Inspection and Quality Control in Manufacturing
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Lecture – 03
Destructive Inspection - I

Hello my friends, today we are going to start our new lecture on destructive inspections Part 1. So, basically in this particular lecture, we going to discuss about the what is the destructive inspections and what kind of tests generally we are following for doing this kind of inspections, so before going to start, let know that what is the definition of the destructive inspections, as I brought before knowing any scientific definitions, first from the name itself we can understand that destructive inspection means we are going to harm the samples.

That means either we can heat the samples or maybe we can put some load over there or maybe we can ban the sample. So ultimately, we are going to give some deformations or may be some kind of chemical reactions on to the sample so that we can get the information.

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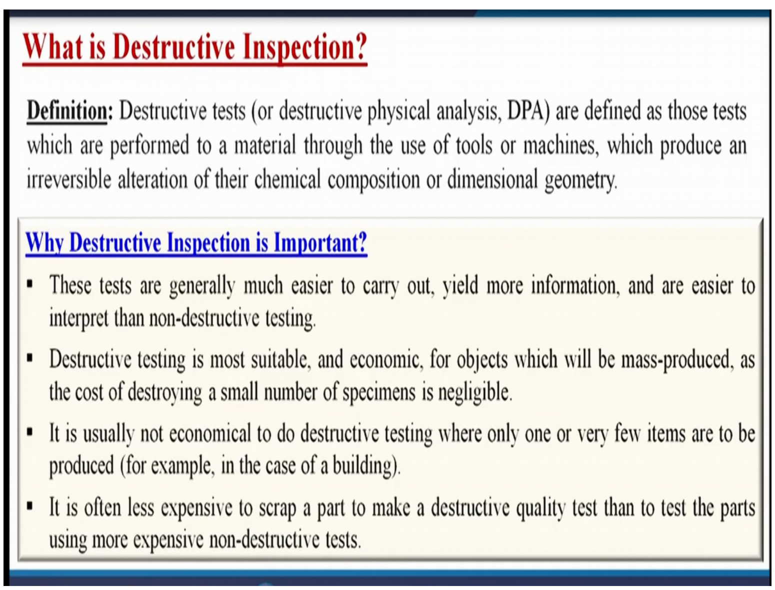

So, come to the definitions, generally destructive test or may be sometimes they are calling it as the destructive physical analysis or may be DPA are defined as those test which are performed to a material through the use of tools or machines as I told already so that means we are giving some kind of deformation which produce an irreversible alteration of their chemical composition or dimensional geometry. So that means, whatever testing we doing to that particular sample after that you cannot use that particular sample in our use, slide so why destructive inspection is important.

So, this tests are much each easier to carry out, yield more information, and easier to interpret than not destructive testing. Yes, when we will come to the discussions about the non-destructive testing at that time you can understand that without sometimes without touching the samples, sometimes without give any kind of external forces to the samples we are going to predict about that particular sample, but in this case directly we are dealing with the samples so that we can get much broader information's about the materials.

Second is that destructive is most suitable and economic, for objects which will be mass-produced as the cost of destroying a small number is negligible. So, suppose in industry we are going to prepare any kind of parts, basically we are going to prepare that parts N number of times, so in between that we are going to take single parts or may be the single portions of that particular part. And we can do this kind of testing, from the wastage point of view is very negligible, but it will help you tremendously to get the all or may be rather I can say the whole information about that particular material.

Next it is usually not economical to do destructive testing where only one or very few items are to be produced, yes of course, suppose we are going to make one or two samples or may be less than 10 number of samples and in between that you are going to break one or two samples that means really that time it a wastage of the money, also the labor cost or may be the labor time but when we are making 1000 number of samples or may be 2000 number of samples 10000 number of samples, that time taking only a single part and doing this kind of non-destructive test, this kind of destructive testing is really helpful

Next it is often less expensive to scrap a part to make a destructive quality test than to test the parts using more expensive non-destructive tests. Yes of course non-destructive testing there are so many tests are there are, that is maximum time that we are doing into the non-contact mode so of course whatever the equipment we are going to use, that equipment is very, very expensive.

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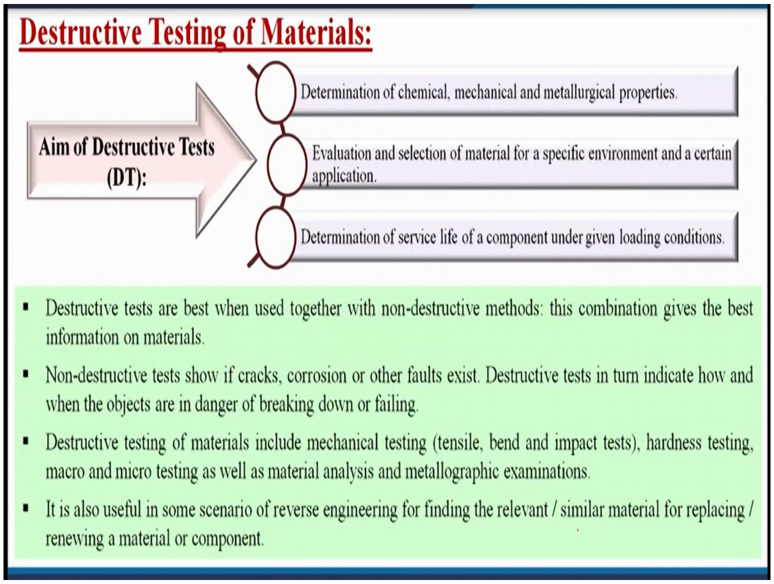

Next, what about the destructive testing of materials? So first is Aim. The aim is that, determination of chemical or mechanical and metallurgical properties, that information we can get number 2 is that evaluation and selection of material for a specific environment and a certain application and number 3 is that determination of service life of a component under given loading conditions.

So, these three are the main aim of the destructive tests. Destructive tests are best when used together with non-destructive methods, this combination gives the best information on materials. Yes of course, say suppose, we are having any samples and we are going to do the tensile test, so first we will do the tensile and also by X-ray which is another example of a non-destructive testing, through that one also we can detect that if there is any crack or may be pores, present inside the material by one way you can say that we are trying to test that materials based on the destructive testing and non destructive testing combinations, it will give you the more clear view about the particular material.

Nondestructive tests show if cracks, corrosion or other faults exist. Destructive tests in turn indicate how and when the objects are in danger of breaking down or failing. Destructive testing of materials include mechanical testing like tensile, bend and impact tests, hardness testing, macro and micro testing as well as material analysis and metallographic examinations. It is also useful in some scenario of reverse engineering, yes of course, reverse engineering though it is not a good practice for the engineers but sometimes we may require.

Suppose if we are having any kind of parts, that parts has been made by some other agency or company or somebody else now we want to know the properties of that particular parts, say suppose we are having one machine, that machine has prepared by some other company, and it has given to us,

Now in between, some parts has been damaged so unless and until we will get or gather the information or the material properties of that particular part, It is difficult to us to make that part again or may be re-cycle that part or may be repaid that part and that is known as the reverse engineering. So generally, we are using it for finding the relevant, similar material for replacing renewing a material or component

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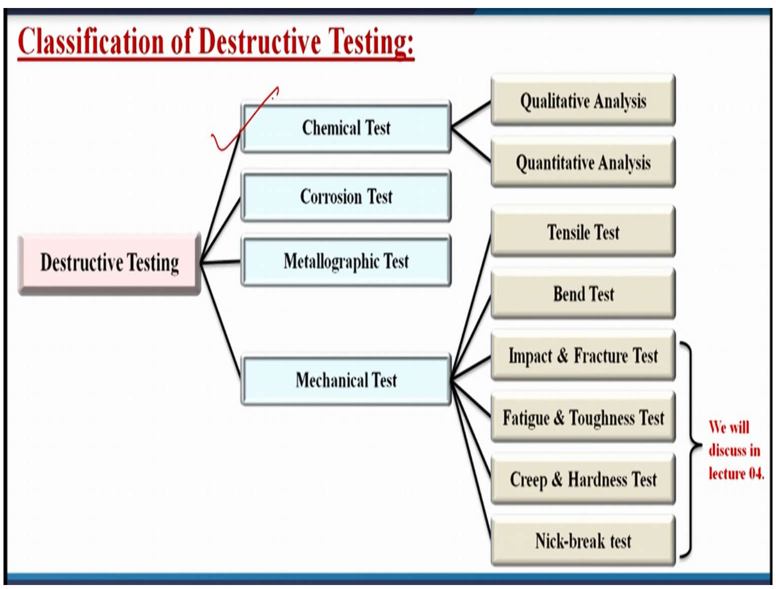

Now what are the classifications of destructive testing, there are several classifications, first it about the chemical test. Chemical test is also divided into two sub categories, one called the qualitative analysis and another one is called as the quantitative analysis. Next corrosion text, next is the metallographic test and the last one is called the mechanical test, mechanical test there are so many will come.

First tensile test will come, then the bend test will come, next impact and fracture test, fatigue and toughness test. Creep and hardness test, nick and break test, the last 4 test we are going to discuss in our next lecture. Now we are going to discuss about the chemical test, from the name itself we can understand that we are trying to do some chemical reactions by which we can gather some information about that particular materials. So what are the objectives of chemical test.

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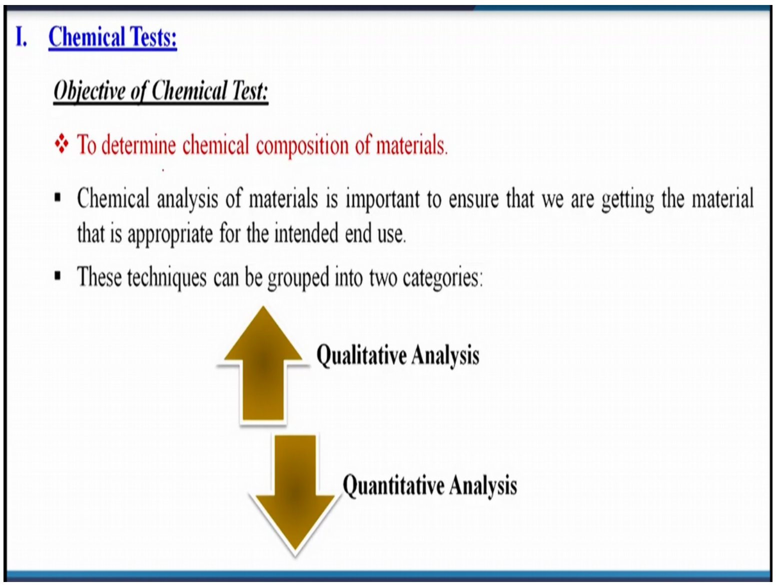

First is that to determine the chemical compositions of materials that means what kind of materials has been used to prepare that parts or may be composites sometimes it is really difficult to get the exact compositions means, at percentage of loading we had prepared that particular part but at least we can get the information.

But say suppose any kind of composites aluminum percentage or may be magnesium percentage or may be iron, what kind of composites or materials, that we can recognize but sometimes it is really very difficult whether aluminum percentage or quantity is 3% or may be 5% or 10% that is sometimes really, really difficult. But anyhow we can gather the information about that particular materials

Now, chemical analysis of materials is important to ensure that we are getting the material that is appropriate for the intended end use. These techniques can be grouped into two categories. First one is called the qualitative analysis and second one is called the quantitative analysis. So, what is qualitative analysis. These methods are used to determine which elements exist in a sample.

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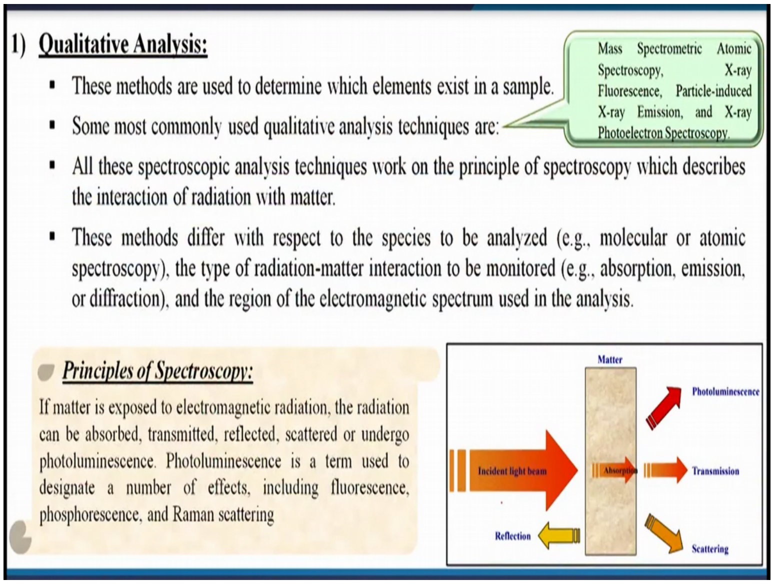

Some most commonly used qualitative analysis techniques are mass spectrometric Atomic spectroscopy, X ray fluorescence, Particle induced X-ray emission and X-ray Photoelectron spectroscopy or in broad name generally we are calling it as a XPS, All these spectroscopic analysis techniques work on the principle of spectroscopy which describes the interaction of radiation with matter.

These methods differ with respect to the species to be analyzed for example its molecular or atomic spectroscopy the type of radiation matter interaction to be monitored like absorption emission or may be the diffraction and region of the electromagnetic spectrum used in the analysis. Now what are the principles of spectroscopy, if the matter is exposed to electromagnetic radiation, the radiation can be absorbed, transmitted, reflected, scattered or undergo photoluminescence, Photoluminescence is a term used to designate a number of effects, including fluorescence Phosphorescence and remain scattering.

So generally in this particular case the matter or may be objects or may be parts is this one, so incident light beam is coming then either it can give you the photoluminescence property or may it can be transmitted through that particular medium or may be it can be scattered and some radiations or may be the incident beam will be reflected by that particular parts also, Now we have to put the detector in all these places and we have to get the information that what kind of material composition it is.

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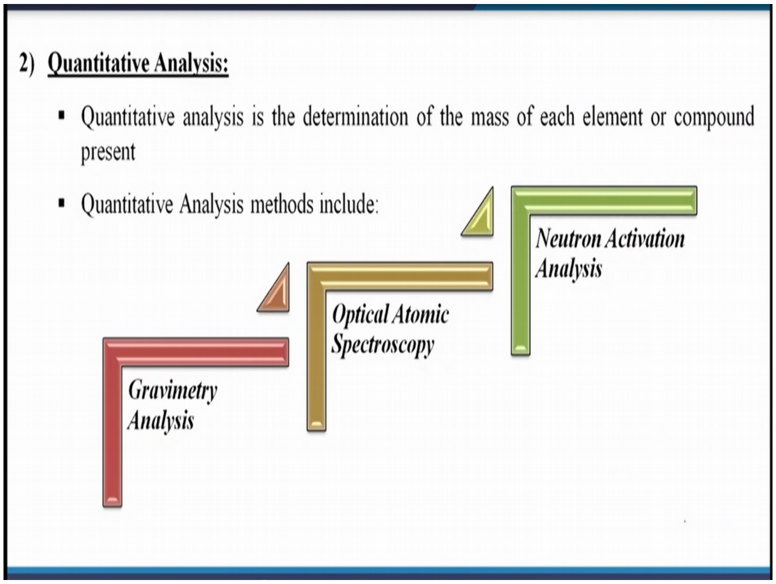

Next is called the quantitative analysis, is the determination of the mass of each element or compound present, As I told already, it is not so easy but it can be achievable, now quantitative analysis methods includes gravimetry analysis optical atomic spectroscopy and the neutron activation analysis

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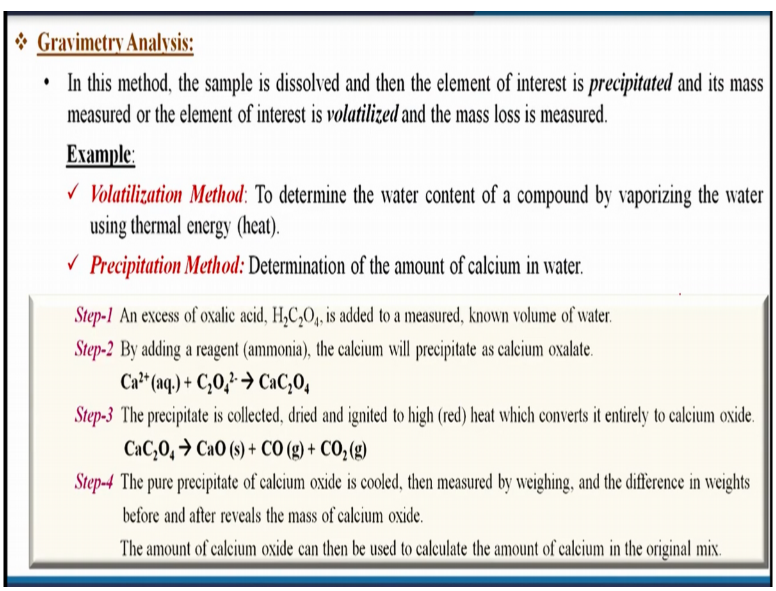

So now what is gravimetry analysis. In this method the sample is dissolved and then the element of interest is precipitated and its mass measured or the element of interest is volatilized and the mass loss is measured, but sometimes it may happen when we are talking about an particular composites we are adding may be 10 number of elements so that time it is very, very difficult to get the actual information about the all the masses of these particular elements but if the number of the elements will be less so that time it is more easier to get the informations to get the amount of the particular element and it can be helpful to detect about the chemical composition of that particular material.

So, what is the example Volatilization method : to determine the water content of a compound by vaporizing the water using thermal energy, say suppose if give the heat, automatically water molecules are present inside the sample it will be evaporated next one is called precipitation method : to determine of the amount of calcium in water, just giving an example step 1 : and excess of oxalic acid H 2 C 2 O 4 is added to a measure known volume of water.

By adding a reagent like ammonia, in this case we are using the calcium will precipitate as calcium oxalate. So, this is the reactions. Now next the precipitate is collected dried and ignited to high read heat which converts it entirely to calcium oxide, so now this is the reaction. At last you see in step 4 a pure precipitate of calcium oxide is cooled, then measured by weighing and the difference in weights before and after the mass of calcium oxide.

The amount of calcium oxide can then be used to calculate the amount of calcium in the original mix. So, in this case it is very, very simple but as I told already that if there are N number of compounds are present so that time it is very, very difficult. Now what is the difference between the optical atomic spectroscopy and neutron activation analysis.

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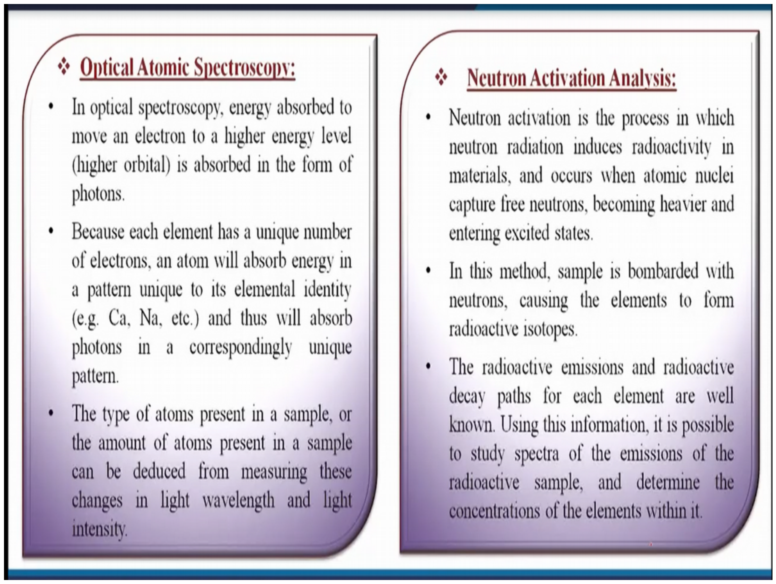

So, in optical atomic spectroscopy energy absorbed to move an electron to a higher energy level is absorbed in the form of photons but in Neutron activation analysis Neutron activation is the process in which neutron radiation includes radioactivity in materials and occurs when atomic nuclei capture free neutrons becoming heavier and entering excited states. For optical atomic spectroscopy in this particular case each element has a unique number of electrons, an atom will absorb energy in a pattern unique to its elemental identity say suppose calcium sodium this kind of things and thus will absorb photons in a correspondingly unique pattern.

But for Neutron activation analysis the sample is bombarded with neutrons, causing the elements to form radioactive isotopes for Optical Atomic spectroscopy, the type of atoms presents in a sample, or the amount of atoms present in a sample can be deducted from measuring these changes in light wavelength and light intensity, but for neutron activation analysis, the radioactive emissions and radioactive decay paths for each element are well known. Using this information, it is possible for study spectra of the emissions of the radioactive sample and determine the concentrations of the elements within it.

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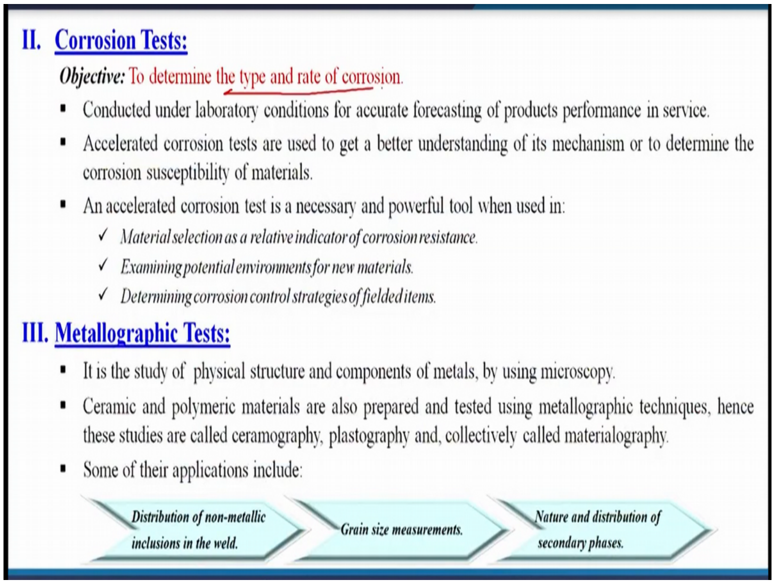

Next, we are going to discuss about the corrosion test. What is that objective of this particular test to determine the type and rate of corrosion, suppose we are making any kind of composites say suppose the ship body, ship body means whatever the materials generally we are using for preparing any kind of ships, so continuously the ship will move, so continuously it will react with the sea water, sea water is nothing but a salty water.

So that means we have to check what is the corrosion properties of that particular material, so in that case we have to use some kind of corrosion resistant materials that it should not react with sea water, in this particular cases say suppose we are sending some pure fluids like for the petroleum industry we are sending the gas or may be petrol's or diesels through the pipelines and then we have to check this kind of corrosion test that whether may be after certain time whether really that gases or may be that petrol's or diesels really corroding that particular pipes are not.

In this particular case conducted under laboratory conditions for accurate forecasting of products performance in service, accelerated corrosion tests are used to get a better understanding of its mechanism or to determine the corrosion susceptibility of materials. An accelerated corrosion test is a necessary and powerful tool when used in material selection as a relative indication of corrosion resistance, examining potential environments for new material, determining corrosion control strategies of fielded item. These all are the requirements generally that we are doing to corrosion test.

Next is called Metallographic test: It is the study of physical and components of metals by using microscopy, Ceramic and polymeric materials are also prepared and tested using metallographic techniques, hence these studies are called ceramography, plastography and collectively called materialography. Some of the application include Distribution of non-metallic inclusions in the weld, grain size measurements, nature and distribution of secondary phases.

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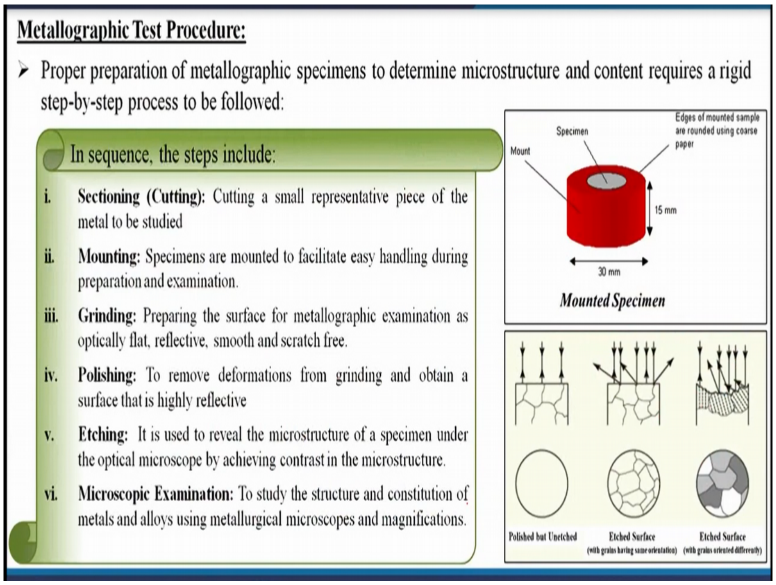

Now what is metallographic test procedure. Proper preparation of metallographic specimens to determine microstructure and content requires a rigid step-by-step process to be followed. What are those process, I will tell you in sequences? First one is called the sectioning or may be the cutting, so exactly cutting a small representative piece of the metal to be studied, suppose we are making a particular parts.

Say suppose in that particular part we are having any base matrix and then we are adding different types of Nano filler so we have to cut the specimen in such a manner that all the materials including the fillers and that particular matrix should be present that means that small parts representing the whole parts now in some cases we are right and in some cases we are wrong also in that case what we have to do, we have to cut that small parts from different places and then we have to do the test and we have to take the average results.

So now first is the sectioning or may be the cutting, cutting a small representative piece of the metal to be studied, number 2 is called the mounting means mounting onto the probe or to the testing area, specimens are mounted to facilitate easy handling during preparation and examination, number 3 is called the grinding, preparation the surface for metallographic examination as optically flat, reflective smooth and scratch free.

Number 4 is polishing so metal testing generally we are doing some kind of polishing testing so that we can get some kind of information's like grind size, grind boundary this kind of information generally we can get, to remove deformations from grinding and obtain a surface that is highly reflective.

Number 5 is called the Etching, it is used to reveal the microstructure of a specimen under the optical microscope by achieving contrast in the microstructure, Number 6 is called the microscopic examination To study the structure and constitution of metals and alloys using metallurgical microscopes and magnifications. In this particular case, just we have examples how we are preparing the samples by etching or how we are putting the samples, so that we can get the maximum information from that particular parts.

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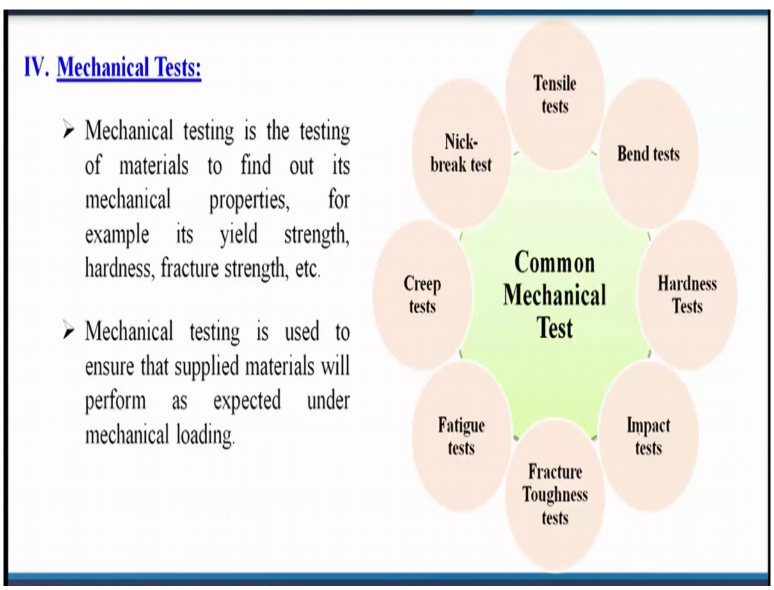

Next is called the mechanical test: mechanical testing is the testing of materials to find out its mechanical properties, for example its yield strength, hardness fracture strength etc. mechanical testing is used to ensure that supplied materials will perform as expected under mechanical loading. So, what are the common mechanical test, say suppose, tensile test, bend test, hardness tests, impact tests, fracture toughness tests, fatigue tests, creep tests, nick break test.

First, we are going to discuss about the tensile test, that is a very common test, as a material scientist every time we are following this kind of tests, say suppose for the polymeric materials, ceramic materials for metals, so generally this is called the preliminary test generally every time we are doing.

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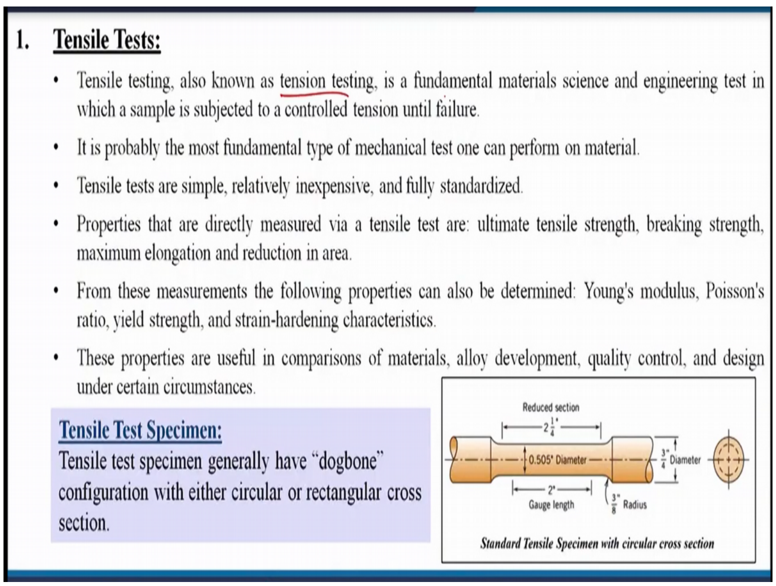

Tensile tests: also known as tension testing, is a fundamental materials science and engineering test in which a sample is subjected to a controlled tension until failure. Yes of course, sometimes we are doing the tensile test, sometimes we are doing the compressive test also. It is probably the most fundamental type of mechanical test one can perform on materials. Tensile tests are simple relatively inexpensive, and fully standardized.

Properties that are directly measured via a tensile test are ultimate tensile strength. Breaking strength maximum elongation and reduction in area. From these measurements the following properties can also be determined like young modulus, Poisson's ratio, yield strength and strain hardening characteristics. These properties are useful in comparisons of materials alloy development, quality control and design under certain circumstances.

Tensile specimen test there are so many standards, like ISO standards are there, as per the standards, we have to prepare the samples and we have to do the testing, generally tensile specimen test have a dog bone configurations with either circular or rectangular cross sections, so now tensile strength with circular cross sections look like this.

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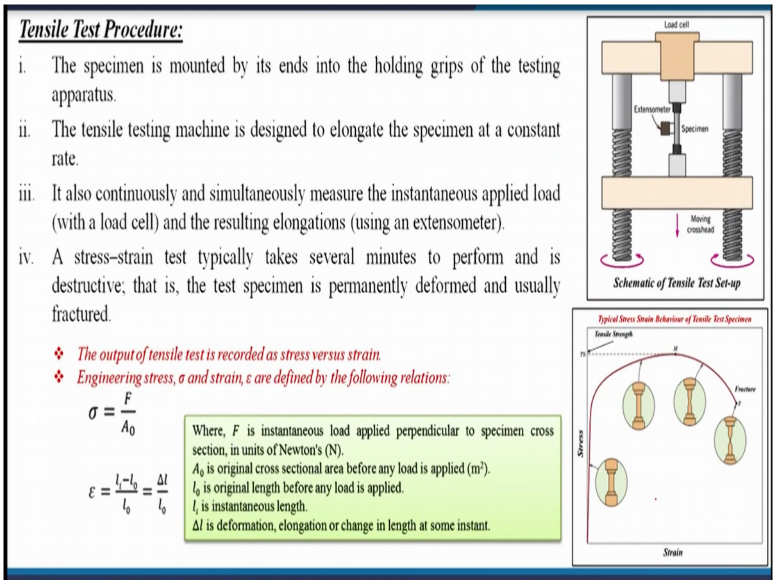

Next tensile test procedure. The specimen is mounted by its ends into the holding grips of the testing apparatus. The tensile testing machine is designed to elongate the specimen at a constant rate. It is also continuously and simultaneously measure the instantaneous applied load with a load cell and the resulting elongations using an extensometer. A stress-strain test typically takes several minutes to perform and is destructive, that is the test specimen is permanently deformed and usually fractured.

So that after testing we cannot use the particular sample or may be the parts. The output of the tensile test is recorded as stress vs strain or may be generally we are plotting the data strain vs strain curve. Engineering stress sigma and strain epsilon are defined by the following relations. So generally, sigma is equal to F by A 0 and epsilon is equal to l i minus l 0 by l 0 that means del l what is the change in length by the original length.

So, in here the F is instantaneous load applied perpendicular to specimen cross section, generally the units in Newton’s. A 0 is original cross-sectional area before any load is applied; l 0 is original length before any load is applied; l i is instantaneous length. So, that means after doing this experiment that how much length has been increased so del l is the deformations, elongation or change in length at some instant.

So, in this particular case, we have given the example that typical stress strain curve, in this case almost there is no change in the material then you can see that the length is increasing and of course its cross section is going to be decreased and after that some types of nicking is taking place and then the fracture is taking in this particular point

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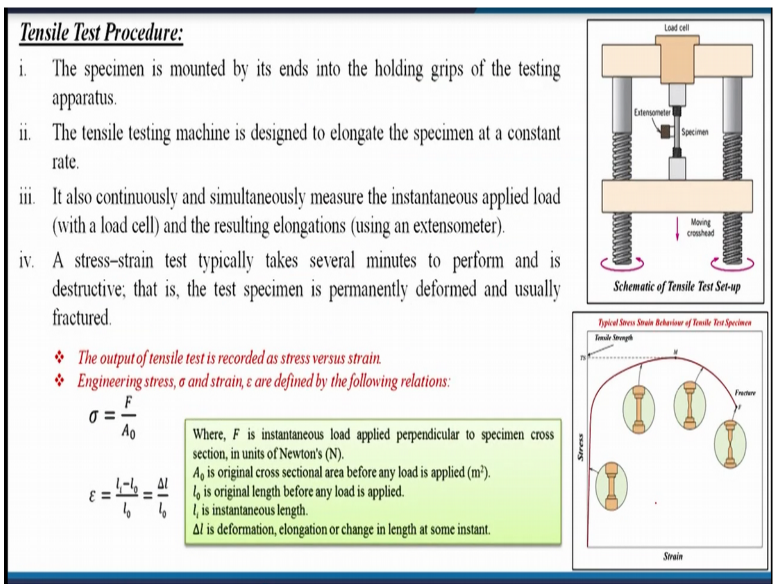

Now other mechanical properties determination from tensile test first one is called the yield strength. The engineering stress at which, it is considered that plastic elongation of the material has commenced. Next is called the ultimate tensile strength UTS, the maximum tensile stress that a material is capable of sustaining, so this is a point generally we are calling it as UTS.

Next is called the ductility, it is the measure of the degree of plastic deformation that has been sustained at fracture. Ductility may be expressed quantitatively as either percent elongation or percent reduction in area. So, what is elongation? So generally, we are denoting as percentage E L so that is l f minus l 0 by l 0 into 100. And reduction of area, percentage R A is equal to A 0 minus A f by A 0 into 100. So, what is l 0 original gauge length; l f the Fracture Length, A 0 Original cross-sectional area, and A f is the Cross sectional area at the point of fracture.

In this particular case, generally when we are plotting this kind of curve, so in this particular case after giving a small amount of release like 0.002 and we have to take a perpendicular line along this graph. In this case after 0.002 we have to a plot a parallel line to this particular curve and where this line will touch, that point is called the yield stress of that particular material. Now next one is called as the Resilience.

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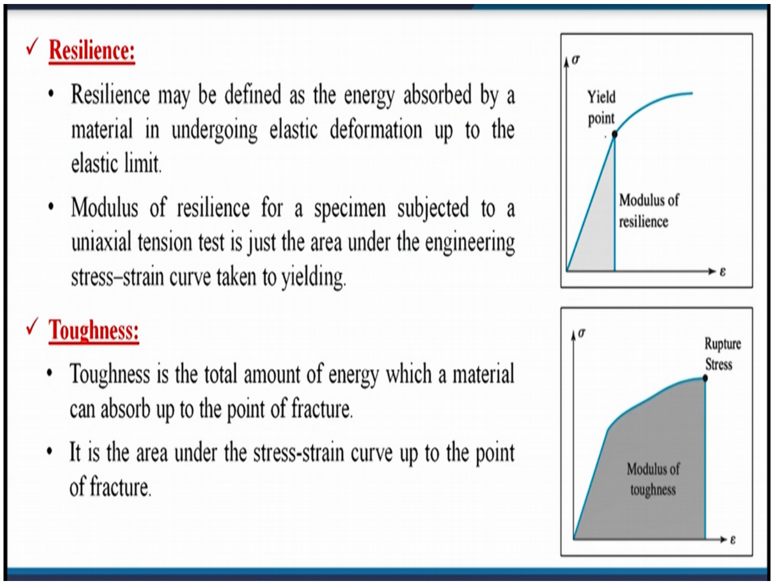

Resilience may be defined as the energy absorbed by a material in undergoing elastic deformation up to the elastic limit. Modulus of resilience for a specimen subjected to a uniaxial tension test is just the area under the engineering stress-strain curve taken to yielding. So this is the area, or may be generally calling it as a resilience or the modulus of resilience of that particular material.

Next one is called the toughness. Toughness is the total amount of energy which a material can absorb up to the point of fracture, it is area under the stress-strain curve up to the point of fracture over there, so this whole area is known as the modulus of toughness because the rupture stress is in this particular one. So, this is the whole area.

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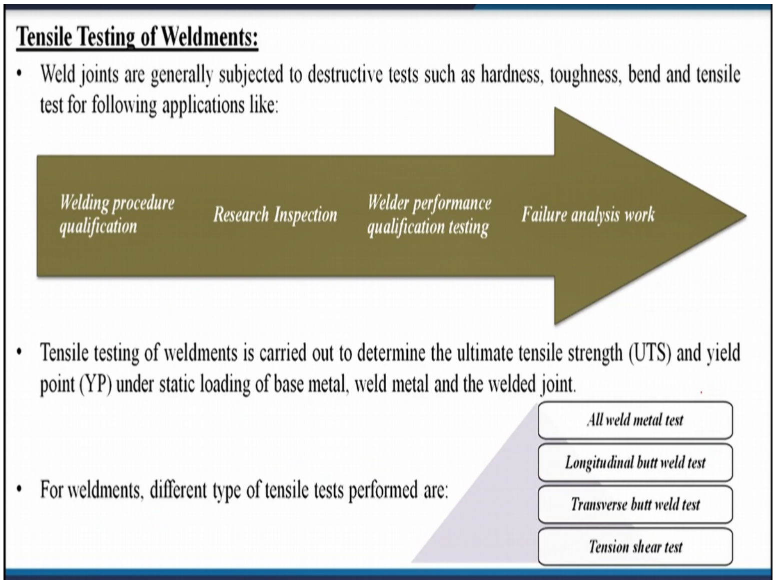

Next tensile testing of weldments. Weld joints are generally subjected to destructive tests such as hardness, toughness, bend and tensile test for following applications like welding procedure qualifications, Research inspection, welder performance qualification testing, failure analysis work. Tensile testing of weldments is carried out to determine the ultimate tensile strength UTS and yield point under static loading of base metal, weld metal and the welded joint.

So, for weldments different type of tensile tests performed are, all weld metal test, longitudinal butt weld test, transverse butt weld test, tension shear test.

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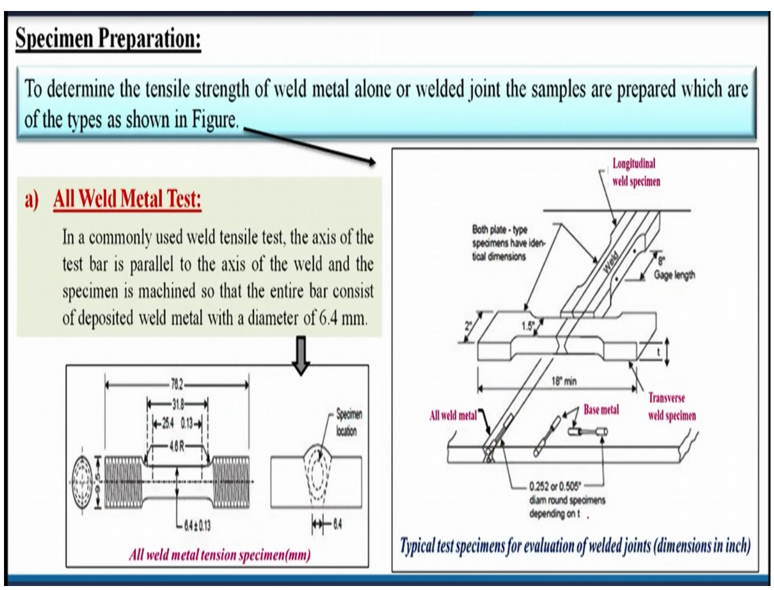

So now, how to prepare the specimen, to determine the tensile strength of weld metal alone or welded joint the samples are prepared which are of the types as shown in figure. So now when we are welding means, it is one kind of a permanent joint of two metals either they are similar or dissimilar metals. Now it depends that how you are going to test the samples whether your welding zone or may be the welding line may be transverse or may longitudinally present inside the samples and how you are going to use, suppose I have done the welding in this way and these two are the dissimilar metals and we are doing the welding now we have to check whether we are going to use the material like these way.

So that we have to take the tensile specimen may be we have to prepare the tensile specimen this way and suppose we are doing the welding this way and we are trying to use the material in this way, may be where we are going to use that particular material the load will come in this way. So according to our requirement we have to prepare the test specimen whether it will be longitudinal or may be the transverse according to the applied load direction then we have to prepare the samples and we have to do the testing.

So first is called the all welt metal test. It is commonly used welt tensile test the axis of the test is parallel to the axis of the weld and the specimen is machined, so that the entire bar consists of deposited weld metal with the diameter of 6.5mm, all welt metal tension specimen looks like this so now this is the zone where the welding has been done.

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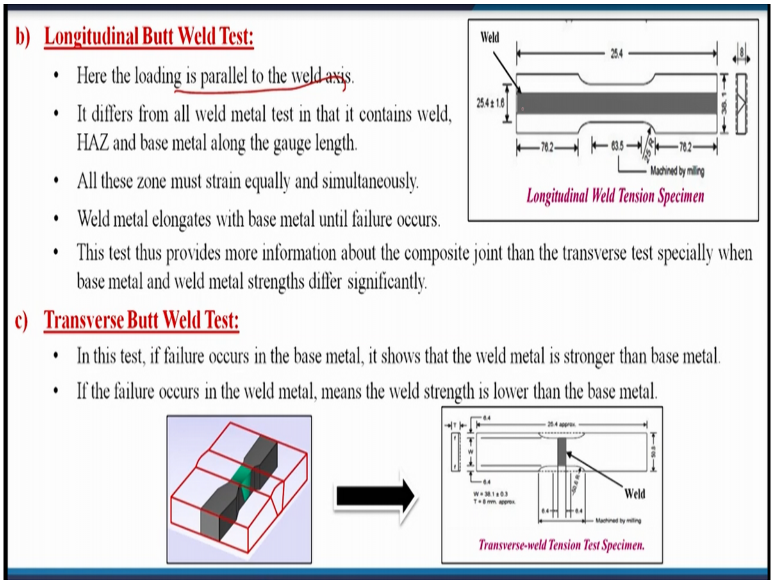

Next is the Longitudinal butt weld test. Here the loading is parallel to the weld axis. You can see the welding zone over there, we are going to test the samples in these two directions, like this way it is parallel to the weld axis. It differs from all weld metal test in that It contains weld Heat affected Zone and base metal along the gauge length.

Yes of course, may be this portion only we have done the welding then of the side, these two are called the heat affected Zone and this is the base metal zone, so all these zones must strain equally and simultaneously, Weld metal elongates with base metal until failure occurs, This test thus provides more information about the composite joint than the transverse test specially when base metal and weld metal strengths differ significantly.

Next one is called the Transverse Butt weld test, in these test if failures occurs in the base metal it shows that the weld metal is stronger that base metal. If the failures occurs in the weld metal means the weld strength is lower than the base metal. So accordingly based on the applications, based on the use of that particular weld parts we are going to test that particular specimen in different tensile testing mode.

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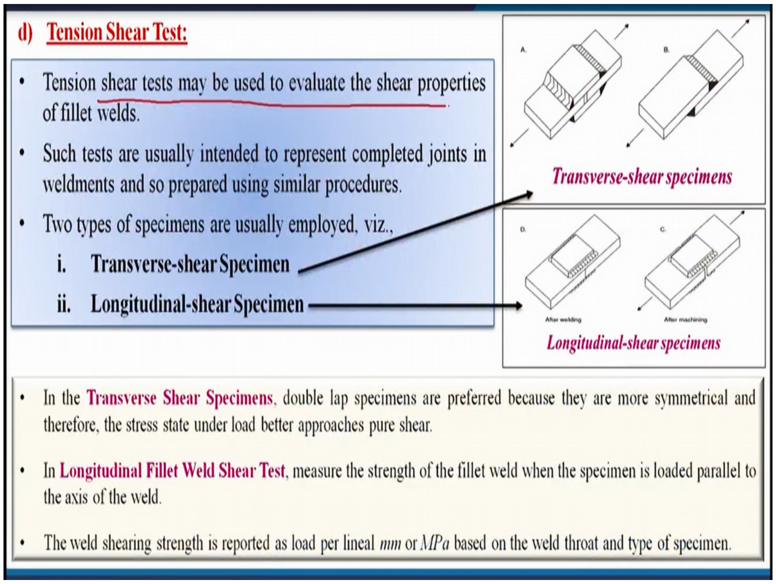

Next one is called tension shear test. So, generally tension shear test may be used evaluate the shear properties of fillet welds, such tests are usually intended to represent completed joints in weldments and so prepared using similar procedures. So basically, here is just you see the preparations of the sample is different two types of specimens are usually employed first one is called the transverse shear specimen.

In this case we can see that we are going to give the load or may be the tension in these directions and how we are preparing the samples because on top of that welding parts and bottom of that also we are putting another kind of plates in this particular case, in this particular case we are doing the welding and we are trying to see that generally that welding parts are giving and next is called the Longitudinal shear specimen, so the preparations of the testing samples is totally different.

In the transverse shear specimens. Double lap specimens are preferred because they are more symmetrical and therefore. The stress state under load better approaches pure shear. In longitudinal fillet weld shear test, measure the strength of the fillet weld when the specimen is loaded parallel to the axis of the weld. The weld shearing strength is reported as load per lineal millimeter in megapascal based on the weld throat and the type of the specimen.

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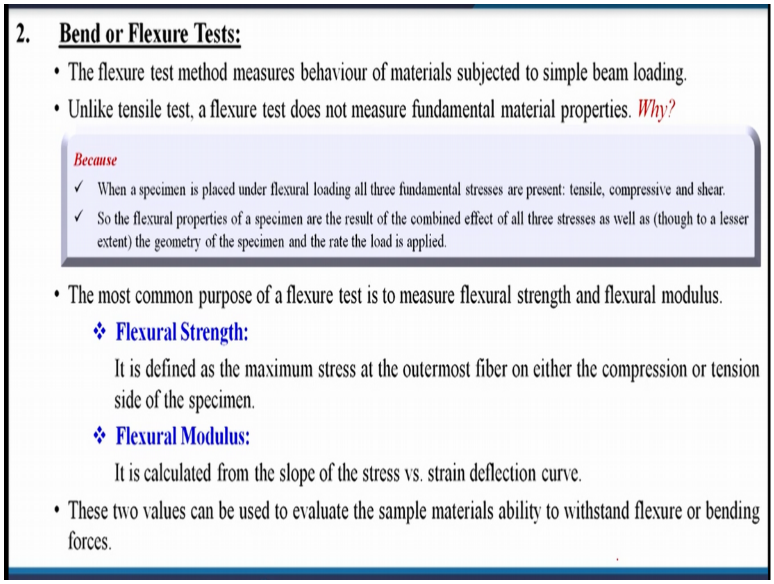

Next one is the bend or flexure tests. The Flexure test method measures behavior of materials subjected to simple beam loading, unlike tensile test a flexure test does not measure fundamental material properties, but now the question is why? Only when a specimen is placed under flexural loading all three fundamental stresses are present, tensile compressive and shear.

So, the flexural properties of a specimen are the result of the combined effect of all three stresses as well as though to a lesser extent the geometry of the specimen and the rate the load is applied, so it a a combinational strength. The most common purpose of a flexure test is to measure flexural strength and flexural modulus. So, what is flexural strength, it is defined as the maximum stress at the outermost fiber on either the compression or tension side of the specimen and what is flexural modulus.

It is calculated from the slope of the stress vs strain deflection curve. These two values can be used to evaluate the sample materials ability to withstand flexure or bending forces.

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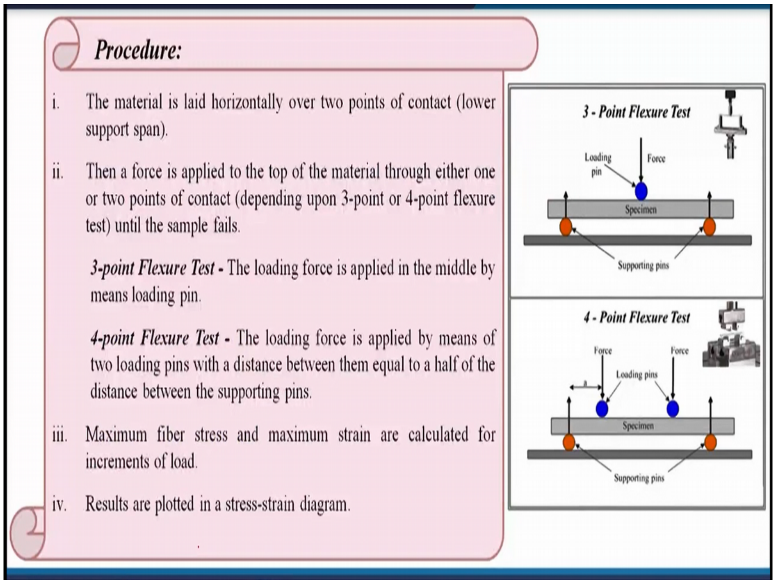

Now which procedure or may be how we are going to prepare the samples and do the testing. The material is laid horizontally over two points of contact by a lower support span. So, like these way we are putting the sample, Then a force is applied to the top of the material through either one or two points of contact depending upon 3 point or 4 point flexure test until the sample fails.

In this case we are using a single one, in this case we are using the two point. So generally 3point flexure test, the loading force is applied in the middle by means loading pin. 4-point flexure test- The loading force is applied by means of two loading pins with a distance between them equal to a half of the distance between the supporting pins, so in this particular case we are using the 3-point flexure test, here we are loading 3 point and here we are doing the loading on a 4-point basis. Maximum fiber stress and maximum strain are calculated for increments of load. Results are plotted in stress-strain diagram.

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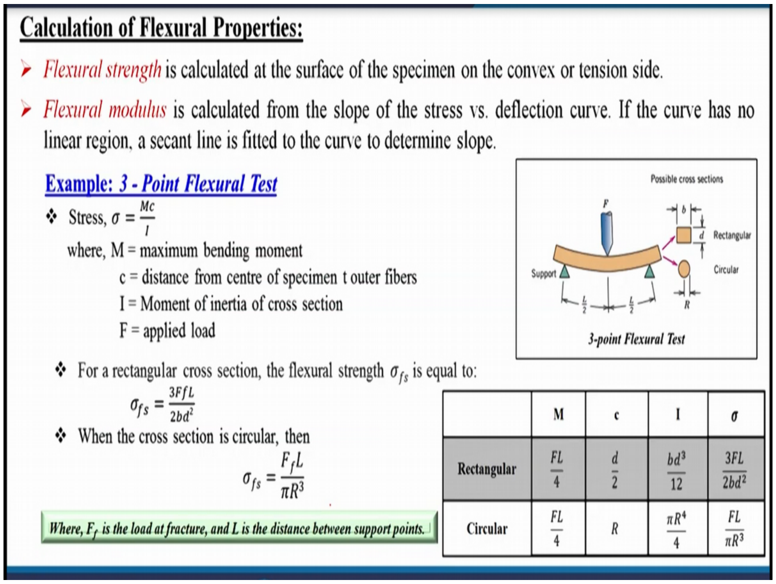

Now next is the Calculation of flexural properties. How we are doing the flexural strength calculations. Generally the flexural strength is calculated at the surface of the specimen on the convex or tension side. Flexural modulus, is calculated from the slope of the stress vs deflection curve, if the curve has no linear region, a scant line is fitted to the curve to determine slope.

For 3 point flexural test generally the stress sigma is known as capital M c by Capital I, where M is the maximum bending moment, small c distance from center of specimen t outer fibers, capital I moment of inertia cross section, and F is of course the applied load. For rectangular cross section the flexural strength sigma f s equal to 3 F capital F small f capital L by 2 small b small d square.

When the cross section is circular then sigma f s is equal to capital F small f capital L by pie R cube, where capital F small f is the load at fracture or may be the F f is the load at fracture and L is the distance between support points, So this is the case, in case of sample is rectangular or may be the sample is circular so, M value is this one small c is the this one, capital I and sigma is this one.

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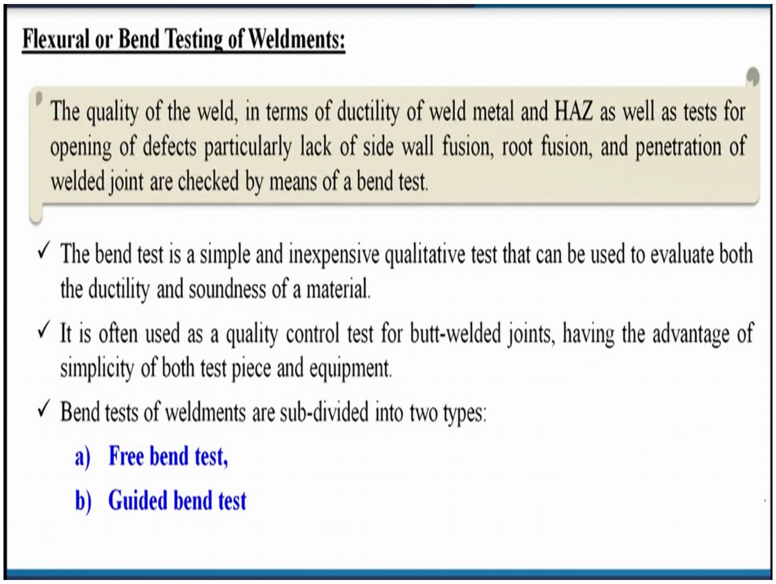

Next is that Flexural or bend testing of weldments. The quality of the weld, in terms of ductility of weld metal and heat affected zone as wells as tests for opening of defects particularly lack of side wall fusion, root fusion and penetration of welded joint are checked by means of a bend test. The bend test is a simple and inexpensive qualitative test that can be used to evaluate both the ductility and soundness of a material.

It is often used as a quality control test for butt welded joints, having the advantage of simplicity of both test piece and equipment. Bend tests of weldments are sub-divided into two types one is the free bend test and another one is guided bend test.

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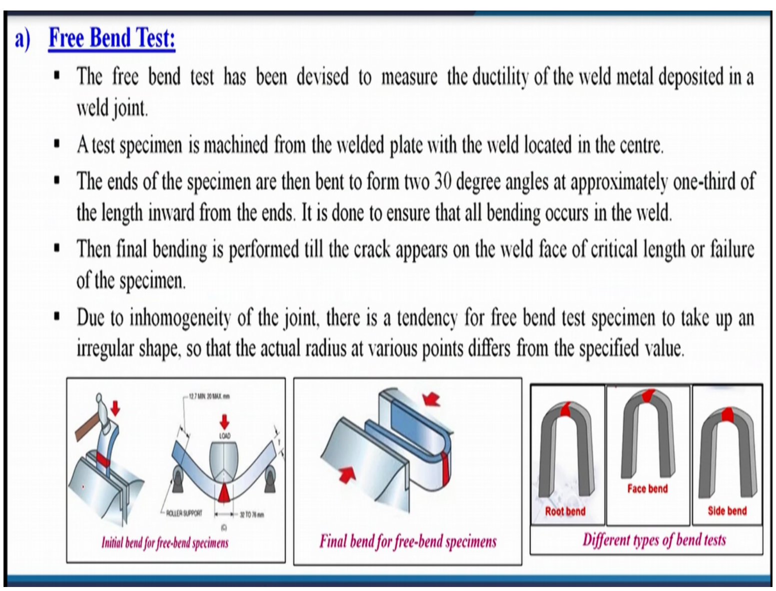

What is called as free bend test. The free bend test has been devised to measure the ductility of the weld metal deposited in a weld joint. A test specimen is machined from the welded plate with the weld located in the centre. The ends of the specimen are then bent to form two 30degree angles at approximately one- third of the length inward from the ends. It is done to ensure that all bending occurs in the weld.

So simple we are giving a 30 degree over there. So Now it is done to ensure that all bending occurs in the weld. Then final bending is performed till the crack appears on the weld face of critical length or failure of the specimen. Due to inhomogeneity of the joint, there is a tendency for free bend test specimen to take up an irregular shape, so that the actual radius at various points differs from the specified value.

So, there are initial bend for free bend specimens, generally we are giving the 30-degree, final bend for free bend specimen, so after giving the load over the samples look like this and there are different types of bend tests are there one is called the root bend then face bend and the side bend. Next one is called guided bend test, so in this particular case, simple we are guiding the sample so that the sample will bend like that or may be the following the guidance.

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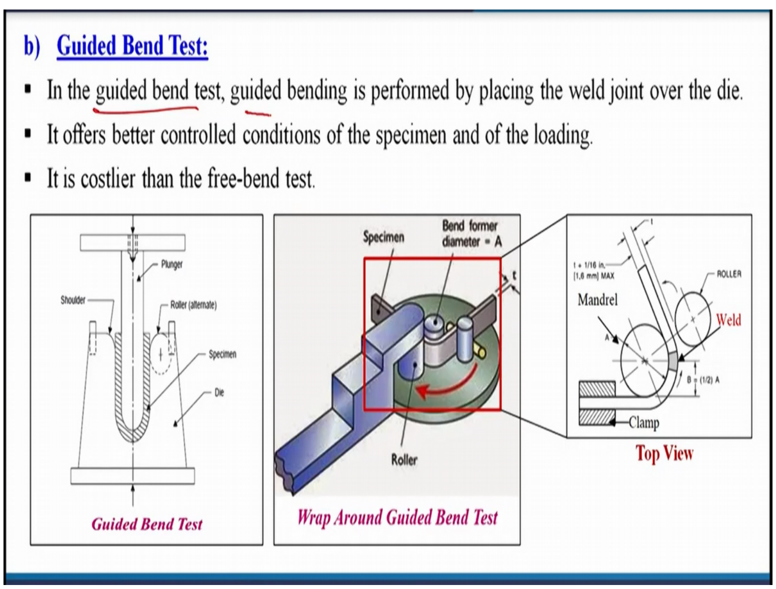

In the guided bend test, guided bending is performed by placing the weld joint over the die. It offers better controlled conditions of the specimen and of the loading, it is costlier than the free bend test. In this particular simple we are pressing the load over here and this is known as the guided and the sample will follow the path and it is going inside, in this particular also we are guiding the sample over there and we are bending it accordingly.

Next we have to come to the last slide of this particular lecture. So, we are going to summarize the whole lecture till now what we have discussed.

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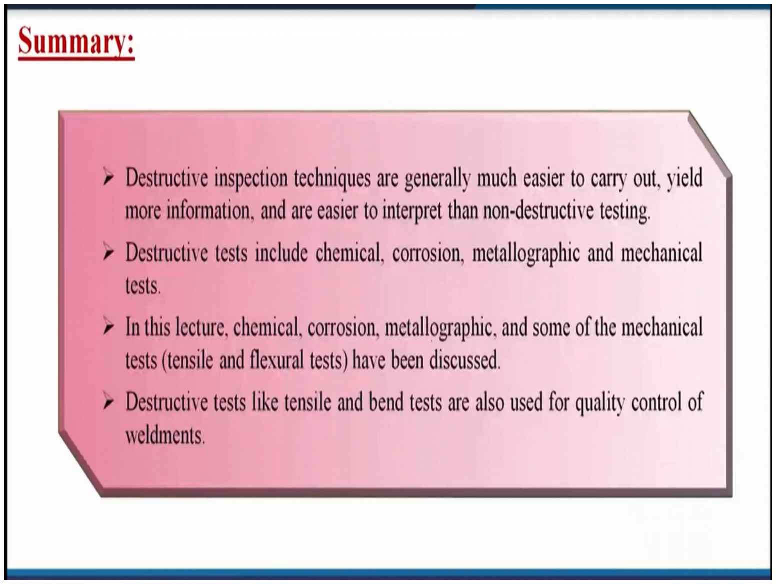

So basically, in this particular lecture we have discussed about the destructive inspection techniques and that is really, really easier to carry out yield more information and are easier to interpret than non-destructive testing, because we are getting the direct result over there, there is a very less chance of any kind of assumptions. This test basically the destructive test include the chemical, corrosion, metallographic and mechanical tests.

In this lecture, chemical, corrosion, metallographic, and some of the mechanical tests tensile and flexural tests have been discussed, and rest we are going to discuss in the next lecture. Destructive tests like tensile and bend tests are also used for quality control of weldments. This thing also we have discussed. Thank you for your patience.