So, that is your you can how here you can see how inspecting a mine shaft by a that drone it is going over there. This type of inspection which is called remote visual inspections that is also possible. So, there could be a lot of features are there of this technology in our.

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LIQUID PENETRANT TESTING (PT)
Definition: Liquid Penetrant Non-Destructive Testing refers to the process of using a liquid to coat a material and then looking for breaks in the liquid to identify imperfections in the material.

How to conduct Penetrant Testing

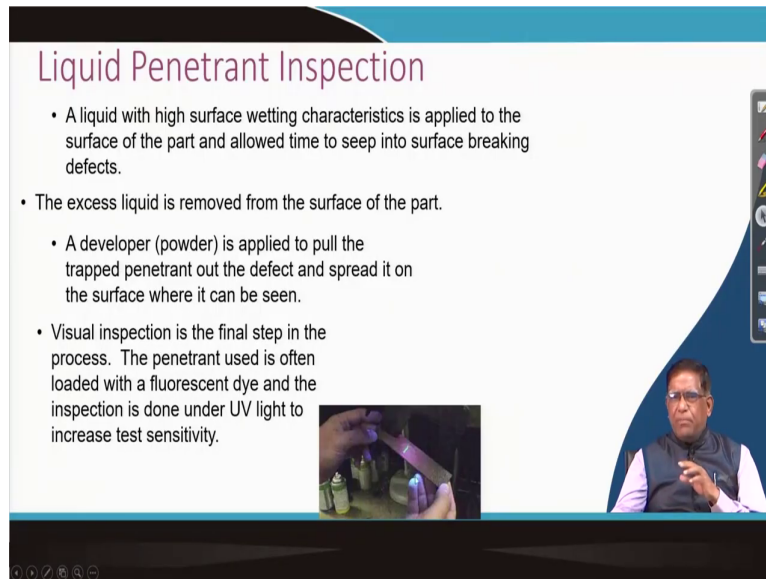
Inspectors conducting a Penetrant Test will first coat the material being tested with a solution that contains a visible or fluorescent dye. Inspectors then remove any extra solution from the material's surface while leaving the solution in defects that "break" the material's surface. After this, inspectors use a developer to draw the solution out of the defects, then use ultraviolet light to reveal imperfections (for fluorescent dyes). For regular dyes, the color shows in the contrast between the penetrant and the developer.

Then, similarly there is another device called liquid penetrant or sometimes called it is a dye penetrant. If there is a surface which the which has got some crack, in that case what it will be done that particular liquid which will be placed over there it will go and then this has got a colour you wipe it out. After that you take a put a high light this wherever some liquid has penetrated that person will give you a illuminations differently and you know that there is a crack. So, that type of your liquid penetrant can give this.

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Liquid Penetrant Inspection

- A liquid with high surface wetting characteristics is applied to the surface of the part and allowed time to seep into surface breaking defects.
- The excess liquid is removed from the surface of the part.
- A developer (powder) is applied to pull the trapped penetrant out the defect and spread it on the surface where it can be seen.
- Visual inspection is the final step in the process. The penetrant used is often loaded with a fluorescent dye and the inspection is done under UV light to increase test sensitivity.



Liquid penetrant inspections is used for exactly that liquid with high surface wetting characteristics. Exactly when the liquid is applied it should be having it should wet the whole surface properly and then you can see that the whatever that excess liquid is there you wipe it out and then you put a developer; that means, whatever has remained over there, with the developer it will react and it can give a coloration that colorations can be seen.

So, like that exactly you can visually the in inspect over here. Suppose this plate there they first they put that liquid then they has put the that is wiped it out after that they put a developer and then they use a laser light with that illuminations they have seen and they can see that inside there is a crack. So, that type of inspections that you have that plate is intact, but you know that there is a the it has weakened.

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MAGNETIC PARTICLE TESTING (MT)

Definition: Magnetic Particle Non-Destructive Testing is the act of identifying imperfections in a material by examining disruptions in the flow of the magnetic field within the material.

How to conduct Magnetic Particle Testing

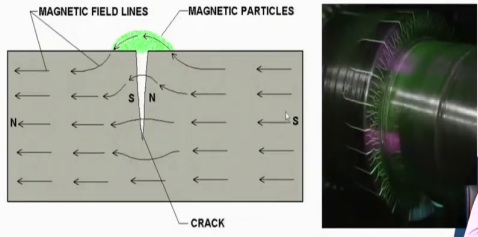
To use Magnetic Particle Testing, inspectors first induce a magnetic field in a material that is highly susceptible to magnetization. After inducing the magnetic field, the surface of the material is then covered with iron particles, which reveal disruptions in the flow of the magnetic field. These disruptions create visual indicators for the locations of imperfections within the material.

So, similarly the magnetic particle the testing this is another device in which the magnetic particle is it exactly the particle is spread over there on a if you magnetize the item, then that your iron particles iron fillings they will get attached with that depending on how the magnetization has taken place.

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Magnetic Particle Inspection

The part is magnetized. Finely milled iron particles coated with a dye pigment are then applied to the specimen. These particles are attracted to magnetic flux leakage fields and will cluster to form an indication directly over the discontinuity. This indication can be visually detected under proper lighting conditions.



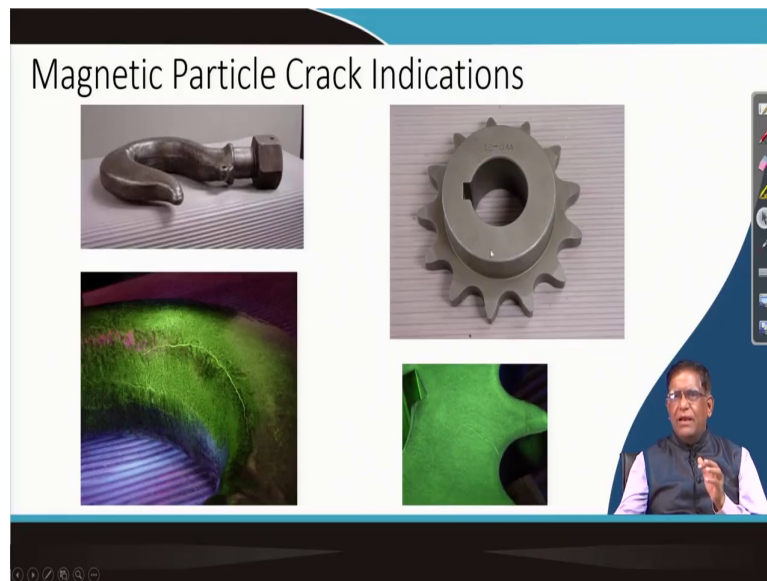
The diagram illustrates the principle of Magnetic Particle Inspection. It shows a metal plate with a vertical crack. Magnetic field lines, represented by arrows, flow from a North (N) pole on the left to a South (S) pole on the right. The crack acts as a magnetic flux leakage point, causing the field lines to curve around it. This creates a magnetic field perpendicular to the crack's surface. Magnetic particles, shown as small green dots, are attracted to these leakage fields and cluster at the crack, forming a visible indication. Labels include 'MAGNETIC FIELD LINES', 'MAGNETIC PARTICLES', and 'CRACK'. To the right, a photograph shows a similar setup on a metal part, with a crack and a cluster of particles forming an indication. A person is visible in the bottom right corner of the slide, gesturing.

So, that means, in a magnetic particle inspection what happens, if there is a crack is there those magnetic particles they will be getting accumulated over here because in this case there will be a magnetic field will be generated, if because of this crack when this plate is being magnetized. So, this principle that can help you to find out if there is any crack.

So, just you magnetize the that is the area where you will have to do and then you just sprinkle the iron particles iron fillings and then you will see that they will go and accumulate in one place. So, you can identify that is there and then you do the next phase of inspections for.

And then what could be how it can be rectified. And, such type of things can help sometimes in a parts when a crack develops it may lead to propagation of the crack and then the collapse of it, the many beam and all they may have got this type of testings necessary.

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So, these are some of the things exactly by the this type of hooks and all if they got a crack inside you cannot see anything by your that by naked eyes, but if you do periodically that this type of hook you are using say in a crane and then or you are using in a pipe layer for conveyor belt laying.

And all at that time when the heavy load comes if already a crack is there it can lead to a big accidents. So, that should be under a condition should be monitored of this type of components so that if there is any problem it can be eliminated. So, you can see that it in this particular member there is a crack inside. So, this member it looks ok, but it could be there

for certain load. But, if you are using in a crane with a heavy load carrying at that time it is breaking strength may not be sufficient may lead to (Refer Time: 20:37).

See similarly, in some of the that your sprockets teeth that will also that may give a problem where it is a in this there is a problem with near the key there is a crack here, but in a normal here you cannot see anything, but with the magnetic particle detector this is possible.

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Radiography

The radiation used in radiography testing is a higher energy (shorter wavelength) version of the electromagnetic waves that we see as visible light. The radiation can come from an X-ray generator or a radioactive source.

The diagram shows the electromagnetic spectrum with categories: Radio, Microwaves, Infrared, Visible, Ultraviolet, X-ray, and Gamma Ray. Below this, it indicates 'Low Frequency' and 'Long Wavelength' on the left, and 'High Frequency' and 'Short Wavelength' on the right. A wave diagram shows a long wavelength wave on the left and a short wavelength wave on the right.

On the right side of the slide, there is a diagram of an X-ray tube. It shows 'High Electrical Potential' applied across the tube. 'Electrons' are shown being accelerated from the cathode towards the anode. The resulting X-rays are shown as a fan beam of yellow dashed lines emanating from the anode.

A small inset video of a presenter is visible in the bottom right corner of the slide.

Then this radiography is another device that is exactly normally in our X-ray range where high frequency wave length is there. If your high frequency that wave length it is allowed and then they will go through. And, then they will find out that exactly it will what is there and from there it will be reflecting.

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Film Radiography

The part is placed between the radiation source and a piece of film. The part will stop some of the radiation. Thicker and more dense area will stop more of the radiation.

The film darkness (density) will vary with the amount of radiation reaching the film through the test object.

X-ray film

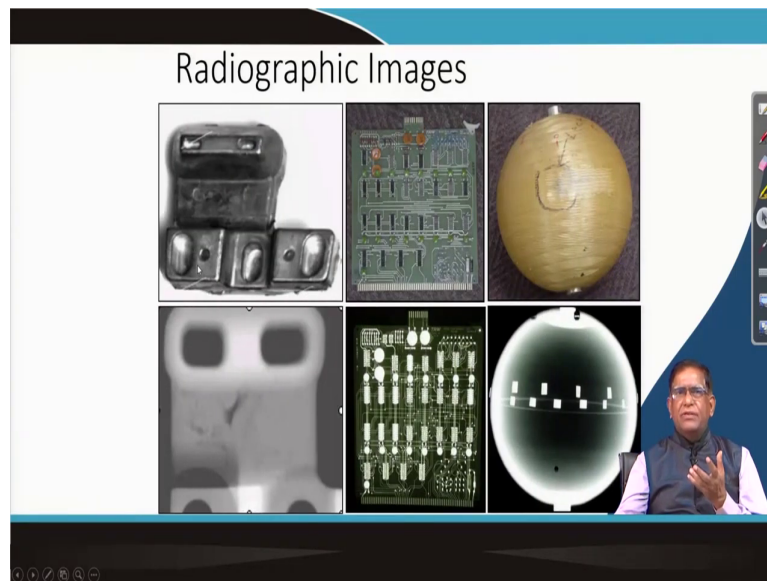
Top view of developed film

= less exposure
= more exposure

The diagram illustrates the process of film radiography. At the top, a red atomic symbol represents the radiation source, with red arrows pointing downwards. These arrows pass through a grey test object with a central hole. Below the test object is a white rectangular area labeled 'X-ray film'. At the bottom, a 'Top view of developed film' shows a grey area with a white hole, corresponding to the test object. A legend indicates that lighter grey represents 'less exposure' and darker grey represents 'more exposure'. A small inset video of a man speaking is visible in the bottom right corner of the slide.

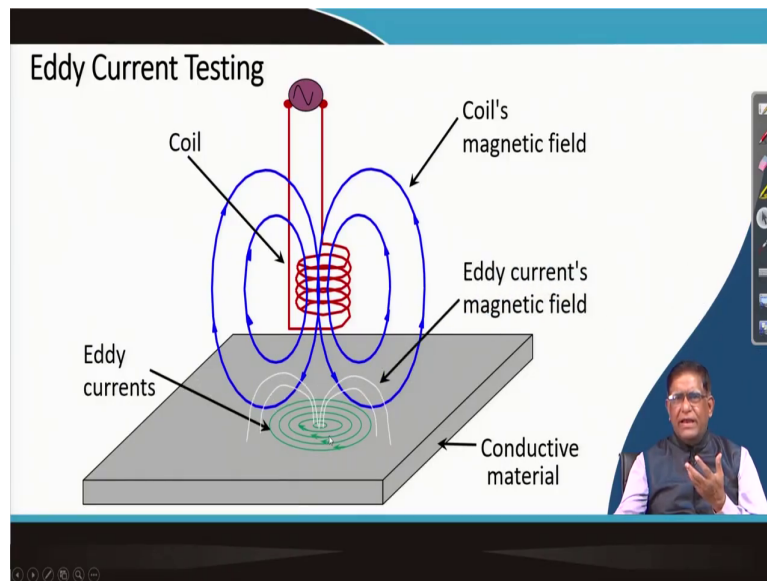
From that you can find out that you can take the X-ray of the film. If that your that X-ray is going through there is a crack or there is a gap something is there fault in the this member. Now, you are keeping one X-ray film below this your this when that your radio graphic rays are coming over there, it is coming on this X-ray film this wherever there is a this is this will not get exposure. So, from here you can find that there is a defect. So, this is the way how X-ray is used for nondestructive testing of some parts.

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So, there is this is a you take radio graphic images of different parts, how they are taking these are used for exactly when you do a systematic different components, their internal flaw if it is to be identified you will have to use this better otherwise you cannot depend on our only judgment without anything.

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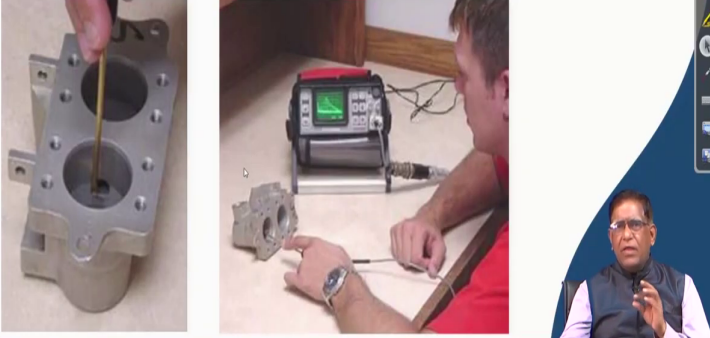


Similarly, there is another system of called your this eddy current which is formed now. If there is a magnetic conducting material and there if a this eddy current when it is formed by giving this you are giving a 2 coil magnetic field, now based on this conductive material if there is any fault over here that fault could be detected.

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Eddy Current Testing

Eddy current testing is particularly well suited for detecting surface cracks but can also be used to make electrical conductivity and coating thickness measurements. Here a small surface probe is scanned over the part surface in an attempt to detect a crack.



The image is a composite of three parts. The left part shows a close-up of a hand holding a thin, cylindrical probe over a metal casting with two circular holes. The middle part shows a person in a red shirt using a handheld eddy current testing device on a similar metal casting. A control unit with a green screen is on a stand in the background. The right part is a small inset video of a man in a dark vest and glasses speaking.

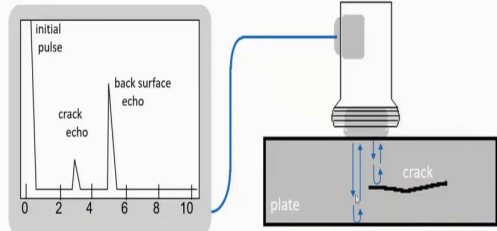
So, this eddy current testing of different components that is done by seeing the way the eddy current is formed, where it is formed, how it is formed on that basis they can identify the detection or the cracks which is there.

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Ultrasonic Inspection (Pulse-Echo)

High frequency sound waves are introduced into a material and they are reflected back from surfaces or flaws.

Reflected sound energy is displayed versus time, and inspector can visualize a cross section of the specimen showing the depth of features that reflect sound.



Oscilloscope, or flaw detector screen

The diagram illustrates the pulse-echo technique. A probe is positioned above a plate. A crack is shown within the plate. The probe sends an initial pulse into the plate. The pulse reflects off the crack, creating a 'crack echo'. The pulse continues to the back surface of the plate and reflects back, creating a 'back surface echo'. The time taken for the pulse to return from the crack is shorter than the time taken to return from the back surface. The oscilloscope screen shows these reflections as peaks on a graph of amplitude versus time.

Similarly, the other one is with your ultrasonic that is you vary high frequency sound wave acoustic waves are sent and then wherever there is a cracks are there it will be rating return. Now, when there is a from that crack; that means, the time to receive it will be here will be less. This principle can be used to find out if there is any fault in any member. So, this is your pulse eco technique of them.

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Automated Ultrasonic Testing (AUT)

- inspection of pipeline circumferential welds in lieu of radiography.
- corrosion detection on difficult to access structures

Phased Array Ultrasonic Testing (PAUT)

Phased Array Ultrasonic Testing (PAUT) is based on the same physics as the Conventional Ultrasound inspection. The differences are mainly the probe technology and configuration as well as the acquisition instrument electronics. A Phased Array probe typically consists of 16 to 128 individual elements and can be customized to include more or fewer elements. The elements can also be arranged in linear, matrix and annular patterns.

The slide also features a small image of a pipeline inspection and a video feed of a presenter in the bottom right corner.

And, there is automated ultrasonic testings these are, there are many methods out of that this is a phased array ultrasonic technique. They take a number of 16 to 128 individual elements can be customized to take this. It is a just a scanning you are doing with an acoustic scanning of the whole member and by that you can detect a corrosion, it can inspect the pipeline and that type of things can be done by this ultrasonic methods.

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Ultrasonic Imaging

High resolution images can be produced by plotting signal strength or time-of-flight using a computer-controlled scanning system.

The slide includes a photograph of a person operating an ultrasonic testing machine, a diagram of an ultrasonic probe emitting waves into a material, and a small video inset of a speaker. The slide also features navigation icons on the right and bottom edges.

Say this is how exactly the testing is done by with the help of these high resolution images and then we get that signal, and then from there you determine where is that. Now, you see the investment in such type of devices it is exactly sometimes it is a very judicious because if you do not identify the problem then it will be creating a problem.

It is something like your whether you are having a fire extinguisher in your house or not that normally the fire will not take place, but if it takes place it will destroy everything. So, similarly if you are that a part or member is working there, but you do not know whether the internally it has become weak or not.

Then if you do not detect at one day you may get totally lost all your things. So, that is why which are the critical item which that by your that knowing the machines that knowing the machine elements machine components you will have to identify from the that is your failure


behavior from your normal observations of the maintenance pattern need to identify which are the critical where this type of things will be there, because to bring each and every component it is not necessary.

Because this ultimately doing testings and all is a costly affair.

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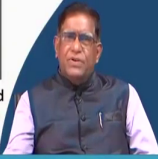
Ultrasonic Imaging

High resolution images can be produced by plotting signal strength or time-of-flight using a computer-controlled scanning system.



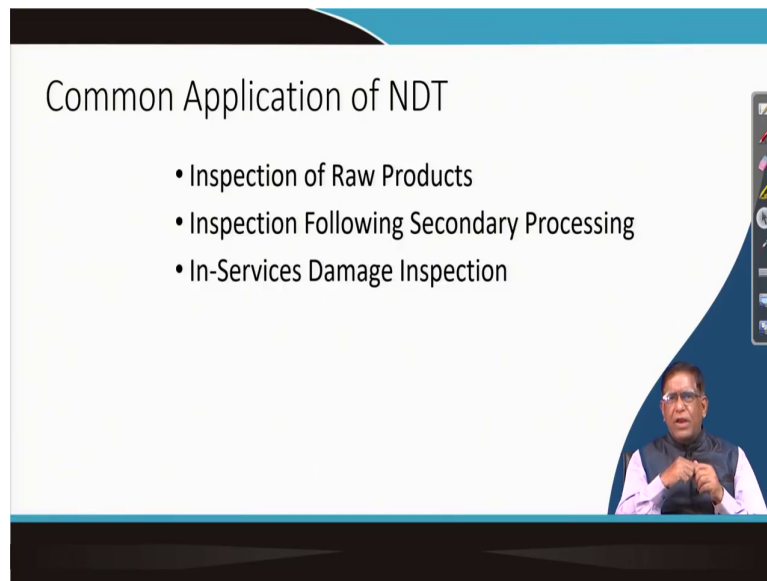
Gray scale image produced using the sound reflected from the front surface of the coin

Gray scale image produced using the sound reflected from the back surface of the coin (inspected from "heads" side)



So, high resolution image can be produced by plotting signal strength of time of light using computer control scanning system. That they scan the things over here and then if this you are getting a grayscale image that is by from sound wave and then you can find out that there is a some the back surface of this coin; that means, there is a some corrosions and erosions taking place.

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Common Application of NDT

- Inspection of Raw Products
- Inspection Following Secondary Processing
- In-Services Damage Inspection

So, like this you have got number of methods, but these NDT methods can be put into the raw product for the inspection of secondary processing, in-service damage inspections all these things can be done.

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Inspection of Raw Products

- Forgings,
- Castings,
- Extrusions,
- etc.



The slide features a collage of four images. The top-left image shows a glowing red cylindrical extrusion. The top-right image shows a worker in protective gear handling a glowing orange casting. The bottom-left image shows a large industrial casting machine. The bottom-right image shows a man in a white shirt and dark vest speaking.

Now, this is a you can see that how different it is applied at different places. Few slides I have collected from this I was nondestructive testing. From that you can see that the in the forging, in the casting, in extrusions. In the metallurgical plant and in manufacturing industry these are very much used.

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Inspection Following Secondary Processing

- Machining
- Welding
- Grinding
- Heat treating
- Plating
- etc.

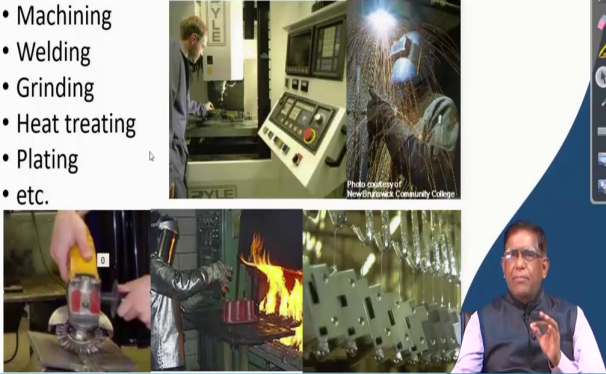


Photo courtesy of NewCollege Community College

So, in that machining, welding, grinding, heat treatment, plating these are also in your manufacturing process when you are making these machines and the components at that time at the time of after developing the component before putting it to assembly line, it should be tested that there is no flaw in it.

That is why in the manufacturing industry manufacturing sector this is very very important. In your mining, in your application sector they will be required only for dump specific then it will be added with the condition monitoring, condition based maintainace system within that we will have to bring.

So, as such all the techniques and all the things how they are used is not very important for us, but for condition monitoring of our very costly equipment where that the that parts which are not manufactured in our country and then which needs to be exactly if we want to venture

for manufacturing we need to know their exact behavior. There, some of these tests need to be carried out.

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Inspection For In-Service Damage

- Cracking
- Corrosion
- Erosion/Wear
- Heat Damage
- etc.

The slide features a grid of four images: a metal hook with a crack, a metal surface with corrosion, a metal pipe with erosion/wear, and a metal pipe with heat damage. A small inset video shows a man speaking.

So, that in service for in the mining industry also you will find that is a crack detections for your corrosion detections for your erosion and wear detections, heat damage those things need to be find out. You can see here that these are the your damage due to the erosion, corrosions.

Then wear has taken place may be that sometimes in your pump impeller where lot of cavitation pitting is there. So, those things exactly the you may not open up whole pump and all, but there you can use some nondestructive visual inspections by inserting probe or by other, by your acoustic applications. There are may be a different type of new principles can

be applied and you can identify if that is your critical component what type of nondestructive testings can be done.

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And, because if the things are not yet known, then exactly the problem is that you are maintaining unnecessary maintenance. One most important thing in using this condition monitoring or bringing nondestructive testing into our normal maintenance system is to avoid unnecessary replacement or unnecessary maintenance.

Many a times if you are sure you are 100 percent sure that there is no problem why should you open it up, why should you go for a maintenance work. So, one area which is of course, you can see here aerial rope way; we have discussed aerial rope way also how it is used for our sand transport for sand stain purposes.

Now, this wire rope is a device or is a is very widely used in mining industry tell whether it is in winding purposes, whether it is in your rock haulage or it is in drag line or in rope shovel then many places in mining you find this wire ropes. And, this wire ropes inspection there a nondestructive testings can be very easily designed.

Here is a winding rope this winder drum you can see where this rope is going there they have kept one that is your magnetic flaw detectors type of things. What they do? That is where they wherever there is any crack any break or anything of the wire around that a magnetic flux is created. So, this flux will be detected and from there you can know that in that particular point there is a wire. So, this type of electromagnetic devices and the visual inspections are used to find broken wires and other damages.

Because if you are creating if you are creating any magnetic flux, suppose you are having a you can create a keep a magnetic flux over here now if a wire is there in this wire if there is something is coming out, so, what will happen? It will create a current type of things and that flux generated will get.


And you can detect these things and then you can put it to that find out that yes, there is a problem. Same type of things can be used in your nondestructive testing without stopping the conveyor belt you can test if it is a steel cord belt. If the in a steel cord conveyor belt, if the upper surface is getting worn out and then the steel cord is getting exposed you need to do the maintenance of the belt, you need to do vulcanizing and things like that.

So, by getting the magnetic signal from that wire rope which is exposed from the conveyor belt you can find out and then you can plan the maintenance for the conveyor belt in a steel cord conveyor belt. So, this the that by the that this type of condition monitoring or that is your nondestructive testing can help you in other maintenance.

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Storage tank Inspection

Robotic crawlers use ultrasound to inspect the walls of large above ground tanks for signs of thinning due to corrosion.



Cameras on long articulating arms are used to inspect underground storage tanks for damage.

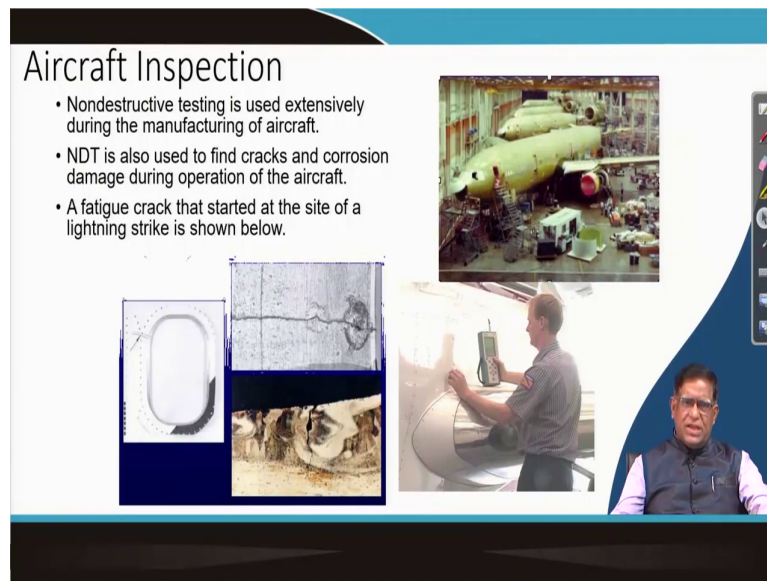


Similarly, you are in a storage tank. There also if you can go for nondestructive testing because you cannot take these things out of service, you can go on testing like this. Similarly, your that whenever you are using in a area which are very critical any failure may give raise to a major problem should be brought under nondestructive testings.

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Aircraft Inspection

- Nondestructive testing is used extensively during the manufacturing of aircraft.
- NDT is also used to find cracks and corrosion damage during operation of the aircraft.
- A fatigue crack that started at the site of a lightning strike is shown below.

The slide features several images illustrating aircraft inspection. At the top right, a large yellow aircraft fuselage is shown in a factory setting. Below this, on the left, are three smaller images: a white oval-shaped component, a close-up of a metal surface with a crack, and a close-up of a metal surface with corrosion. In the center, a man in a grey shirt is using a handheld device to inspect a large white cylindrical component. In the bottom right corner, there is a small inset video of a man in a dark vest and glasses speaking.

Many people do in that your they say, aircrafts this these things were exactly this nondestructive testings and all it were much of these development scheme in the aviation industry where they were very much safety conscious.

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Rail Inspection

Special cars are used to inspect thousands of miles of rail to find cracks that could lead to a derailment.



The slide features a collage of four images illustrating rail inspection. The top right image shows a yellow inspection car on a track. The bottom right image shows a control room with a person. The bottom left image shows a close-up of a rail joint. The middle left image shows a close-up of a rail with a crack.

So, then in the railway system also we can have some of these railway they say crack and other monitoring railway rail monitoring system which is also very much developed.

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Pipeline Inspection

NDT is used to inspect pipelines to prevent leaks that could damage the environment. Visual inspection, radiography and electromagnetic testing are some of the NDT methods used.





Photo Courtesy of Inuktun

Remote visual inspection using a robotic crawler.



Magnetic flux leakage inspection. This device, known as a pig, is pushed along the pipeline and collects data on the condition of the pipe as it is pushed along by whatever is being transported.





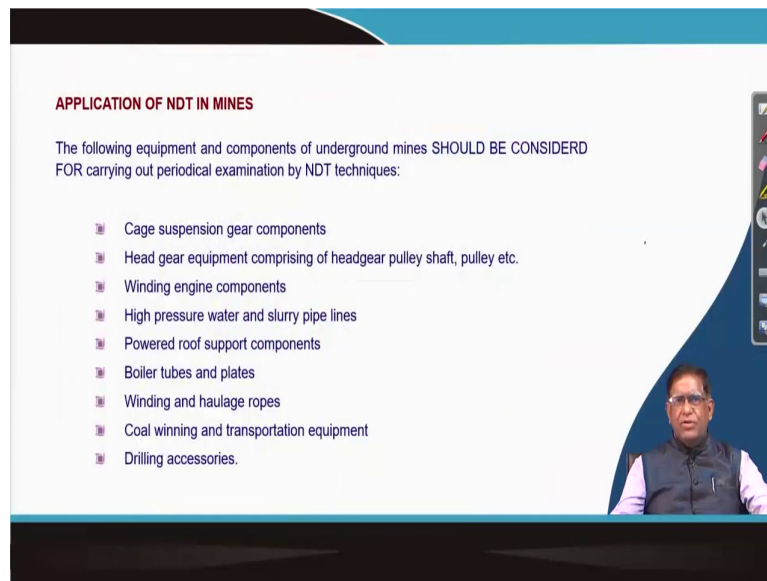
Photo Courtesy of Yxlon International

Radiography of weld joints.



Then this pipe inspection – this pipeline which are used for in many mining industry we are having slurry pipeline, in we are having also different type of pipeline is used in the mining industry their monitoring is also possible.

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APPLICATION OF NDT IN MINES

The following equipment and components of underground mines SHOULD BE CONSIDERED FOR carrying out periodical examination by NDT techniques:

- Cage suspension gear components
- Head gear equipment comprising of headgear pulley shaft, pulley etc.
- Winding engine components
- High pressure water and slurry pipe lines
- Powered roof support components
- Boiler tubes and plates
- Winding and haulage ropes
- Coal winning and transportation equipment
- Drilling accessories.

So, ultimately now you have got a general idea about what is nondestructive testing, what are the different type of nondestructive technique tools are there and then now, you can identify if you wish you can take up your own learning project in your BTech project or any other where you want to get a business in future.

May be the cage suspension gear components, how those things can be tested non destructively and we can see be sure that because in our mines in our industry there are many winder installations which are now more than 40 – 50 years old. So, those how to find out the remaining life.

For that you will have to do them and make some systematic testing. So, in that there is a possibility that some company in India will be doing that assessment of the remaining life of

those installations and to assess the remaining life you will have to do a lot of nondestructive testing.

Now, head gear equipment that is your comprising of the head gear pulley shaft that in a winder you have seen that structure as well as there is a pulley; pulley is mounted on a shaft, shaft is mounted on a bearing their conditions can be tested. Even that your winding engines, they have got their component gearbox, their breaks that all that can be tested then powered roof support. In the underground mine that roof supports are also that is a very very important things.

If they fail that whole gallery can collapse and exactly sometimes that to identify that how much load with the load how it is behaving. It is periodically should be tested because in India also it happened a long wall whole gallery it collapsed because the power supports which were that lakes were designed for the type of load exactly that in situ load was much more. So, that definitely before it finally collapse there were definitely an indications that they are internally becoming that is stressed.

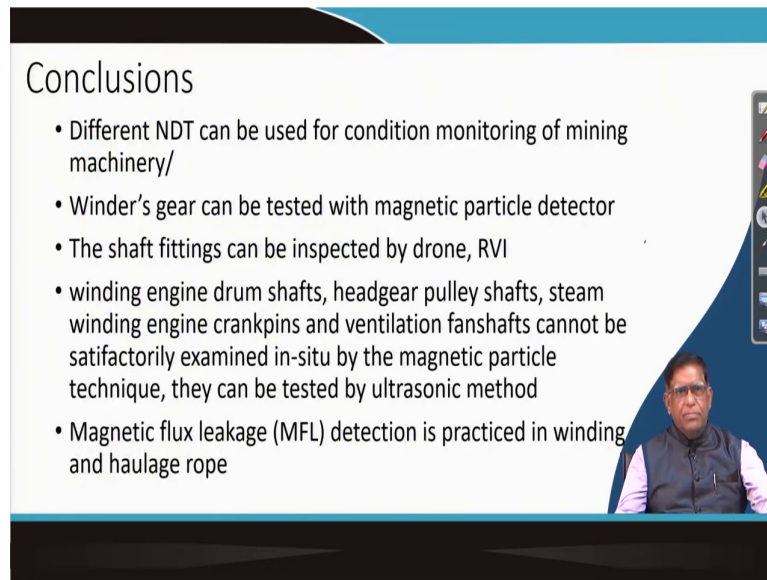
So, those type of testings were not there now exactly it should be brought under some testing like that. Similarly, the that is your boiler tubes and plates wherever we are having any steam powered boilers in the boiler testing also it can be done. But, nowadays in the mines very few boilers are still there, but that is all almost everywhere we are not using boiler here, they are early in the thermal power stations. Then winding and haulage ropes these are very much used; then the coal winning.

And transportation equipment like I told you conveyor belt, rope haulage, then this your in the machines like your the shovel, drag line the everywhere bucket wheel excavator all these machines also has got this wire rope. Then in the drilling also sometimes this you are having a exploratory drilling.

Many times you use this rope for the drill strings and there is also in the wire line rope in a drilling also in the drilling assembly number of components how they are exist sub they say

or their testing is very very essential. So, in that way that some the nondestructive testing also could be done in some of the cutting tools that in the bucket teeth and others.

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The image shows a presentation slide with a white background and a blue header. The title 'Conclusions' is in a large, black, sans-serif font. Below the title is a bulleted list of six items. In the bottom right corner of the slide, there is a small video inset showing a man with glasses and a dark vest over a light-colored shirt. The slide is framed by a dark blue border.

Conclusions

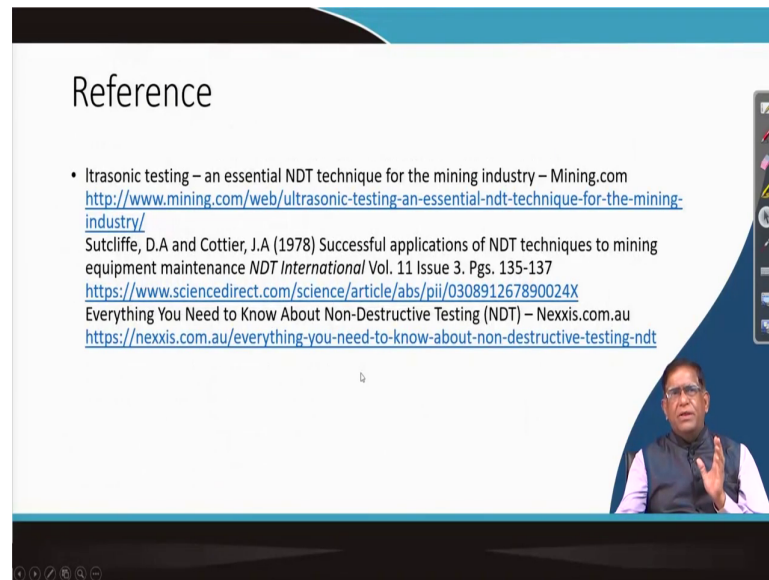
- Different NDT can be used for condition monitoring of mining machinery/
- Winder's gear can be tested with magnetic particle detector
- The shaft fittings can be inspected by drone, RVI
- winding engine drum shafts, headgear pulley shafts, steam winding engine crankpins and ventilation fanshafts cannot be satisfactorily examined in-situ by the magnetic particle technique, they can be tested by ultrasonic method
- Magnetic flux leakage (MFL) detection is practiced in winding and haulage rope

So, to coming a conclusions that different NDT can be used for condition monitoring of mining machinery. So, that is where we need to exactly focus, then winder gear can be tested with magnetic particle detector, the shaft fittings can be inspected by drone, remote visual inspection.

Then winding engine drum shafts, head gear, pulley shaft that stream winding engine crankpins, ventilation fan shaft this cannot be satisfactorily examined in-situ by magnetic particle technique and they should be done by ultrasonic method. So, those type of devices need to be found out. If one method is not usable other method can be done that magnetic

flux leakage this can be done for the winding and haulage ropes we can test it. So, there are different way it could be used.

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Reference

- Ultrasonic testing – an essential NDT technique for the mining industry – Mining.com
<http://www.mining.com/web/ultrasonic-testing-an-essential-ndt-technique-for-the-mining-industry/>
- Sutcliffe, D.A and Cottier, J.A (1978) Successful applications of NDT techniques to mining equipment maintenance *NDT International* Vol. 11 Issue 3. Pgs. 135-137
<https://www.sciencedirect.com/science/article/abs/pii/030891267890024X>
- Everything You Need to Know About Non-Destructive Testing (NDT) – Nexxis.com.au
<https://nexxis.com.au/everything-you-need-to-know-about-non-destructive-testing-ndt>

The slide also features a small video inset in the bottom right corner showing a man in a white shirt and dark vest speaking, and a vertical toolbar on the right side of the slide.

So, please go through various these literatures. Particularly, we will find interesting that when it first developed during the 80s and early 90s lot of innovations were made in this field and today, there is a majority in this industry of nondestructive testing. And, they simultaneously a lot of condition monitoring has been improved.

We have not touched upon the condition monitoring and in maintenance how vibration signature that is the equipment component signature is analyzed and then on that basis how you can predict failure those things are there. So, my dear friends you have learned about mining machinery.

And it is from the very basic mechanical engineering to the maintenance level. The everything is put in a very this is too much to learn in one semester. However, I hope now you have got a general interest that is necessary to become a professional in the mining industry.

So, I hope you have got a general outlook about this subject. This if you are interested to carry out any further studies on this, you are welcome to contact and also as I said earlier I will be having a module that free sites where you can yourself also get in contact with me from wherever you are.

And, then if any further study you want to carry out, you want to develop some entrepreneurship, if you want to do any new innovative exercise on it all these matters can be discussed with different your peer group through that module site. If you are there if for any further informations you can contact me.

So, I thank you very much for undertaking this course and I wish you all the best in your next endeavor and I hope that you will be serving the mining industry with a proper objectives that we need to get the benefit out of our deployed machinery and whenever necessary we should be able to prescribe that what new machines are needed in the mining industry, whatever is there it may not be sufficient for tomorrow. So, that innovations, that creativity we expect from you.

Thank you very much.