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NPTEL ONLINE COURSE

NPTEL Online Certification Course (NOC)

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Theory and Practice of Non Destructive Testing

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Hello, my name is Ranjit Bauri. I am from the department of metallurgical and materials engineering at IIT Madras. Today, we are going to start this NPTEL course on theory and practice of nondestructive testing, which is being offered under NPTEL online certification course or NOC.

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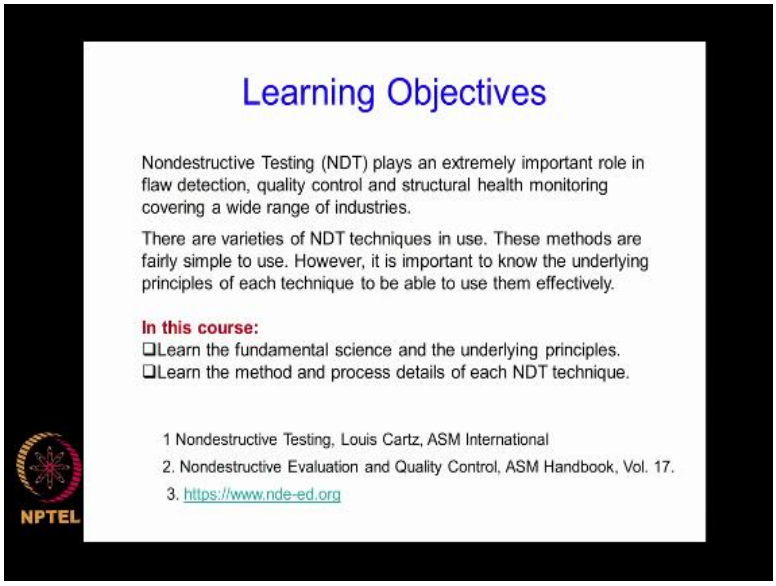

So before I start the course let me first tell you what are the main learning objectives for this course. As you may know nondestructive testing plays an extremely important role in flaw

detection, quality control and structural health monitoring in engineering components and system across a wide range of industries. There are varieties of NDT techniques which are in use, this methods are as such fairly simple to use.

However, it is important to know the underlying principles of each of the techniques to be able to use them effectively. So if you are practicing engineer or a NDT professional or looking to be one, then knowing the basic principle apart from the method will surely give you an advantage, because if you know the underlying principle behind a particular NDT method, then you will know exactly what is going on inside, when the test is being done.

So that is why one of the main learning objectives of this particular course on NDT is to learn the fundamental basic principle behind each of the NDT methods that we are going to cover. So that you develop an understanding about the science and underlying principles which govern a particular entity method, so that is the first objective. And the other objective of course is to know about the method, learn about the method, as to how the method is done, what process is followed, what are the process parameters and so on.

So these are the two primary learning objective one is to first learn the basic principle and then to learn about the method and the process details. So this is how we will go about this particular course. And as you could see these are the two books which are listed over here that I recommend for you to follow. Most of the topics that we are going to cover in this course will be available in these two books.

The first one is on nondestructive testing by Louis Cartz, which is published by ASM International. And the second one is ASM handbook, volume number 17, which is on nondestructive evaluation and quality control. So ASM handbook, volume number 17, is totally dedicated to NDT, so you can follow that book also for most of the topics that we are going to cover. And the third one that you have over here this is an online resource, this www.nde-ed.org, this also has a lot of information about the NDT methods.

So these are the three references that I recommend you to follow for this particular course. So that is about learning objective. At this point in time, I should also tell you that if you have any doubt for any of the topics that we are going to cover in this particular course, you can always come back to us, please feel free to ask whatever doubt you have no matters whether it is a small doubt or a big doubt. You please feel free to ask and clear your doubts, clarify your doubts.

So you can either use the discussion forum that we have for every course or if you wish you can write back to me also. I will be happy to answer all the questions.

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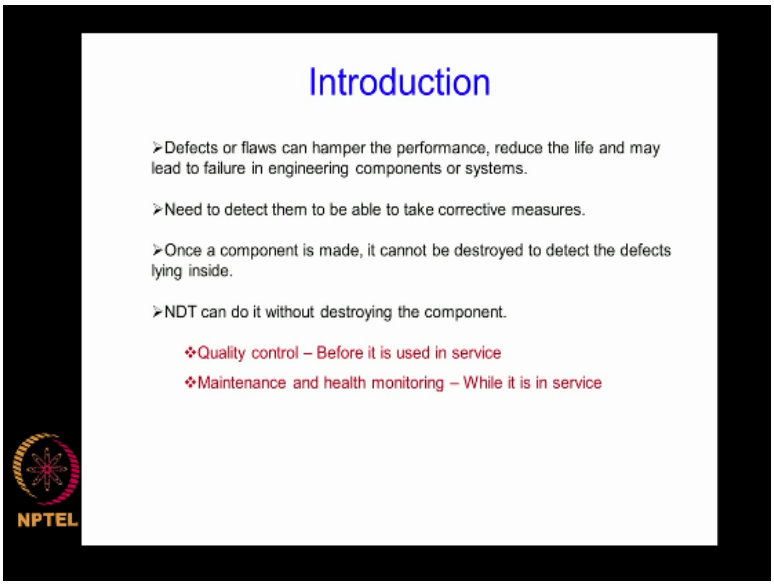

So let us start, so to begin with, I want to just give you a small introduction about nondestructive testing before we actually begin the course and the methods. Defects and flaws, can be present inside the component or an engineering system. And, if they are not addressed, they can hamper the performance of a particular component or an engineering system, the defects can also reduce the life of the component and make them lead to failure, if they are not detected and addressed.

So, it is important to detect these defects to be able to take collective measure so that the performance of the system is not hampered. And you do not end up with the failure in an

engineering system. But the thing is, if once a component is made, you cannot destroy it, you cannot break it again to see if there is a defect inside it. So that is where the NDT methods come into picture, wherein you can detect the defect, you can detect the flaw without destroying the component.

So there are two primary objectives of doing NDT, as you could see, which is listed over here, in the first slide. One, as I told, is to ensure that when you release a component to the market, to the end user, you need to ensure that the component is free of defects and flaws, otherwise the performance of the component will be seriously affected. So, that is before the component is used. So that is one aspect which is about quality control of a particular component or a particular product. Now, when this component is being used in a particular system, there are possibilities that some kind of flaws or defect can develop during service.

So, there again you need to ensure that this defects and flaws are detected, so that the performance of the system is not affected, but there again, you cannot destroy or cannot disturb the system or the component to know that if there is a defect or not. So, there again, for the maintenance part of it, when you are monitoring the health of a particular component or of a particular system or structure you have to do it without destroying or without disturbing the system.

So, there again NDT methods come into picture. Wherein during in service condition you would be able to check and detect if there is any flaw or any damage which is developed in the system, which may affect either the performance or life of the system. So, this is the second objective that is to do maintenance and do health monitoring of a given system or competent when it is in use. So, these are the two primary objectives of doing NDT.

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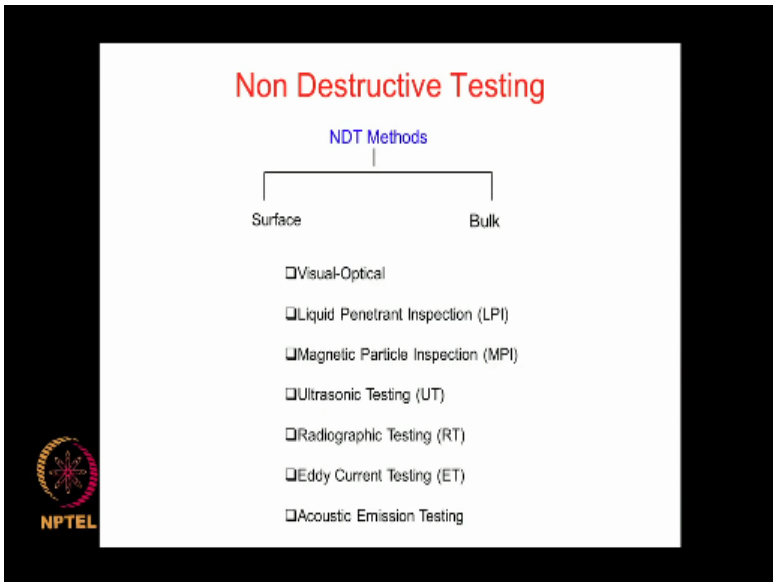

So, having said that now if you come to actual NDT methods, we are going to cover all the commonly used NDT techniques and what we are going to do in this course; first, we will cover the basic principle behind a particular NDT method. So, all the methods are listed over here as you could see. So, we will pick one at a time and then first cover the basic principle behind that particular method and then learn about the method itself, as to how it is done, what process is followed and what are the process parameters and process details. So, these are methods which will be covered in this particular course during next 8 weeks or so.

So, now if you talk about the methods and their classification, NDT methods can be broadly classified into two categories; one is surface NDT and the other is bulk NDT. So, this depends on whether the defect or the flaw, whether it is located on the surface or it is located inside the bulk or volume of the component or the material which is been tested. So, if you know beforehand that most of your defects are going to be limited on the surface, then you need to select a surface NDT method. Similarly, if you know that the defects are going to be inside the material below the surface then you select the bulk or volume NDT method.

So, the different methods which are listed over here some of them will fall under the first category of surface NDT and some of them will fall under the second category. So, liquid

penetrant inspection or LPI, magnetic particle inspection and Eddy current testing, so these are the methods which will fall under the first category that is surface NDT method.

On the other hand techniques like ultrasonic testing, radiographic testing, acoustic emission testing, will all fall under the second category, which is bulk or volume NDT and there some techniques like, for example, the ultrasonic testing, which can do both; it can do surface NDT as well as it can also be used for bulk or volume NDT. So, these are all other techniques that will be covered in this particular course.

And as I said, there will be two aspects; one, the basic fundamental principle behind each of these technique and the second aspect would be to cover the method and learn about the method in more details. Now, if you see on the top of the list, there is something called visual optical, this is coming in the list because before you do any NDT, before you use any NDT technique to detect flaws, what you first do, you try and see visually, on the external surface of a component of your part, if something is visible to the naked eye.

Sometime, you may also want to take help of some kind of visual or optical aides, which will help you out to visualize, of course externally, on the surface, if there is any damage or defect that you can easily detect and see, so that is why this is coming in this list also or although it is not really in strict sense a NDT method. But as I said that is the first thing which people will do to see, if any flaws are visible externally. So, we will start with the visual optical method first and then we will go on to the other NDT methods, one by one, as I said and then cover them in more detail. So, I will project the first slide right now.

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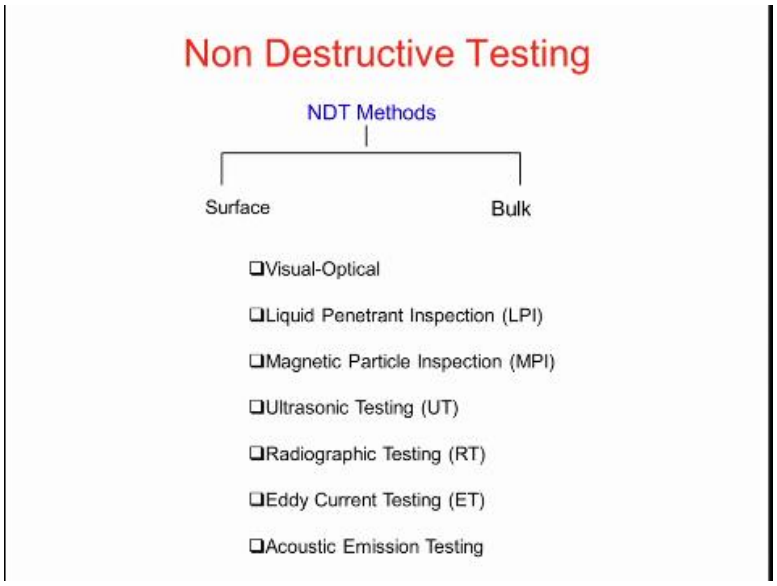

To start with the visual optical method.

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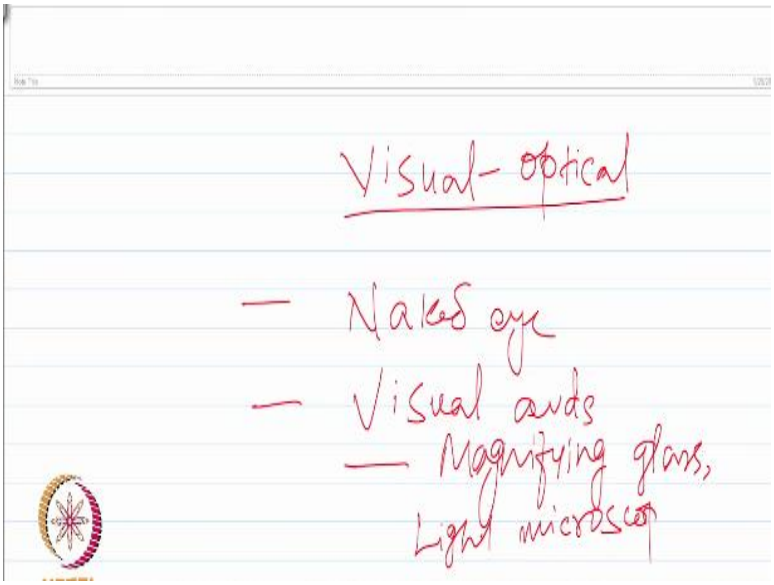

As I said, the first topic of this series of lectures will be on this visual optical method, that means as I said, you try and see externally on the surface of the component or of a part, if you could see something visually. So, you could simply take that part or take the component and see it in a well

illuminated area on different portions, all the areas and then see first of all, whether you can see something by naked eye.

If you do not see anything by naked eye, then you can take the help of some visual aids, for example, you can use a magnifying glass, which will enhance the visibility of the surface of the component and then see using a magnifying glass, if something is visible extremely on the surface of the component or not. If it is a smaller component which can be put under a light microscope, then you can take that component, put it under a light microscope and then you can observe it through the microscope with some bit of magnification, which will help you out again to visualize and see if any damage or any defect is visible on the surface. So, this is what you could see. You could try and see with naked eye, or you could use some visual aids, which could be a magnifying glass, a light microscope and things like that, which will enhance the visibilities of the surface of the component and help you out in visualizing any external defect or any external damage.

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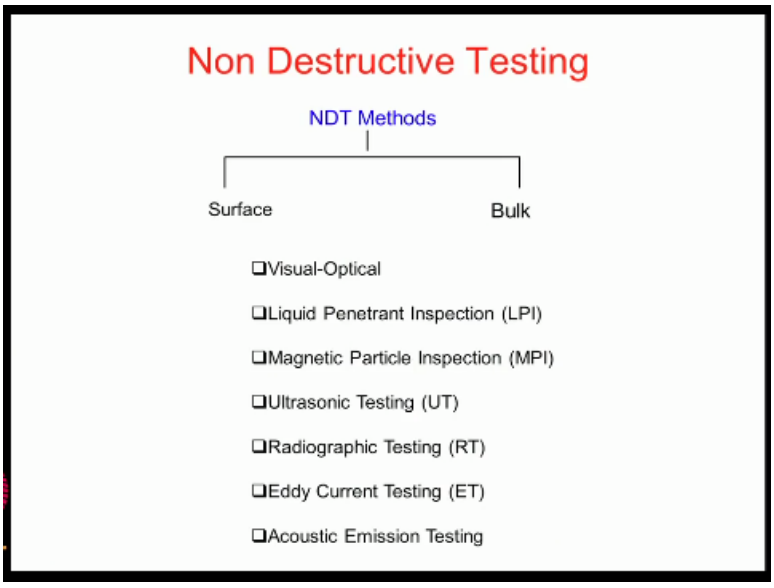

Coming back to this, when you are doing visual inspection there could be cases, wherein your physical access to the area that you want to examine is limited or the visibilities is limited. So, if

there are issues with the physical access or visibility, for example if you want to inspect the inner diameter of the bolt hole, then inside the bolt hole you cannot really see and you cannot really physically access it, as an examiner.

So, in such scenario, wherein you have limited physical access or limited visibility, then you have to use some other device, for example this one, which will again help you out in visualizing the area that you are trying to examine.

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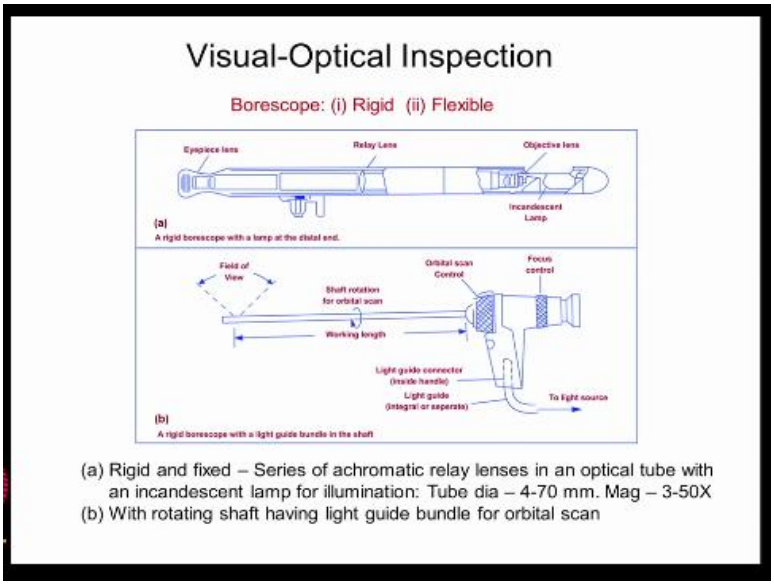

So, in cases like these kind of bore hole or bolt hole where you need to go inside and inspect the diameter, this particular device, which is known as Bore scope is very useful. So, let us talk about this in little more detail as to what it is and how it is used to inspect visually. Parts where you do not have direct physical access or where visibility is limited.

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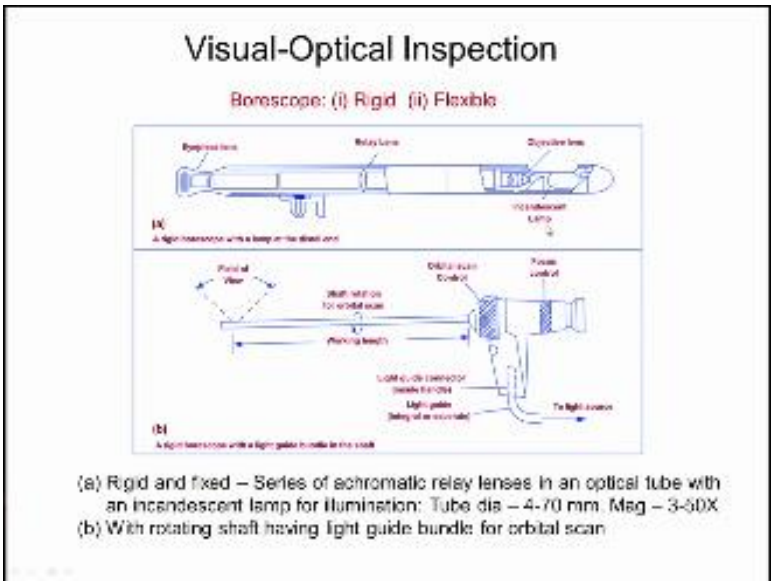

So, this is nothing but a tube, the diameter of which will depend on the diameter of the part or the diameter of the area that you are trying to inspect, so there is a range for example, as you could see from this. There is a range from 4 to 70 mm. So, depending on what is your part diameter, you could select a particular tube of a given size. So, this is primarily a tube and it has two ends as you could see, this one and the other one.

So this end, which is also known as the distal end will go inside the area which will be examined. So, this end should also have a light source, for example, in this case as we could see there is an incandescent lamp, which will illuminate the area which is being examined and then it will enhance the visibility, right. And in this end, you can see that there is an objective lens also, which will form the image of the area that you are trying to examine.

And then inside the tube, we can see, there is a series of achromatic relay lenses, so this lenses will help you focus the light on the area to image it and then this image will be send back to this eye piece, which is at the other hand. So one end which is going inside the part, this distal end will have the light source to illuminate the area and will also have the objective lens to form the image and then on the other hand, on the other side, you have an eye piece, over here, through which you see this image of the area and then inspect it. Try and see if you could see some external damage, some surface defect and things like that.

And this eye piece can be interchangeable so that you would be able to provide some magnification also to certain extend, for example, in the range of 3 to 50x, so through that eye piece you should be able to also magnify that will again enhance the visibility of the area and help you out in visualizing damage or defects on the external surface. So, in terms of the flexibility or the rigidity of this tube, there are two categories in this, there are two categories of Borescope; the first one is rigid.

So, as the name suggest in this case, it is a solid tube and it is fixed. You cannot bend it or you cannot move it. So it is a fixed solid tube and that is why this is called a rigid system. But in the rigid category itself, we could have two short of categories; one is completely rigid, which is the first one, which just now I described. And in the second one, in order to broaden up the field of view, you could also have, on the tube, which goes inside the area being examined, we can provide some movement like some rotational movement.

So, you could have a shaft, which is basically the tube that contains the light guide bundles, in order to form the image, but this tube can also rotate. So, there is a rotating shaft in this case to give you a kind of orbital scan around the area which is being examined. So, as you could see from this end; so this is the end which is going inside the area being examined and this light guide bundle, which is inside the shaft, because of this rotational motion, this will provide you an orbital scan and that will in turn enhance the field of view.

So, that is the advantage you have in this case over this fixed one, wherein you do not have any movement at all. So in this case, we have a rotating shaft and that will improve or broaden up the field of view.

So, there are two parts; one is this tube, which goes inside the area being examined and this primarily contains light guide bundle to illuminate the area and also to form the image. So, this will be connected to a light source and on the other hand, you have an eye piece connected and there is some mechanical attachment over here, through which you would be able to control this

rotation or the orbital scan. So, there is a control unit, small control unit over here, which will control the rotational motion of this rotating shaft.

And then at this end you have that eye piece through which you see the image, which is formed at this end and then try and analyze, if you could see something, some visual defects or some visual damage on the external surface of the part. So, this is about the rigid kind of Borescope.

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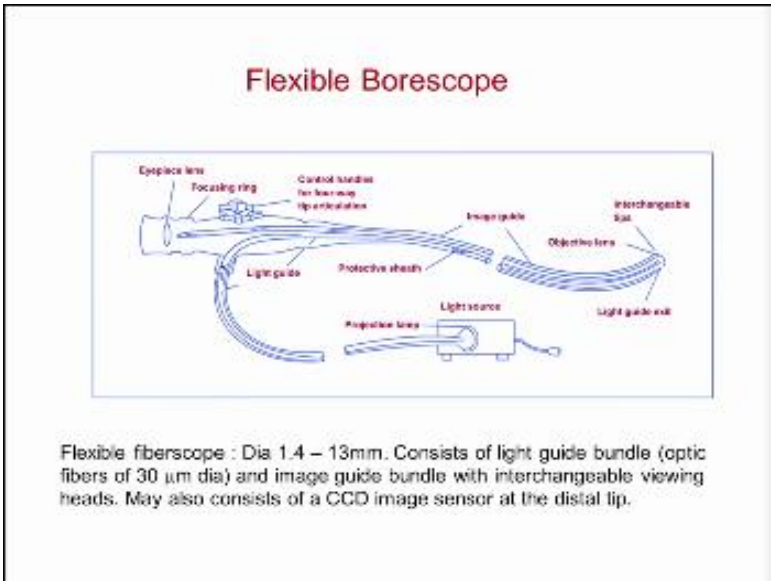

But there may be cases wherein you need to have more flexibility, in the sense, you may have to go around inside the area which is being examined. So, in those cases this kind of rigid system will have some limitations, some difficulty because you need to move around here and there around the examining area. So, to overcome this difficulty, there is another system which is flexible Borescope, as you could see this tube that you have in this case, this is the flexible one. So, you can band it easily.

So that we can move around and go around and you will be able to cover different areas and go in different angles and so on. So, this flexibility of the tube will help you out in moving around

and going around and then cover a broader area. So that is our purpose here, to give you more flexibility, when you are examining a particular area, where you do not have physical access.

So, let us see what are the different parts of this. Here again, the basic function is same, you need to form an image at this end, which goes inside the area which is being examined and this image is being transferred to the other end, where you have this eye piece lens, through which you see the area, the image of the area and then analyze. Try and see if you could see some damage or defect.

So the basic function is same but the different parts could be different. So, in this case, there are basically two light guide bundles; one is to form the image and to carry the light to the area being examined to illuminate it and also to form the image. And there is one more light guide bundle, which is known as the image guide. So, both of these are made of optical fibers, thin optical fibers, which are of the size of around 30mm in diameter.

So with the help of this image guide bundle and light guide bundle, which is made of optic fibers you would be able to form the image first. So, this will be connected to a light source as I said to carry the light all the way to this end to illuminate the area and then form the image and then once the image is formed at this end and here again you could see you have objective lens to form the image. And once the image is formed, this will be transferred through this image guide bundle to the eye piece and then you will be able to see it and analyze it.

This will give you one more possibility of connecting a CCD image sensor at this end, instead of an objective lens, so that you will be able to capture digital images. So, if you have a digital camera and if you connect this CCD sensor at this end and the other end then you can have a digital camera and capture digital images. So this is the other advantage of this particular devise which is flexible apart from the flexibility, it also provides you an opportunity to store the images, so that if you want, you can analyze them later on also, oaky.
So the advantages here are more flexibility, broader coverage and if you want, you can store and save the images and you can analyze them as and when you want.

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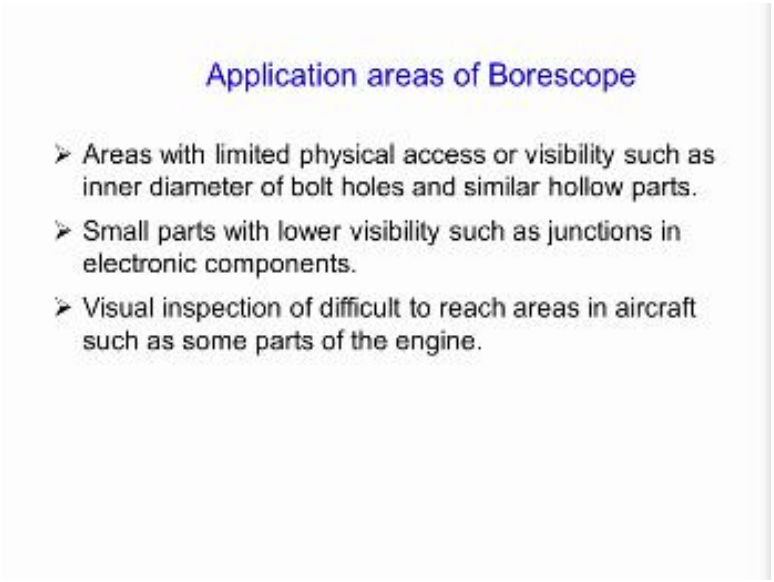

Then finally let us see, what are the different application areas of this kind of devices, of borescopes.

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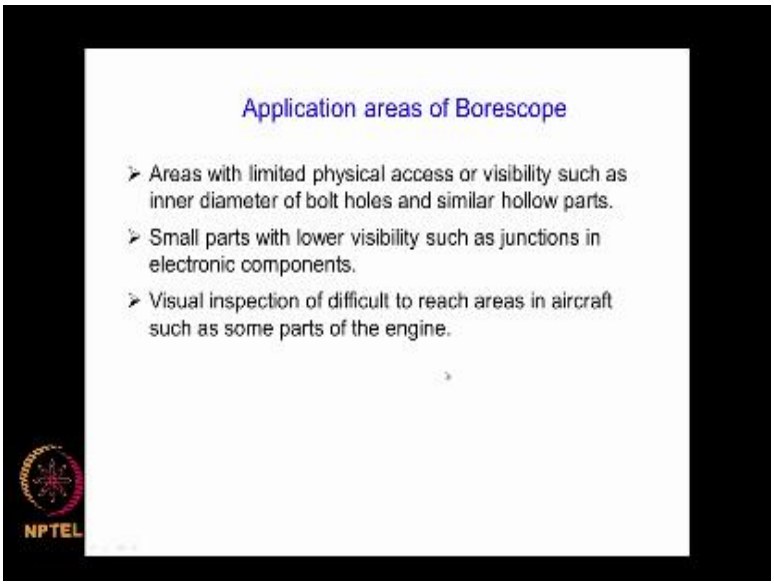

So as I said in the beginning, this is particularly useful in areas where we have limited physical access or you have limited visibility, such as inner diameter of bolt holes or similar hollow parts. So, in this kind of areas, where you need to go inside a hole or inside a bore, you can use this Borescope to help out in analyzing the inner surface.

If you have parts which are very small, for example, junctions in electronics components, you have problem in the visibility, so in this case the visibility is limited. So, here again the Borescope can be used. You can illuminate the area first and then you can capture an image, magnify a bit, so it will enhance the visibility and you will be able to see the junctions and the smaller parts like that and you would be able to see if there are any external damage or not. And finally it can also be used for visual inspection of difficult to reach areas in bigger systems or bigger structures. For example, in aircrafts, in parts such as some parts of the engine, if you go to the inner areas of the engine, where the examiner really does not have physical access, direct physical access. So, in those areas again, this Borescope are quite useful wherein you can take that and you can, put that inside a hole or things like that where you do not have physical access and then capture the image and analyze it.

Having said that all these are fine, you can do it using some kind of visual or optical aid or using a Borescope but this is limited to certain extent of inspection. In the sense, you would only be

able to see the surface and you would be able to see, if there is an external damage or not, right at the top of the surface. So, this kind of inspection, this visual optical inspection, is only limited to examining the external damage on the surface, if it is visible by naked eye or with the help of some kind of visual aid or some kind of optical devices like a Borescope or things like that.

So you cannot beyond that means if you have something underneath, if you have something below the surface or in the bulk of the component, the bulk of the material, which is not visible to the naked eye, then this particular technique cannot be used. As I told you in the beginning that is why probably, we are not listing this in a strict sense, as a NDT method because if something is not visible externally on the surface, this particular method cannot be used. This is only for examining the external damages and things like that, which may be either visible to the naked eye or visible to human eye with the aid of some kind of optical or visual devises.

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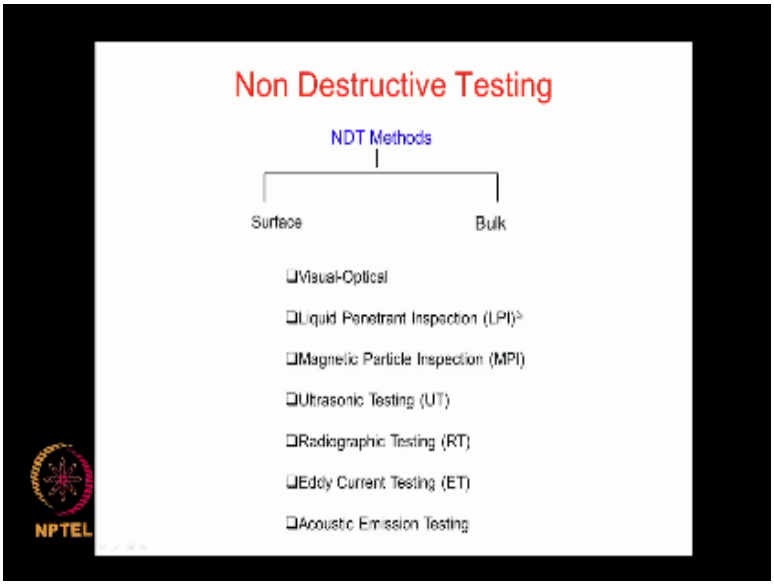

So if you want to examine which is lying beneath, you need to come back to these NDT methods, that is where lies the utility of the NDT methods, where you can apply a particular NDT method to visualize and get visible indication of deflects and flaws which are not visible to the naked eye. So, that's the purpose of this particular course to see how exactly a particular

NDT method is applied to make visible indications of defects and flaws, which are either on the surface, sub surface, or into the bulk of the material.

So this class was for the visual optical method. So, I will stop here today. From next class onwards, what we are going to do, pick up these NDT techniques, one at a time and then as I said in the beginning, first, we will cover the basic principle behind the technique and then we will see, about the method, as to how the method is done, what is the process and the process details. So, that we are going to start from next class onwards. So, today I will stop here. Thank you for your attention.

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