Welding Metallurgy
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Lecture No 57
Surface and Subsurface Welding Defects

Welcome to the lecture on Surface and Subsurface Welding Defects. So, we had the introduction to some of the welding defects and also we discussed about the causes of those welding defects and in this lecture we are going to have some detailed study of typical welding defects which usually occur in the different processes. Welding processes may be arc welding processes or other than arc welding processes.

And we will only have some discussion by referring to the typical images of certain type of important welding defects and also, as we discussed that also about the different type of welding processes and related defects. So, as we discussed that normally you have the surface defects and you have the subsurface defects in the case of welding.

And then, these defects may be because of the arc welding because most of the welding processes are based on the arc welding principle, so we will have some understanding about the defects based on arc welding processes.

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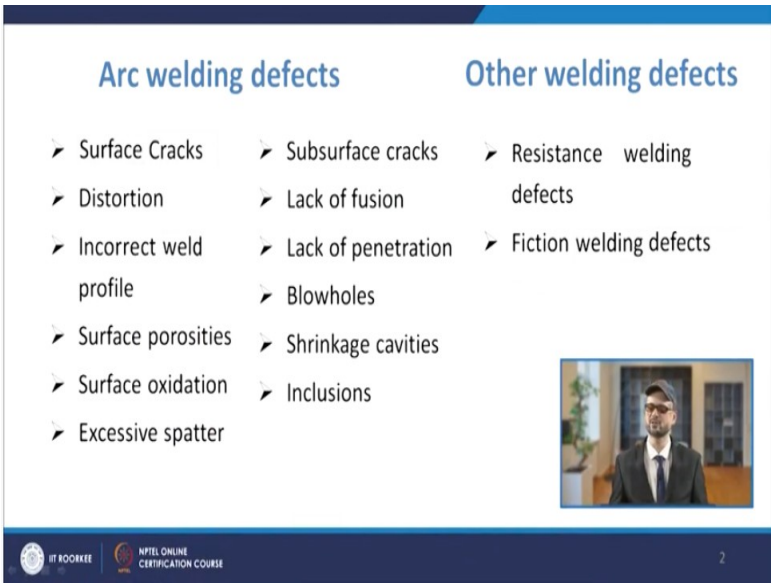

And then also we will discuss about some prominent type of welding defects which occur because of the other welding processes like may be the resistance welding defects or friction

welding defects. So, if you come to the arc welding defect, then as we know that on this side you have these are the surface defects and this is among the subsurface defects. So, they are visible on the surface or they are visible from outside, whereas, these defects are inside the geometry and they need to be seen using microscope or so.

So, coming to the cracks, so, we have studied very much about the cracks.

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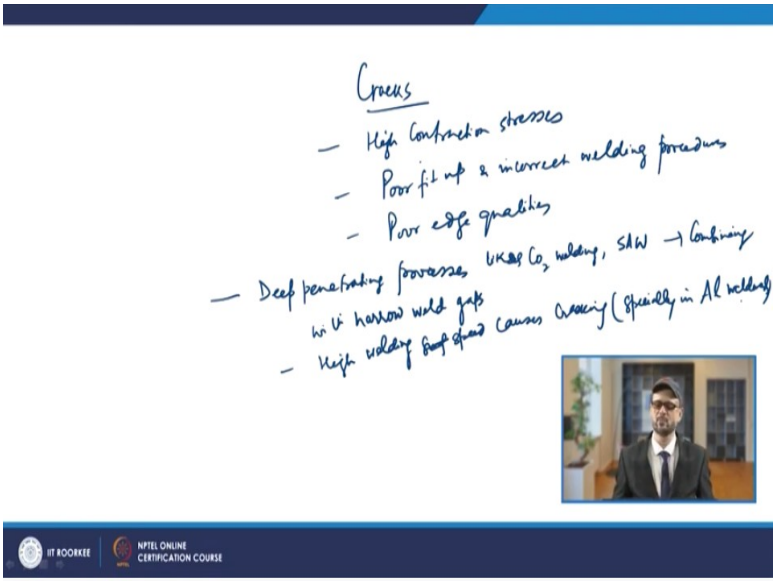

And as we see that if you talk about the cracks, we have already studied that there are many reasons and this is because of the high contraction stresses. So, when these stresses result into and its value is more than the strength of the metal at that particular high temperature in that case the crack results into then it may be because of the poor fit up and also incorrect welding procedures. And then you may have also the poor edge qualities.

So, this way, you have the emanation of the surface cracks, we have already seen that there are longitudinal cracks, there are transverse cracks, there are crater cracks. So these different type of cracks are available. Then if you talk about the different processes, in many cases if you have the deep penetrating processes, like you have CO_2 welding, then you have SAW. So these combined with narrow weld gaps, if they are combining with narrow weld gaps.

So they cause the hot cracks and the normally at the root, so, they will be causing the hot crack at the root level. Similarly, if you are having the very high welding speed, in those cases also you have the chance of cracking. So, high welding speed causes cracking, especially in aluminum weldments. So, these are the different reasons for the crack. Then,

you talk about the different types of cracks we have already studied that depending upon the way they are oriented, you have longitudinal and transverse cracks, you have the crater cracks.

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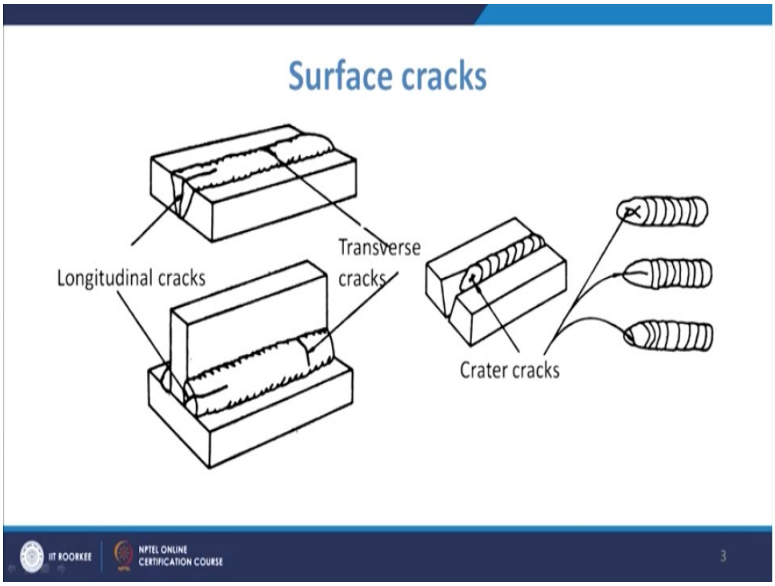

So, this is seen as the longitudinal crack, you have the presence of the transverse cracks and then also you can see here these are the crater cracks. So, crater cracks normally occur when the welding is interrupted. So, as you see, this crack which you see because this is interrupted, so there basically there is a tendency of the crack to form in this crater. So, normally, they are of star shaped, so that also we had seen in our earlier lectures and as we see, that these crater cracks are normally because of the material properties.

Also because when the material has very high coefficient of thermal expansion, so, in those cases like austenitic stainless steel, so, in those cases, these crater cracks are very much likely to happen as it seems to be. So, there are certainly some reasons also for that. Then, the next type of defect which is very much prominent, so, that is your incorrect weld profile.

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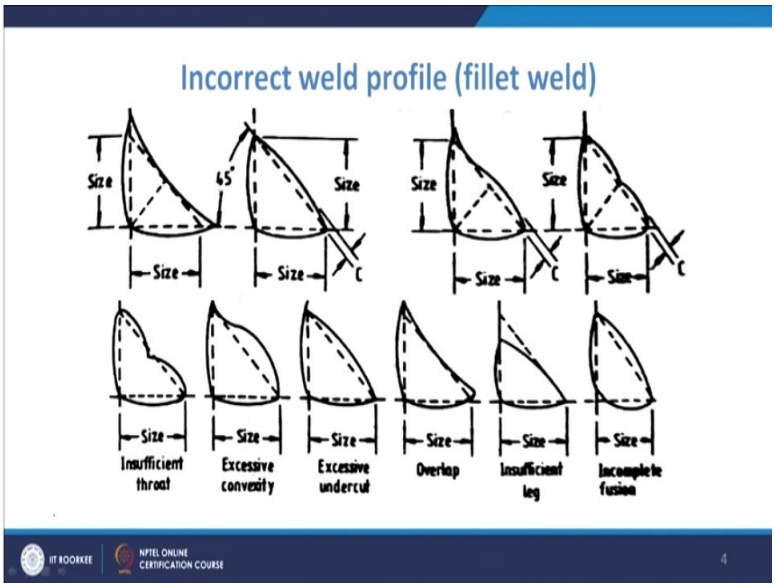

So, if you look at the weld profile, so, normally what you see is that this is the desirable weld profile in the case of fillet welds and this is how you take it as acceptable ones. So, this may be acceptable in those cases. So, if you see that this C is basically showing the convexity, which is shown here and here also. So, this may be, acceptable and what you desire is like this, so, this is what is desired, normally, in the case of fillet weld.

However, you basically see many a times, different types of weld profiles in case of fillet welds and if you see these kind of welds normally you come across, which is basically not desirable basically not acceptable. So, if you look at this, so, here you have the insufficient throat so that case is there, in this case if you look at this, now, here you see that this is excessive convexity which is found in this case.

Now, if you look at this, this is, in this case you have the excessive undercut which is shown here. Then, if you look at this geometry, this is the case of overlap what you see on this side also, overlap is seen in this case. If you see this weld profile for the fillet weld, now in this case you what you see is that you have the insufficient leg that is there. So, this type of fillet weld profile is not acceptable in many cases.

Then if you look at this case, now here you see that there is no proper fusion, which is observed in this case, you have the case of incomplete fusion in such cases. So, these are basically the incorrect weld profile in the fillet weld. Similarly, you have also weld profile which is acceptable, it may be there in the case of butt weld and in butt weld also you may have the different kind of profile, which is not basically acceptable.

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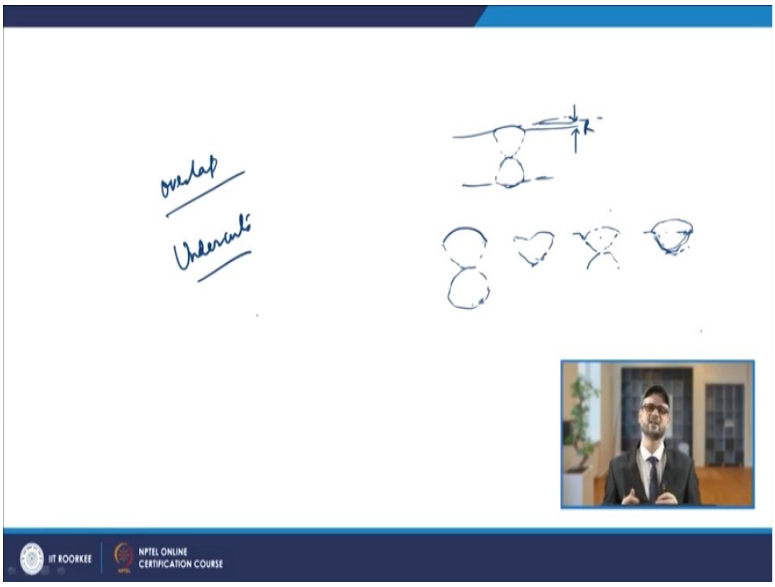

So, if you look at a proper butt weld. So on both these sides you have, so this is how, you know, you will have the convexity. So, this way what is acceptable, butt weld profile should look like. Again, you will have the R, which is here that is defined, this R is basically just denoting the reinforcement. So, and then in butt weld, there may be a different kind of problems like you may have the excessive convexity.

So, you may have such kind of excessive convexity will be there. Then you may have the insufficient throat may be there, so, it may go like this. So, this way, if it goes this maybe even a case of insufficient throat. Many a times what we see is that, so, from here basically your weld profile looks like it will start from here. So, basically it will be a case of excessive undercut. So, that way the weld profile may look like.

So similarly, there may be overlap many a times you have this way, so, it will be going like this. So, you will have, the overlap. So, this way your overlap kind of defect also may occur. So, this way, different types of incorrect weld profiles are basically caused while welding. Now, so, you will have to follow the specification and accordingly you will have the production of the acceptable weld profile in the cases of weld.

So, there may be many reasons for sometimes the undercut or maybe the overlap. So, you will have to have the control of the parameters to avoid these defects. Then, if you look at the other kind of weld profile, which is not very much acceptable, so apart from that, you may have the dimensional defects. So, that is maybe because the shape or size, which you

want to achieve that is not properly achieved.

So, that may be the dimensional defects, then you may have defects like you may have the overlap. So, as we saw that, you may have the overlap and overlap basically will be producing the mechanical notch. So, overlaps are many times formed and this overlap will be forming the mechanical notch and that will decrease the property of the weld. So, basically a crack may start at those points so, due to notching effect you may have the formation of the cracks and that will ultimately reduce the strength.

Then there may be undercuts also as we saw. So, these are undercuts, they are normally located parallel to the junction of the weld metal and base metal at the toe or root of the weld. So, that way you get these location of these undercuts, and they also lead to cracking because they normally, so once there is undercut, so they reduce the cross-sectional area and because of the notch effect, again there may be failure in the material.

Undercuts maybe because of the excessive arc voltage and even current values also, so, many a times the undercut is formed because of those reasons.

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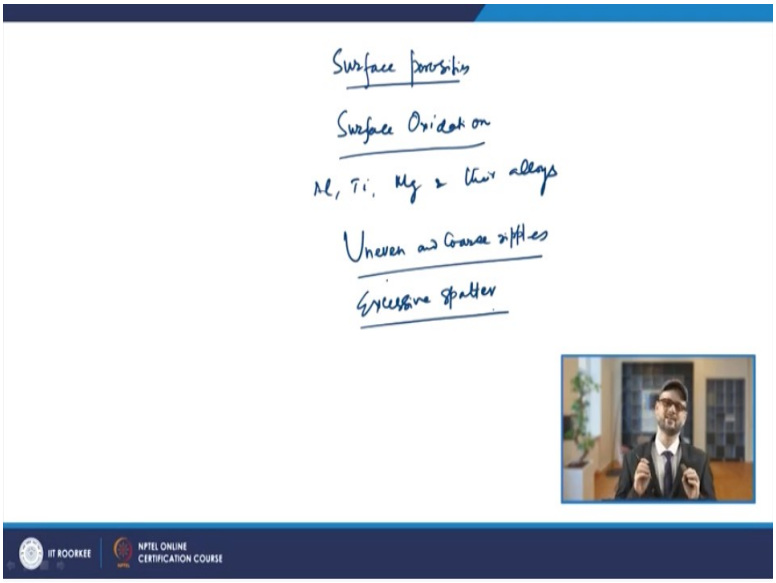

Apart from that, you have among the surface defects, you have the presence of surface porosities also. So, surface velocities basically occur when the welder is basically using the undried covered electrodes. So, many a times, he is using these undried and covered electrodes or electrodes with the self-life, whose self-life has expired, so it has long expired. So in those cases, you will have the presence of the surface porosities because they contain

the moisture.

And then that basically leads to the presence of these surface porosities so, that basically has to be avoided. Apart from that, you also have the many a times, you come across the surface oxidation. So, when you are doing the welding of metals, which are very easily oxidizable, like, if you take the example of aluminum or titanium or magnesium and their alloys. So, the surface oxidation will take place in this cases and typically it will happen if you are not providing adequate shielding environment near the surface.

So, in those cases these surface oxidation takes place and that will be certainly if sites of formed then that will be detrimental for the product quality or the weld quality. So, this is another type of defect, which occur in the case of welding, if you say other defects like on surface, what is taking is uneven and coarse ripples. So, basically, what is happening that these ripples if they are found on the surface, they will be aesthetically not desirable.

So, the appearance on the surface that will be, so, there will be inconsistency in the appearance. So, normally you will have the generation of these because of the uneven heat inputs many a times. So, many a times because they are aesthetically so important, so many a times, because of that, the rejection will be more because of these factors rather than the internal flaws, which are there in the material.

So, these are the kind of surface defects, apart from that you also get some marks that is your flat spots or pockmarks also you get in the case of flux code arc welding or submerged arc welding. So, they will be like you have in the form of slight depressants which will be there so because of the improper welding current or source, if you control these welding currents and gas flow rate, and also the moisture content of the flux so you can have the control on these pockmarks.

Many a times we also see that you have the excessive spatter. So, as we have, you might have the idea that this kind of defect is caused by the arc blow which is, because of the wrong selection of electrodes or maybe you have the bad electrode or with the use of heavy current. So, these excessive spatter occurs it may be because of the poor technique of the welder also. So, you can have the prevention of the spatter by suitable coating to the metal adjacent to the weld.

So, that way, you can have these avoidance of these excessive spatter. Apart from that you have other also surface defects like in there are arc strikes or so, so, when the welder will hold that inadvertently or without knowingly, when he strikes the electrode against the work, so, in that case, you have the arc strike is taking place and you have the unwanted arc. So, that can spoil your finished work also. So, these kind of surface defects may occur.

There are examples if you come to the subsurface kind of defects. So far, we discussed about the defects which are visible, if you talk about the subsurface defects in the subsurface defects, again, you will have the cracks which are internal cracks, so, internal cracks will be seen in the case of subsurface cracks.

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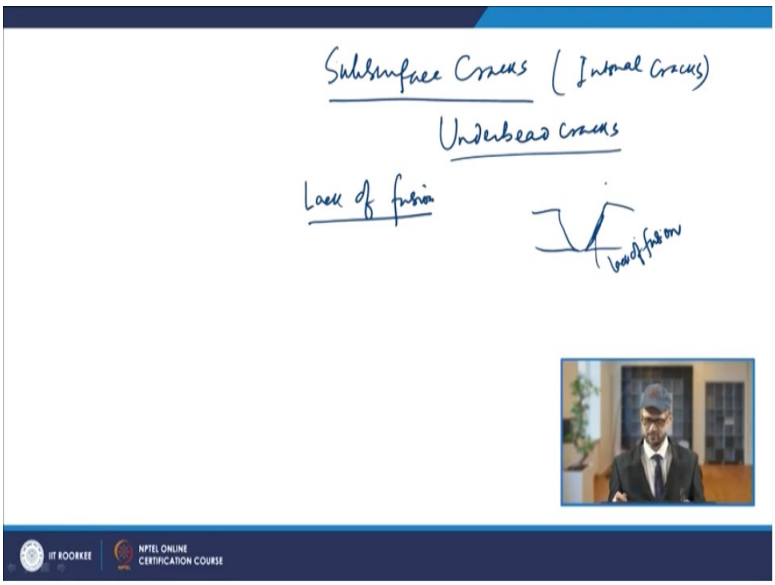

And apart from that you will have the, so, if you come to the subsurface cracks, so, that is known as internal cracks. So, in that, basically you have the underbead cracks as we had already seen that these underbead cracks are basically the example of this cracks which are not seen from outside. They are cracks under that region and you have also, many a times you have small cracks like fissures are also there. And also you have extremely small, so then we call it as micro-fissures.

They are very much dangerous, they are considered to be very much dangerous, because they will be creating a large reduction in the strength. So, these cracks are more important because they will create sudden failure of the material, especially under the impact loading or the kind of low temperature service conditions. Then among them, under subsurface defects

you have the lack of fusion. So, as you see that there will be, in many cases you will have the weld profile which is here.

So, basically it goes like this, so, you will have the lack of fusion taking place in this region. So, that is also called as the incomplete fusion. So, mostly in case of multi-pass welding, you come across these cases and in these cases the main reason is because of the insufficient welding current. Suppose, then many a times you have the opposite of the electrode from the axis or you have the high welding speed. So, these are the main reasons for the lack of fusion where the one of the side or the edges they are not melted thoroughly.

So, that is how the incomplete fusion takes place in these cases. So, just like the undercut this also been reducing the strength and that will be creating the failure of the component. Then apart from that, we also have among the subsurface defects, you have more importantly the blowholes or subsurface porosities.

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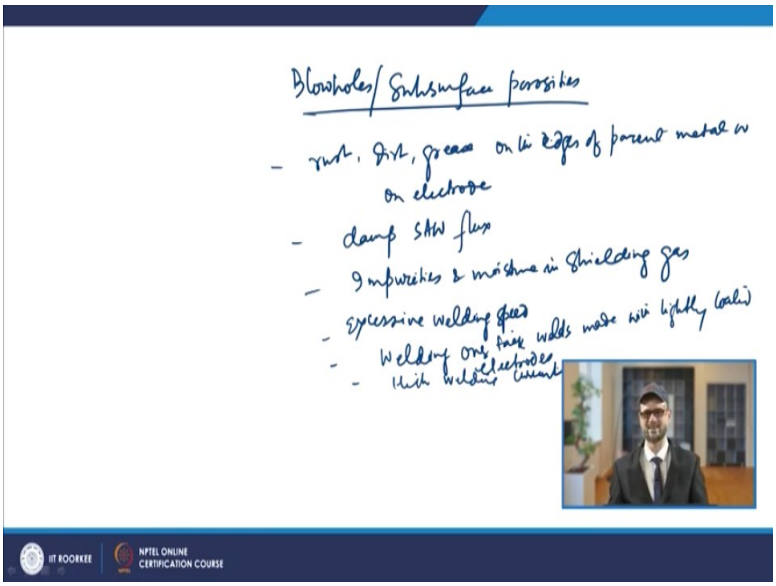

So they basically are formed because of many reasons and they are because of the presence of rust, dirt, or grease, they are normally there. So, if you are not able to clean them, so, on the edges of the parent metal or on electrode. So, this may be the reason for the blowholes or the subsurface porosity, so you will have the porosities formed inside then you will have the reason one more in case of SAW, if you have the damp SAW flux in the submerge arc welding.

If you have the damp flux in that case, that may go inside the weld and you may have the

subsurface porosities or blowholes. Then, also if you have the impurities and moisture in the shielding gas, so that may be the reason for the blowholes or surface porosities. Further, you will have the excessive building the speed. So, what happens that the gas pool, which is formed around the weld pool, so, when you have the very high welding speed, then that envelop which is created for shielding, that becomes ineffective.

And then in that case, you have the chances of having these blowholes or subsurface porosities. Then when you are making these, so the welding over the tack welds, made with lightly coated electrodes. So, in those cases also, the chances are porosities are there. Apart from that, you have also the reason is the high welding current. So, these are basically the reasons for the porosities, which are formed in the case of welds and this is normally known as the subsurface porosities.

And porosities basically are of different types, if you look at the porosities, so, we can have the example of these porosities.

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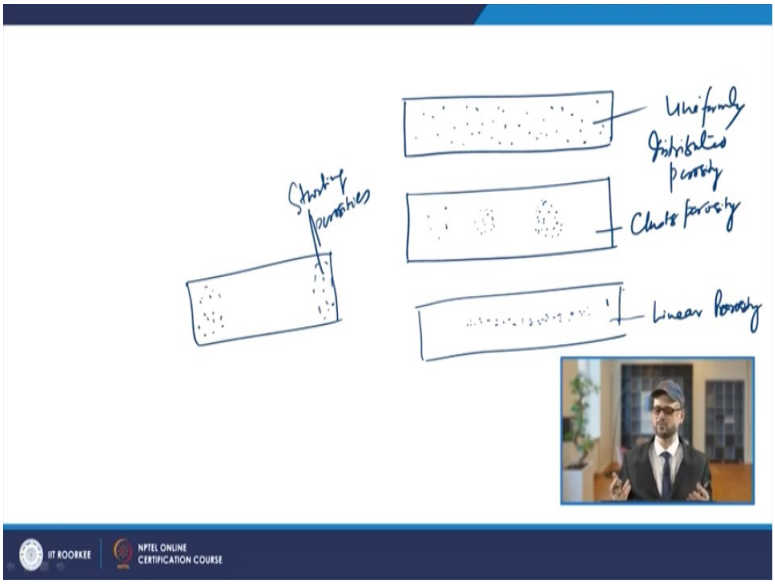

So, what we see, if you look in normal case, the porosities will, you have the, so, this way if you get the porosities, so, this will be basically the uniformly distributed porosity. So, this is your uniformly distributed porosity. Then, porosities are of different types, so you may have the cluster porosity, so, what happens that, in that case, you will have the porosities in the form of clusters. So, you will have here then you may have at some places you have so in this cluster, so these porosities will be formed in the form of clusters.

So, this is the example of cluster porosity. So, they are basically because of the change in the welding conditions like changes in the arc settings. So, because of that, these cluster type of porosities come up or sometimes may be many a times you stop the welding. So, in those cases, these cluster welding, cluster type of porosities develop and these are basically not very good for the welding. Similarly, you have the starting porosity. So, many times you will have the starting porosity.

And starting porosity will be looking like, it will go like this. So, normally, it is used stick electrodes are used and in that the porosity is placed at distances just like the weld metal is stuck to the stick electrode. So, normally it is because of the excessive moisture in the electrode covering. So, because of that, you will have such kind of the, this is basically known as the linear porosity. So, this is the example of linear porosity. So, it is normally in the root pass of the weld, but if you talk about the starting porosity.

So, you will have in the starting regions, so this is your, this region, so, you will have these as the starting porosities. So, you have different types of porosities, which normally come across in the case of the subsurface defects. Apart from that, you also come across other defects like inclusions.

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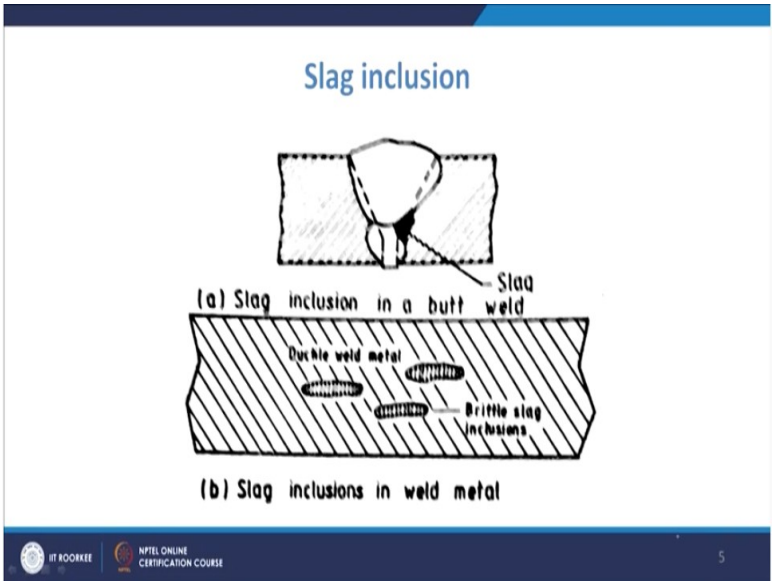

So, you will have the slag inclusion, which is as shown in this case. So, you will have the presence of slag inclusion in the butt weld. So, if look at this, what you see is that, this is a slag which is there in this case and these are the brittle slag inclusions which is there in the weld. So, basically it is because of the trapment of the slag and may be many a times you

have the trapment of the flux that creates or you have the inclusions which are there inside.

So, many a times these slags are forced, in case of shielded metal arc welding, they are forced to go inside and then they are not able to come up. So, they are basically coming up especially in the mult-pass welding, when you are not removing the slags in between or cleaning the slags, so, these kind of defects come across in this welds and normally they are detrimental, because they will decrease the mechanical strength of the weld. Other than arc welding, if you look at, there are other type of weld, so, if to try to refer to our, the slides.

So, if you have other than arc welding, you have other welding, like you have the resistance welding and the friction welding. Now, in the case of resistance welding, you have the different kind of welding and you have the spot welding defects.

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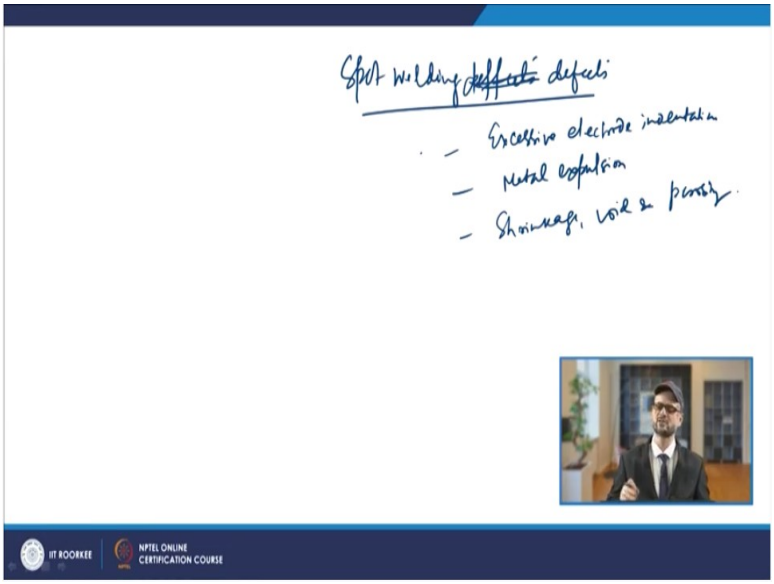

So, in case of spot welding, you will have so, you have spot welding defects, and in spot welding defects you may have the excessive electrode indentation and then similarly, you will have the metal expulsion, then you have shrinkage void and porosity. So, you have then cracks, surface burning, all these are kind of the defects which are occurring in the case of the spot welding of electrodes that is under the resistance welding. And you have many a times the electrode skidding also taking place, you have the edge bulging or excessive penetration.

So, these kind of defects occur in the case of electrode, spot welding and you get to know many a times.

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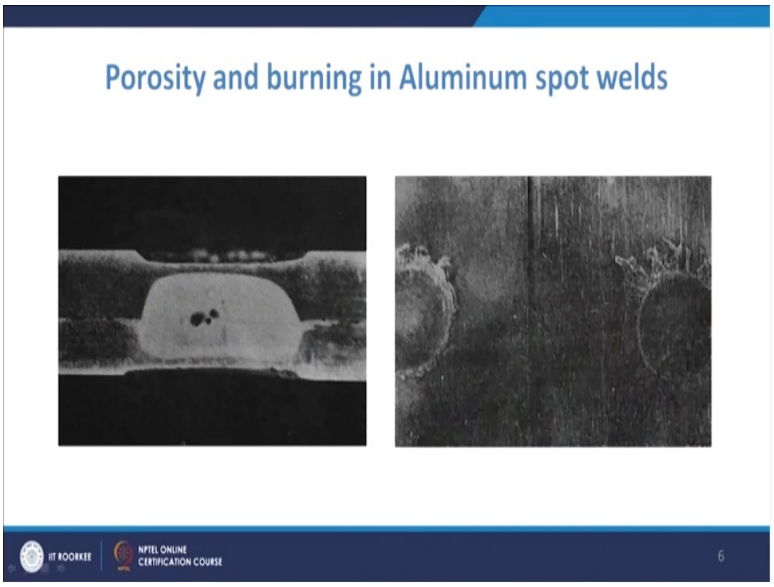

If you talk about the defect, so, this is what you see that we will see is that this is the porosity and burning in the case of aluminium spot welds, what you see this is the porosity which is seen in the case of spot weld. Similarly, you have the case of burning that is also observed in the case of aluminium spot welds and that is shown by this picture here. And similarly, in the case of other welding processes, you have the process like you have the other defects like you have the separation of sheets or so.

So, this way, the different kinds of defects occur in the case of resistance welding also and there basically you have the material properties, that also plays an important role and basically the process parameters which will be like the property of the material or the value of the current and what is used. So, those important parameters are to be looked into, to avoid such kind of defects and you need to study more for the better understanding about the different types of defects which is likely to come in the case of these other kinds of welding processes. Thank you very much.