Inspection and Quality Control in Manufacturing
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Lecture – 06
Non-Destructive Inspection – Visual Inspection

Hello my friends, now we are going to discuss about new lecture on non-destructive inspections. Through this lecture you can understand their, there are so many various types of non-destruction inspections generally we are using for testing the different material characteristic. So, by this particular lecture we are going to discuss about the visual inspections.

So, now first let us know that what is nondestructive inspection? So, Non-destructive inspections from the name itself you can understand that basically we are not destroying the materials, that means we are not hampering the materials neither we are giving any load, pressure, or anything or may be any touch to that particular materials. Just from the outside we are getting the information about that particular materials.

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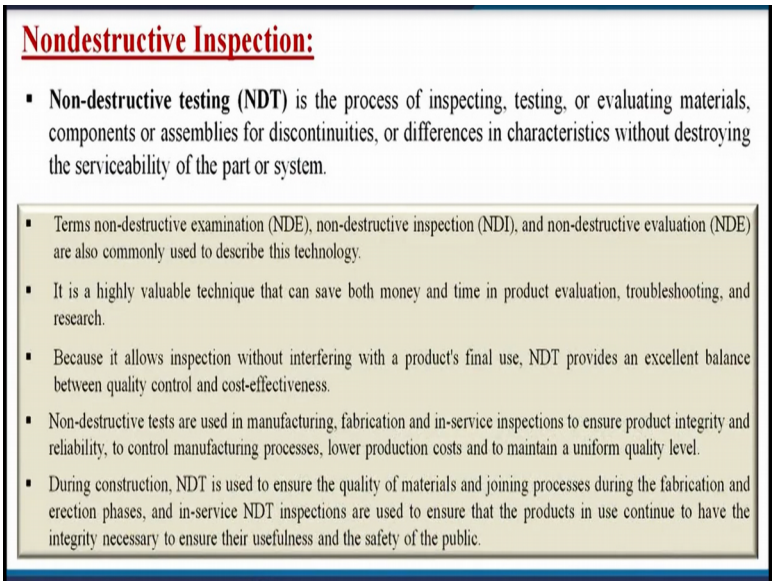

By definition, generally, nondestructive inspections is the process of inspecting, testing or evaluating materials, components or assemblies for discontinuities or differences in characteristic without destroying the serviceability of the part or system. So, this the main factor over there. Now, terms non-destructive examinations in short, we are generally calling it as NDE, or may be sometimes we are calling it as NDI that is the non-destructive

inspection and non-destructive evaluation NDE are also commonly used to describe this particular technology.

It is highly valuable technique that can save both money and time in product evaluation, troubleshooting, and research. Yes, of course, sometime it may happen that we are using particular material, so at the mid-point of that particular materials, we can take it out and we can check it, whether any cracks or anything has been occurred to that particular material or not and then again, we can put that particular materials for reusing it. Also, it allows inspection without interfering with a products final use, NDT provides an excellent balance between quality control and the cost-effectiveness.

Sometimes it may happen that ahh fa as an ahh may be the user or may be the operator sometimes I am thinking that may be this material can fill may be after certain time or may be really it has got some kind of damage. So, at the middle of the operation just we can take that particular sample or maybe that equipment or maybe the materials or may be the parts we can check it and then if we do not find anything over there or may be any severe damage over there so later again, we can put that particular materials and we can use it for certain time.

So, by this way we can save the money and also, we can save the time. Because, if the machine will failure, after certain time so automatically either we have to replace that particular part or maybe it needs some time to bring that particular parts. So, by these ways we can save the time as well as the cost. Non-destructive test are used in manufacturing, fabrication and in-service inspections to ensure product integrity and reliability, to control manufacturing processes, lower production costs and to maintain a uniform quality level.

So not only that when you are using that particular materials, we are doing this kind of testing. No. at the time of preparing that particular materials also when we are doing some batch production in between that productions also we can test this particular testing. During construction, NDT is used to ensure the quality of materials and joining processes during the fabrication and erection phases, and in-service NDT inspections are used to ensure that the products in use continue to have the integrity necessary to ensure their usefulness and the safety of the public.

Yes, of course, some times it may happen that if the material will fell in between maybe it can damage the other parts or maybe it can damage the operator. So, it is better means or rather I can say it is quite advisable that in between this operation we should do this kind of testing frequently, so that we can minimize the cost we can increase the productivity time as well as the we can sometimes save the human life.

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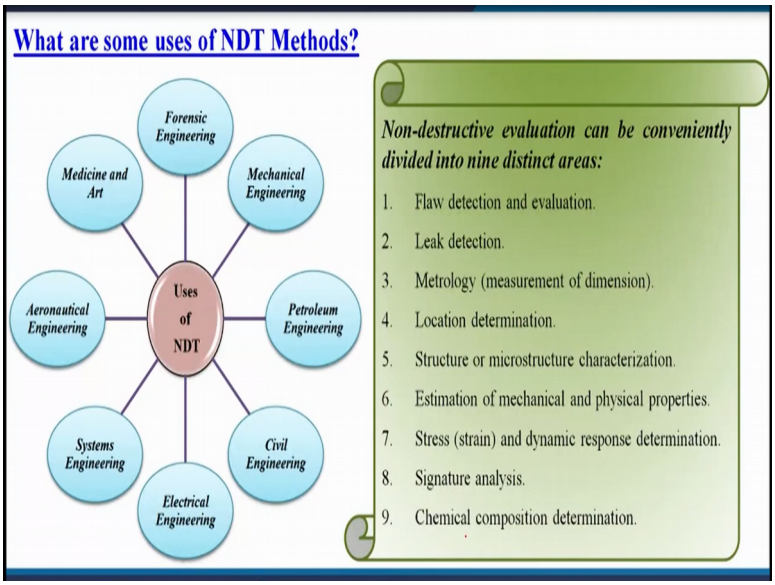

Now, what are the use of this kind of NDT methods? So generally, use of NDT, we are doing for the medicine and art, forensic engineering, mechanical engineering, petroleum engineering, civil engineering, electrical engineering, systems engineering, and of course the aeronautical engineering.

Now, generally this evolution can be conveniently divided into nine distinct areas. Okay. So, first it that Flaw detection and evaluation so whether while doing this operation or maybe while doing any kind of operation whether in between that if there is any flaw or maybe there is some error easily, we can detect. Leak detections suppose we are sending some kind of gas or maybe the fluids or maybe the, some kind of liquids through a pipe so easily we can detect that whether any leakage is there inside it or not.

Next is the metrology that measurement of dimension, say suppose I am using certain material for certain applications so after certain time I can check that whether there is any due to the friction due to the heat the material shape and size has been changed or not. The best example is the bearing generally we can do it. Then next one is the location determination,

structure or microstructure characterization sometimes it may happen we are using certain kind of materials where the heat generation is more.

So, due to that heat generations whether the any kind of heat treatment, the kind of things is going on to this particular material or maybe the material is its own properties that kind of testing we can do. Then estimation of mechanical and physical properties, stress strain or maybe the dynamic response determinations we can do, we can do some kind of signature analysis and last one is the chemical composition determination.

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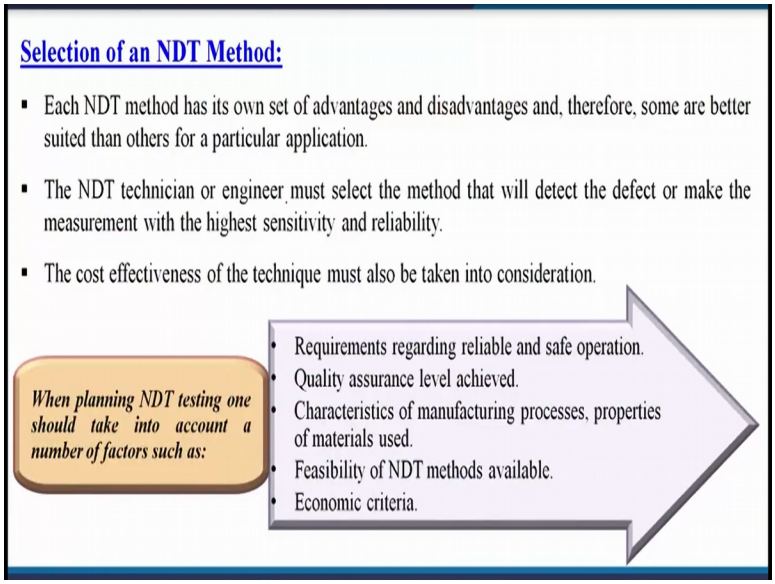

Now, how to select. That which method or may be the which technique is best for this particular testing. Because they have, I have told already there are n number of testing. But it is not possible that every time to do all testing for a particular material. So, depends upon the applications, it depends upon the material properties, it depends upon the which kind of materials to or you are going to use or may be where you are going to use.

So basically, each NDT methods has its own set of advantages and disadvantages and therefore some are better suited than other for a particular application. The NDT technique or engineer must select the method that will detect the defect or make the measurement with the highest sensitivity and reliability. Yes, of courses, say suppose testing a particular material of measuring the shape and size, there are may be 2 or 3 different types of methods are there.

But as an engineer or maybe as an expertise only we are the best judge that which method we have to follow so that I can get the 100 percent error free result. The cost effectiveness of the

technique must also be taken into consideration. So, when planning for the NDT testing one should take into account a number of factors what are those first is that, requirements regarding reliable and safe operation, second quality assurance level achieved.

Third one is the characteristics of manufacturing processes, properties of material used, fourth one is the feasibility of NDT methods available and the last one is the economic criteria. So, these are all the main criteria by which we judge that which method is the best for my application.

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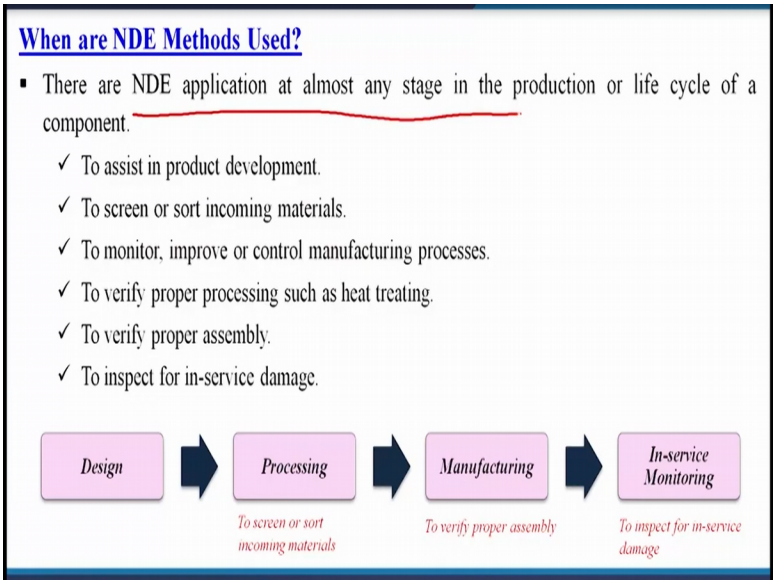

When we are using the NDE method? There are NDE application at almost any stage in the production or life cycle of a component. As I told already, to assist a product development, to screen or sort incoming materials, to monitor, improve or control manufacturing processes. To verify proper processing such as heat treating, to verify proper assembly to inspect for in service damage.

So, generally when we are doing the design after that we are doing the processing. In processing to screen or sort incoming materials. Say suppose, first we have done the drawing, what materials we are going to prepare and after that we are acquiring different materials. Say suppose, I can give you the examples of composite materials, so now we are taking three or four different constituent or components now we are mixing then properly.

So now, whether the mixing is proper or not and addition is proper or not after that there is a imports and crack or not, so we are doing at the time of processing. After that we are doing

the manufacturing. Say suppose I am doing the casting or maybe the I am doing some other operation maybe I can make some kind of films over there, or maybe I can make some products over there so to verify the proper assembly of that particular parts.

And then after that I am using that particular parts into some applications. Either maybe automotive parts or maybe some other parts and while working, of that particular parts we are checking that whether that material is working properly or nor or maybe in service it is creating or maybe it is getting some kind of problems or maybe creating some kind of errors or maybe the noise or may be the vibration. So, that is known as the in-service monitoring.

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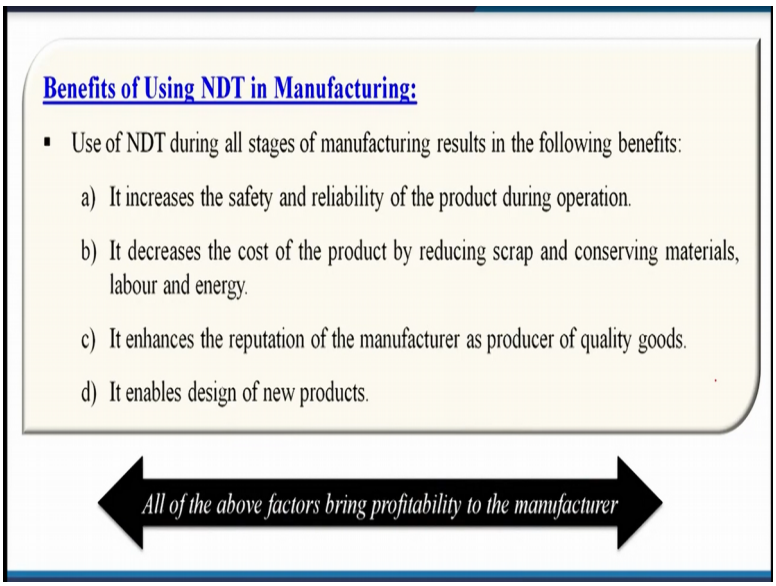

Now what are the benefit of using NDT in manufacturing techniques. So first, it increases the safety and reliability of the product during operation. It decreases the cost of the product by reducing scrap and conserving materials, labor and energy. It enhances the reputation of the manufacturer as producer of quality goods. It enables design of new products. But one thing I can tell you that NDT testing does not means that material will never fail in future.

No, but I can say that it is a one kind of a precaution technique. So, that I can maximize the service life of that particular products. So, all of the above factor brings profitability to the manufacturer. That is the ultimate goal.

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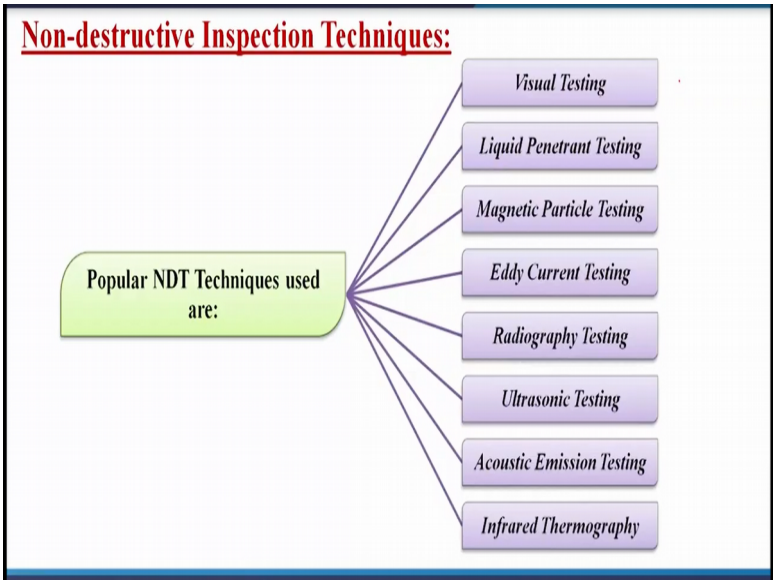

Now, what are the techniques? So, there are so many techniques are available but most popular techniques are like that visual testing, liquid penetrant testing, magnetic particle testing, eddy current testing, radiography testing, ultrasonic testing, acoustic emission testing and infrared thermography.

Now, first let us discuss about the visual inspection. So, from the name itself you can understand that we are depending on our eyes. So, we are seeing that particular material and then after that we are taking the decisions that whether that material can workable or maybe it can get some of failure or maybe it can get some damage or maybe the some error.

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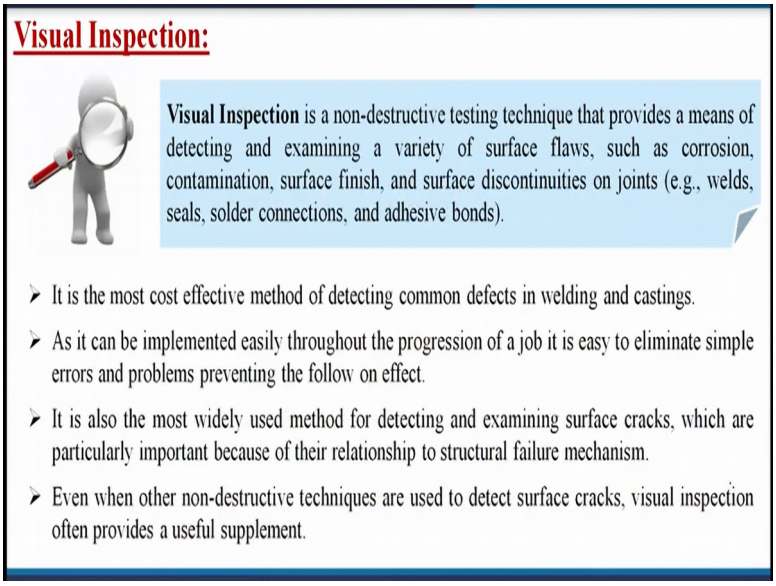

So generally, the visual inspection is a nondestructive testing technique that provides a means of detecting and examining a variety of surface flaws, such as corrosion, contamination,

surface finish, and the surface discontinuities on joints. Like welds, seals, solder connections, and adhesive bonds. It is the most cost-effective method of detecting commons defects in welding and castings.

As it can be implemented easily throughout the progression of a job it is easy to eliminate simple errors and problems preventing the follow-on effect. Say suppose a continuous batch process is going on so sometimes we can take the samples randomly and we can check by our eye and if we see any kind of flaws or maybe the discontinuities. So certainly, we can stop the productions we can rectify the problems so that it can save the money and wastage too.

Next, it is also the most widely used method for detecting and examining surface cracks, which are particularly important because of their relationship to structural failure mechanism. But, one thing I can tell you that these surface cracks mean it this crack are generated on the surface not inside the materials. If it is inside the materials, we cannot do it by the visual inspection. Even when other nondestructive techniques are used to detect surface cracks, visual inspection often provides a useful supplement.

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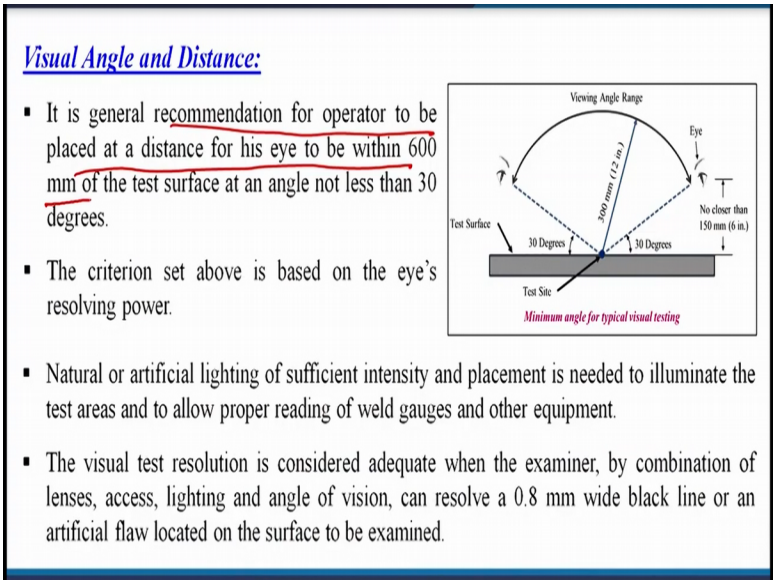

Next how we can do this particular experiment. So generally, it is general recommendation for operator to be placed at a distance for his eye to be within 600 millimeters of the test surface at an angle not less than 30 degrees. Say suppose this is your total sample right, so in this particular sample you can see up to the maximum 300 millimeters or maybe the 12 inches so, up to 12-inch distance you can see that material clearly and the angle should be within this range.

So, that means if I take 180 degrees you minus that 30 degree from this sides and 30 degree from this sides, so 120 degree you can see properly. So, if you keep your eyes here and if you keep your eyes maximum to here you can see the material surface clearly. If it is below 30 degree, you cannot see the surface properly. The criterion set above is based on the eye's resolving power.

Natural or artificial lighting of sufficient intensity and placement is needed to illuminate the test areas and to follow proper reading of weld gauges and other equipment. The visual test resolution is considered adequate when the examiner, by combination of lenses, access, lighting and angle of vision, can resolve a 0.8 millimeters wide back line or an artificial flaw located on the surface to be examined. So, this is the standard procedure.

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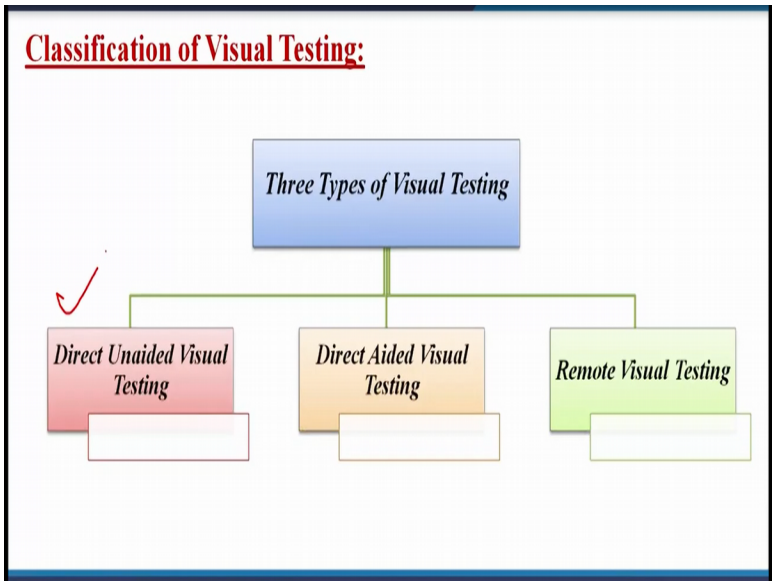

Now there are three distinct classification of the visual testing. So, number 1 is called the direct unaided visual testing, second one direct aided visual testing and the third one is the remote visual testing.

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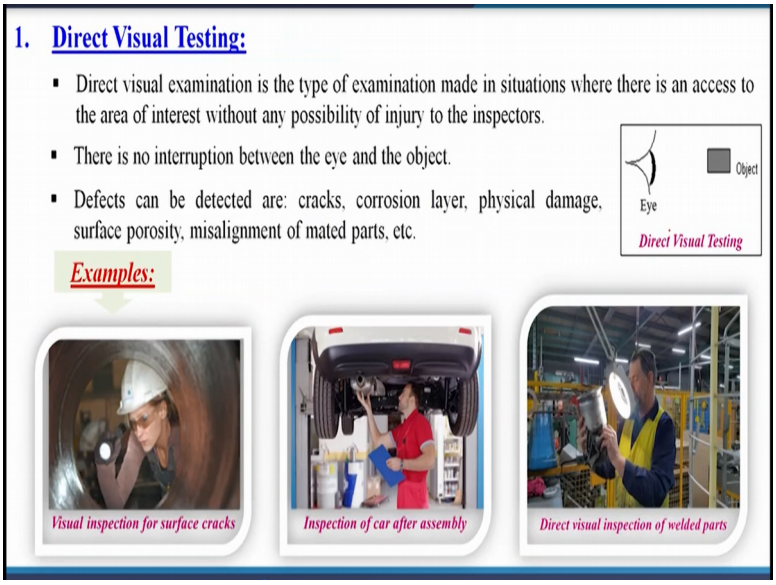

So, when you talk about the direct visual testing. Direct visual examination is the type of examination made in situations where there is an access to the area of interest without any possibility of injury to the inspector. That means we can directly see that particular zone. There is no interruption between the eye and the object. Defects can be detected are cracks, corrosion layer, physical damage, surface porosity, misalignment of mated parts etc.

So, that means direct visual testing in between the eyes and the objects there is no barrier. So, these all are the examples where we are generally doing the direct visual inspections.

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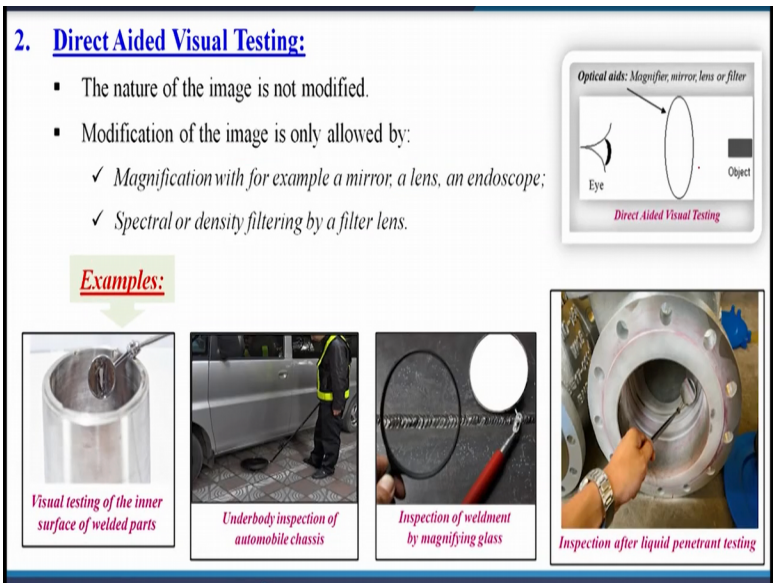

Next, we are coming to direct aided visual testing. So, from the name itself you can understand that aided part has been added; that means with the help of something. So, the nature of the image is not modified. Modifications of the image is only allowed by

magnification with for example a mirror, a lens, an endoscope; spectral or density filtering by a filter lens.

So, these all are the examples where we cannot detect this kind of crack or pores by directly with our eyes. So, we are taking the help of some kind of lens or maybe the mirror.

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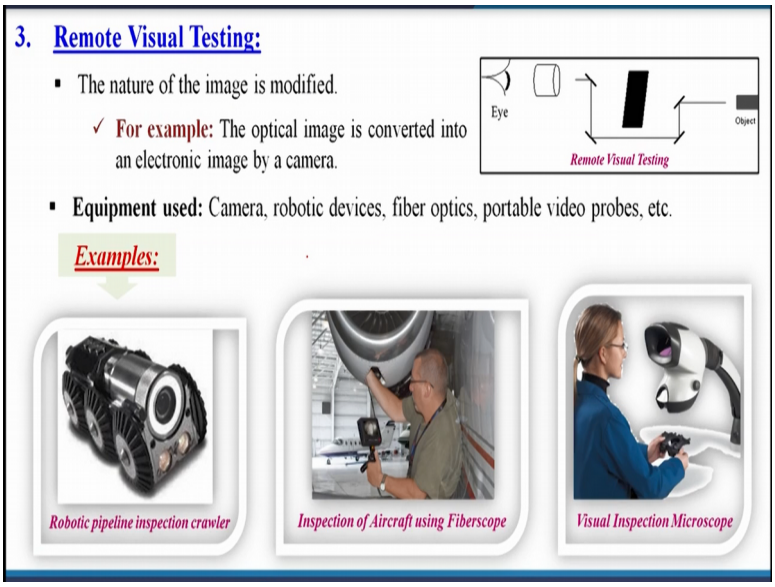

Next, remote visual sensing. The nature of the image is modified. Suppose in our surface a very tiny crack or maybe the small crack is there, but we cannot see it eye, by our naked eyes so that time we are using some kind of techniques which is zooming that particular zone and by zooming or getting the zooming figure we are getting some kind of information about that particular materials.

Or maybe we are having a very complex shapes where we cannot see that particular problem directly so we are taking some kind of camera over there or maybe the some kind of video photography by which we are getting the image and then we can understand what is the problem has been happened. So, equipment used, generally camera, robotic devices, fiber optics, portable video probes so these are all the examples where we are using some remote visual testing.

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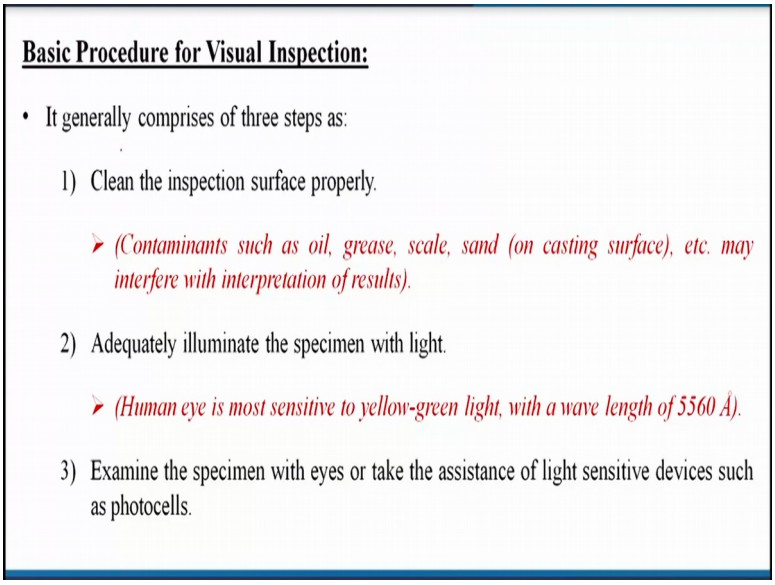

Now, what are the basic procedure for Visual Inspection? So generally, it comprises of three steps. First one is the clean the inspection surface properly. Yes, of course, because if it is the new materials directly it is coming from the machines that time, sometimes it will not require but, if I am using that material parts several times and then after that at the mid of the operations, I am thinking that I need to check that particular materials.

So, in that case I need to clean that material surface properly, because maybe some oil or maybe some grease or maybe some other paints is already there on the top of the surface. So, first is the clean the inspection surface properly. Contaminants such as oil, grease, scale, sand etc. may interfere with interpretation of the results. Sand is coming when we are taking about the casting surfaces.

Now, second one is that, adequately illuminate the specimen with light. Yes of course, so, if the proper lighting on that particular surface so that we can get the best visual view. Human eye is most sensitive to yellow green light, with a wave length of 5560 Armstrong. Third one is the examine the specimen with eyes or take the assistance of light sensitive devices such as photocells.

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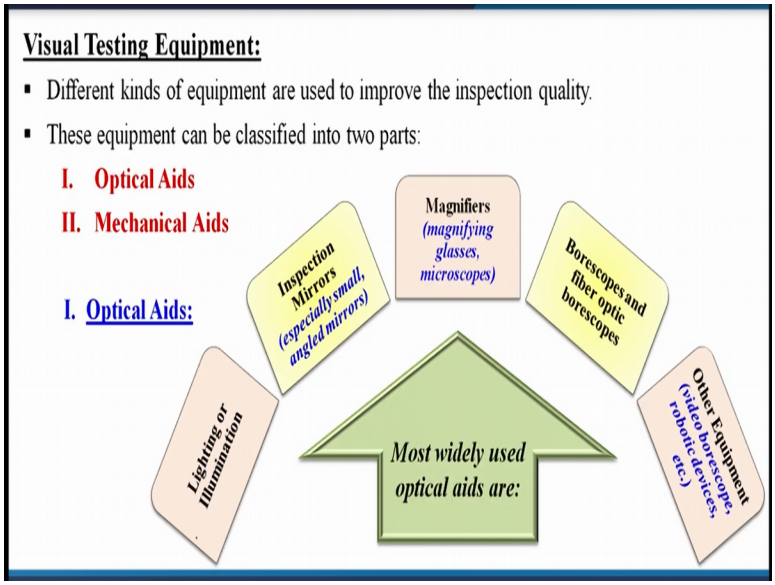

Now, what are the instrument? Different kinds of equipment are used to improve the inspection quality. These equipment can be classified into two parts; one is called the Optical aids and the second one is called the mechanical aids. So, what is optical aids? So generally, there are several types of optical aids are available.

So, one is called the Lighting or illumination, second one is called the inspection mirrors especially for small or maybe the angled mirrors, magnifiers generally magnifying glasses or maybe the microscopes, borescopes and fiber optic borescope and other equipment like video borescope, robotic devices etc.

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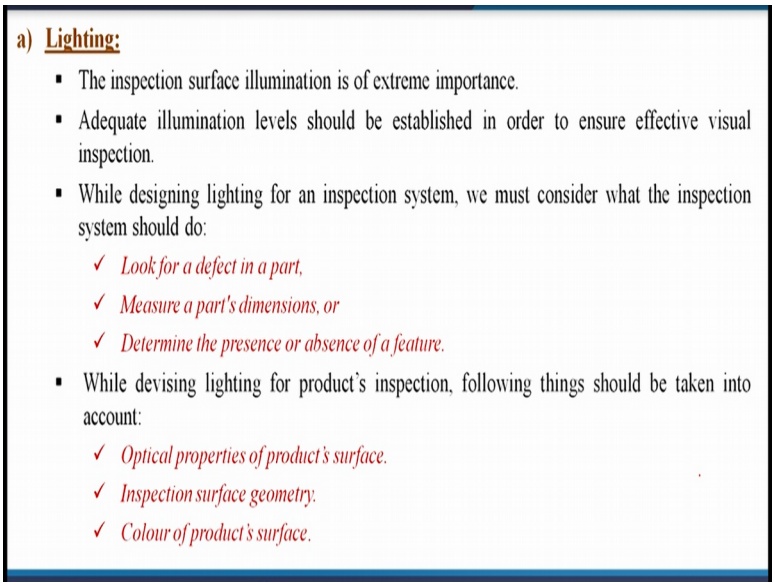

So, what is called lightning? The inspection surface illumination is of extreme importance. Adequate illumination levels should be established in order to ensure effective visual

inspection. As I told already, we need a clear light over there to see that particular cracks or maybe the defects. While designing lightning for an inspection system, we must consider what the inspection system should do. Look for a defect in a part, or maybe measure a part's dimensions, or maybe the determine the presence or absence of a feature.

While devising lighting for product's inspection, following things should be taken into account. Optical properties of product's surface it should not be very glossy the light will fall on to it and then it will reflect directly to our eyes so, that we cannot see properly, inspection surface geometry and the last one is that color of product's surface. Sometimes it may happen that whatever the light we are putting on to that material surface it can absorb that light so that we cannot see it properly.

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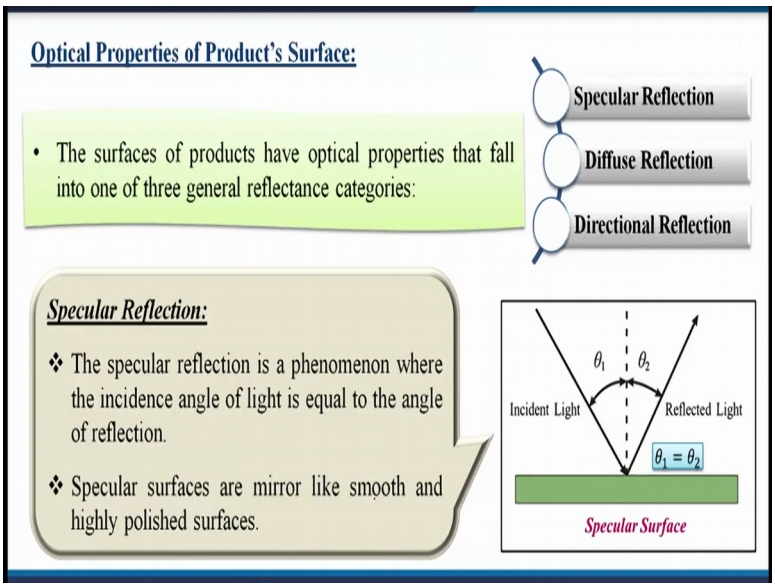

Optical properties of products surface. So generally, the surface of products have optical properties that fall into one of three general reflectance categories. What are those? First one is called the Specular Reflection, second one is called the diffuse reflection and third one is called the directional reflection. What is specular reflection?

The specular reflection is a phenomenon where the incidence angle of light is equal to the angle of reflection. That means in this particular case, the incident light is coming in this way and the reflection is taking in this way. So, that means in this particular case theta 1 is equal to theta 2. Specular surface are mirror like smooth and highly polished surfaces.

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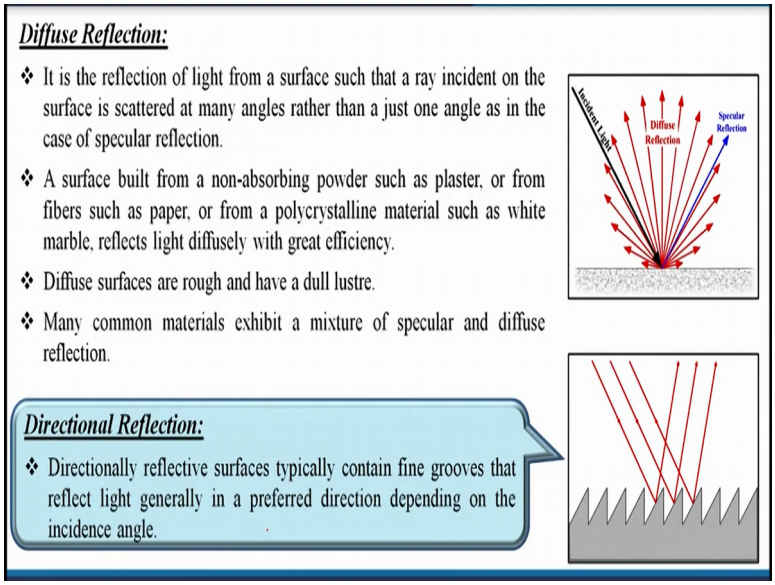

Next, diffuse reflection. It is the reflection of light from a surface such that a ray incident on the surface is scattered at many angles rather than a just one angle as in the case of specular reflection. So, when the incident light is coming for specular inspections, it should go through the blue color. But in the diffuse reflections it is going in to different angle.

A surface build from a non-absorbing powder such as plaster, or from fibers such as paper, or from a polycrystalline material such as white marble, reflects light diffusely with great efficiency. So, these all are the examples. Diffuse surface are rough and have a dull luster. Many common materials exhibit a mixture of specular and diffuse reflection.

And the last one is called the direction reflection? So, directionally reflective surfaces typically contain fine grooves that reflect light generally in a preferred direction depending on the incidence angle. So, when we are putting the light on the saw tooth, so in that case you can see this kind of directional reflection over there.

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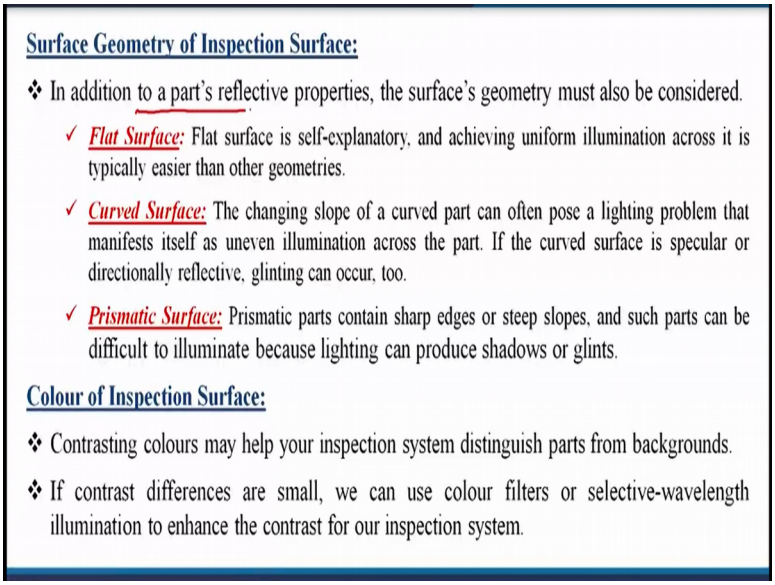

Next, surface geometry of inspection surface. In addition to a part's reflective properties, the surfaces geometry must also be considered. What are those? First one is called the Flat surface. Flat surface is self-explanatory, and achieving uniform illumination across it is typically easier than other geometries.

Second is the Curved surface. The changing slope of the curved part can often pose a lighting problem that manifests itself as uneven illumination across the part. If the curved surface is specular or directionally reflective, glinting can occur, too. Say suppose I can give the examples of this one if there is a flat surface so simple the light is coming then it is reflecting then I can see it clearly but, when we have that curvy nature some lights are going in this angle and some lights are going in to this angle that time it is very, very difficult to see all the whole portions of this particular material.

And the third one is called the Prismatic surface. Prismatic surface parts contain sharp edges or steep slopes, and such parts can be difficult to illuminate because lightning can produce shadows or maybe the glints. Color of inspection surface. Contrasting colors may help your inspection system distinguish parts from backgrounds. If contrast differences are small, we can use color filters or selective wavelength illumination to enhance the contrast for our inspection system.

Yes, of course, say suppose I am having a sample black in color and below that if I keep any kind of black surface so it is very difficult to get the image or maybe get do the inspections. So, I need a white color or maybe some kind of reflective kind of materials so that easily I can see the material properly or maybe the parts of that materials properly.

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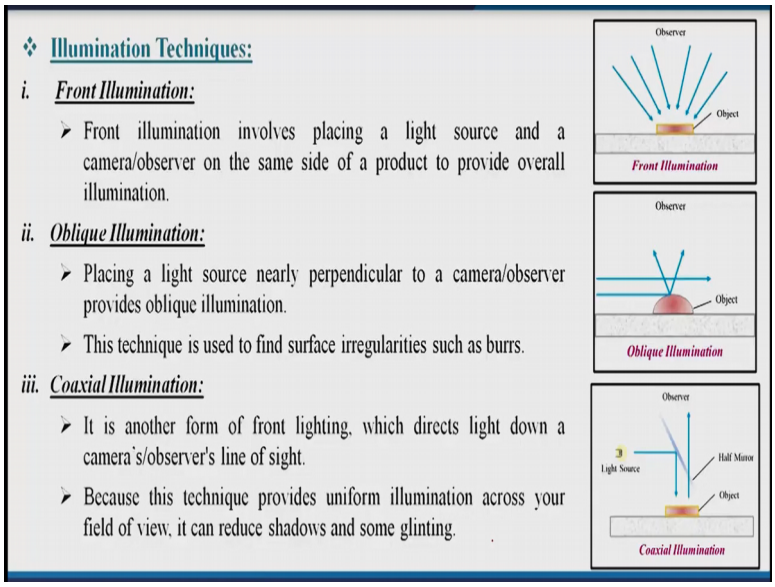

Next illumination techniques. So, there are different types of illumination techniques available. First one is called the front illuminations. So, from front illuminations involves placing a light source and a camera observer on the same side of a product to provide the overall illuminations. So, that is called the front illuminations. So, here I am having that object, and the light is coming and the observer eyes over here so that is known as the front illuminations.

Then Oblique illuminations. Placing a light source nearly perpendicular to a camera or maybe the observer provides obliques illuminations. This technique is used to find surface irregularities such as burrs. So, this is the object, I am putting the light in this direction and then after reflecting the light is coming to the observer eyes, so we are getting the image.

And third one is called the coaxial illumination. So, it is another form of front lightning, which directs light down a camera's observer's line of sight. Because this technique provides uniform illuminations across your field of view, it can reduce shadows and some glinting. So, light sources are over there, so I am using some kind of half mirror over there it is reflecting the light on to the object and then from object the light is coming to the observer eyes.

So, in this way you can typically adjust the spot area or maybe the light where actually you want to see.

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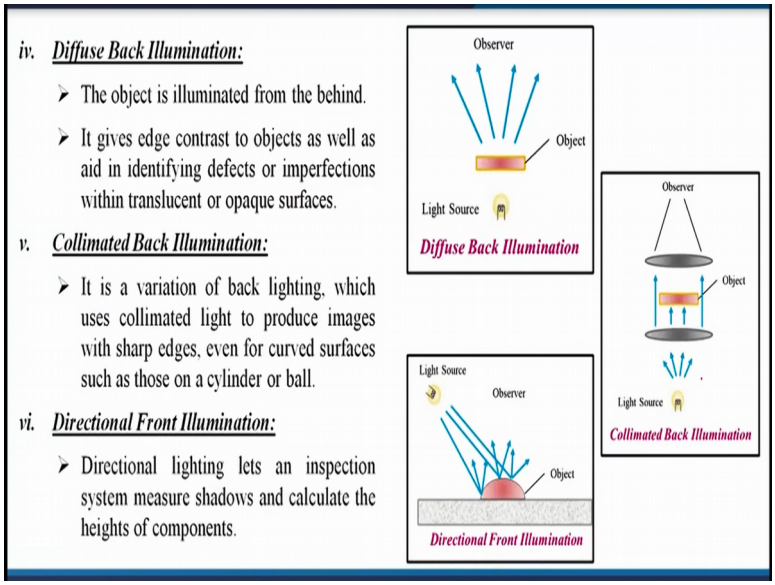

Next one is called the diffusive, diffuse back illumination. So, the object is illuminated from the behind. It gives edge contrast to objects as well as aid in identifying defects or imperfections within translucent or opaque surfaces. So, in this case, the light source is behind the object and through that the light is coming to the observer eyes.

Next one is called the collimated back illumination. It is a variation of back lighting, which uses collimated light to produce images with sharp edges, even for curved surfaces such as those on cylindrical cylinder or ball. So, this is the known as the collimated back illusion.

And directional front illumination. Directional lighting lets an inspection system measure shadows and calculate the heights of components itself. So, there are several techniques by which we can illuminate the object and we can get the best results.

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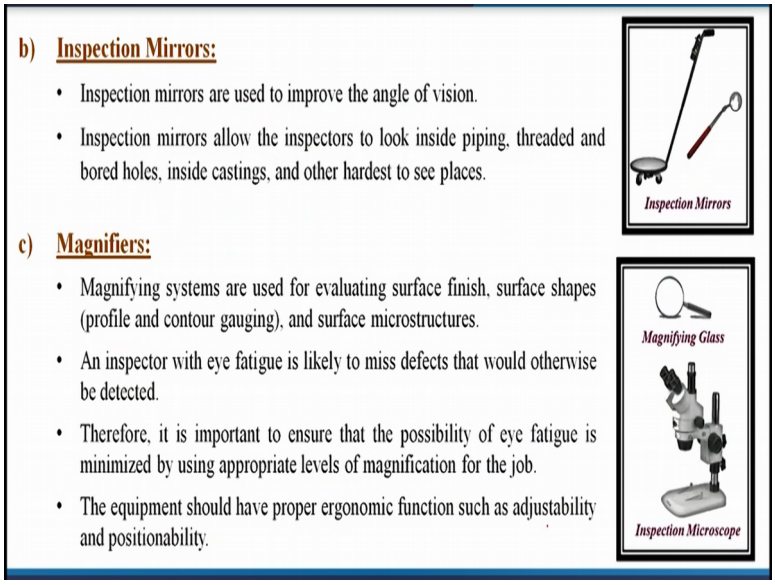

Then next one is called the inspection mirrors. Inspection mirrors are used to improve the angle of vision. Inspection mirrors allow the inspectors to look inside piping, threaded and bored holes, inside castings, and other hardest to see places. The best example I can tell you that when you are taking our car or maybe the vehicles to some complex or maybe the malls, generally or maybe the, some good hotels they are checking by this illuminations mirror by the lower part of our car that is there is any kind of problems or not.

Then next one is called the Magnifiers. Magnifying systems are used for evaluating surface finish, surface shapes profile and contour gauging, and surface microstructures. An inspector with eye fatigue is likely to miss defects that would otherwise be detected. Yes of course, of course being a human being, we are having certain limitations. It does not mean that we can see any kind of defects of any size.

So, sometimes it may happen with naked eyes we cannot able to see those kind of defects so at that time we are taking the help of the magnifying glass or maybe the microscope so that any very tiny defects or maybe the cracks we can see very easily. Therefore, it is important to ensure that the possibility of eye fatigue is minimized by using appropriate levels of magnification for these particular jobs. The equipment should have proper ahh ergonomic function such as adjustability and the positionability.

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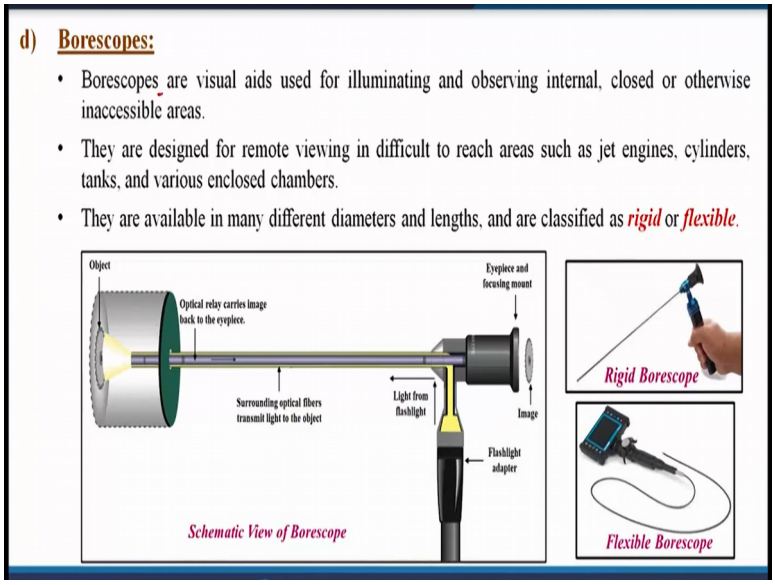

Next is called the borescopes. So, borescopes are visual aids used for illuminating and observing internal, closed and otherwise inaccessible areas. They are designed for remote viewing in difficult to reach areas such as jet engines, cylinders, tanks, and various enclosed chambers. They are available in many different diameters and lengths, and are classified as rigid or maybe the flexible. So, this is the schematic view of the borescope.

So, borescope generally, when we are having the object simultaneously it is giving the light as well as it is giving us the image. So, this is known as the rigid borescope and this is known as the flexible borescope.

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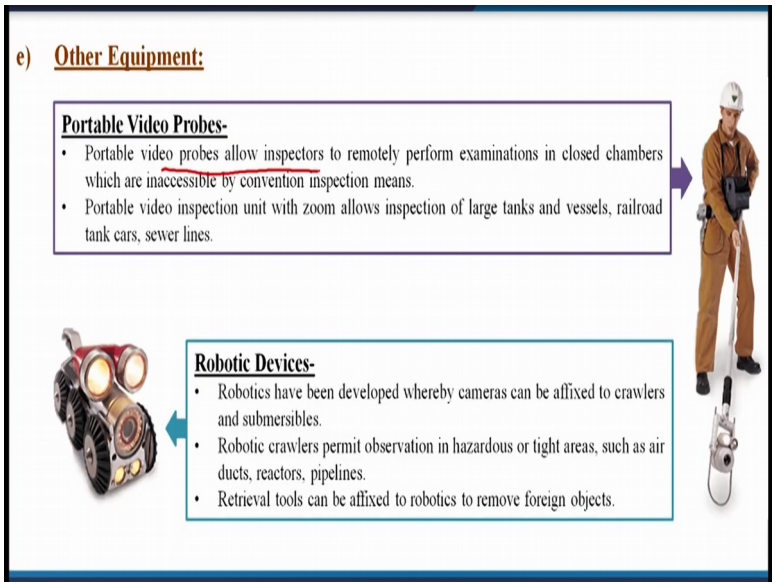

Other equipment like portable video probes. Portable video probes allow inspectors to remotely perform examinations in closed chambers which are inaccessible by convention

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

Then next one is the Robotic devices. Robotics have been developed whereby cameras can be affixed to crawlers and the submersibles. Nowadays we are using this devices widely. Say suppose we are using it for the petroleum industry to check the thing inside the pipe, sometimes we are using it for the sewage purpose, because in sewage we know that it is not assessable to the, for the human being, because maybe there is general kind of toxic gases or some other means.

So, that time we are putting these robotic cameras inside the pipes or maybe the drainage systems and we are taking the image of the whole from the outside and then we can solve the particular problem. Robotic crawlers permit observation in hazardous or may be the tight areas, such as air ducts, reactors, pipelines. Retrieval tools can be affixed to robotics to remove foreign objects.

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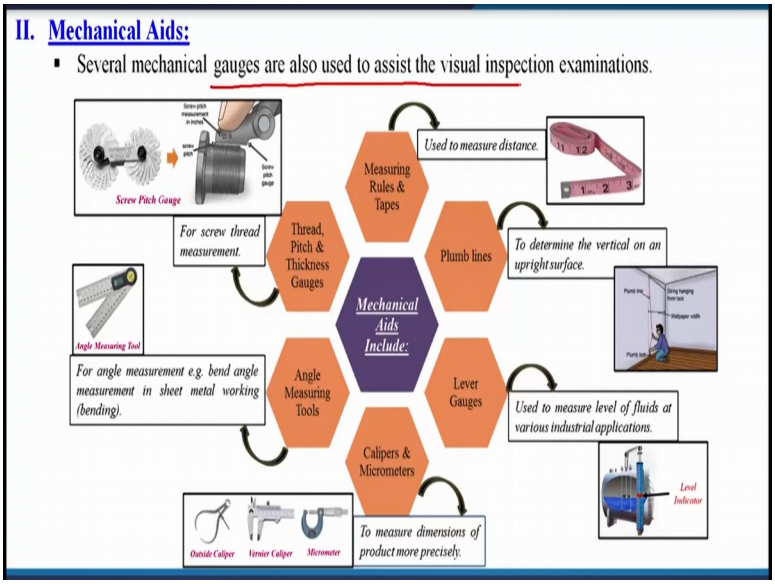

Next second one is the mechanical aids. Several mechanical gauges are also used to assist the visual inspection examinations. So, those are some kind of screw pitch gauge, some kind of angle measuring tool, outside caliper, Vernier caliper, micrometer, level indicator.

So generally, mechanical aids are like this for measuring rules and tapes generally used to measure the distance, plumb lines to determine the vertical on an upright surfaces, lever gauges used to measure level of fluids at various industrial applications, calipers and

micrometers to measure dimensions of product and more precisely, angle measuring tools for angle measurement like bend angle measurement in sheet metal working for bending testing and thread, pitch and thickness gauges generally for screw thread measurements. So, we are using various types of mechanical aids to get the perfect information.

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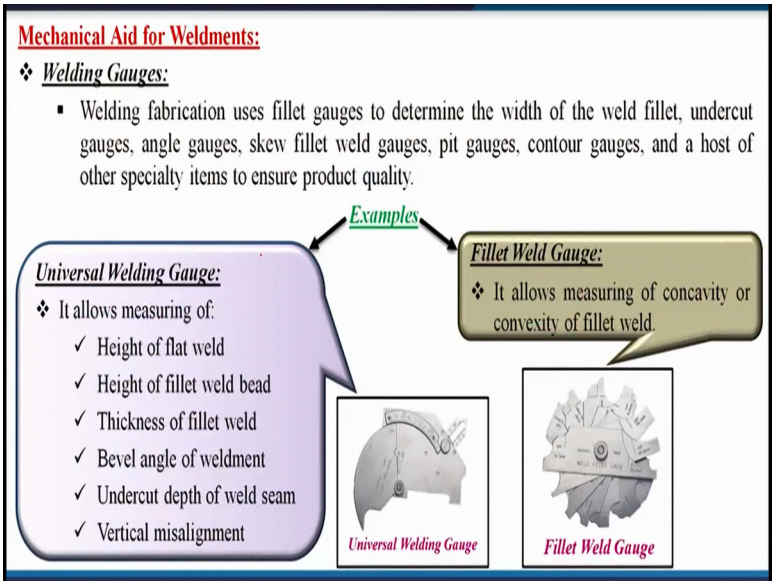

So, mechanical aids for weldment. So generally, we are calling it as a welding gauge. Welding fabrications uses fillet gauges to determine the width of the weld fillet, undercut gauges, angle gauges, skew fillet weld gauges, pit gauges, contour gauges, and a host of other specialty items to ensure product quality. So, what are the examples? Like universal welding gauge. It allows the measuring of height of flat weld, height of fillet weld bead, thickness of fillet weld, bevel angle of weldment, undercut depth of weld seam and vertical misalignment.

So generally, the universal welding gauge looks like this. Second one is that fillet weld gauge. It allows measuring of concavity or maybe the convexity of fillet weld. So generally, the fillet weld gauge looks like this.

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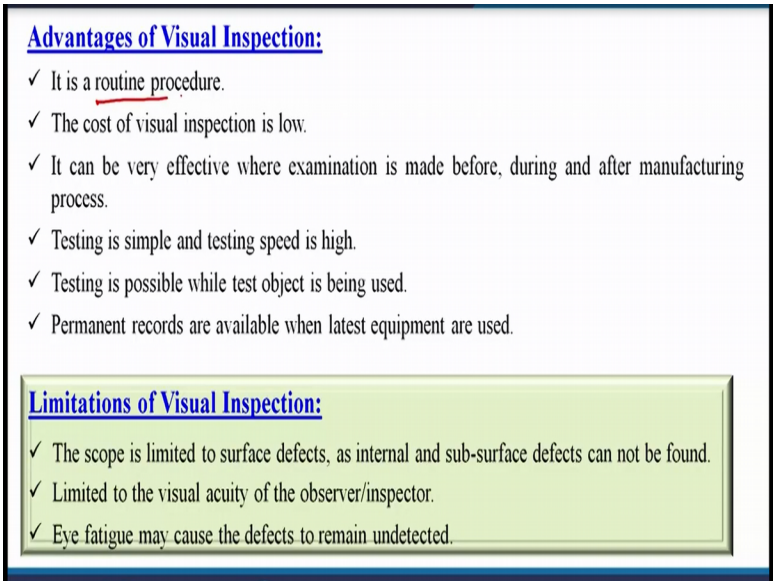

Now, what are the advantages of visual inspection? It is a routine procedure. The cost of visual inspection is low. It can be very effective where examination is made before, during and after manufacturing process. As I told already, testing is very simple and the testing speed is high and also less time consuming. Testing is possible while test objects is being used. Permanent records are available when latest equipment are used.

Limitations of visual inspection. Of course, there are certain limitations. The scope is limited to surface defects, as internal and sub-surface defects can not be found. I told already. Limited to the visual acuity of the observer and inspector. Yes, of course, we are having certain kind of limitation. We cannot go beyond that. Eye fatigue may cause the defects to remain undetected.

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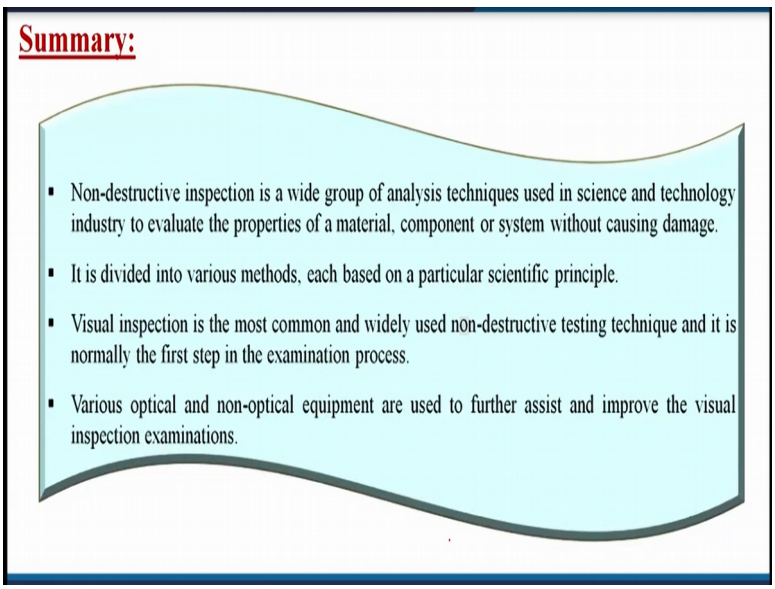

Now, we have come to the last part of this particular lecture. So, as a summary we can say that nondestructive inspection is a wide group of analysis techniques used in science and technology industry to evaluate the properties of a material, component or system without causing any kind of damage to that particular material. It is divided into various methods, each based on a particular scientific principle.

Visual inspections is the most common and widely used nondestructive testing technique and it is normally the first step generally we are calling it as first step of any examination techniques. Various optical and non-optical equipment are used to further assist or maybe the improve the visual inspection examinations. Thank you very much.