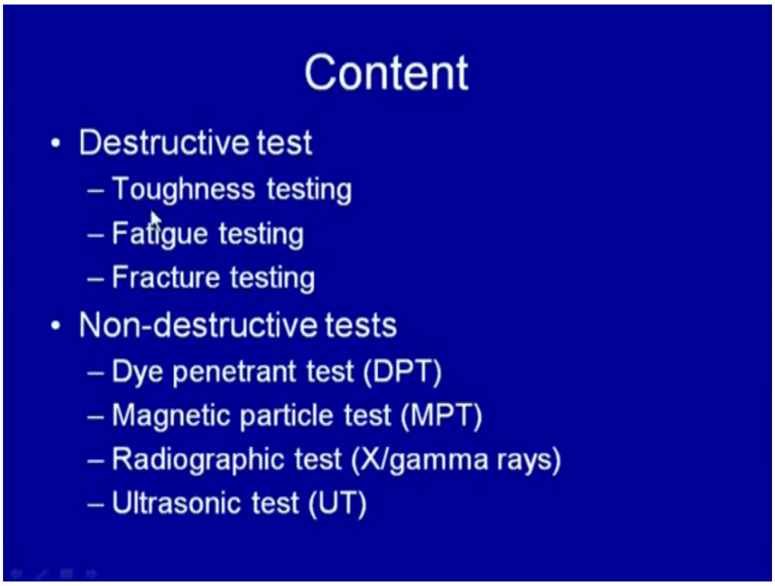
Welding Engineering
Prof. Dr. D. K. Dwivedi
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

Module - 7
Inspection and Testing of Weld Joint
Lecture - 2
DT & NDT

Dear students this is a the 7th module based on the Inspection and Testing of the Weld Joint and in this module this will be the second lecture, this lecture will be based on the distractive testing and non distractive techniques. Some of the distractive techniques we have talked about in the last lecture; in the last lecture we have also seen the need of conducting the inspection and testing of the weld joints.

And some of the techniques like the hardness testing, tensile testing, band test we have talked in the last lecture. In this presentation we will be focusing first on the other three important the testing methods, which are commonly used in the weld joints to assess the quality of the weld joints and there capability to take up the load. And thereafter, we will take up few important the non distractive testing's, like the ultrasonic testing, radiographic testing, magnetic particle testing and the dye penetrate testing. So, these testing's NDT testing's are mainly used for assessing the presence of the surface and the subsurface defects.

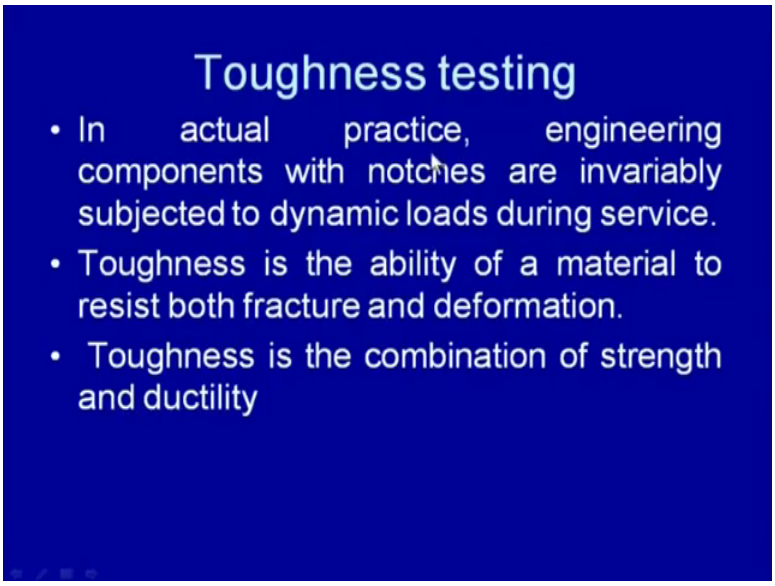
(Refer Slide Time: 01:43)



So, as far as content is concerned for this presentation, in this presentation when mainly we will be taking up the 3 destructive test, these are the toughness tests, fatigue test and fracture toughness test. And then we will take up the non destructive testing methods, which will include the Dye penetrant Test commonly known as DPT, then Magnetic Particle Test it is known as MPT, and radiographic test which will be based on either X rays or gamma rays; and then ultrasonic tests this is one of the very commonly used test now, a days for assessing the presence of the subsurface defects and to locate it.

So, starting with the toughness test, we know that the engineering components are frequently designed with the variety of the features like holes, key ways, slots etcetera. And the engineering components are expected to perform during the service with these features, which are present in these components. However, presence of these special features like notches or the keyway, holes, bring in the very rapid change in the cross section and which in turn increases the stress concentration. And many times under the dynamic load conditions these become the point of the weakness and sometimes lead to the failure of the component during the service.

(Refer Slide Time: 03:16)

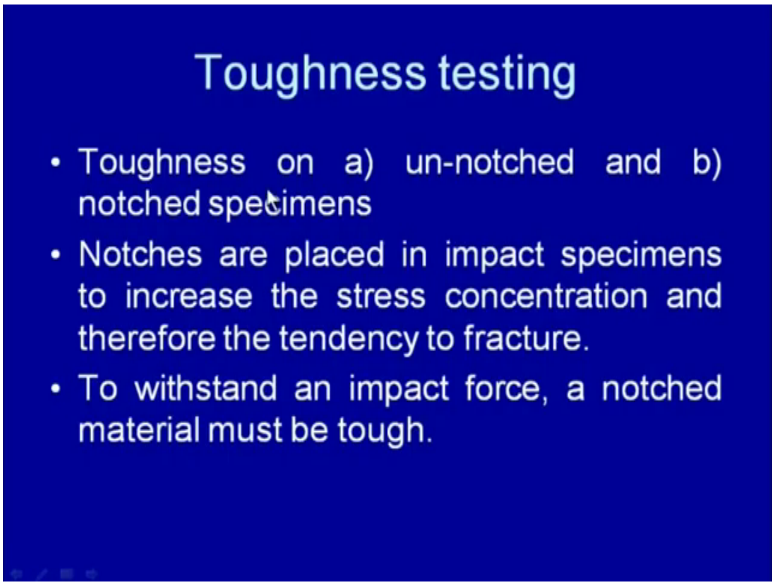


So, since we know that in actual practice, engineering components many times have variety of the notches and these are frequently subjected to the dynamic loads means the loads whose magnitude is fluctuating or they are subjected to the very high rate of the loading during the surveys. So, to with stand a material should have the reasonable degree of reasonably good toughness.

So, that it can with stand during the service even under the high rate of the loading conditions with the and when the component is having the variety of the notches or the variation in cross sections. So, that to measure to assess the ability of the component or of a given material to with stand under such high rate of the loading conditions, with the notches test which is commonly conducted is called a toughness test. The toughness test shows the ability of the material to resist the external load, which is especially of the impact kind means the rate of loading is high.

So, the toughness test shows the ability of the material to resist both fracture and deformation and thus it is a found a combination of the strength and ductility. When toughness test is conducted it shows that how much resistance it can offer to the impact loads and so that it can perform. So, that it can with stand for longer duration under the impact load conditions.

(Refer Slide Time: 04:51)

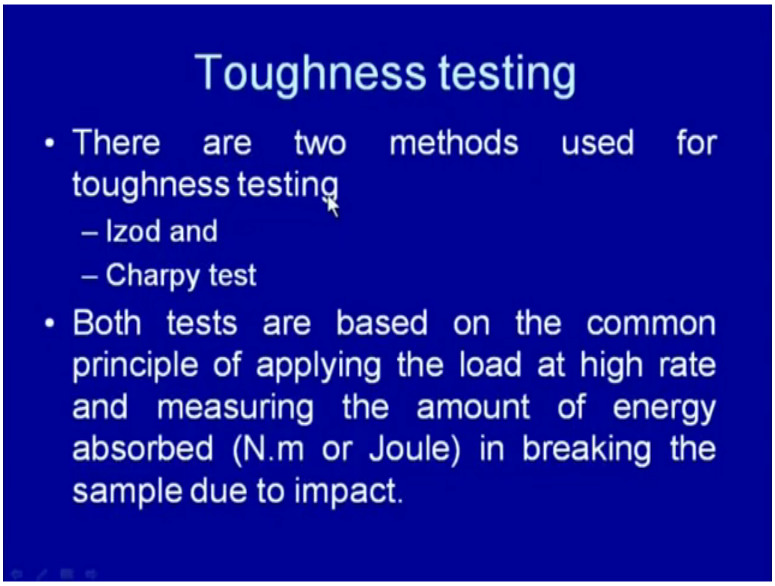


So, the there are two approaches which are normally, used for conducting the toughness test means the test specimen can be the notched or without notch also. So, accordingly we will be saying the notch toughness or un-notched toughness of the material. So, this notch toughness will be indicating that how material will behave under the impact load conditions means, how much energy it will absorb for fracture to take place under the impact load conditions, while un-notched sample will be showing that the amount of energy that it will absorb without presence of any notch.

Since the presence of notch increases the tendency of the material to fail especially under the impact load conditions and that is why notch toughness becomes more useful way of assessing the toughness of the material. So, the notches are placed in the impact specimens to increase the stress concentration and with those, with the presence of those notches the tendency of the material to resist the fracture under the impact load condition is assessed.

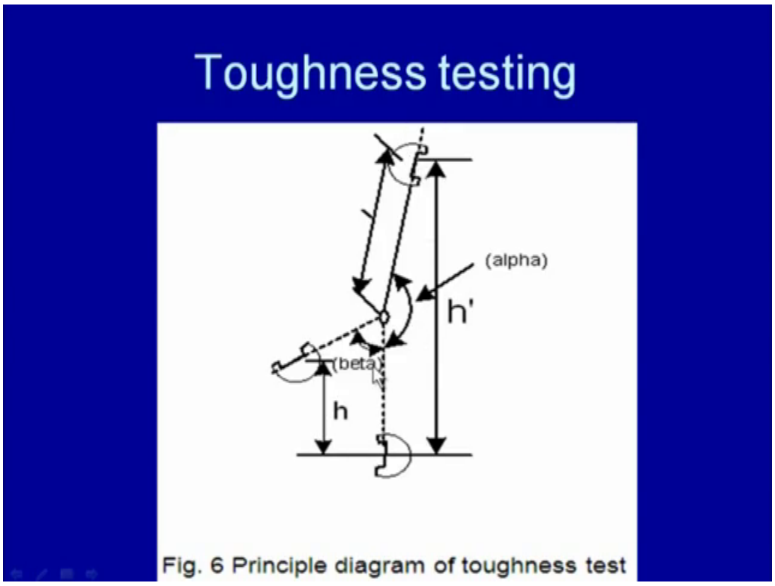
So, to withstand an impact force or notched specimen, a notched material must be tough. So, if the material is provided with the notch and under those conditions how much energy it absorbs to before facture take place under the impact conditions. So, that indicates the toughness and which can be related, in better way with the service life performance because material means the engineering components are frequently subjected to the impact load conditions during the service.

(Refer Slide Time: 06:44)



And there are two methods which are commonly used for toughness testing, one is izod another is charpy test and both these tests are based on the common principle of applying the load at a high rate and measuring the amount of energy that it absorbs for breaking the sample due to the impact. So, basically the impact load is applied and it is observed that how much energy the sample will be absorbing for fracture to take place.

(Refer Slide Time: 07:23)

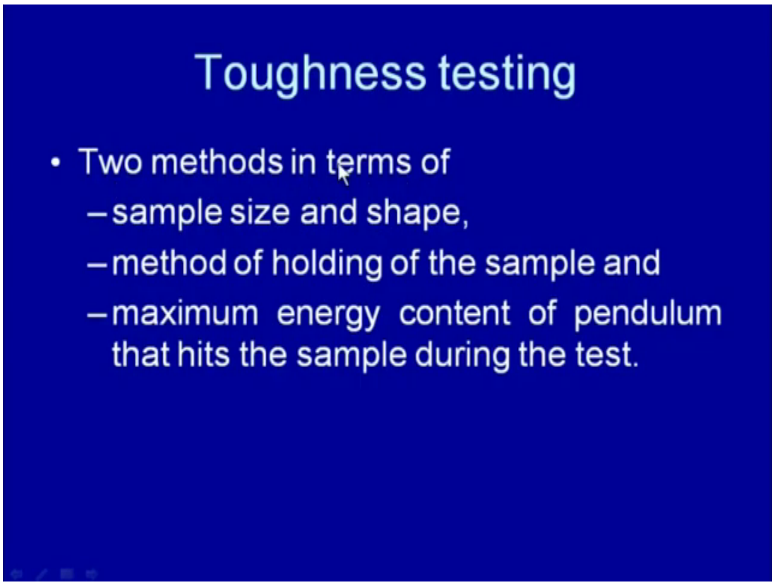


So, that energy is expressed either in terms of Joule or in terms of the Newton meter for this purpose one common principle which is used that one pendulum with having, heavy hammer kind of object is raised to high levels. So, that it has the potential energy and then it is dropped under the gravity conditions. So, it hits when it hits to the sample with the impact the energy is absorbed by the sample in this fracture process.

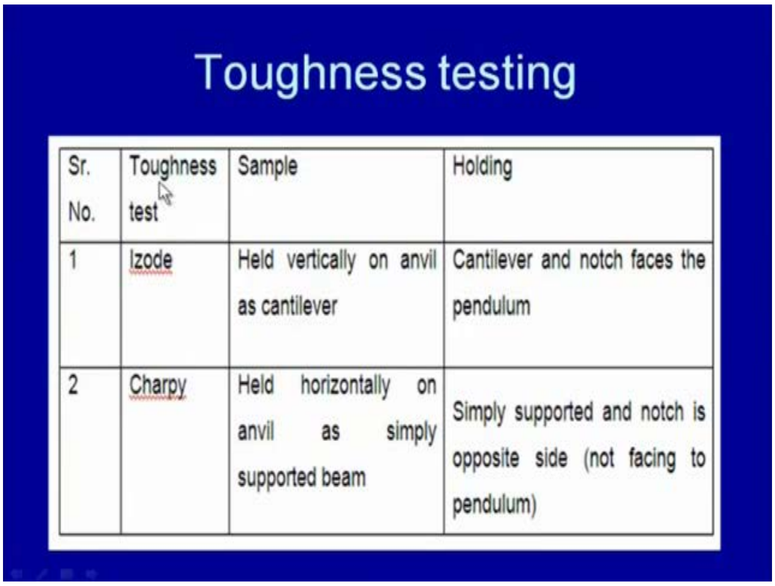
And left and this then amount of energy which is left with the pendulum when it is going another side, it will decide that how much height it will be covering say, initially height of this pendulum is of h dash and when it comes down and hits the specimen some amount of the energy is absorbed. And whatever amount of the energy is left with this it goes other side and say if it goes to the height of the h then the height difference indicates the amount of energy it has absorbed in this fracture process.

So, the two methods, these two methods which are i zod and impact test largely in both the methods the same principle is used where one pendulum is raised to the higher level, and then it is allowed to fall to struck with a specimen to be tested. And then amount of energy absorbed in this fracture process is recorded to see that, how much toughness of the material is and but the placement of the specimen type of the specimen and the energy that pendulum has these are different for the three cases for the two methods. And so the two methods are found different in terms of the sample size and the shape and the method of the holding the sample, and the amount of energy that the pendulum contains before impacting the specimen.

(Refer Slide Time: 08:32)



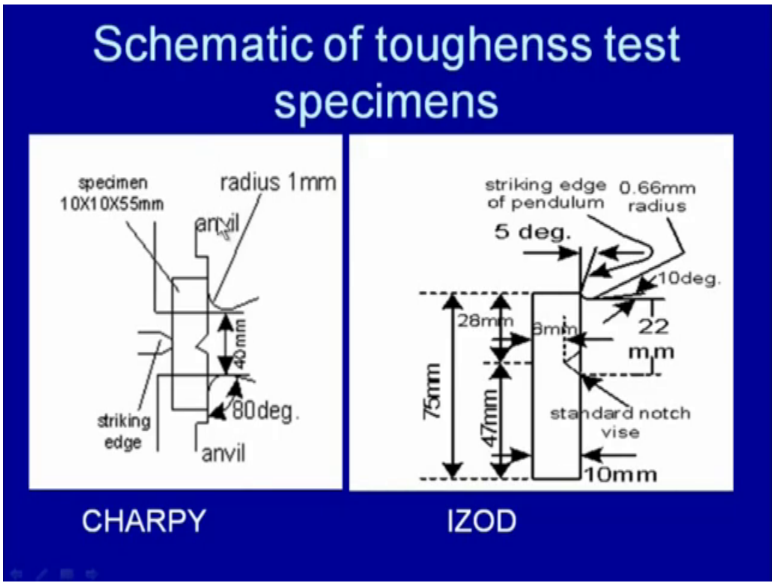
(Refer Slide Time: 09:25)



Sr. No.	Toughness test	Sample	Holding
1	Izode	Held vertically on anvil as cantilever	Cantilever and notch faces the pendulum
2	Charpy	Held horizontally on anvil as simply supported beam	Simply supported and notch is opposite side (not facing to pendulum)

In case if the i zod test, the specimen is held vertically in cantilever manner and while in case of the charpy test, the specimen is held horizontally on the anvil as a simply supported beam. In case of the i zod the cantilever and the notch face the pendulum when it hits to the to it is surface, while in case of the simply supported beam while in case of the charpy test the simply supported. And the notch, means the notch of the specimen is opposite side means this pendulum hits from the hits the specimen from the backside of the notch and not from the facing side of the of the specimen.

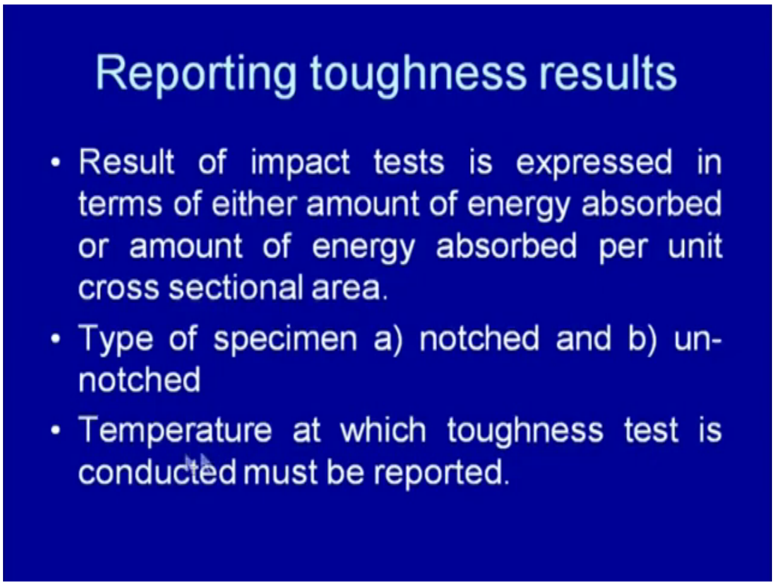
(Refer Slide Time: 10:23)



So, this is a the difference which exist in these two methods, just to show these the schematic of the two schematic of the specimen and there dimensions is shown here, in the first shows the charpy test where the specimen to be tested is placed on this anvil, in simply supported manner. So, it gets support from both the ends and then pendulum hits means this striking edge of the pendulum hits from the back side and then amount of energy absorbed is recorded.

In this test, while in case of the i zod test, the specimen is held like a cantilever and this pendulum hits from this, the face side of this notch and these are the different dimensions of the specimen, which is commonly used for the i zod test. In both the cases, we find the toughness of the material in terms of the energy absorbed by, the material with the notch. In terms of the Newton meter or the Joule higher is the amount of the energy absorbed in this fracture process greater is the toughness of the material, which indicates that material can withstand under the impact load conditions without failure. So, and if the material requires very less amount of the energy for fracture to take place. So, that will indicate the lower toughness of the material and poor ability of the material to withstand and the impact load condition.

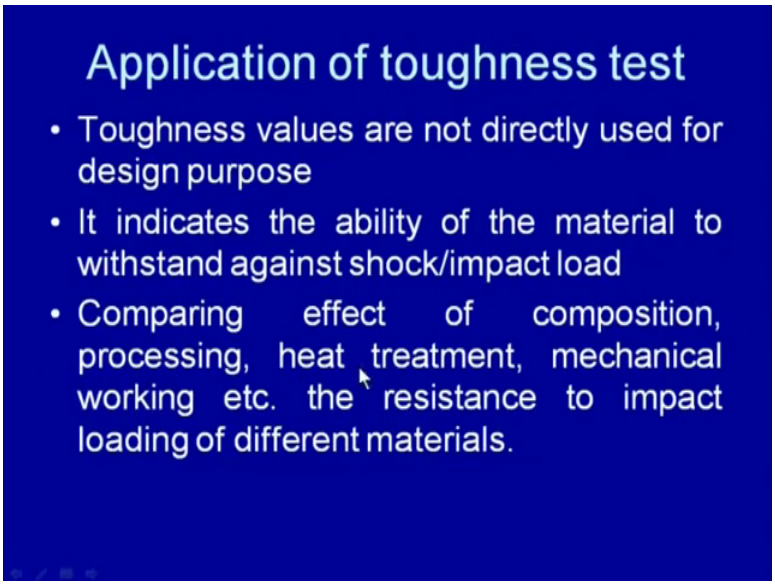
(Refer Slide Time: 11:57)



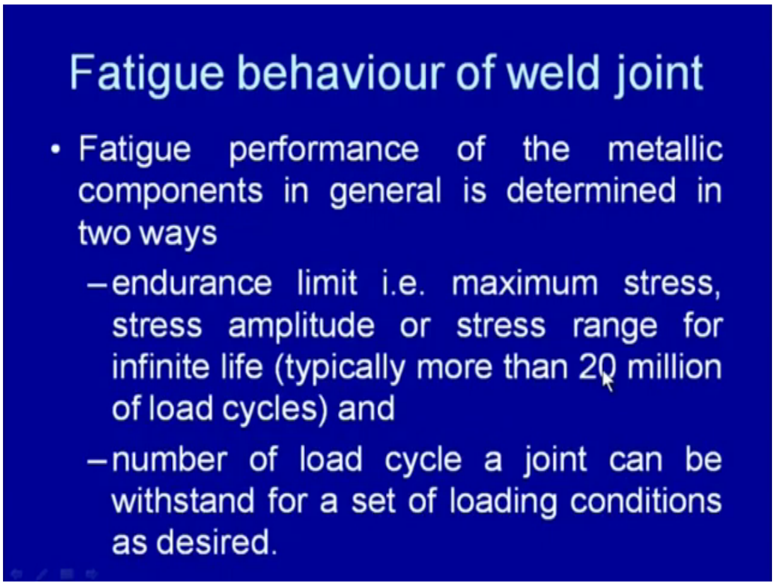
Once the impact test is this toughness test is completed the reports, are results are reported in terms of the amount of energy absorbed by the specimen in this process or amount of energy absorbed per unit cross sectional area is also reported. Thereafter, it is also mentioned what type of this specimen, was used whether it was notched or un-notched specimen or the temperature at which toughness test was conducted because toughness temperature of the material significantly affects the toughness value of the material. Therefore it is important to mention, the amount of energy, absorbed the type of specimen used whether it was notched or un-notched or the temperature in which test was conducted and it is also, important to mention which method of the test was used either it was i zod or the h r p test.

Now, after conducting the test we will be getting some value of the toughness in terms of the energy absorbed by the specimen during this test, but these values are not used directly for any design purpose, these simply indicates the ability of the material to withstand and the impact load condition. So, now but this test can be effectively used to see that how the variation in composition, variation processing method, variation in heat treatment or variation in mechanical properties, will be affecting its ability to withstand under the defend impact load conditions. So, this impact test, this toughness test can be effectively used to compare that how the material's ability to withstand under the impact load condition is affected, with the change of composition processing, heat treatment or the mechanical working.

(Refer Slide Time: 12:58)



(Refer Slide Time: 13:46)

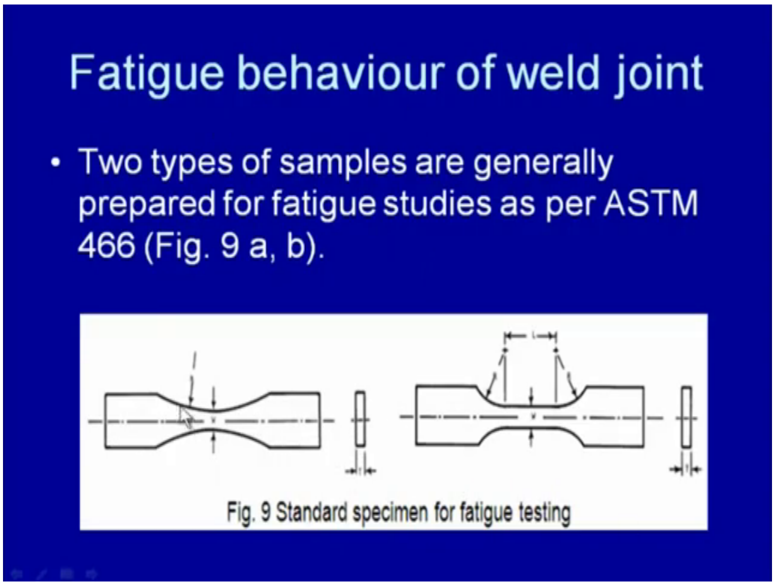


Now, another important test is the fatigue test and we know that, in real life most of the engineering components are subjected to the fatigue because the load magnitude and magnitude of the load and it is direction keeps on changing, for which these are subjected during the surveys. So, the application of the fatigue load on a engineering component reduces the life of the component very drastically.

And to assess that how material will perform or how weld joint will perform under the impact load conditions the fatigue behavior is investigated and fatigue behavior of the weld joint is studied in the two ways. One first to identify the endurance limit means the kind of the stress maximum stress at which it, can withstand for infinite life that is typically more than 2 million load cycles. So, here it is a 2 million load cycles then the number alternatively.

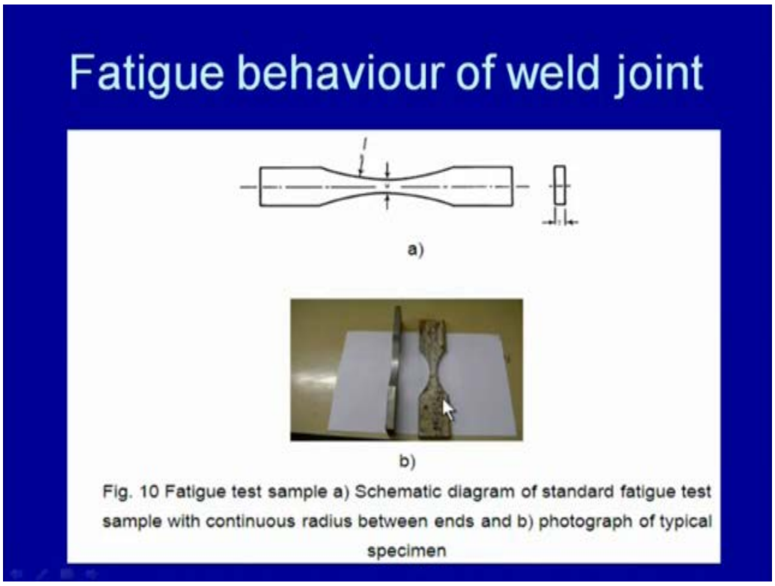
So, fast fatigue test is conducted mainly to see the endurance limit or. So, that will indicate the maximum stresses at which it can withstand for infinite life. That is mostly considered as, 2 million load cycles or another is that number of load cycles say, it will withstand for given loading conditions. So, if you have identified the kind of fluctuation which will be occurring in the loading magnitude or the kind of the stress range or the stress amplitude is available. So, for that particular stress amplitude how many, load cycles component can withstand. So, the fatigue life for given loading conditions or endurance limit; these are the two things which are identified when the fatigue, behavior of the weld joint is studied.

(Refer Slide Time: 15:39)



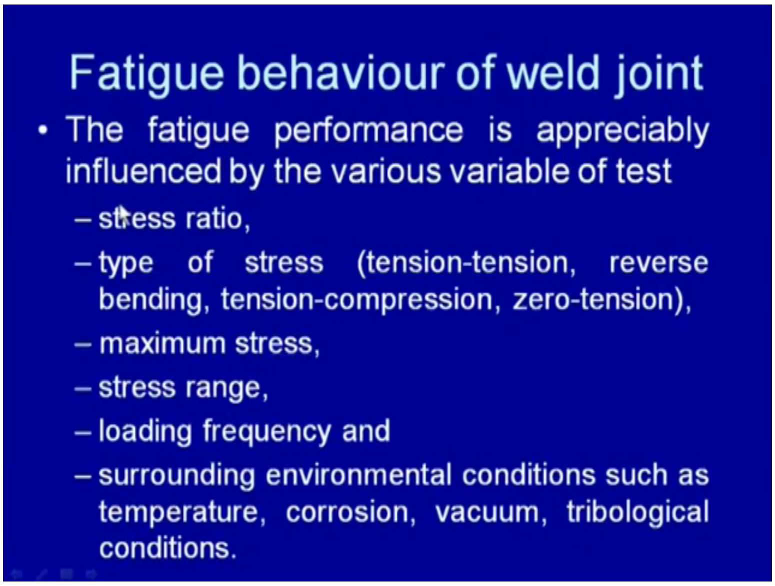
And this is done using the two types of the samples, one is this reducing radius sample, where the radius of the means, the cross section of the specimen is reduced, gradually and this is another kind of sample which is used for fatigue testing. In this case, in the first case reducing radius cross section, reducing radius specimen here the stresses are always localized in the minimum cross sectional area zone and this is mostly kept in the weld region. So, it helps to assess the fatigue performance of the weld joint itself. So, these are typical the specimens which are used for conducting the fatigue test.

(Refer Slide Time: 16:26)



And, here this is schematic diagram showing the reduced radius specimen, and this is the real photograph of this specimen, which is showing the reduced radius specimen for fatigue testing. And when the fatigue test is conducted it is important to see that what are the loading conditions being used.

(Refer Slide Time: 16:46)



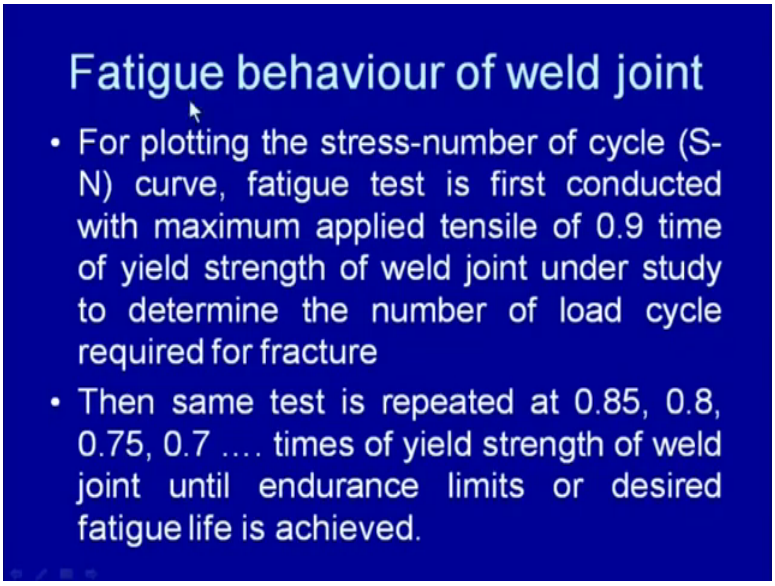
So, the fatigue performance, we know that is appreciably is influenced by the various parameters related with this test. So, first is to see that what is the stress ratio being applied means, what is the minimum and the maximum stress. So, the ratio of the minimum and the maximum stress gives us the, stress ratio and the commonly used stress ratio is 0.1 or 0.5.

Then the type of the stresses being used means, what type of the stress load cycle is being developed, is stress whatever stresses are being used for conducting the test it is tension to tension means the stress is varying from some minimum value of tension tensile stresses to the higher value or it is reverse bending, where or it is tension to compression or 0 to tension, what type of a stresses are being used that is established.

Then maximum stress magnitude is also identified, then stress range is identified from the difference of the maximum to the minimum stresses. And then at what rate the load is being applied that is indicated in terms of the loading frequency. So, depending upon the kind of system being used, we can use loading frequency 5 hertz, 10 hertz, 20 hertz, depending upon the capability of the, system which is being used for conducting the test.

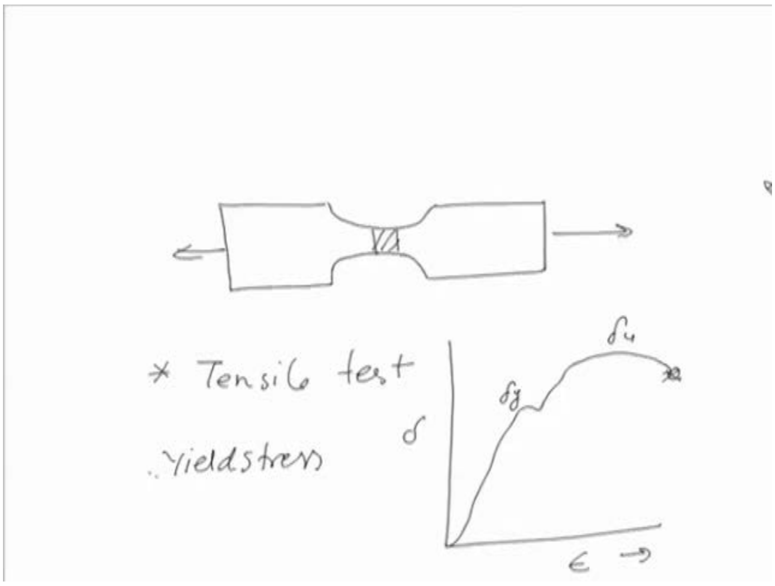
And then if any a special kind of the environment is being applied for conducting the test like, in the low or high temperature the corrosive temperature, vacuum or some tribological conditions, like the fatigue test in the under the ((Refer Time: 18:24)) conditions or the abrasion conditions or erosion conditions or cavitation conditions. So, depending upon the kind of the conditions, in which the fatigue test is to be conducted suitable environment is developed and that is reported.

(Refer Slide Time: 18:40)



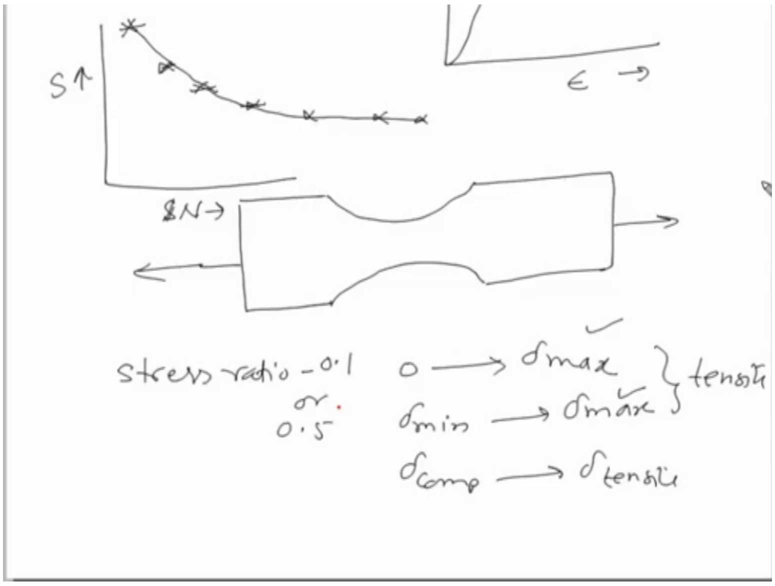
So, for conducting the fatigue test basically, suitable kind of the stresses are developed and they are applied onto the specimen, as per requirement. And it is common to conduct the root tree bending test is conducted which will be developing the tensile and compressive stresses, in each cycle of the load, while the axial stresses are also used where either 0 to tension or tension to tension stresses are applied, apart from the root tree test the axial loading is commonly used for conducting the fatigue test where to conduct the this fatigue test. In case of the axial loading, we try to first conduct the tensile test of the specimen. So, that we know, that what is the yield strength and ultimate strength of the material, to understand this we will try to see this step by step methodology.

(Refer Slide Time: 19:42)



Say, the weld joint for which this is the weld joint specimen, tensile specimen for which it has been developed and at the, centre say we have here this is the weld region. So, the first step is to conduct the tensile test of the specimen. So, tensile test when will be conducted it will give us stress strain curve of this kind. So, this will be giving us the yield stress, ultimate stress and the percentage elongation corresponding to this point. So, this yield stress basically, the information related with yield stress of the material is used for conducting the fatigue test.

(Refer Slide Time: 20:41)



So, another specimen which will be, say of the reduced radius cross section will be developed. And this reduced radius cross section will then be subjected to the fatigue test may be say, in case of the axial loading and depending upon the kind of the stresses that are to be developed ranging from say 0 to some maximum or some say minimum to the maximum. So, all these are of tensile kind, and then these can be say minimum compressive stresses and the maximum tensile stress their values can be identified.

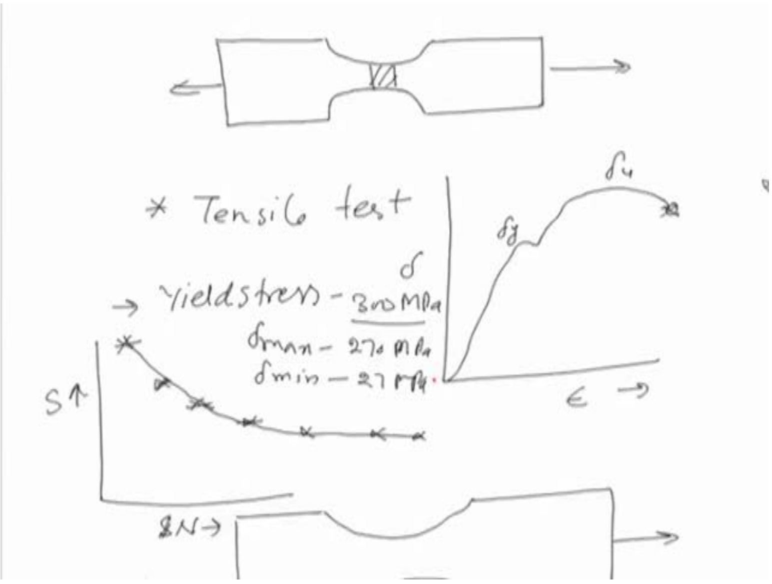
So, what we do, this is how we I we can identify the kind of a stress and the maximum stress is to be applied and based on this, we need we try to apply the loading conditions. So, as far as the development of the s n curve is concerned what we do, we need to plot the relationship between then number of load cycles that a specimen can withstand. And here, we can have either maximum stresses or the stress amplitude. So, it is common to put the s for the stress amplitude which is the half of the stress range.

So, we will be starting with the putting in maximum stress to the tune of the 0.9 times of the yield stress. So, we are starting with this say 0.9 maximum stresses corresponding to the 0.9 times of the yield stress. So, that will be taken as first. So, it will be consuming very, it will be using very few number of the load cycles, thereafter we will be conducting at 0.8 number of 0.8 times of the yield stress. It will be taking for somewhat longer.

And this is how we will keep on reducing 0.7 times of the yield strength, maximum stress corresponding to the 0.7 times, then 0.6 times of the yield stress. And this is how we keep on doing it. So, we will find that after reaching somewhere in the band of 0.4 to the 0.5 times of the yield stress the number of load cycles. So, in case of the ferrous metals it becomes the endurance limit. So, here we can show it like this. So, here the first test will be conducted corresponding to the 0.9, time maximum stress corresponding to the 0.9 times of the yield strength.

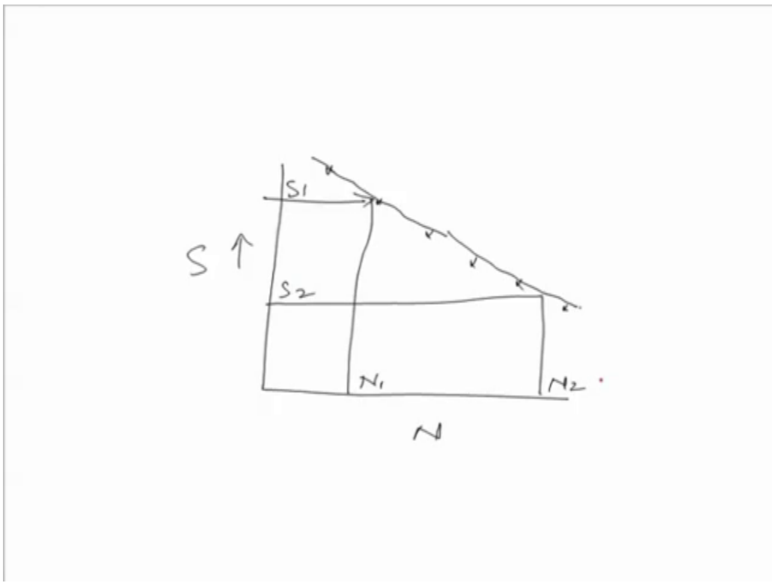
So, here this is the maximum stress, this is the maximum stress, the maximum stress value should be about 0.9 times of the yield stress and thereafter the and depending upon the kind of a stress ratio which is being used. Now, stress ratio can be 0.1 or 0.5. So, if we are taking. So, point stress ratio of 0.1 indicates a that the minimum stress ((Refer Time: 23:50)) maximum stress will be, above 10 times of the minimum stress, say if the yield strength comes out to be 300 M P a.

(Refer Slide Time: 24:00)



Then the, we start with the sigma max, we can take 270 M P a and sigma minimum when using the stress ratio we will be 27 M P a. This is how it can be done. So, if it is the tension to tension, then minimum stress will be of 27 M P a, maximum stress will be of 270 M P a and then accordingly the stress ratio means the stress range will be that can be, calculated to find out. So, this is one way which can be used for conducting the fatigue test, there is another way when we know that the material is ferrous metal systems like, aluminum and we will not be getting the clear cut endurance limit.

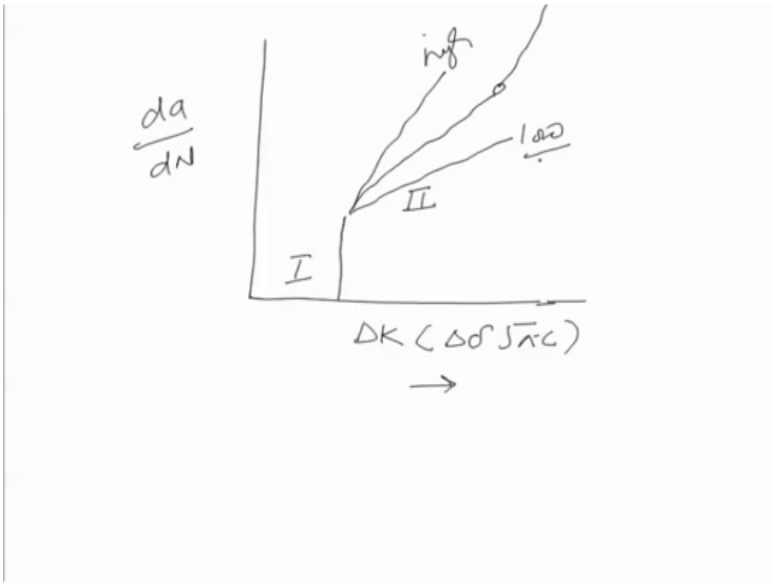
(Refer Slide Time: 24:51)



So, for conducting the test for those metals system basically, we just corresponding to the different stress amplitudes. We conduct the fatigue test and in that case we keep on continuously decreasing the fatigue load cycles and we do not get very specific and clear cut endurance limit. So, here for given stress amplitude value, we get one value of say for s 1 stress amplitude, we get one N 1 life and if the s 2 is the stress amplitude then we get another N 2 the life, of the component under the fatigue conditions.

So, these are the two ways through which, the fatigue behavior of the material is studied especially in respect of the life one is the endurance limit, another is that number of load cycles system will be with standing for a given, loading conditions. And another important aspect that is, related with the fatigue behavior is the studies of the crack growth rate, we know that the crack fatigue failure takes place in the three stages one is the crack nucleation, second is crack growth and third is catastrophic failure. So, the first and last stage that is nucleation and the catastrophic failure stage these form about 15 to 20 percent of the total fatigue life cycle, while the 80 percent of the fatigue life is composed of the second stage, where the stable crack growth will be taking place.

(Refer Slide Time: 26:33)



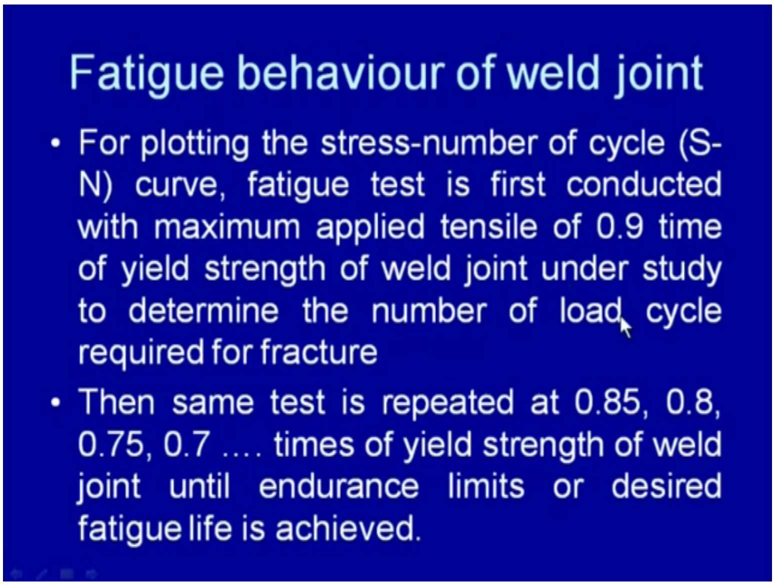
So, basically we try to study the crack growth behavior of the material, under the fatigue conditions to study that fatigue crack growth rate study basically, the delta k which is the stress intensity factor range indicating, the stress range that is the delta sigma means difference of the maximum stress and minimum stress, and then pi c root pi c. So, this gives us the stress intensity factor range, where the c is the half crack length for internal defects and the full crack length of the external discontinuities and the defect.

So, the stress intensity factor range is put in the x axis and in the y axis, we put in the d a by d n which indicates the crack growth rate. And we get, curve of this kind where there is no crack growth rate m means crack even if it is there it will be non propagating kind. And when the stress range increases beyond a certain value, we get curve of this kind where, very stable smooth and crack growth occurs, crack growth rate increases continuously, and then in third stage.

It increases means this is the first stage, this is the second stage where the crack growth rate versus the stress intensity factor range, have the linear relationship largely. And in the third stage, the crack growth rate increases at the increasing rate which is clear from its positive slope, while in this case slope largely remains constant. So, here for the different metal systems this slope is found at the different angles. So, for those metal systems where, slope is low the crack growth rate will be occurring at slowly.

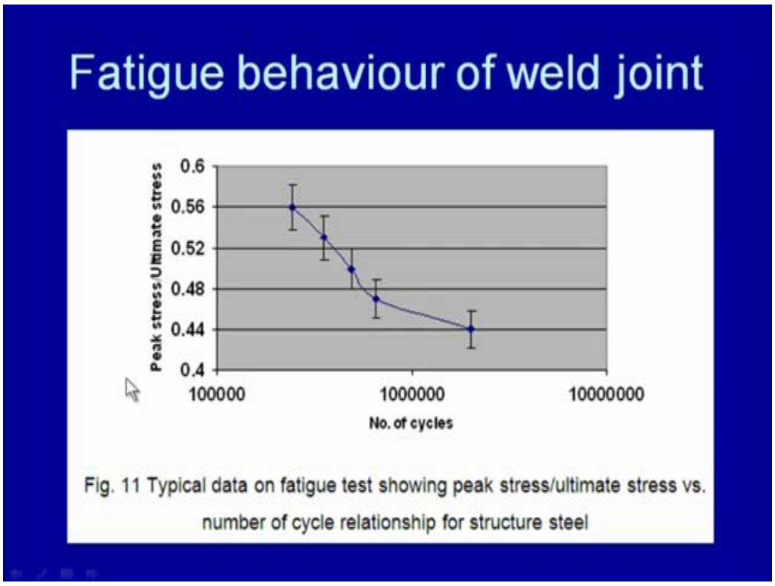
And the fatigue performance will be, better as compared to the material systems for which show the higher crack growth rate. So, here this is say for low crack growth rate, and this is for high crack growth rate and this high crack growth rate materials will be, showing the poor performance under the fatigue load conditions. So, this is the another zone, where the fatigue crack growth related studies are conducted.

(Refer Slide Time: 29:04)



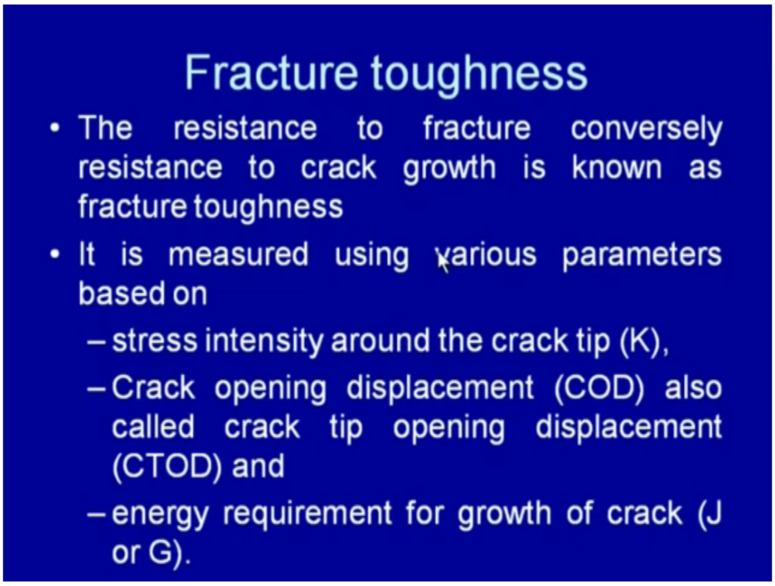
So, as far as the fatigue behavior is concerned the important aspects related with this like for plotting the S N curve means the stress amplitude, stress maximum stress or the stress range the number of and the load number that is the number of loads cycles, called S N curve the fatigue test is first, conducted with the maximum applied tensile stress of 0.9 times of the yield strength of the weld joint under the study to determine the number of load cycles required for fracture. And then the same test is repeated at 0.85, 0.8 0.75, 0.7, 0.65 and like this, the corresponding with the different maximum stress levels, this test is conducted and the number of load cycles required for failure are identified.

(Refer Slide Time: 29:48)



So, then we develop a plot between the either the stress range or stress amplitude of the maximum stress, in the y axis and the number of load cycles in the x axis to have the S N curve. So, in these S N curves can be plotted on the linear scales or the log scales.

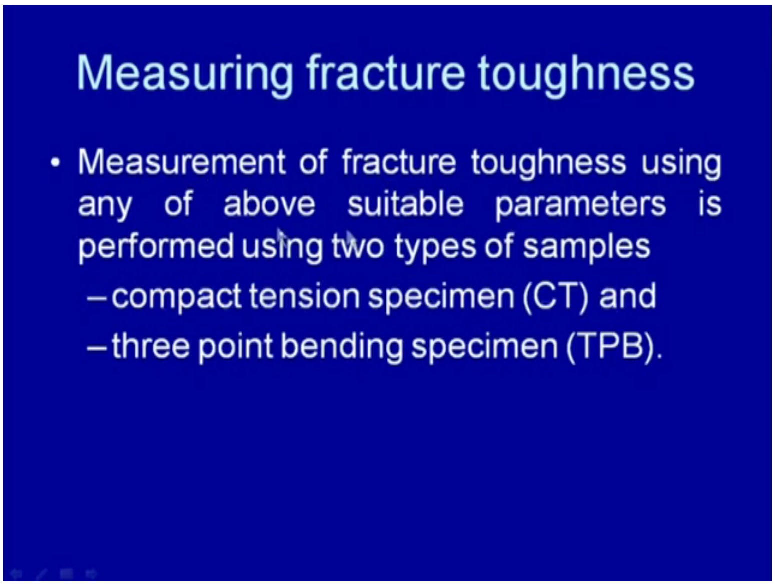
(Refer Slide Time: 30:07)



Then the fracture toughness, this is another important the test which is commonly used for measuring the resistance to the fracture of the material, and it indirectly it shows that if the crack is present then under what conditions it will start growing. So, the resistance to the crack growth is measured in terms of the fracture toughness. So, the fracture toughness of the material shows the resistance to fracture or resistance to the crack growth.

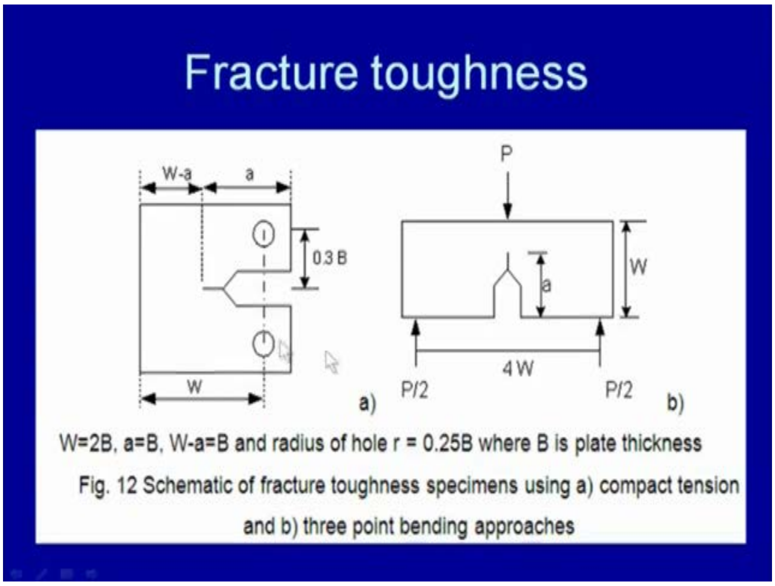
And this is a known as, the fracture toughness it is measured using the various approaches like, the stress intensity factor, around stress intensity around the crack tip is commonly known as the stress intensity factor and denoted by K. Then the Crack Opening Displacement it is called C O D or also called C T O D Crack Tip Opening Displacement and the energy required for the growth of the crack we use the J or the G parameters. So, we will be talking mainly about the stress intensity factor parameter, where and this material is used for the plain strain conditions especially, when the yield strength of material is high ductility is very limited, while the crack opening displacement and the energy related parameters are used for somewhat the ductile materials.

(Refer Slide Time: 31:28)



So, for measuring measurement of the fracture toughness uses the two types of the specimens, one is called Compact Tension specimen commonly known as the C T specimen or the three point bending specimen it is called T P B as in abbreviation form.

(Refer Slide Time: 31:48)

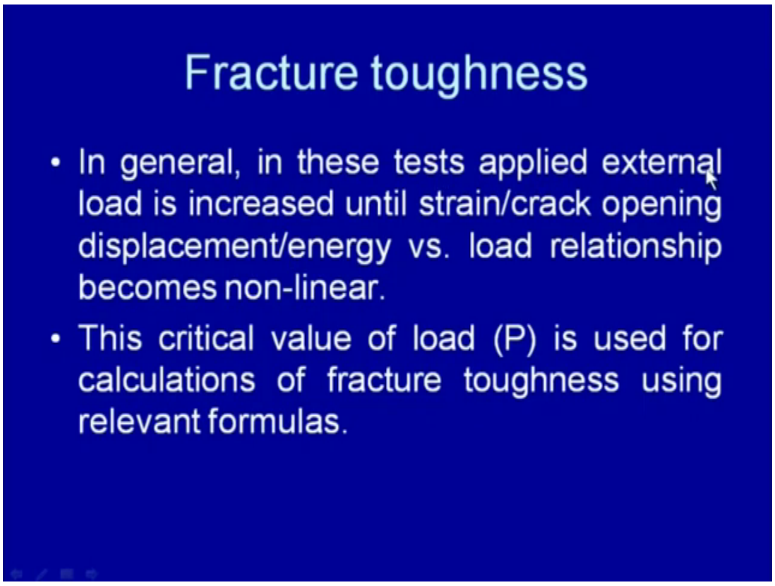


So, these are the standard sample and the different dimensions which are been shown here, and here the B is the plate thickness, this is the B always start with the plate thickness for the fracture toughness because it plays a big role in determining which type of test is to be conducted for assessing the fracture toughness. So, B is the fracture toughness of the material, and the w is this the distance of the plate from the in the width of the plate from the centre of the hole, it is that is kept around 2B.

And then the crack length, that is this length this is the crack this and pre cracked and this is crack size, which is measured from this edge. So, we make first notch by machining and then crack is developed and this total length is measured as a and the remaining length, where we do not have do not have crack that is measured as w minus a, this is similar dimensions are used here, but here in this case the load is applied in tensile manner for opening of this crack mouth.

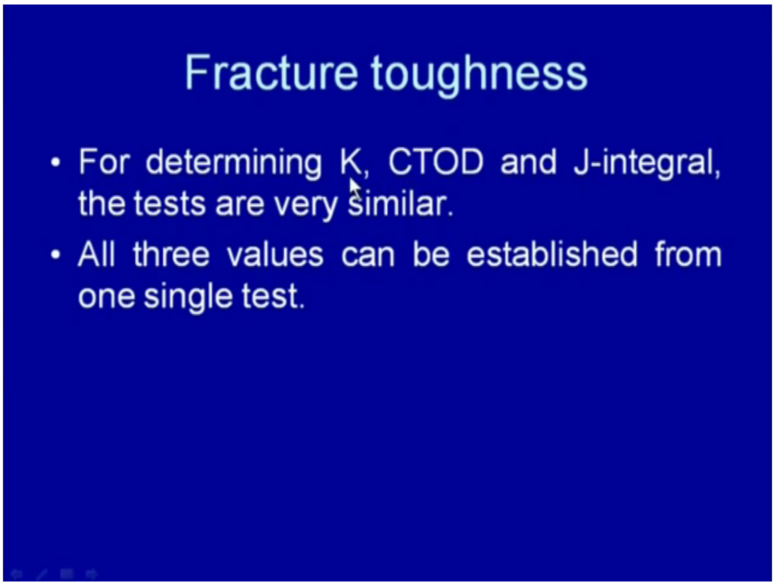
So, we try to measure that at under what loading conditions, the crack starts to propagate. In case of the three point bending specimen the and that the specimen is simply supported and the bending load is applied from the top like this. And this hole which is made this a hole is made of about 0.25 times of the plate thickness.

(Refer Slide Time: 33:31)



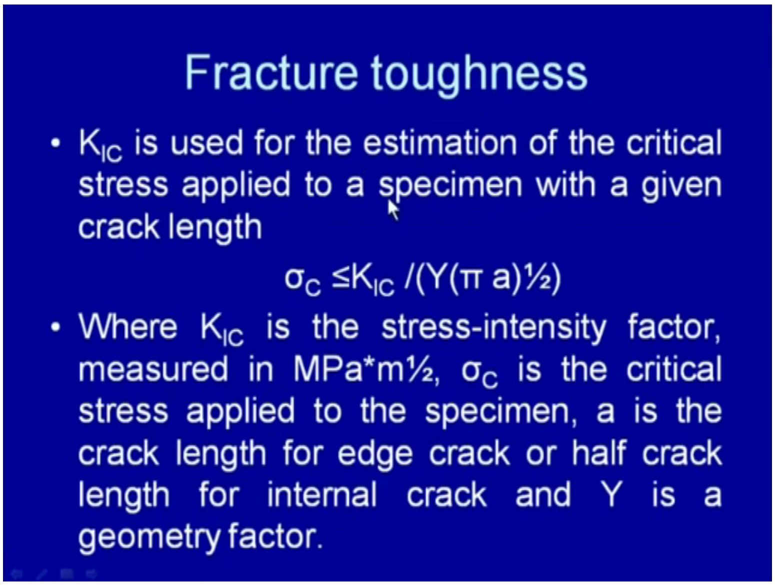
In general, these stresses are applied for conducting these tests external load is applied and it is increased until the strain on the crack opening displacement or energy versus the load relationship becomes linear. So, means we keep on applying the load until the strain or crack opening or the energy relationship, versus the load energy, versus the load relationship becomes the non-linear. And that critical value of the load where it, deviates from the linearity is used for calculation of the fracture toughness using the relevant formulas.

(Refer Slide Time: 34:12)



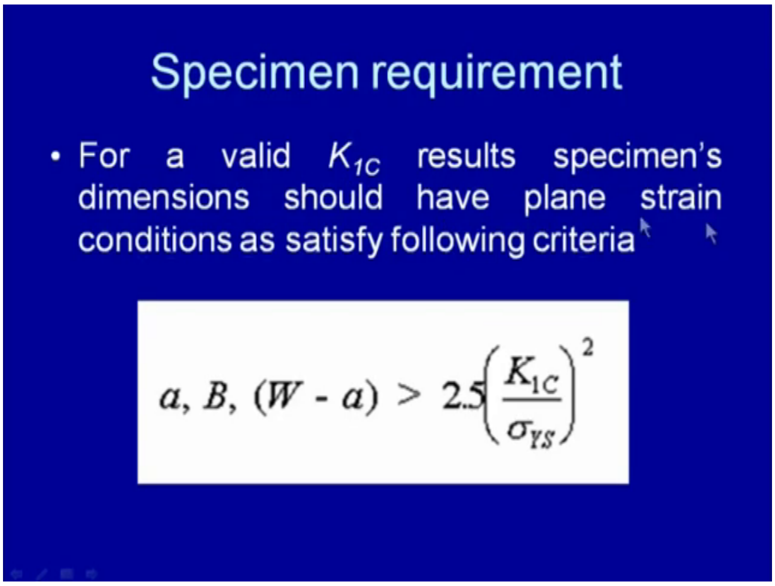
So, for determining the K, C T O D that is Crack Tip Opening Displacement stress intensity factor and the j-integral, tests are very similar and all three values can be established from a single test, whether they are valid or not to check the validity separate calculations are made.

(Refer Slide Time: 34:30)



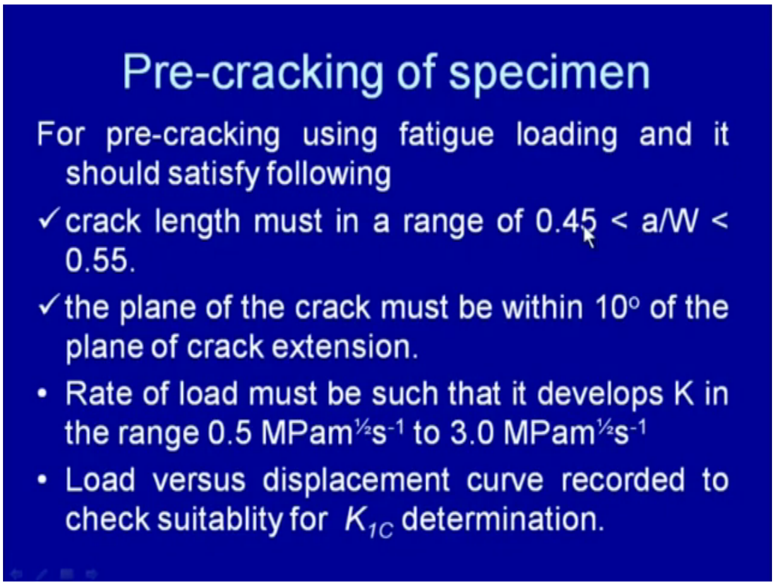
Say, for K 1 c is used for estimation of the critical stress applied to the specimen with the given crack length. So, if we know crack length, if the critical intensity factor has been identified then we can identify the critical stress required for catastrophic failure of the component. So, this can be used if the K 1 c is the material parameter ,and we know the crack length of the material then we can assess the, critical stress which will be required for propagation of the crack. So, here K 1 c is the critical stress intensity factor, measured in terms of the M P a dot square root of the meter, and the sigma c is the critical stress applied to the specimen a is the crack length for the edge crack and half crack length, for the internal crack and y is the geometric factor.

(Refer Slide Time: 35:24)



So, for valid K 1 c results specimen dimensions should have the plane strain conditions and satisfy the following criteria. And this is the kind of the criteria which should be a satisfied like, the alpha B that is the thickness of the plate W minus a these should be greater than 2.5 times of the K 1 c divided by the yield strength of the material sigma y s whole square. For before conducting the before, applying the external load for conducting the facture toughness test the after machining crack is developed by pre cracking.

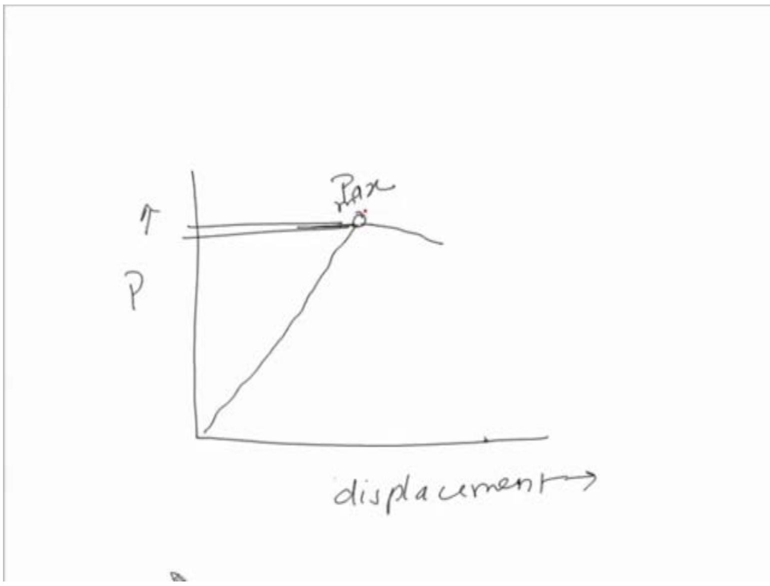
(Refer Slide Time: 36:07)



And for pre cracking fatigue load is applied and for pre cracking certain conditions must be kept in mind like the, crack length must be in the range of 0.45 to the 0.55 and here, in between this can have the value of a by w, a is the crack length and that we have already defined these a and w parameters. And the plane of the crack must be within the 10 degree of the plane of a crack extension.

And the rate of the load must be such that it develops the k that is the stress intensity factor while load increasing the load that is in range of 0.5 M P a dot the meter per square per second and meter square root of meter per second to the 3 M P a dot square root of meter divided by per second. So, the load versus displacement curve is recorded to check the suitability for determination of the K 1 c.

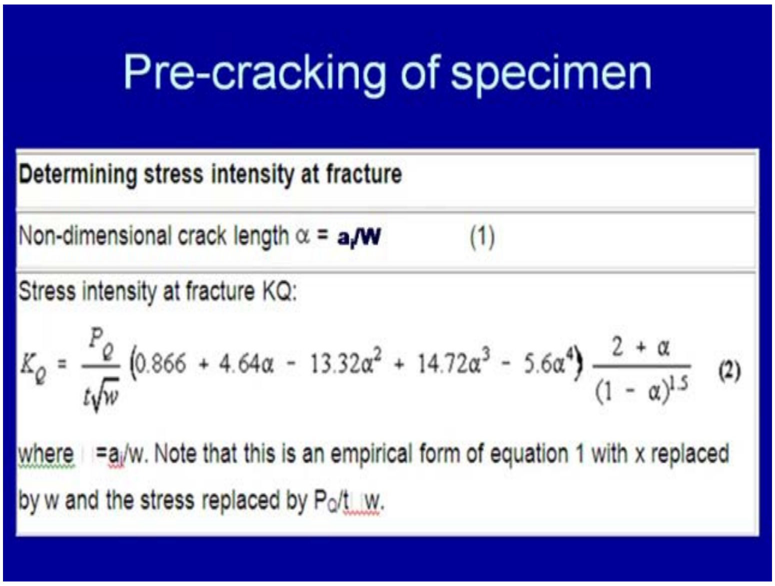
(Refer Slide Time: 37:20)



When this test is conducted basically, we get the load displacement curve and in this load displacement curve here, in y axis especially for those metal systems which have the plane strain conditions. We find the load and the displacement or the load extension in the x axis and here, we have load. So, here load increases linearly and for those metal systems where it is the plane strain conditions are developed it deviates directly.

So, this load corresponding to which we have, this p max the value of the maximum load at which the load versus the displacement relationship for the C T specimen is linear. That load value is, identified and this value of the maximum load at which the two have the liner relationship, is used means this p max value is used for establishing for calculating the fracture toughness of the material.

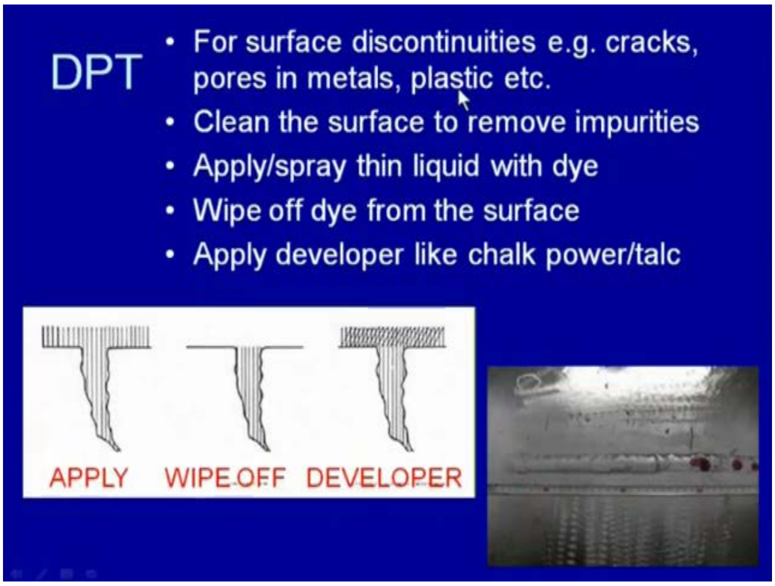
(Refer Slide Time: 38:24)



So, and this fracture toughness is calculated using this equation where, P Q is corresponding to that the maximum value of the load up to which the metal system has the linear relationship between the load and displacement. So, if you see here the main parameter is the t is this the thickness, w we have already defined P Q is the maximum load for up to which these have the linear relationship. And the alpha is the ratio of the a by w this is the non dimensional crack length.

And, now we will be talking about the destructive test sorry non-destructive test. Non-destructive test are those test which are commonly carried out to assess the soundness of the weld joints because the weld joints are frequently carry the various types of the discontinuities. So, to check whether the weld joint is sound or not it is free from the defect or not the variety of the non-destructive test are conducted, even the final weld joints which have been developed in the component for final use those are subjected to the non destructive test, because the destructive test we cannot conduct on those specimens because otherwise they will be, damaged during these destructive tests.

(Refer Slide Time: 39:46)



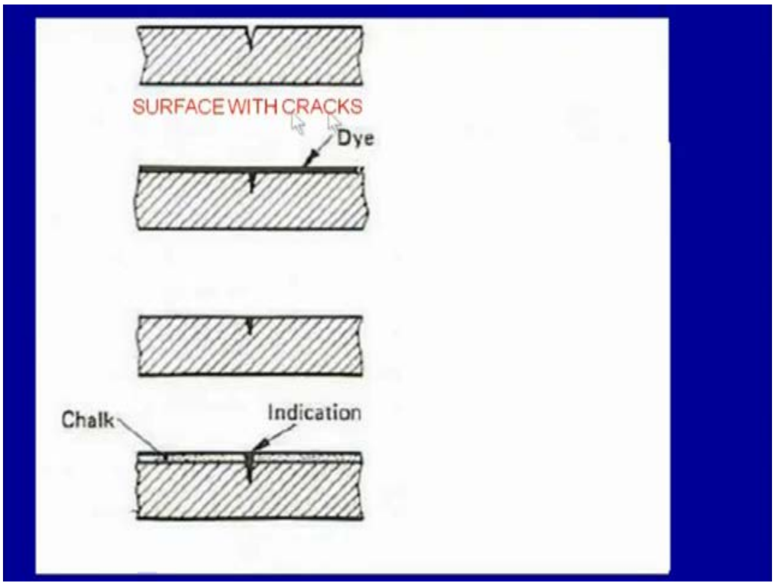
So, for conducting the destructive test the various types of the non destructive tests are available like the dye penetrate test, magnetic particle test, radiographic test and the ultrasonic test. We have other tests also like eddy current test, but in this presentation we will be talking about the, first four kind of the test. Some of these tests are used only surface defects to assess the presence of the surface defects, while others are used for the both surfaces as well as sub surface defects.

So, Dye Penetrate Test is one of the commonly used non destructive test, which is used for assessing, the presence of the defect or the surface defects and discontinuities such as, cracks, pores, in metals and the plastics this test is not used for testing the soft surface defects, which are present below the surface. So, it is mainly used for assessing the surface discontinuities. So, in this test first the surface to be test is cleaned to remove the impurities, and then a thin liquid having very low viscosity.

And the low surface tension, and some sort of dyes also with them that is spread onto the surface which is to be tested after cleaning. And then once it is spread then that fill that liquid is allowed to stay there, for some time and then it is whipped off. So, the dye or the liquid which was spread is whipped off. So, this is can say apply the stress and then it is whipped off. So, when the this liquid, thin liquid is applied it is sucked by, the capillary reaction inside these defects which are present at the surface.

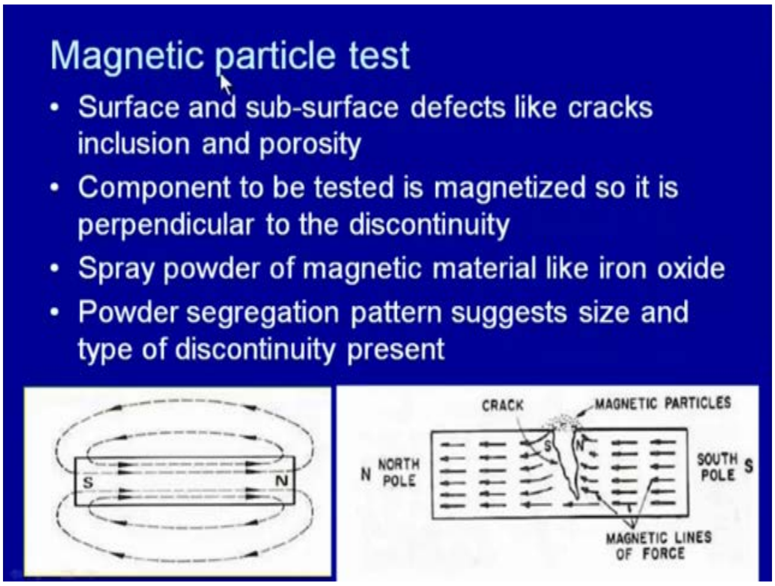
And then after whipping it off the developer is applied like the, chalk powder or talc is applied. So, that these developers suck the liquid from those fine discontinuities present at the surface, and it develops some sort of stain and say these red stains strain zone in the weld joint indicating the presence of has the some sort of discontinuities at the surface. And if the no defect is present then on removal of the liquid, whole of the liquid will be removed and on the application of the developer no stains will be developed.

(Refer Slide Time: 42:15)



So, here say the, first the surface is having some sort of the defect. So, surface with crack and then when the dye is applied. So, the dye will be sucked means, that liquid will be sucked inside this defect on the spraying the dye or the liquid with the dye. And then that liquid is whipped off, but the liquid which was sucked inside the defect, that will remain there and on the application of the developer like chalk powder, the some stains will come in the chalk powder and that will show the presence of the defect.

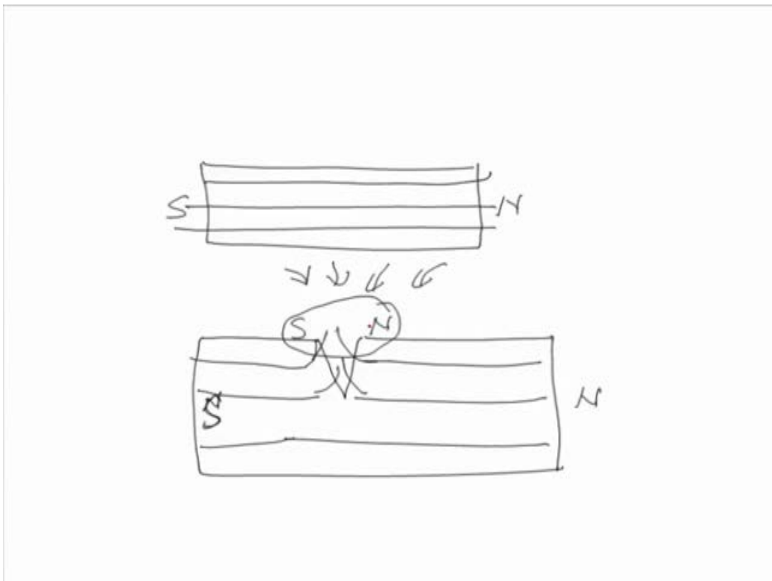
(Refer Slide Time: 42:48)



And then this is another non destructive test this magnetic particle test and this test is used for, both surface as well as, subsurface defects like cracks inclusions and the porosity. Then and this test the component to be tested is magnetized. So, and it is magnetized in such a way that the magnetic field is perpendicular to the discontinuity. And thereafter, magnetizing this the magnetic particle like iron oxide is spread over the surface, that is sprinkled over the surface.

And then based on the segregation of the powder pattern, means based on after observing the pattern of the powder segregation it will, indicate or it will suggest the size and type of discontinuity, which is present.

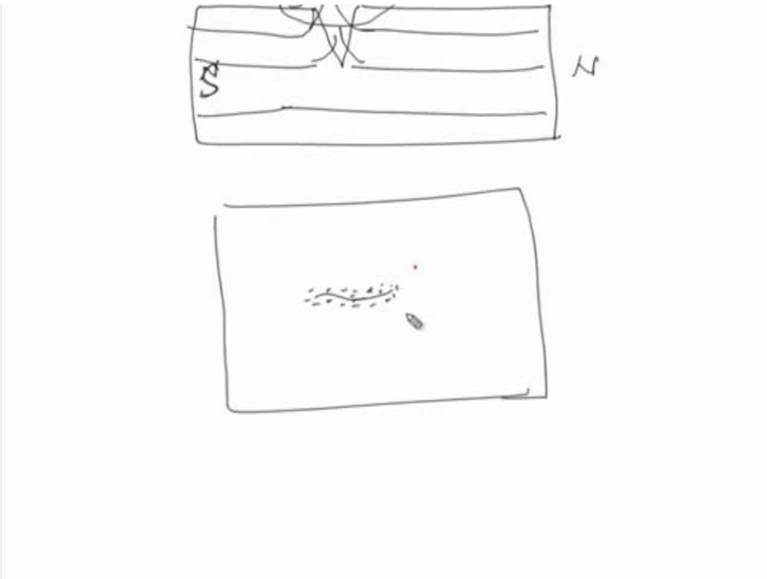
(Refer Slide Time: 43:43)



And this magnetic particle test works on the very simple principle that a typical magnet has, the north and South Pole. And the magnetic lines pass through these, smoothly and the movement you see if there is some sort of defect in the component. Then in addition to these the poles, the two poles wherever, the discontinuities are present this leakage of the magnetic flux start. So, this will start the leakage will be taking place here wherever, discontinuities are present and it will be forming press poles.

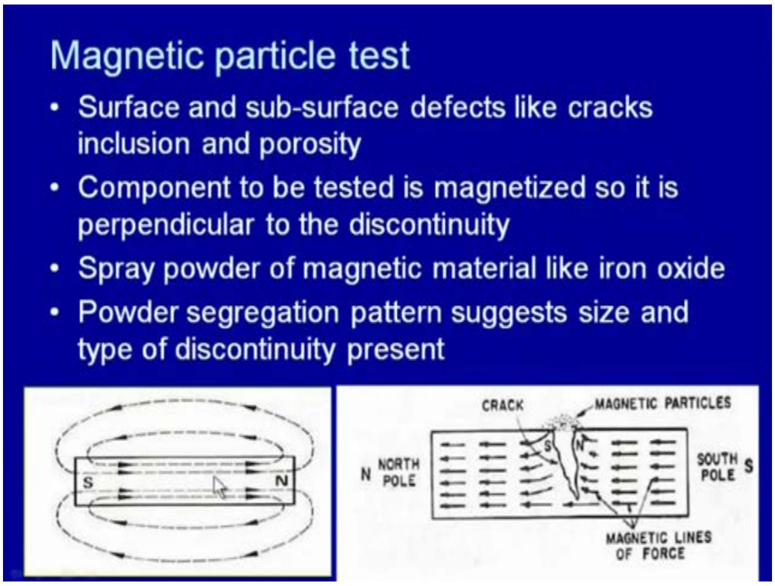
So, when the powder is sprinkled over the surface it tends to segregate near the areas where we have discontinuities. So, if the this defect is very clear, then powders will tend to segregate in the areas where defect is present because these will be easily attracted this leaking, magnetic field will be attracting to the powder particles and segregating them in particular pattern.

(Refer Slide Time: 44:51)



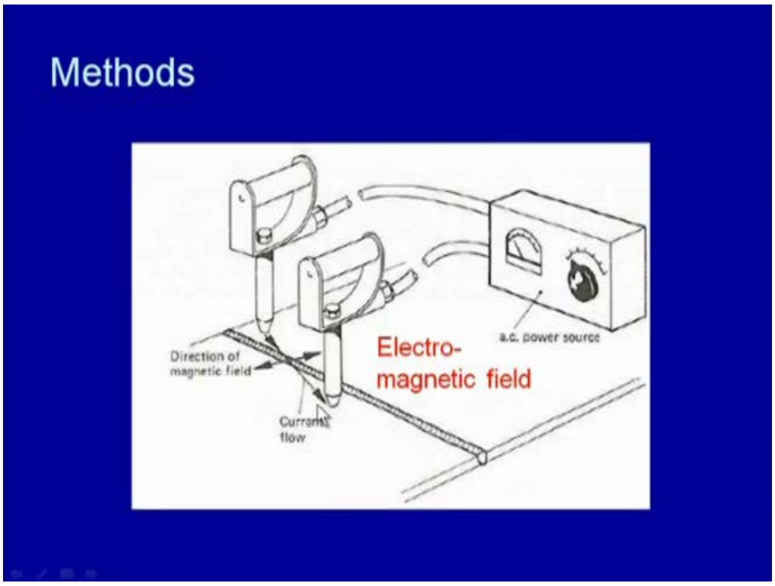
So, if we see wherever the defect is present say this is the line along which defect is present, then powder particles will tend to get cluster and segregate around them. So, if the clustering of the powder particles is very limited and very diffused, then that presence, if the clustering or the segregation of the powder particle is very diffused kind then that suggest the presence of some internal defect and if it is very clear and sharp. Then depending upon the kind of the length up to which the particle have been segregated or the path on which these, have been segregated, that will indicate the location of the defect and the size of that defect.

(Refer Slide Time: 45:37)



So, here this is the normal, you see the normal magnet without any defect, where magnetic lines of forces are passing going from the S to N and then the cycle is completing, but when there is a defect in the component it forms the magnetic lines of forces start leaking from the location where there, is defect and it forms the two additional poles. And when we, sprinkle the powder particles it tends to get cluster in the areas where from these magnetic particles lines are means wherever there is a leakage of the magnetic lines of the forces and the clustering of the powder particles happens. So, the by seeing the pattern of the segregation of the powder particles and the size of where the segregation is taking place this the size and the presence of the discontinuity, is established.

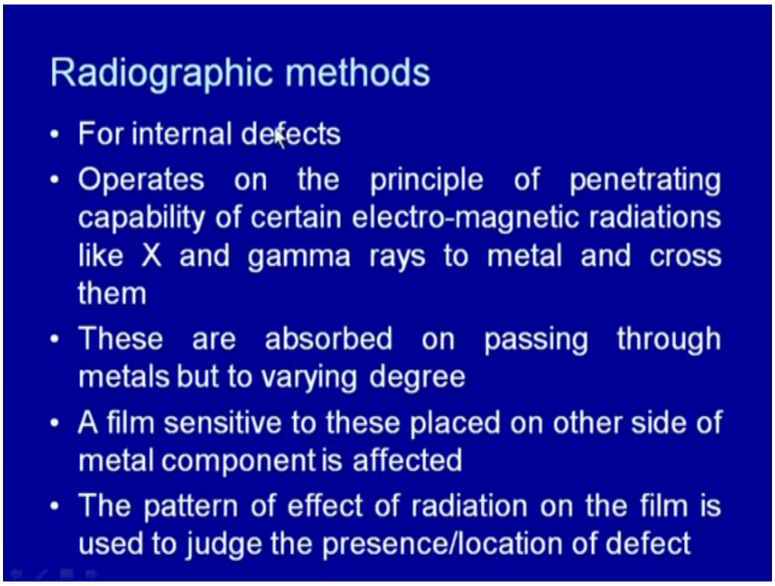
(Refer Slide Time: 46:44)



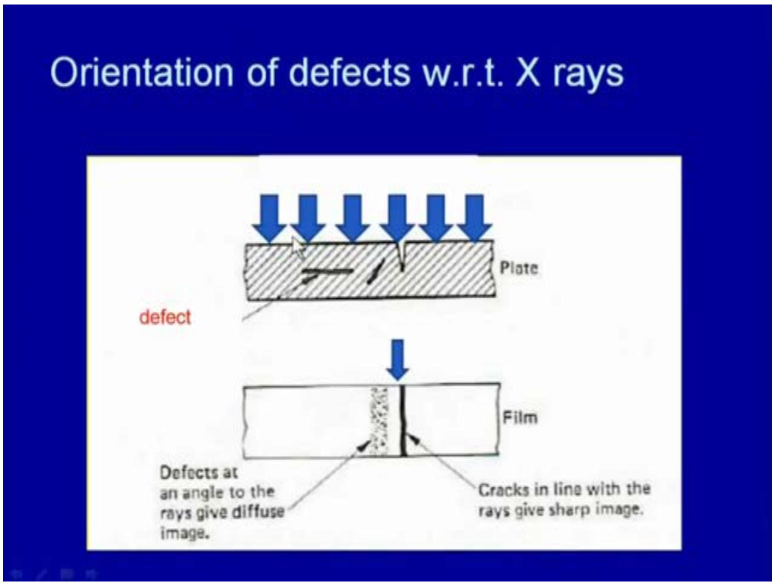
So, for magnetizing for developing the magnetic field in such a way, that it is largely perpendicular to the discontinuities the suitable plots are used to develop the electromagnetic field. So, here first it is developed you say, depending upon the path of flow of current magnetic field is developed, once in this direction then it can be developed in some other direction. So, when this is the flow of current then magnetic field will be developed in this path.

So, the like this these plots can be kept at different locations, in order to have the presence of magnetic field perpendicular to the discontinuities, but we know that when the magnetic materials are magnetized they, even after removal of the magnetic field they remain magnetized. So, that is sometimes intentional demagnetized to have an adverse effect on the performance of the component. So, demagnetizing is also done intentionally, in order to have any adverse effect on the performance of the component.

(Refer Slide Time: 47:36)



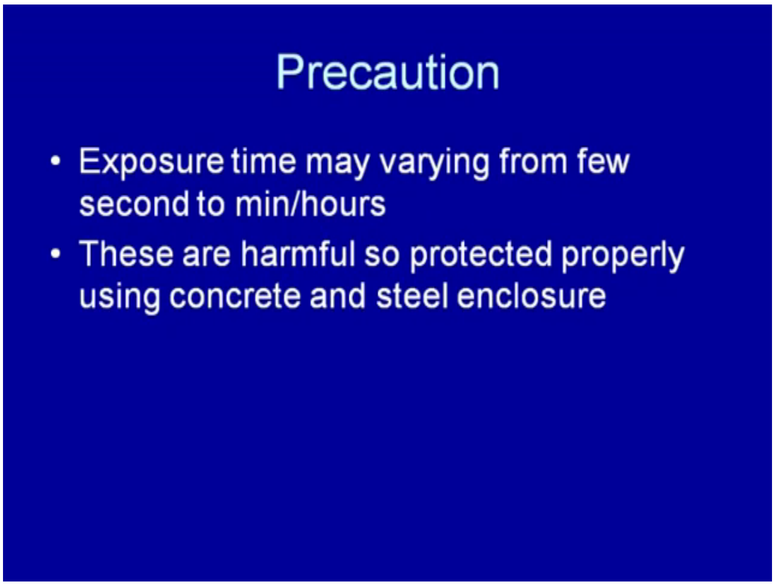
(Refer Slide Time: 48:10)



Now, radiographic test the it is mainly used for internal defects, and it operates on the principal of a penetrating capability of the electromagnetic radiations like x rays and gamma rays to the metals and to cross them. And these are absorbed on passing through the metals through varying degree, and the film sensitive to these placed on the other side of the metal component is affected and pattern of the effect of the radiation on the film is used to judge the presence oblique location of the defects.

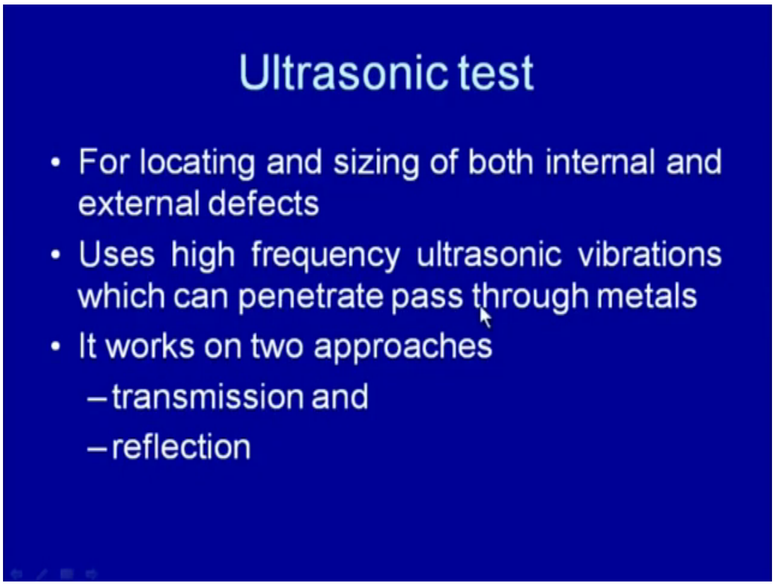
So, this is typical kind of the schematic diagram shows that x rays are being supplied from the top. So, the location where we do not have any defect, these will be absorbed to the greater extent and we will be reaching less, on the other side where film is placed, but wherever, we have defect the through defects are of the low density materials. So, these will be absorbed less, and more amount of the radiations will be reaching to the other side and will be affecting through the film to the greater extent, and so the darkening the film to the greater extent. So, wherever more darkening has taken place that will be showing the greater presence of the defect over the larger size of the defect. So, we can have this kind, of the radiograph in the two different directions in order to locate.

(Refer Slide Time: 49:00)



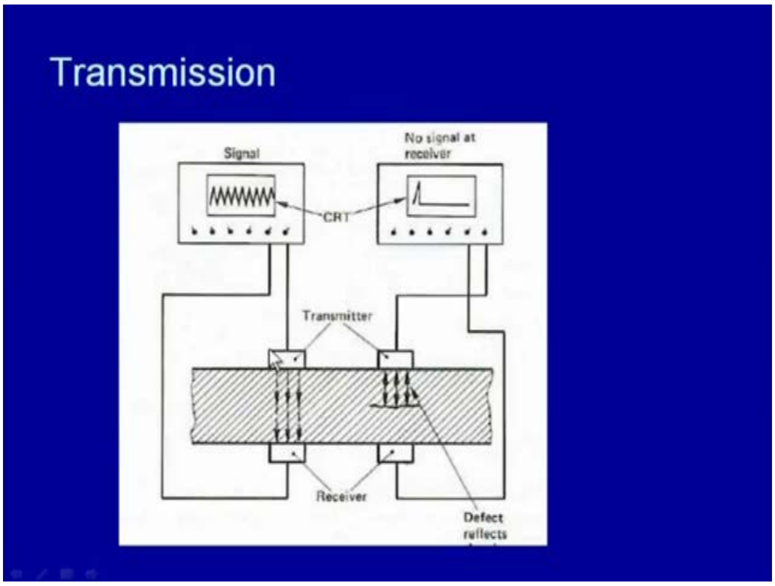
Exactly, where defect is present this kind of test can be conducted by, giving the exposure to the few seconds, to the few minutes and to the few hours like gamma ray test is conducted for longer durations, while the x ray test is conducted for the exposure means the exposure is given for few seconds itself. So, the x rays are more useful for the thinner components or thinner sections while gamma rays are used for heavy sections. You know that all these radiations are very harmful to the people. So, proper protection must be given and for this purpose wherever, this sources for these radiations exist they are properly isolated using concrete and the steel again closures. So, that they do not leak.

(Refer Slide Time: 49:40)



Now, the ultrasonic test is the another important test which is commonly used now, a days for assessing the internal and as well as, the external defects. It uses high frequency ultrasonic vibrations, which can penetrate easily through the metals and it works the two approaches.

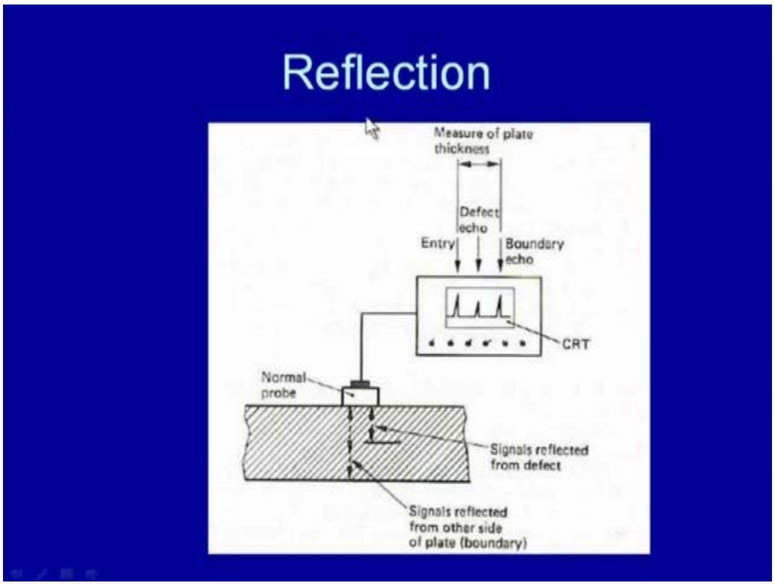
(Refer Slide Time: 50:00)



One is transmission, another is reflection in case of the transmission the ultrasonic vibrations are transmitted from the one side and they are, received from the other side if we are able to receive all the radiations that will indicate that there is no defect in the metal system is present. So, here we are transmitting and receiving both the sides and it the, these are observed in the oscilloscope.

So, continuous presence of these vibrations in the oscilloscope indicates a in the presence of no defect, but when it comes across the discontinuity like this, these are being transmitted, but not received on the other side this will be suggesting. So, the no vibrations will be received in the receiving end. So, the receiving end will not be giving any signal in the oscilloscope, and will be getting just one sign, one on peak and the no other peak is observed.

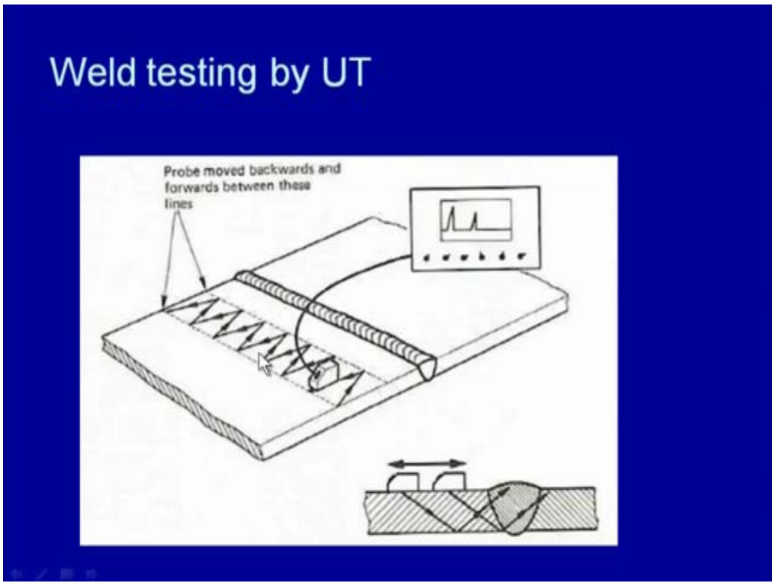
(Refer Slide Time: 50:55)



So, this suggests that some sort of peak defect is present in the component the reflection works on the simple principle, that the same transducer works as a transmitter and receiver. So, in one first it transmits the signal and if there, is no defect it will be send back from the other side of the metal and we will be getting another peak, but if there is some internal defect it will be reflected back in from the in between and will be getting some intermediate peak.

So, the first peak and the last peak indicates that, the peaks coming from the top surface and the bottom surface, but the moment we get some internal means intermediate peak, that will indicate that there some discontinuity is present. And the location of this intermediate peak, will indicate the location of the defect between the top surface and the bottom surface, if this is the corresponding to the top surface peak and this corresponding to the bottom surface peak. So, the relative distance between the top and the bottom surface can be calibrate to see exactly, where the defect is present. So, this is how the ultrasonic test is conducted.

(Refer Slide Time: 52:04)



Now, for conducting the U T test on the weld joint very specific pattern of the movement is done, here say we are using either 45 degree or 60 degree the for conducting the ultrasonic test and then it. So, 60 degree or 45 degree depending upon the type of which is being used it will be directing the vibrations at certain angle. So, these are will be transmitted, and then on transmission it will be reflected back first from the bottom surface then will be reflected back from the another side.

So, this kind of movement is done. So, this is for this location, this area will be scanned, for this location of the probe this area will be scanned. So, if we are oscillating it between the two then entire weld zones will be scanned. So, if we want to scan another complete length of the weld then the two lines are drawn in such a way, that the entire length of the entire width, the whole weld joint throughout the length is scanned.

So, after drawing these two lines in such a way that this the can be oscillated or moved between these two lines. So, that the entire weld length is scanned. So, depending upon the type of the probe which is being used these, the location of these lines will be affected away from the weld zone. So, this is how now, we have completed the ultra this, non destructive test and we have covered the four types of the non destructive test.

So, as summary of this presentation in this presentation, I have talked about the both destructive and non destructive test. And the very specialized kind of destructive test, like the fatigue test, impact test, and the fracture toughness test for discussed. And in the non destructive test the very commercially used non destructive tests like, the ultrasonic test, radiographic test, magnetic particle test and dye penetrate test will were conducted.

Now, the last lecture based on the, last chapter based on this forty lecture series, we will be started from the next presentation and that will be based on the weld ability of metal system. And approximately four presentations will be given on the weld ability of the metals that will start from the next presentation.

Thank you for your attention.