Fundamental of Welding Science and Technology
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Lecture - 24
Welding Defects

In last lecture, I was discussing about submerged arc welding. Today I am going to deliver a lecture on Welding Defect.

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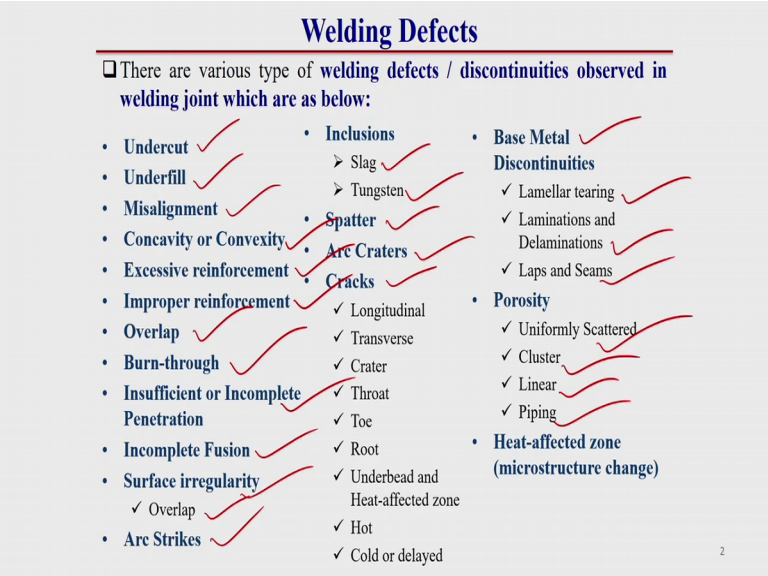

There are various types of welding defects or discontinuity generally observed in welding joint which are as follows, like this can be the undercut, this can be under fill, this can be misalignment; that means, these are the different categories of welding defects. this can be conventional, concavity or convexity this can be excessive reinforcement, this can be improper reinforcement, overlap, burn-through, insufficient or incomplete penetration, this can be incomplete fusion, this can be surface irregularity like overlap, this can be arc strike, there can be inclusion of slag as well as tungsten these are the different defects actually which we observe in case of arc welding technique.

There can be spatter, then arc crater, there can be various types of welding cracks, like here it is almost 8 to 9 different categories of crack is observed in welding operation or in case of welded sample then there can be some base metal discontinuity also in base metal there we can observe 3, 4 different types of base metal discontinuity that also create

some weld effects like that can be lamellar tearing, that can be lamination and delamination of base metal, that can be laps and seams in base metal.

Apart from this thing there can be different types of welding porosity, blowholes also like this porosity can be uniformly scattered porosity, it can be cluster porosity, it can be linear or piping types of porosity, apart from these things there is also some microstructural discontinuity observed in welding joint that is especially heat affected zone microstructural change is a very critical types of defect in welding joints.

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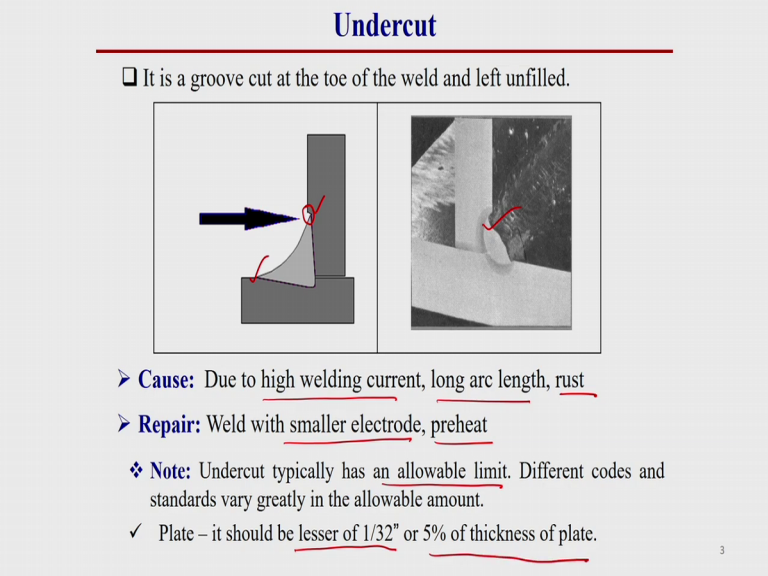

Now, one by one I will discuss about this welding defects in detail and what is the reason first of all I will discuss what is this welding defects? What is the main cause of this welding defects? How we can prevent these welding defects and how we can repair this welding defect? In detail in subsequent slide.

So, first of all we will discuss one by one, what is undercut types of defect? It is a groove cut at the toe of the weld and left unfilled. Like here it is showing this is a actually groove cut here you see at the toe location of the welded joint. Toe we know this is one toe this is another this corner point of a fillet welded joint this is generally called toe or you can say edge of the welded joints is generally called toe. This is in this toe generally there is seen some sort of groove types of cut during welding operation this is called undercut. Here it is observed here in case of actual welding joint case.

Now, what is the reason of this undercut this reason of this undercut is due to high welding current, long arc length rust, how we can repair this thing? Once we can adjust this parameter then we can easily control this undercut also. So, here what are the thing what are the repair technique here weld with a smaller electrode or preheat the welding by this technique generally we can eliminate this types of undercut defects in welding.

Here one things you should note it down, undercut typically has an allowable limit. Generally different codes and standard are there for this different code or standard is there for this undercut limit. Especially for plate it should be lesser than 1 by 32 inch or around 0.75 millimetre or 5 percent of the thickness of the plate which should be the minimum one that we should consider. That we can that; that means, in case of plate if the plate thickness 5 percent is lesser than 1 by 32 inch then we should consider that 5 percent plate thickness undercut values.

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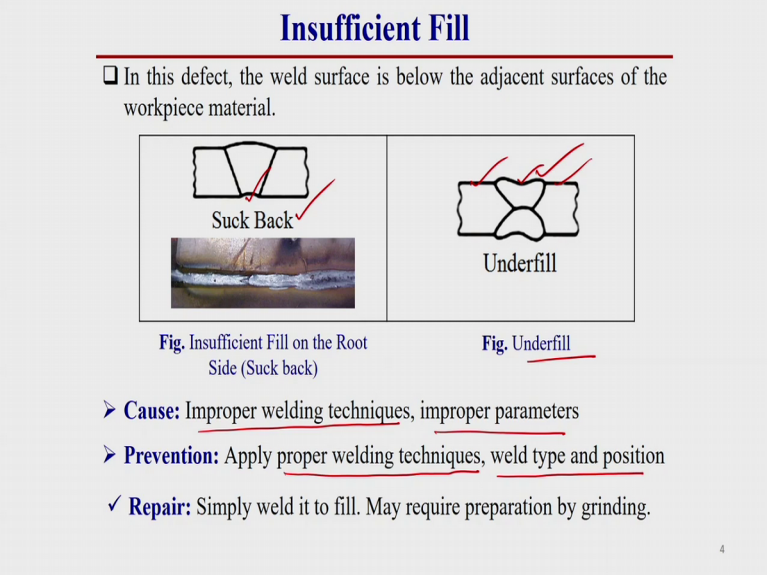

Now, the insufficient fill. What is insufficient fill? In this is also a welding defect in this defect the weld surface is below the adjacent surface of the workpiece material. That means, here this weld surface, this is weld surface it is below the adjacent base material surface. Or the in back side also it can here it is insufficient fill is there because this weld surface is below the surface of the base material surface. If it is occurs in back side of the welding then this is also termed as suck back welding defect these types of welding defect then it is called under fill welding defect.

Now, the main cause of this welding defect is improper welding techniques then, improper welding parameter. So, how we can prevent these things? The so the prevention of this welding techniques is apply proper welding techniques that means, whatever the root cause of this welding defect if we can eliminate that cause then we can prevent these thing. that is why we here we have to apply proper welding techniques, proper welding type and proper welding position. If we use this thing then we can eliminate or prevent these types of welding defect.

Now, how we can repair let us this welding defects already workout in the welded structure how we can repair? The repairing technique of this welding defect is simply weld it to fill. For this filling of welding generally there may require some surface operation. That means, we can we have to prepare the surface for doing the for the welding operation.

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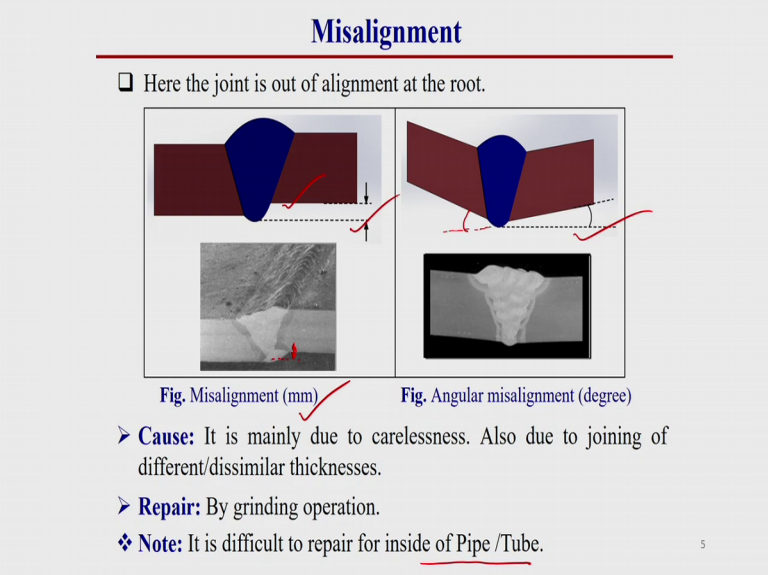

Now, we will go for misalignment. Misalignment this is also a welding defect, here the joint is out of alignment at the root. You see here this joint out of alignment. Because these types of welding defects generally occurs if we use dissimilar types of plate thickness. That means, if we go for 2 different thickness plate to weld.

Or this is generally occurs due to carelessness. So, if we be careful during welding operation then we can eliminate these types of defect. This or misalignment generally occurs in 2 different way this misalignment can occurs. This misalignment can be linear

types or this can be angular types here you see from this figure you can observe this thing. This is a example of linear types here you see generally this misalignment is occur because 2 plate generally is not aligned parallel to each other. So, here there is a linear types of shifting of 1 plate over another plate. So, this is linear misalignment of the plate.

How it is occurs in case of angular types of misalignment? Here 1 plate deformation is more compared to another plate angular deformation. Here you see here 1 plate angular deformation is like this, another plate angular deformation is like this. So, these types of misalignment can occurs in case of welding joint. This is a welding defect. So, how we can repair this welding defect? First of all we have to grind the welding defect portion and make the required shape.

So, it is difficult to repair for inside of pipe or tube. If this types of shifting of plate occurs inside the pipe then how we can repair this things. So, this creates some difficulty for repairing if it is occur inside the pipe or tube.

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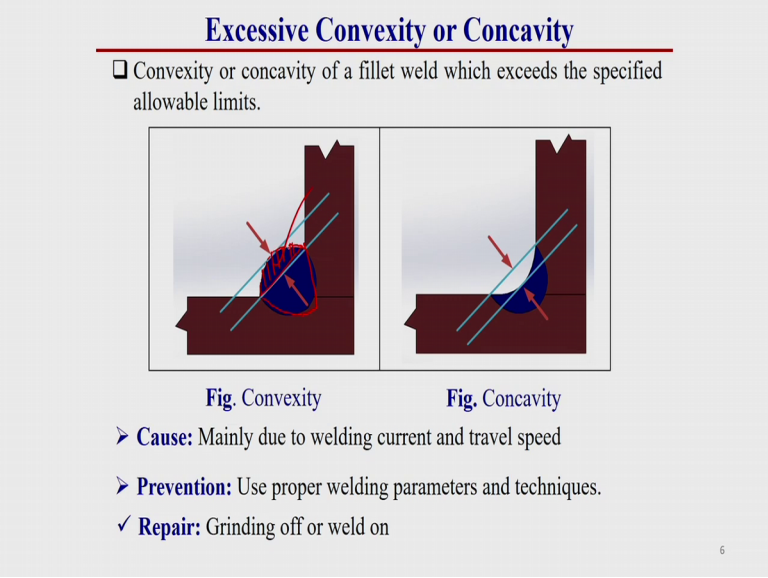

Now, excessive convexity on concavity: Convexity or concavity of a fillet weld which exceed the specific or a specified allowable limits. You see this convexity; that means so from this figure here this weld bead shape is convex in nature actually our required weld bead especially these types of convexity or concavity occurs in case of fillet welding types of joint. We know fillet welding shape should be almost triangular in nature. So, this shape should be look like almost this, but here if this excess portion of material is

deposited over there; that means, excess the rate create a convex types of shape. So, this extra material whatever it is deposited over this triangular shape that is generally access material. This is a type of defect in case of fillet welding. That means, this much of a excess material is not required for this fillet welding joint. So, this is a defect for fillet welding joint. This can be convex type or this can be concave type; that means, here this triangular shape of the welded joint should be look like this, but here you see if it is create like this which is concave in nature that means, this much of filler material is not deposited over this.

So, if this is not deposited over this then this is also a defect this is not a good weld quality. So, these types of welding defects is mainly due to welding current and welding travel speed or you can say welding travel speed. This we can prevent by using proper welding current and proper welding technique as well. So, how we can repair this types of welding defect? This we can repair by if it is convex in nature then we have to just grind this excess portion or if it is concave in nature then we have to fill this portion by re welding. So, it can be repaired by grinding off or weld on depending upon its convexity or concavity respectively.

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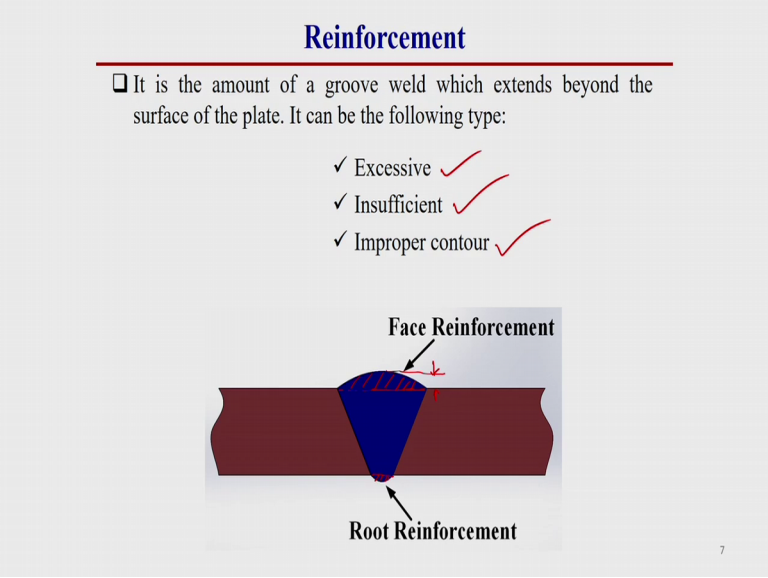

Now, reinforcement: Reinforcement is essential part for welding operation. Essential part means there is some standard reinforcement required to get required strength of a welded joint. But if it is excess then that is a welding defect. If it is lesser than that then that is

also a welding defect, that is why reinforcement means what you can observe that means, some portion of the welded material is outside of this surface of this base material. You see this portion is extra material which is deposited over the surface of this base material. That means, we can say this bead height portion.

This generally provide the reinforcement of the welded joint. Similarly and back side also there is some extra material which is deposited over the surface of the base material. So, this is also generally provide some reinforcement of the welded joint, this is required for a strength point of view, but if it is excess then that is a defect of welding, if it is lesser then that is also a defect of welding. But there is some standard top reinforcement as well as root reinforcement or bottom reinforcement is there. That is generally required for strength purpose of the welded joint. That is why this reinforcement it is an amount of groove weld.

So, we can extracted this reinforcement like it is an amount of groove weld which extend beyond the surface of the plate. This reinforcement when we categorise into three different categories one is excessive reinforcement, this is a welding defect, this can be insufficient reinforcement then, that will be a defect or there can be due to this reinforcement there can be improper welding contour. So, this is also a welding defect. So, this reinforcement is actually a weld bead contour defect.

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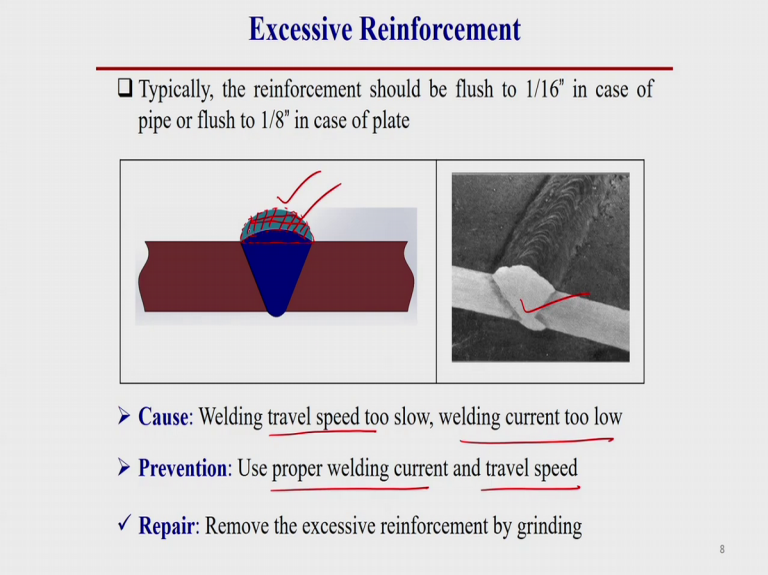

So, one by one I will discuss in subsequent slide like first of all excessive reinforcement. Excessive reinforcement what I have told you here the reinforcement require this region, but due to some different welding material or different welding techniques, if the weld deposit is more than the required reinforcement; that means, this much of green colour portion we can say, excess weld material it deposited over the top of the required reinforcement. So, this is called excessive reinforcement.

Generally one things you should keep it in mind, this reinforcement should be flush maximum 1 by 16 inch in case of pipe weld and if it is a fillet butt weld or in case of fillet weld it should less than or equal to 1 by 8 inch. That means, for pipe weld 1 by 16 inch means around 1.5 millimetre bead height as well as in case of plate if this should around 3 millimetre, maximum around 3 millimetre bead height. Then it is a standard means this is then it is a standard reinforcement. Over this; that means, if it exceed over 1.5 millimetre for pipe welding then this is a defect. If it is for plate if this reinforcement exceed 3 millimetre then this is a defect. So, this excess portion is not essential part this is a welding defect. So, we should do our welding so that this excess portion should not be there.

So, the main cause of this excessive reinforcement is welding travel speed if it is too low then the metal deposition will be more as well as for lower welding current then penetration will be less we know this thing. So, these types of excessive reinforcement main reason is slow welding speed and slow welding current this is a example of actual excessive reinforcement. How we can prevent this thing? These we can prevent by use proper welding current as well as proper travel speed, for welding travel speed. For repairing this we should remove the excessive reinforcement by grinding operation. This excessive whatever the reinforcement part are there this excessive portion we have to remove out by grinding operation.

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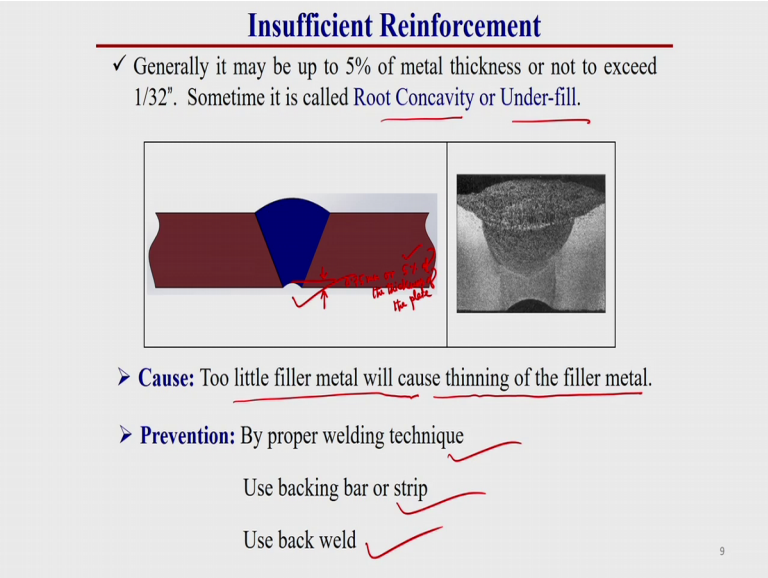

Then insufficient reinforcement: This insufficient reinforcement what I have already told you it is a type of suck back types of contour. This insufficient reinforcement occur at the back side of the or root side of the welded joint it may be up to 5 percent of metal thickness or not to exceed one by 32 inch; that means, around 0.75 millimetre. This suck back this maximum height, either 0.75 millimetre or 5 percent of the thickness of the plate of the plate whichever should be the minimum that you should consider. If this 5 percent is minimum then we have to consider; that means, it should not exceed 0.75 millimetre. If it exceed 0.75 millimetre it will be a defect this types of insufficient reinforcement also some time called root concavity or under fill.

The main cause of this root concavity or insufficient reinforcement is too little filler metal will cause thinning of the filler metal. That means, due to insufficient amount of filler material this types of welding defect can occur. The prevention of this welding defect is by proper welding technique use backing bar or backing strip at the back side to support the molten material to pass through the root and use back weld. This suck back effect occur over there then we have to do some back welding on this region to fill this suck back portion this way we can prevent or repair this insufficient reinforcement.

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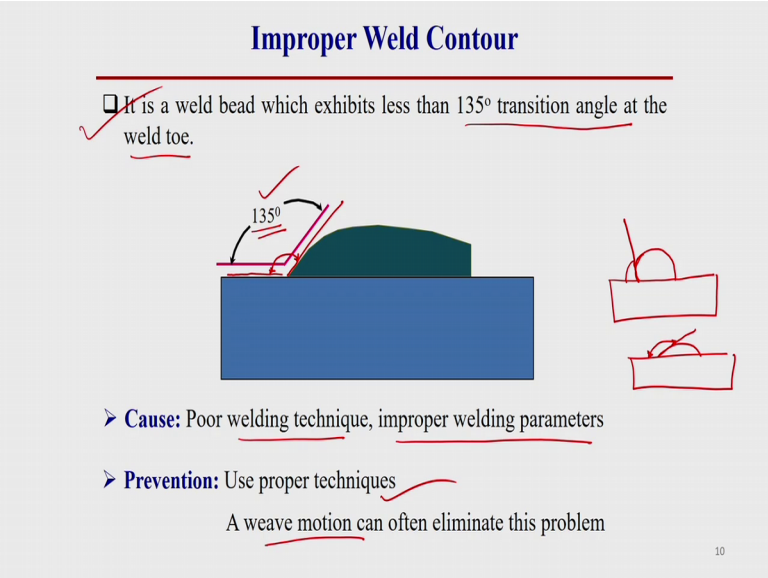

Now, the third categories of weld bead defect is called improper weld control it is a weld bead which exhibit less than 135 degree transition angle at the weld toe. Transition angle means if you draw a tangent at the toe this tangent makes a angle with this horizontal flat surface this angle is called generally transition angle. If this transition angle is less than 135 degree then, this is considered as a welding defect like; that means, if the weld contour is look like this then we can see this transition angle here it is less than 90 degree if it is like this here the transition angle is more than 135 degree higher the flattening of the weld bead height better the quality of the welding joint that we should keep it in mind.

Here the main cause of this welding defect is poor welding technique then improper welding parameter. How we can prevent this welding defect? This we can prevent by using proper welding techniques or this we can eliminate by using some wave motion during welding operation. So, why this 2 technique generally we can prevent this welding defect.

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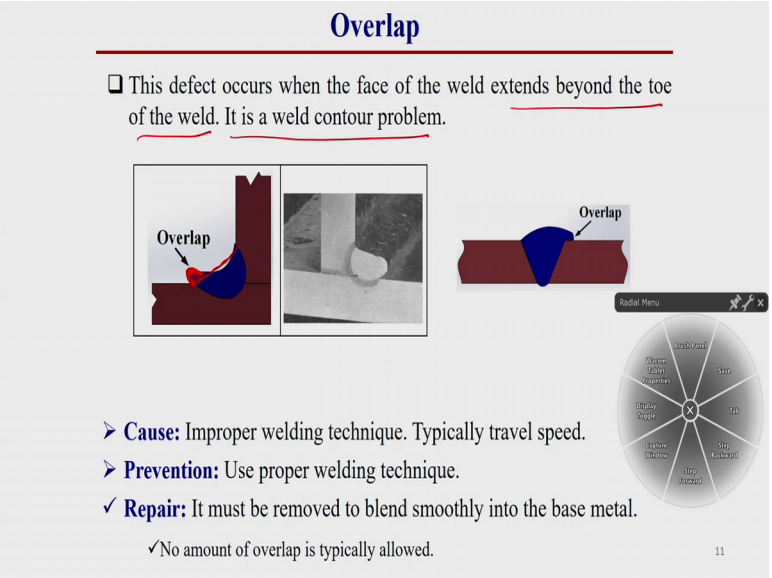

Now, overlap this defect is occurs when the face overlap. This defect occur when the face of the weld extend beyond the toe of the weld. It is a weld contour problem. What I have already told you, this is also weld bead geometry defect. Here you see this portion of welding which is extended out of the toe of the weld. So, this is not required actually our weld bead should be like this, but here in toe position some sort of overlapping of material outside the toe is there. So, this types of excess material which is not required. This is a type of welding defect this create problem during service life of the welded structure.

So, the main cause of this welding defects is. Improper welding technique and this is also can occur due to some welding parameter also. So, especially this types of welding defects main cause is welding travel speed. Generally lower the travel speed chances of this types of welding defects is more. So, the prevention of this welding defect is the once we able to eliminate the cause, root cause of this welding technique; that means, here we have to use proper welding technique then we have to use proper welding parameter also. Always one things we keep it in mind the main cause of this all defect is either welding techniques or the inappropriate welding parameter. So, once we use appropriate welding techniques as well as appropriate welding parameter then we can eliminate all this welding defect as much as possible.

So, how we can repair this things? The repairing of this thing is you see here there is some excess material is there. So, we have to just remove that portion by grinding operation or it must be removed to blend smoothly into the base surface. Here one things you should keep it in mind this overlapping is highly avoidable in welding operation or welding structural operation, no amount of overlap is typically allowed this you keep it in mind. This overlap is here such a defect no amount is allowed in welding a structure you see here this overlapping actual welding sample, here you see this much of overlapping is occur; that means, from toe outside this toe this much of welding material is coming out.

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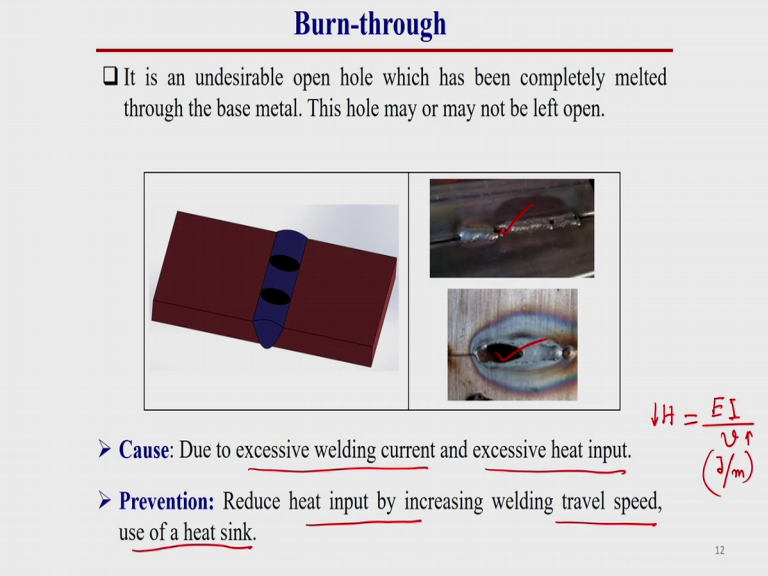

Then burn through it is an undesirable open hole which has been completely melted through the base metal. This burn through it is an undesirable open hole which generally completely melted through the base metal. Like this is a burn through; that means, through the entire thickness of the weld there is a hole. This hole can be sometimes visible by naked eye or may not be left open that means, when it is open then we can see it if it will not be open then it will not be visible. These types of hole can remain inside the welding joint.

So, this is a through hole that means this is a through hole through the thickness of the plate. This is a welding defect once it is visible then it is good, once it is not visible then you will feel there is no defect, but this we can determine by using some non destructive

technique over some destructive technique also this we can determine. The main cause of this welding defect is due to excessive welding current as well as excessive heat input that means, if there will be excessive welding current then there will be forceful arc due to this forceful arc generally there is a chance of burn through the plate thickness and if there is more heat, then your weld material will be more fluid. So, there is a more chance of this burn through.

How we can prevent? Reduce the heat input. That means, what is the root cause if we just eliminate that thing then we can eliminate this types of defect also. So, here this main causes is excessive heat input so reduce the heat input by increasing the travel speed or use of a heat sink by using some heat sink also this types of burn through we can eliminate how it is by increasing the speed how we can eliminate this burn through? Because if we increase the speed then the heat input per unit length of the weld will decrease that you know because heat input per unit length of the weld is calculated voltage into current divided by welding speed.

The unit of this thing is Joule per millimetre or Joule per metre. So, if the welding speed is more than, this heat input per unit length will be less. So, if heat input per unit length will be less, there will be less excessive heat input so there will be less chance of these types of burn through effect.

Another thing by use of heat sink if we use some copper backing or some heat sink method back side of the welding then that way also we can eliminate this burn through effect, because that heat sink will generally take away the excessive heat by conduction of the heat from this weld material then there will be less chance of this excessive or the burn through of the welded plate. So, we can eliminate that way this welding defect.

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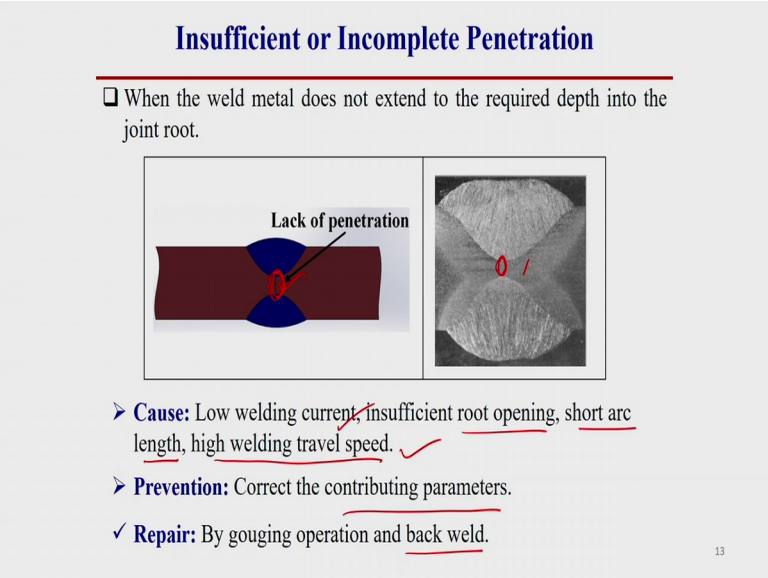

Then insufficient or incomplete penetration: Insufficient or incomplete penetration is look like this here you see, here this weld metal does not able to pass through this weld root region or weld seam region. So, this we can define when the weld metal does not extend to the required depth into the joint root then these types of lack of penetration is occur. Lack of penetration means, insufficient penetration or insufficient filling of weld root. Here you see this portion is not fused here there is a gap. This is a welding defect. Actually our welding bead should be like this as well as like this; that means, there should be some overlapping, there should be some overlapping of this 2 weld parts, but what happens instead of overlapping here you can see there is a gap between 2 weld parts. So, this is a insufficient or incomplete penetration.

The cause of this defect is low welding current definitely if the current will be low then depth of penetration will be less then insufficient root opening, if this route opening also is less then what happens this weld material is prevented to follow through this join root. So, there is a less chance to flow the weld material through this joint root easily. Then these types of weld defect can occur. So, first cause is low welding current, second cause is insufficient root opening or you can say insufficient root gap then short arc length high welding travel speed. So, if the arc length will be short then it can occur, if the travel speed is high then also it can occur. How? Generally if the travel speed will be high then less heat per unit length will be there. So, less chance to fuse root so there can be this types of welding defect. How we can prevent? Whatever the cause of this thing if we can

able to eliminate that thing then we can prevent this types of welding defect. So, correct the contributing parameter. Then whatever the parameter causing this defect, if we can correct this thing we can prevent this thing how we can repair? So, far repairing these types of welding generally we have to gouge gouging this operation and do the back welding. That means, whatever the lack of fusion portion is there that we have to gouge it properly; that means, clean or remove the excess of material over there. After that we have to refill that portion by rewelding. That means, there should not be any lack of fusion. What I have told you there should be some overlapping in between this to weld bead, then your weld quality will be good. So, that is incomplete penetration.

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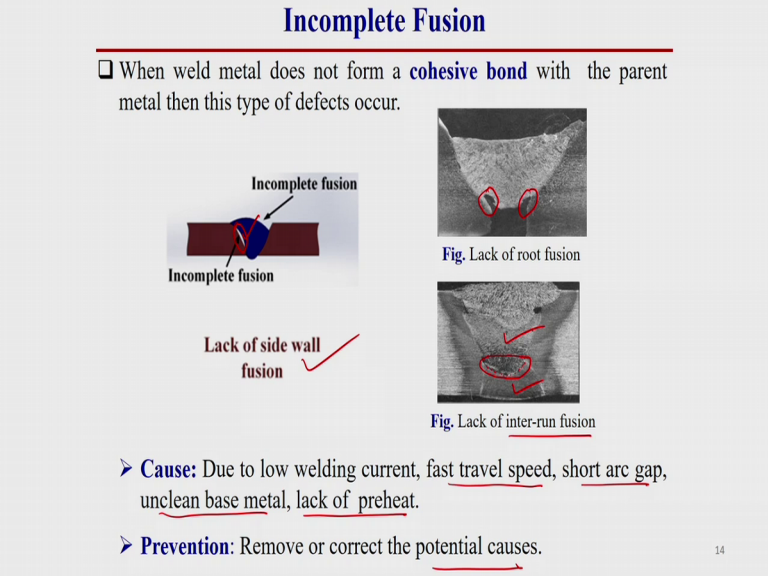

Now, this is incomplete fusion. Incomplete fusion means when weld metal does not form a cohesive bond with the parent metal then these types of defect occur. That means, there is a mismatch or misjoining between parent metal and weld material. That means, there is not occur some cohesive bond between these 2 so, there is create some sort of gap we can say. So, this is called incomplete fusion. This incomplete fusion can be side wall fusion here you see there is a side wall fusion in this portion there is not cohesive bonding between low weld material and base material. So, there is a gap. So, this is called lack of side wall fusion these types of defect can be lack of root fusion at the root side there is lack of fusion is there. This can be some interrun fusion also ok. Inter run fusion means here this is one pass this is another pass. So, in between these 2 pass here

there is not occurs cohesive bonding or we can say there is a gap in between these 2 weld pass. So, this is called lack of inter run fusion.

So, in this portion there is occur lack of inter run fusion. So, this is incomplete fusion the main cause of this thing due to low welding current, fast travel speed, short arc length, unclean base material and lack of preheat. So, this is the main reason of these types of weld defect. These we can prevent by remove or correct the potential causes that prevention can be done whatever the reason of this types of welding defect. So, if we know the cause and if you can eliminate that cause then we can prevent this thing.

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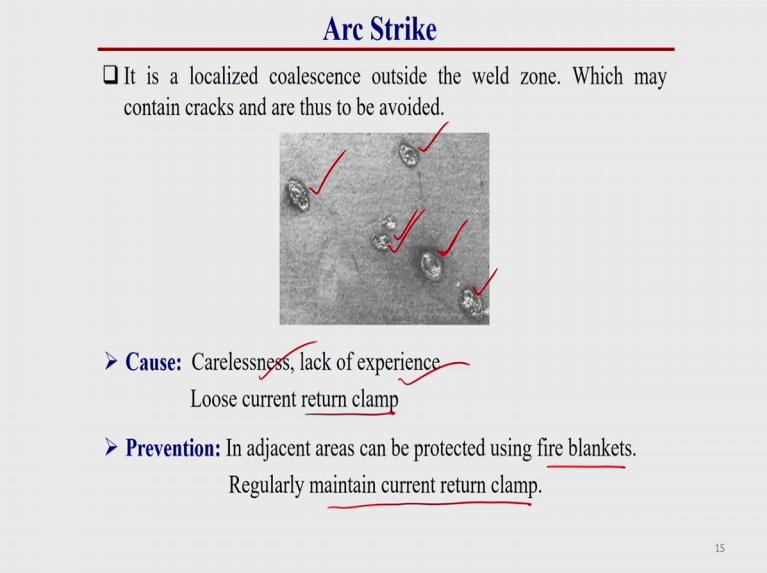

Now, arc strike. It is a localized coalescence outside the weld zone. You see these types of coalescence of arc can occur during welding operation. Which may contain crack and thus to be avoided. So, these types of coalescence can contain crack. So, we this should avoid. This is occur generally once welder is not that much of experienced one, then this types of welding defects chance is more over there and this also can occur due to carelessness. Carelessness means, what happens a sometimes the electrode can shift from it is intended location to another location.

So, once it shifted from it is intended location to base material location and if it is strike over the surface then this arc can create some sort of these types of defect or arc strike defect. So, once this arc strike this base material there is a chance of these types of defect and over this region there is a chance of generate crack also. So, this is the main cause of

this arc strike is carelessness, lack of experience then, loose current return clamp. So, if the return clamp of the current is loose, there is a chance of these types of arc strike is more.

So, prevention is it adjust area can be protected using fire blanket. Regularly maintain current return clamp. So, whatever the root cause if we can eliminate this thing then we can prevent this defect. Another way also we can prevent; that means, by providing some fire blanket. So, if the arc strike over the fire blanket then it will not create defect over the base material surface. So, by some fire blanket we can prevent these types of arc strike.

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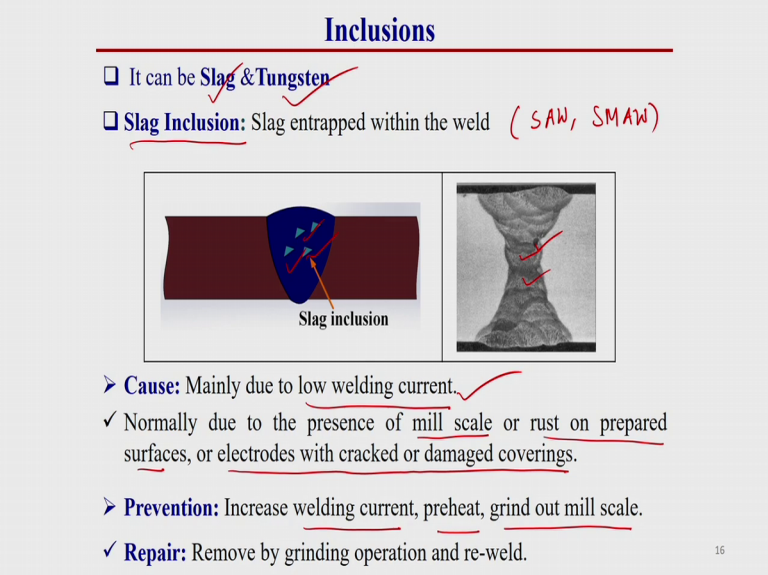

Then inclusion this is a welding defect in which there occurs some inclusion of flux or inclusion of tungsten. That is depending upon the type of compound of this inclusion material it can be slag inclusion, it can be tungsten inclusion. Generally slag inclusion occurs in case of those welding operation where; slag is used as a protecting medium like this. Slag inclusion generally occurs in case of submerged arc welding, then SMAW welding where generally slag protected medium is used to prevent the weld pool. Slag inclusion means, slag entrapped within the weld this types of slag entrapment can occur. Like here you see slag entrapment is occur in between 2 layer of welding chances of this types of entrapment is more once there is multilayer welding or multi pass welding is

there. Then because during cleaning operation of the slag there can be chance of some slang over this region.

So, another cause of this welding defect is mainly due to low welding current also. This is more visible in case of multiple apart from multi pass it is also can occur in case of single pass welding also when the current range is lower side then chances of this types of slag inclusion is more, normally due to the presence of mill scale rust on the prepared surface or electrode with crack or damage covering. So, if the electrode having damage covering then there is a chance of uneven breaking of this slag covering of this electrode. So, that can create some slag inclusion over the welding inside the welding region.

So now, prevention how we can prevent this thing? increase the welding current, preheat it or grind out the mill scale; that means, remove this slag portion from there after that we have to re weld that portion.

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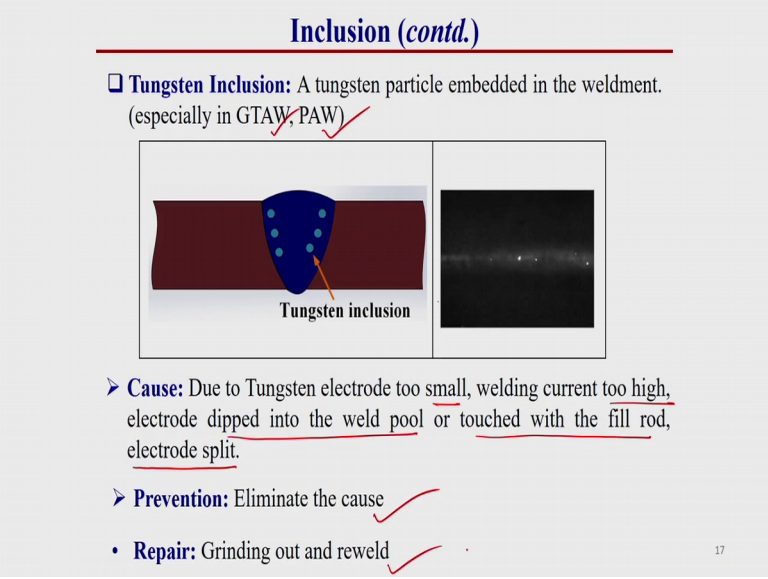

Then tungsten inclusion: This is occur especially for non consumable types of electrode like TIG welding, plasma arc welding where tungsten electrode is used to generate the arc. So, there can be this tungsten can sometime melt or break and it can make contaminant inside the welding zone or welding weld pool region. So, that create a tungsten inclusion over inside the welding region. So, that is a defect actually this is occur special in GTAW or plasma arc welding process.

The cause of this defect is due to tungsten electrode too small, welding current too high, electrode dipped into the weld pool or touch with the fill rod or electrode split. So, these main cause of this things tungsten electrode if the electrode size is too short then, if the current is too high then there is a chance of more heat generation in the electrode. So, there is a chance of melting or eroding of this tungsten electrode and it can deposited inside the weld pool region or this can sometime due to the reason of dip this electrode inside the weld pool region. If it is dip inside then due to this overeating also it can melt and it can be deposited. So, this can create some defect inside the weld metal.

So, how we can prevent? We have to eliminate the cause; that means, we should use proper size of tungsten electrode, then we should use the reasonable current, we should not touch the electrode with molten pool like this actually whatever the root cause we have to just eliminate that thing. So, if there is already occur these types of tungsten inclusion then we have to remove this tungsten by gouging operation or grinding operation and we have to re weld this zone.

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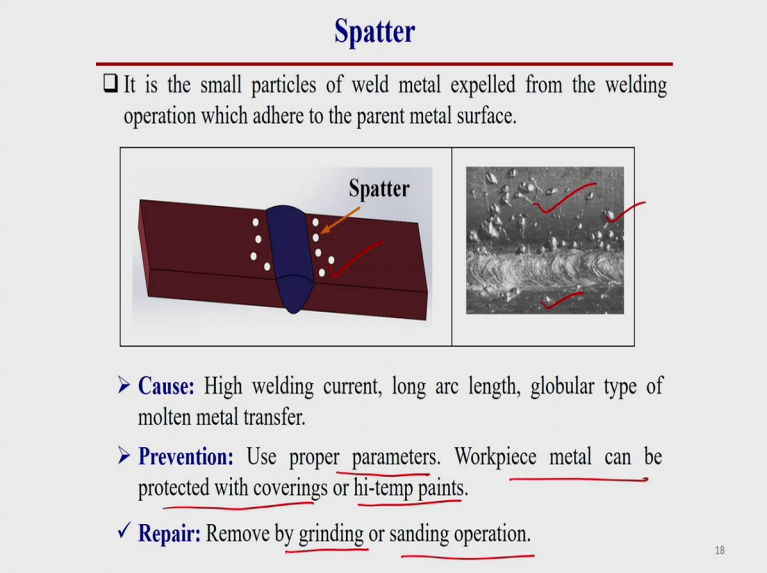

Then a spatter, this is the a small particle of weld metal expelled from the welding operation which adhere to the parent metal surface. You see this is generally called a spatter this is occur especially when the arc length is high, when the metal droplet is globular in nature, then if this globular metal droplet drop down to the weld pool region

there is a chance of flushing out this molten metal outside the weld pool region that it can deposited outside of this welding region which is look like this is called spattering.

So, how we can prevent this spattering or this is spatter? Use proper welding parameter then work piece metal can be protected with covering or high temperature paint. So, by paint also these types of high temperature paint or some fire blanket we can prevent this types of a spatter. So, repairing of this defect is remove by grinding and sanding operation. There is some techniques that is sanding operation means some solid blasting technique is there by solid blasting of sand particle we can eliminate this is spatter over the surface of the base material region.

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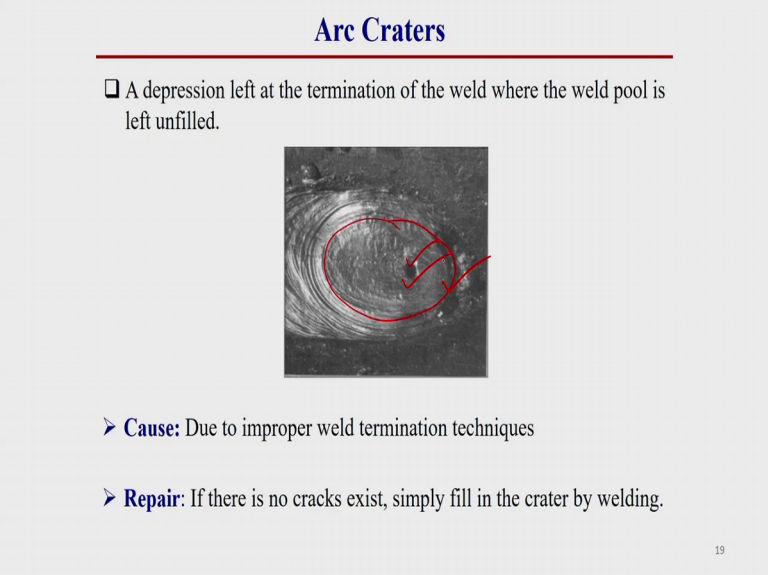

Then arc crater, this arc crater what I have already discussed in case of SMAW welding process this is a actually a defect. Arc crater actually a depression left at the termination of the weld where the weld pool is left unfilled. You see this arc crater generally here this weld pool region is remain unfilled. So, here this arc crater generally occurs where the welding is stop that in that location generally this types of depression of weld pool is occur over this region. So, this is generally due to improper weld termination technique. If the weld termination technique is not proper then there will be these types of arc crater which is a defect because from here crack can generate and welded joint can damage. So, repairing technique of this welding technique is. In this arc crater region if there is no crack exists then just we have to refill this thing by welding operation. Apart from this

thing we can also fill this crater by do the welding operation slightly back side and fill this arc crater region.

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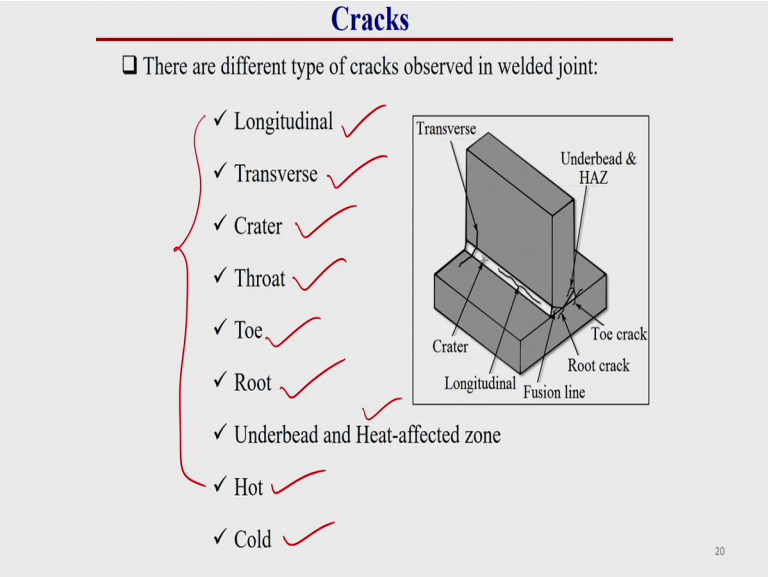

Next is crack, there are different types of crack observe in case of welding joint this crack generally depending upon this position there is a different categories of crack we can observe in case of welded joint. Apart from this 7, 8 category depending upon position there is some other categories of welding joint also are there, that crack generally generated due to cooling effect or heating effect of the weldment.

So, depending upon this cooling effect, heating effect as well as location in welding joint this crack can be categorised around 9, 10 different categories that are one is called longitudinal crack, another one is called transverse crack, another one is called crater crack, throat crack, toe crack, root crack you see this and heat affected zone crack this all this 7 different categories crack are this name is come due to its position. That means if its direction is along longitudinal direction then it is called longitudinal crack.

If it is in transverse direction then it is called transverse crack if it is occur in crater, then it is called crater crack, if it is occur in throat then it is called throat crack like these actually. Apart from this thing there is some other 2 different categories of crack one is called hot crack or this hot crack also sometimes called solidification crack another one is called cold crack.

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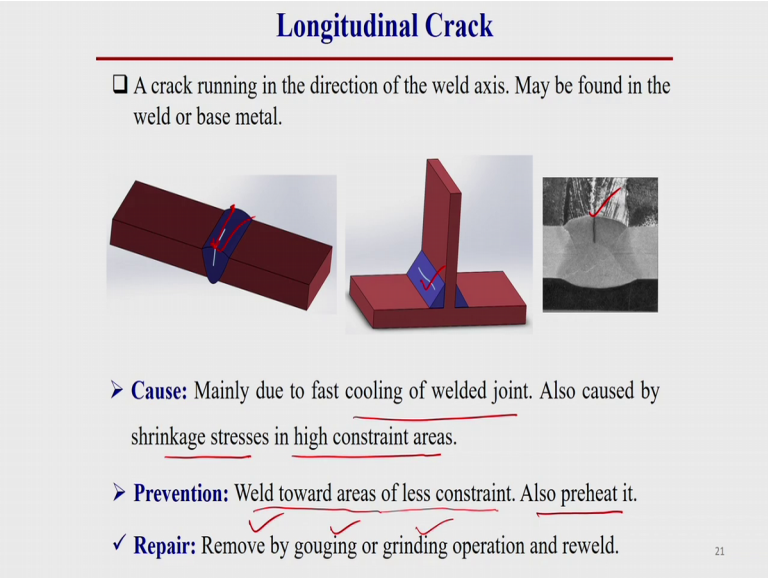

So, one by one I will explain in detail about this crack. So, first of all longitudinal crack you see this is generally called longitudinal crack. A crack which generally running in the direction of weld axis, this is the weld axis you see; that means, welding direction and may be found in weld or in the base metal. That means along the weld axis it can found along the weld line, here you see this is generally called longitudinal crack. That means, we see this direction is along the welding direction. The main cause of due to fast cooling of weld joint also caused by shrinkage stress in high constraint area. So, due to the shrinkage effect in high constraint area means if there is over constraint of this structure then during heating or cooling this weld material may not get it is required position. So, that there is a chance of this types of welding cracking.

So, how we can prevent this thing? So, weld toward area of less constraint region and also by preheating also we can eliminate these types of longitudinal crack. Always keep it in my if there will be some crack so, how we can repair this thing? This crack portion should remove either by grinding or some gouging operation gouging, gouging operation means by some heating remove that material portion that means, melting that region and remove that material portion by some force full medium forceful arc. So, what happens that crack should be cleaned after that there should be re weld. So, keep this thing in mind wherever there will be crack should eliminate thoroughly, after that we have to weld this or re weld this portion. So, here the how we can repair this thing? So, remove by gouging or grinding operation and re weld gouging operation means, by high forceful

arc we have to melt that crack region and remove that crack region weld material and fill this region by re welding.

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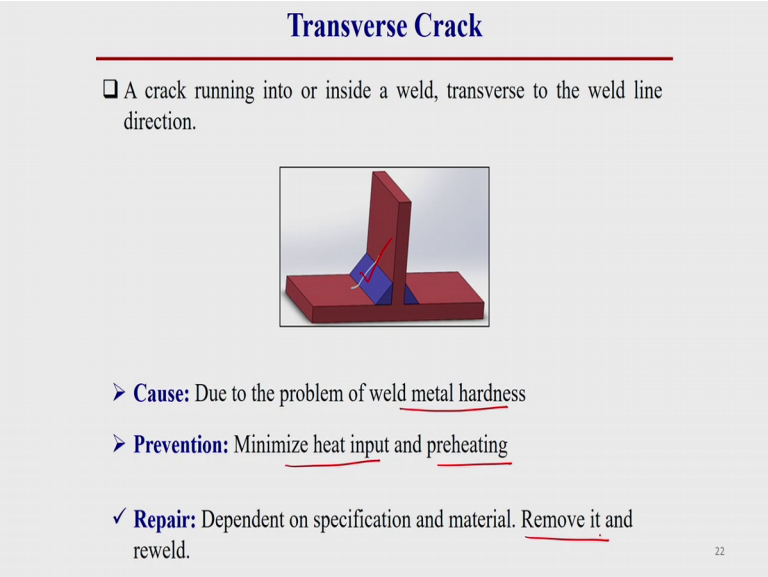

Then transverse crack, here this transverse crack direction is perpendicular to the welding direction. That means transverse direction of the welding axis. So, that what I have told you depending upon position and direction this crack is named. The cause of this crack is due to weld metal hardness. Hardness is the main reason of this transverse crack. How we can prevent this thing? Minimise the heat input or by preheating we can prevent this transverse crack and repairing the what I have already told you remove this crack portion region by grinding or gouging operation and re weld it.

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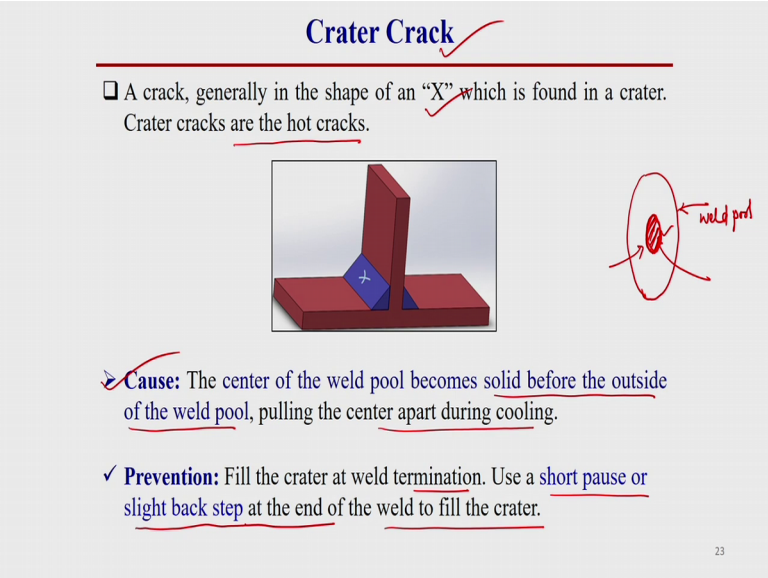

Crater crack, this is also a crack which is generally occur at crater location. Crater what I have already told you where the arc or you can say welding is stopped in this location there is occurs some depression types of weld metal zone. So, in this region if there is a crack occurs that crack termed as crater crack. So, this crater crack generally look like X shape. This crater crack is a type of hot crack this you should keep it in mind. This crater crack occur in hot condition that is why it is called hot crack. The cause of this crack is the centre of the weld pool becomes solidify before the outside of the weld pool that means, here first the centre portion of this weld pool region solidify first then what happens the rest of the side weld material then solidify.

So, what happens during the solidification of the rest of the weld pool there creates some shrinkage or we can say tensile types of force over this solidifying region, due to this there can occur these types of crack. So, due to this solidification of outside weld pool and there can be occur pulling the centre part of the solid region and there can occur some crack.

How we can prevent this thing? The prevention of this crater crack is fill the crater at the termination use a short pause or slide back step at the end of the weld and fill the region. Apart from this if there is already occur some crack then we have to just remove this crack by grinding or gouging operation and fill this by re welding. So, little bit this I am explaining then it will be more clear to you, let us this is the crater means this is welding

region. So, what happens here, let this is the centre portion centre location of this weld pool let this is the weld pool let us weld pool. So, here generally this centre portion solidify first. So, once it solidify, after that rest of the part then start solidifying. So, once this rest of the part start solidifying it creates some craft in this solid portion region. It create some tensile stress in this solid portion region. Then what happened there is a chance of creating this types of carter crack is there, that is written in this cause of this crater crack.

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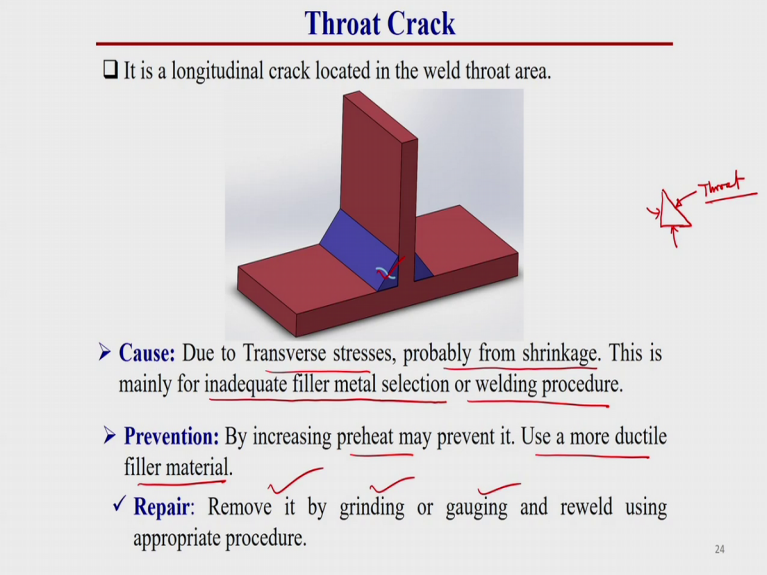

Now, throat crack it is a longitudinal types of crack which is occur at the throat of a fillet welded joint. We know throat of a fillet welded joint means, that this is a fillet welded joint this is called leg, this is called leg and this is called throat. So, this throat if the crack location is at throat of the fillet welded joint then that is called throat crack. The cause of this throat crack is due to transverse stress probably from shrinkage. This is mainly for inadequate filler material selection or welding procedure.

Prevention of this throat crack is by increasing preheat and another technique is use a more ductile filler material. Then if there is already occurred this throat crack how we can repair this thing? Remove it by grinding or gouging operation and re weld that by appropriate procedure. What I have already told you. Means wherever there will be some crack you have to eliminate this thing and fill it by re welding.

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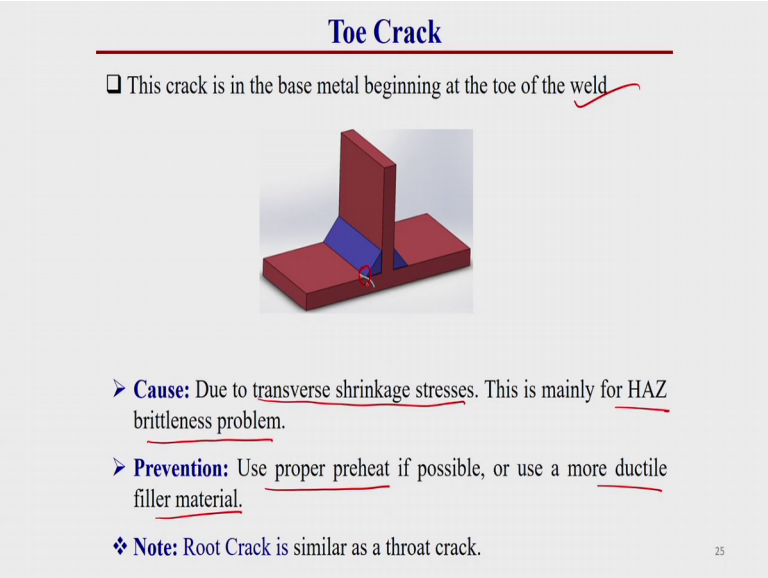

Toe crack means, here this thing occur at the toe location of a fillet joint. So, this crack is in the base metal beginning at the toe of the weld. You see the main cause of this toe crack is due to transverse shrinkage stresses. This is mainly for heat affected zone brittleness problem. This toe crack occurs near the heat affected zone and at the toe of the welding region.

So, this is occurs generally due to brittleness problem of heat affected zone. Prevention of this toe crack is use proper preheat or use more ductile filler material generally this crack problem most of the crack problem we can eliminate if we can use ductile types of filler material or ductile types of base materials ductile material case this crack issue is less because there is more ductility. Generally chances of crack is more in case of brittle types of material. So, here one things we should keep it in mind this toe crack and root crack is similar.

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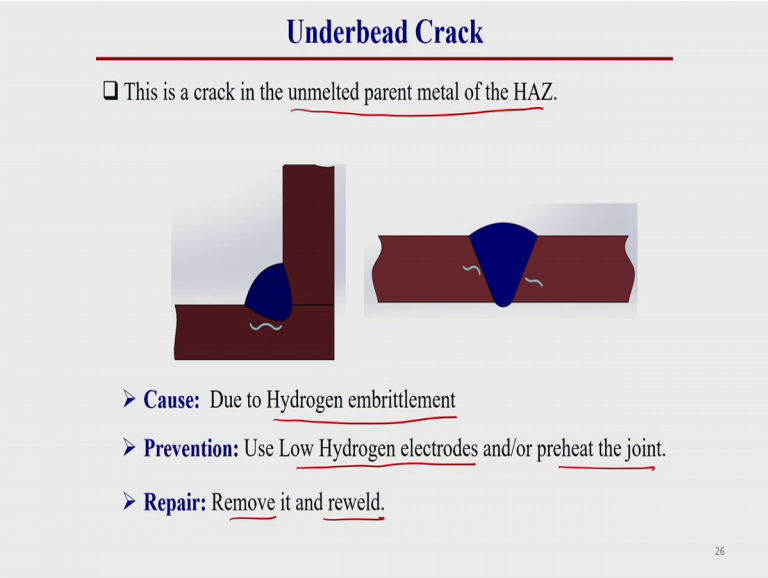

Then underbead crack this is a crack in the under unmelted parent metal of the heat affected zone. So, this is the crack which is occur at the heat affected zone which is the unmelted portion. This portion generally heated by some heat there is no molten material is there. So, due to the heating here generally microstructural change is occur. So, this heating temperature is above bead recrystallization temperature. So, from melting zone to recrystallization zone position where the microstructure is changed due to heating only in this location generally this under bead crack occurs. In this zone this crack occur due to hydrogen embrittlement this I have already discussed in details about hydrogen embrittlement. So, the prevention of this crack is use low hydrogen electrode and preheat the joint. How we can repair this thing remove it and re weld it. So, every case you see the main repairing technique is just remove that crack portion and re weld this crack should not be there because crack should remove thoroughly after that re weld it.

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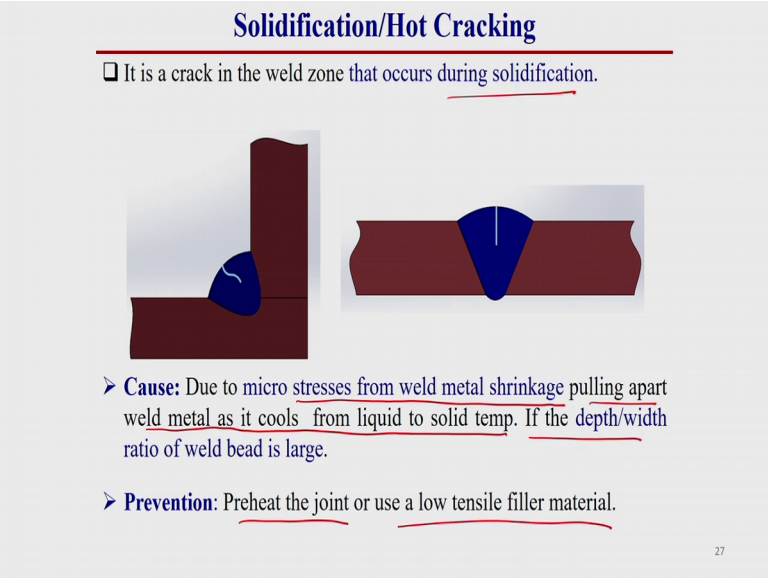

Then solidification crack? It is a crack in the weld zone that occur during solidification. This I have already discussed in submerged arc welding technique in detail. The cause of this crack is due to micro stresses from weld metal shrinkage pulling apart weld metal as it cool from liquid to solid temperature. That means when it cool from liquid to solid temperature then due to the micro stresses this types of solidification crack is occur. That means, during solidification time these types of crack is occur that is why this is called solidification crack. This is also called as hot crack because during hot condition this types of crack is occur.

The main reason of this crack is base metal composition what I have already discussed in submerged arc welding apart from this thing if there is depth to width ratio of the weld bead is high then there is a more chance of this solidification crack.

How we can prevent this thing? Just preheat the joint or use low tensile filler material or more ductile filler material.

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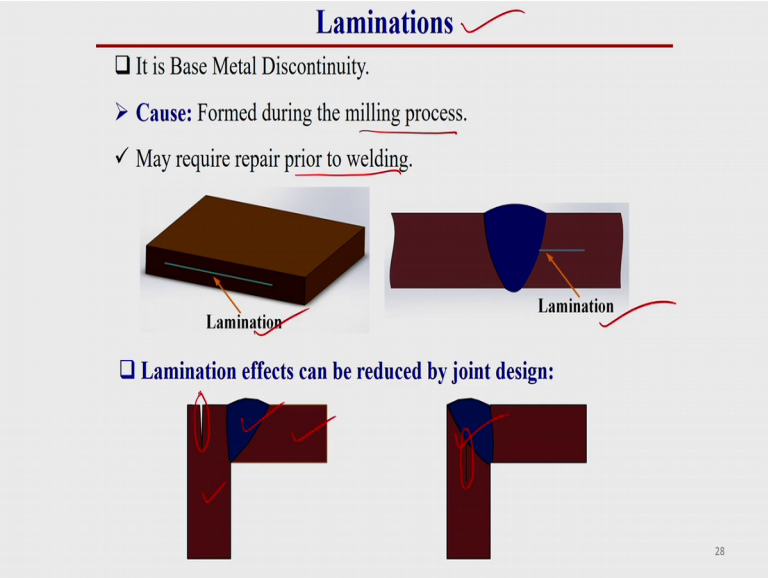

Then base material defect. So, this lamination is a base metal discontinuity this lamination generally occurs when we go for preparing the base metal before welding. Generally to prepare the required shape or required size there is some machining operation can required in base material. So, during machining operation specially for milling operation some sort of lamination or some sort of cut can be there in the base material itself. So, this is the main cause of this lamination this cut mark or this types of scratches generated in the base material is called lamination.

The cause of this lamination is this is formed during milling operation what I have told you and may require repair prior to welding. Like this types of lamination due to this milling operation or cutting operation can be there is this type some scratch or some sort of cut mark in the base material surface can be there, let us 2 base plate we are joining together. Let us here is there is some lamination. So, so we have to join this 2 plate like one perpendicular to another. So, instead of joining this way if we join this things this way then this types of defect we can eliminate. Then you see this lamination portion is covered by this weld pool material. But here you see this laminated film portion is open over there so this can create some further deterioration of the welding structure.

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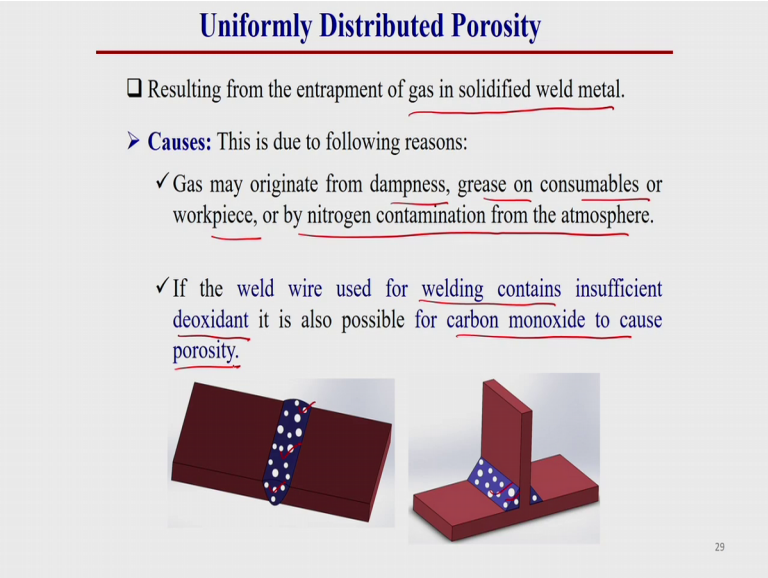

Now, this uniformly distributed porosity, this is another welding defect this is generally resulting from the entrapment of gas in solidified weld metal. That means, after solidification some gas is entrapped inside the weldment. The cause of this porosity or uniformly distributed porosity generally which is look like this actually you see, inside the weld pool or weldment this gas generally entrapped. The causes of this uniformly distributed porosity is gas may originate from dampness, grease, consumable or workpiece or by nitrogen contamination from atmosphere. So, this can entrapped inside the weldment or weld pool region and when it solidify this may not coming out from this region and it can entrapped inside. So, this create some porosity.

So, if the weld wire used for welding contain insufficient deoxidant, then it is also possible for carbon monoxide to cause porosity. So, if there is insufficient deoxidant what I have told you already then there is a chance of formation of carbon monoxide and that also can entrapped inside the weldment. So, due to this thing these types of porosity can generate.

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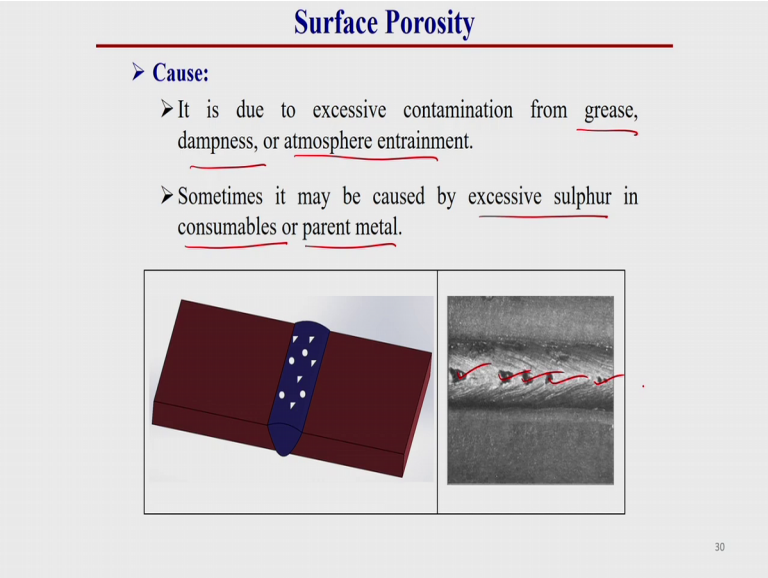

Then surface porosity, it is due to excessive contamination from grease, dampness or atmospheric entrainment. Sometime it may be caused by excessive sulphur presence in consumable or parent material. So, due to the excessive sulphur content in parent material or weld material, these types of defect can occur. You see which is expose over the surface of the weldment itself this is called surface porosity. This occur due to gas entrapment this is a gaseous. So, due to the high sulphur content this may occur. Now inspection and testing here just I will discuss what are the different inspection or testing carried out to investigate this types of defect or to investigate quality of the welding just before briefly I will discuss within 1, 2 slide about this inspection and testing of weld.

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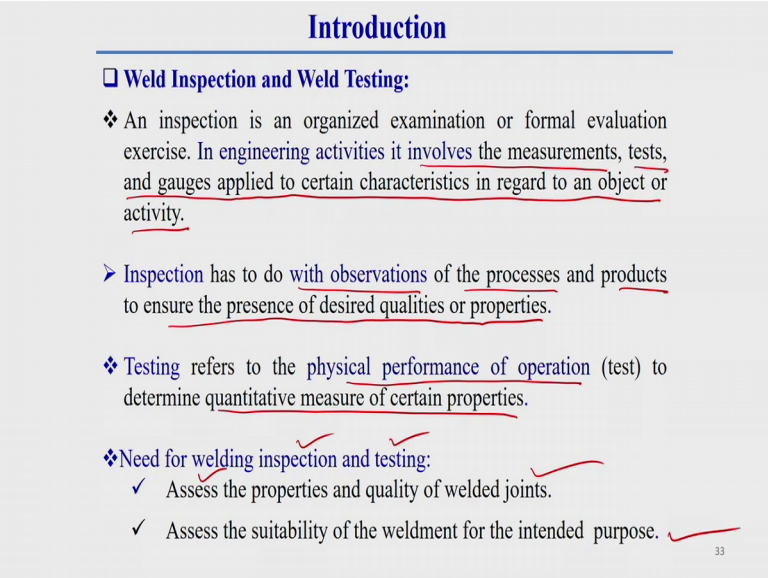

So, you see first of all what is inspection and what is testing and why it is required? Then I will tell you what are the different categories of inspection and testing method are there. So, first inspection, inspection is an organized examination or formal evaluation exercise in engineering activities it involves the measurement test and gauges applied to certain characteristic in regard to an object or activity.

Inspection has to do with observation of the process or product to ensure the presence of desired qualities or properties. That means, whether there is desired qualities or property in weld bend joint or welded joint is there are not that we can calculate by observation itself. And testing referred the physical performance of the operation. So, testing means physical performation of operation to determine the quantitative measure of the certain property here generally quantitative measurement is there by some physical performance.

So, what is the need of this inspection or testing? The need for inspection or testing are. assess the properties and quality of the weld joint then assess the suitability of the weldment for the intended purpose the main purpose of this test or inspection is this; that means, assess the property and quality of the welded joint and its suitability.

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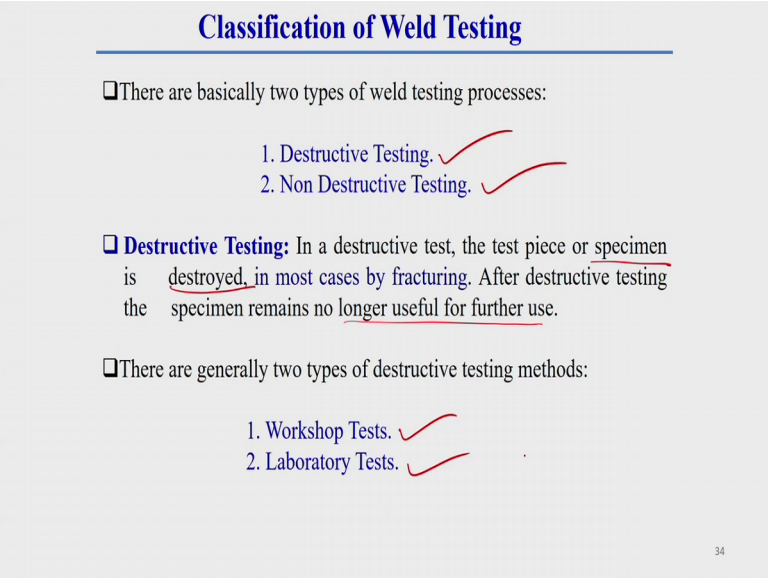

There are basically 2 types of welding testing method is there, one is called destructive testing another one is called non destructive testing. Destructive testing in destructive test the test piece or a specimen is destroyed, this you keep it in mind. So, after destroying the specimen remain no longer useful for further use. This testing generally is done by cracking of the simple sample; that means, here the product is destroyed then the testing is done. So, generally this destructive testing is categorized into 2 different categories. One is called workshop test another one is called laboratory test.

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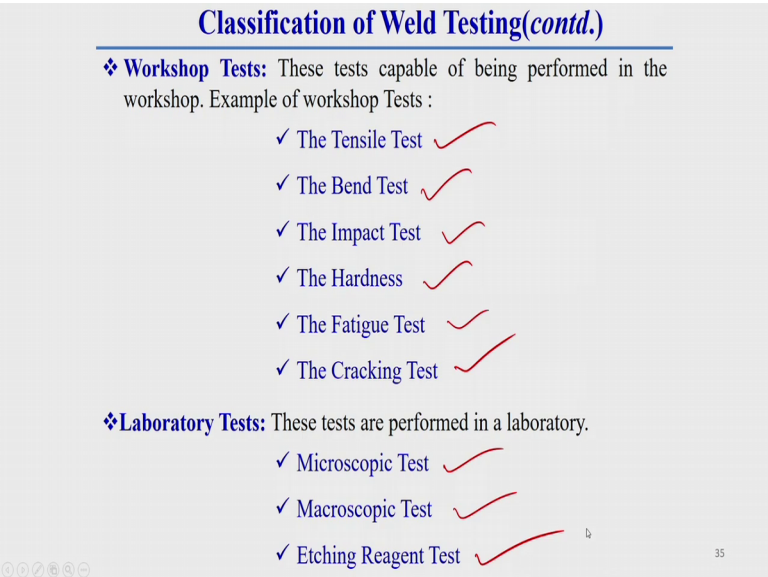

What are the different workshop test? Generally the workshop test where that much of cleanliness is not required. Whereas, in laboratory test there is required huge cleanliness; that means, there should not be any dust there should be neat and clean and other things, but in case of workshop test that much of cleanliness is not required. There can be around 6 different categories of workshop test for destructive testing. What are this testing? That is called tensile test, bend test, impact test, hardness test, fatigue test or cracking test.

A laboratory test that should be neat clean dust free region actually. This laboratory test can be also 3 different categories, for weld testing, quality testing which are microstructural test, macroscopic test or etching reagent test. So, to do all these tests there is required to destroy the welding structure or here test is done by destruction of the weldment sample. So, that is why this is called destructive testing.

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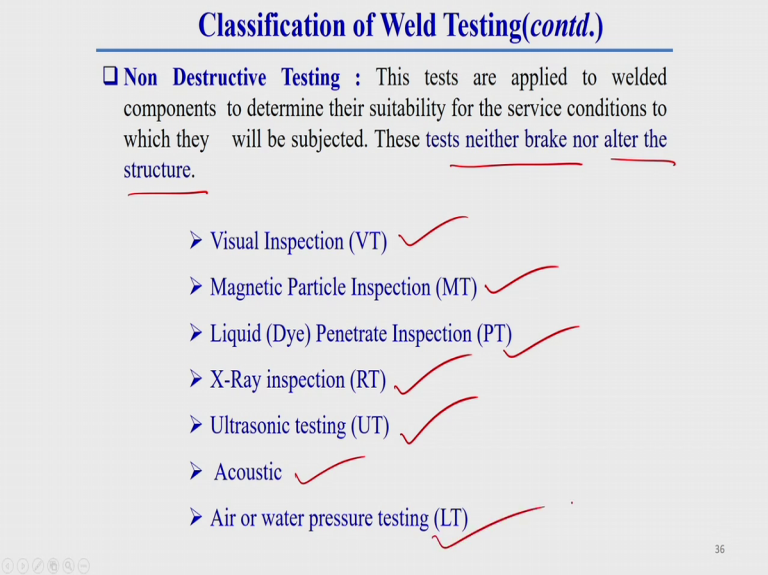

Now, the non destructive testing this test are applied to welded component to determine their suitability for the service condition to which they will be subjected. This test neither break nor alter the structure. So, this test also can have 6, 7 different categories like this can be done by visual inspection, that is VT test, this can be magnetic particle inspection, this can be liquid penetrate inspection, this can be X-Ray inspection, this can be ultrasonic testing, this can be acoustic technique or this can be air or water pressure technique. So, these are all generally non destructive testing where this weld weldment

or welded sample is not required to crack or required to break. So, this all today's lecture. So, by this actually I am finishing this course.

Thank you very much.