Welding Metallurgy
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Lecture - 35
Introduction to Preheat and Postweld Heat Treatment

Welcome to the lecture on introduction to preheat and post weld heat treatment. So, you know we have talked about the heat treatment processes and there we came across different type of heat treatments which are given you know we talked with reference to the material that is steel but then that can be for any material and then we also had the idea that how that heat treatment is you know able to change the properties or with one specific objective what kind of heat treatment has to be given.

Now, when we talk about the welding process, now in that case what we see that you have the formation of the heat affected zone and certainly this zone width or the extent to which the heat affected zones are formed. So, that is an area of concern, so many a times for you know for getting the optimum properties of the welded joint, we do certain measures. That measures may be you know the necessity many a times for the successful welding operation.

And many a times some of the processes are done you know some either preheating or the post weld heat treatment processes are employed you know, so that you are ensuring a better property in the welded joint. So, in that direction there are you know two things which we must know, one is the preheating of the specimen you know which is to be welded or joined and another is the post weld heat treatment.

Because after welding also as we have seen you know there are likelihood of you know the development of stresses and all that. So, normally we will have to understand why there is need of preheating, what is preheating and what are the preheating methods? Similarly, you know why post weld heat treatment is required, what are the advantages you know associated with that, how you know that is applied to different materials.

So, coming to the preheating, you know if you talk about the you know we have talked about the HAZ you know.

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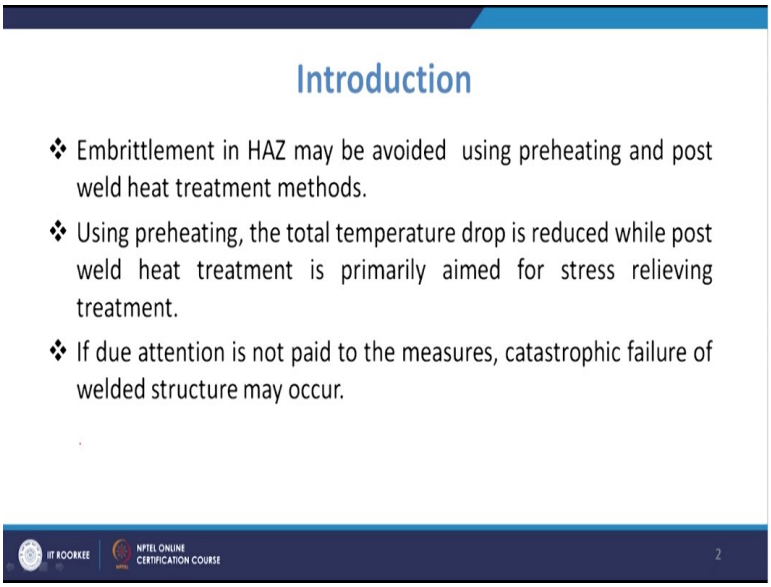

And as we have seen that the embrittlement in the HAZ, they may be avoided using the preheating and post weld heat treatment methods. So, as we can recall that if we talk about our discussions regarding the HAZ, so in that embrittlement a serious issue and embrittlement is formed because of many reasons and for that you know that may be avoided in the heat affected zone using the preheating and the post weld heat treatment methods.

So, you know using preheating the total temperature drop is reduced while post weld heat treatment is primarily aimed for the you know stress relieving treatment. So, normally what happens that when you are not doing the you know preheating, so actually the actual temperature drop you know you have the temperature which is attained to a very high level and if you see the you know the specimen temperature where the heat is flowing, so they are at the room temperature.

So, basically in a normal case, the temperature drop is quite high. So, that gives a very large cooling rate. So and that too because the you know weld metal zone which is surrounded by this metal which is having very high thermal conductivity and then if the temperature is so high, so in that case the cooling rate becomes very high. So, what happens that when we do the preheating, in that case the difference between the weld metal zone temperature.

And the parent metal temperature I mean through which the heat has to be you know pass or heat has to flow and that will set up the temperature gradient which has certain value at any moment. So, basically that temperature gradient will be less if you are heating the specimen to a certain temperature. So, that is how you know this preheating concept is you know

coming into picture because that very high you know cooling rate that you know leads to many a times the unfavorable type of microstructure.

So, what happens that if you talk about you know normal case of iron, so suppose if we take the steel case.

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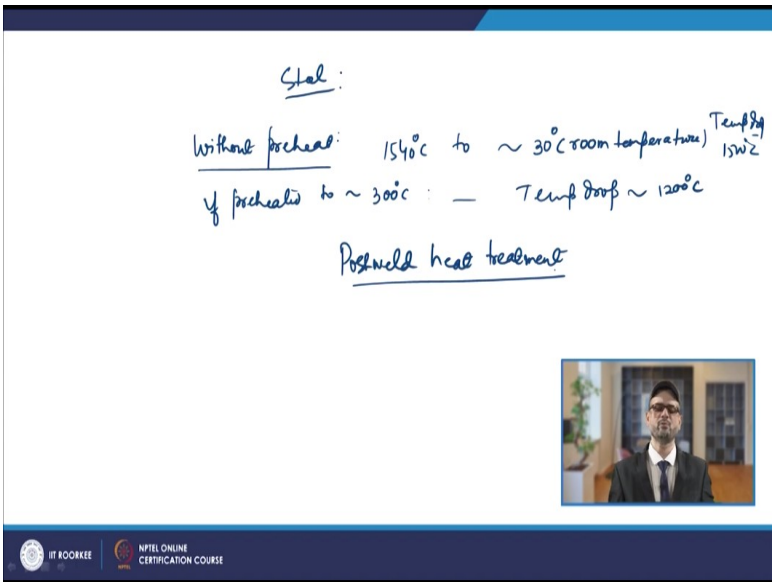

So, in normal case, you know you have if you do that without preheat so what we do? We have the you know we are decreasing the temperature from 1540 ^{0}C to about 30 ^{0}C that is if you take the 30 ^{0}C as the room temperature. So, in normal case you know we are taking this you know specimen to this temperature. So, your you know temperature drop is about 1500 ^{0}C.

But if you preheat, so if you preheated you know to about 300 ^{0}C, so in that case you know your temperature drop will be maybe about so 1200 ^{0}C. So, here temperature drop is you know temperature drop is about 1500 ^{0}C and here the temperature drop will be you know close to 1200 ^{0}C. So, that will lead to the reduced cooling rate you know.

And that gives the you know different properties you know different cooling rate will be giving you know that there are other associated results also because of that and also you will have you know the once you do the preheating, so in those cases the properties of the material also is likely to be changed basically. So, you know more rapidly this and when we talk about the multi-pass welds, so in that you know what happens that the bead which is deposited basically you have the earlier bead which is being you know laid over.

That is it seems like it is the preheated kind of you know, so preheated condition is there. So, you have the inter-pass temperature that is you know that you can say that it will be the preheat or the inter-pass temperature. Now, normally when we talk about the post weld heat treatment, so the post weld heat treatment is it is basically if you talk about, so they are normally intended for the primarily for the stress relief treatment.

So, what happens that when there is large cooling rate, so many at times you know when we are mostly doing the welding for the high carbon steel or high alloy steel, then you know the post heating is also important. If not preheating, the post heating becomes you know important. So, what happens that the preheating basically will be controlling the cooling rate you know that way.

But when we look at the post weld phenomena, so basically there will be chances of the formation of residual stresses you know after while cooling. So, in those cases if the residual stresses levels are to a higher you know amount, in that case that may lead to the you know decreased service life of the component. So, that way the welded component may fail. So, post weld heat treatment is mostly for you know for the stress relief treatment.

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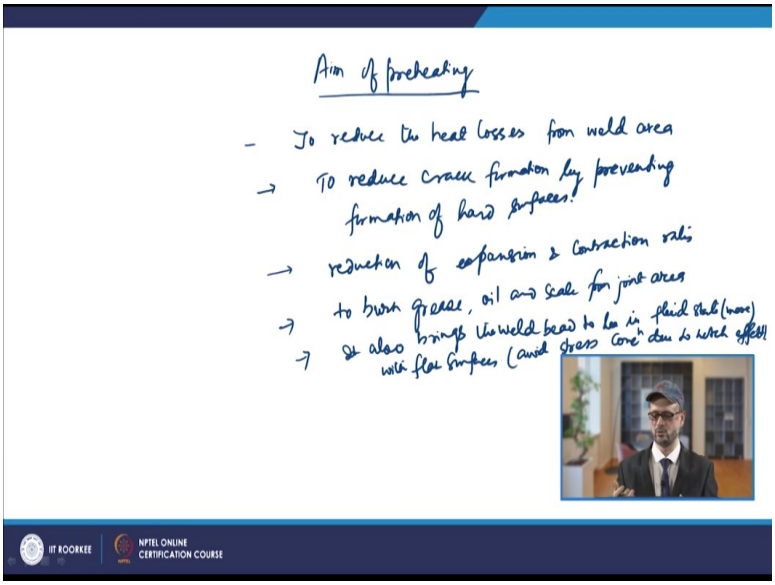

Now, if we talk about the you know aim of preheating, so if we try to you know summarize these points which we discussed and try to look at other points also, so apart from what we discussed the aim of preheating may be because you know when we see that you have the

weld metal zone and also you have, so you will be having you know heat losses from the weld area.

So, one of the purpose is to reduce the heat losses from weld area. So, you know that is one of the aim, next will be to reduce the you know crack you know crack by preventing the formation of you know hard services. So, to reduce crack formation by preventing formation of hard surfaces. Now, this is basically likely related to the formation of hard surface when we have the higher cooling rate.

So, when you have the formation of hard surfaces, then you know the chances of the crack formation will be higher and these cracks basically so that they will limit the properties especially the ductility properties of the material. Now, also you know there will be another you know aspect that is your expansion and contraction rates. So, because the temperature you know difference becomes smaller as you preheat the material.

So, temperature difference becoming smaller, you know contraction and the expansion will be different because the coefficient of that value are multiplied by the you know temperature difference. So, temperature difference it becomes less then that order will also be less. So, you have reduction of expansion and contraction rates. So, once you have the reduction of expansion and contraction rates, so they will reduce the chances of you know distortion and residual stresses.

Basically the residual stress which is there inside the material, so that leads to the distortion of the material. So, once you have the reduction of these values, so your chances of you know distortion and you know residual stresses are becoming you know less. The next you know another important objective of preheating is that many a times you have the surfaces of you know during the welding in that zone.

They may have moisture or they may have some you know grease or some kind of material which have moisture and if you do the welding, so there are likelihood of having the entrapment of those grease or maybe moisture may be trapped into. So, that way you know you can reduce those chances if you pre-heat. So, if you are preheating then anyway they will be blown away, they will be you know they will be turning into vapors.

And then you can get rid of those undesirable you know consequences. So, it is used to burn grease, oil and scale from joint area. So, that may also lead to so that will also necessitate or that will also result into faster welding because many a times you have to remove them, you have to you know have the external means to remove these scales or maybe grease and oil by cleaning it.

So, that will take an extra time, so that will also help in you know reduction of the time you know, so that will increase the speed of the welding. So, then you know once you do the so it will also keep bead more fluid for more time. So, that will you know avoid the stress concentration and the notch effects is also reduced. So, you know preheating it also brings you know that will be the weld bead to be in fluid state you know more.

So, you know and with flat surfaces and then that will avoid so stress concentration due to notch effect. So, that is you know another reason which is you know preheating is given and also when you have the fluid or liquid metal is there for a longer time then many a times you are giving more time for the gases which are dissolved into the weld pool. So, you are giving more time to let them come out.

So, that is you know another you know advantage of the you know these preheating methods. So, they will be coming out from the weld in HAZ. So, they will be giving sufficient time for the hydrogen to come out, so that will be you know that will be helping to improve the microstructure and the embrittlement which is there because of hydrogen. So, that also can be avoided. So, that is you know another you know advantage of the or the another aim of the preheating.

Now, the preheating is normally done from 100 to 300 ^{0}C. So, that you know is normally the practice; however, we can go maybe to higher temperature also may be up to 600 ^{0}C also the preheating has been reported. Now, the preheating has basically some effect also on the HAZ formation. So, although preheating will be improving the quality of the weld but then it you know it leads to bigger HAZ.

Because you have up to more reason the effect of temperature can be seen. So, what happens that when you do you know it has been done for the steels, this is was for 1040 steel and when the you know fusion zone and HAZ zone were measured, then it was seen that when

you do without preheating the zone was a little narrow whereas when you did with preheating that that zone became more wide.

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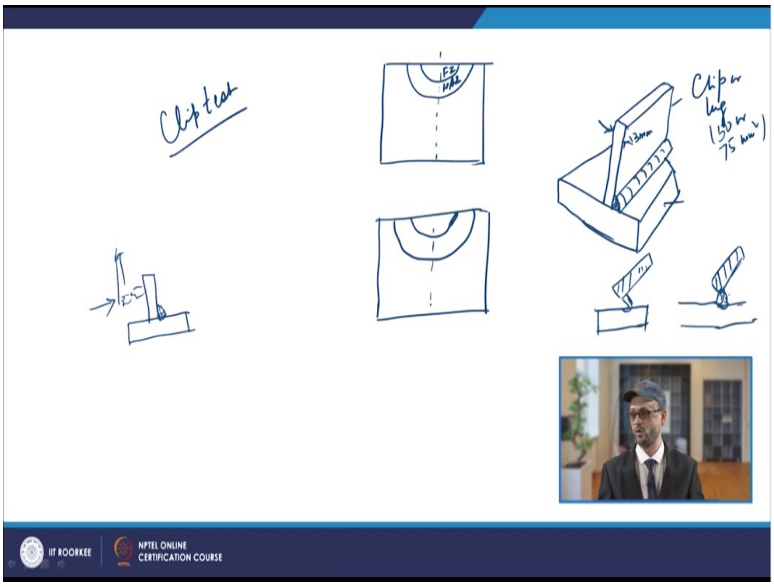

So, basically you can understand by referring to some schematic figures like you know your fusion zone earlier was this and your heat affected zone suppose was can be you know shown by this way. So, you have some temperature also in those zones. So, if suppose your heat affected zone is like this. Now, if you preheat, if you are preheating to maybe 250 ^{0}C, so it was seen that this zone basically got you know widened.

So, this fusion zone you know it was earlier here, so fusion zone became somewhat wider. Similarly, the HAZ zone also became somewhat wider. So, this way you know the HAZ zone was seen to be you know more wide when we did the preheating. Then, you know this preheating what we do they basically depend upon other you know factors also. They are you know the geometrical factors or technological factors are there.

So, that also determines you know what should be the extent of preheating you know in those cases. Then, you know once more thing which we should know that there are tests you know which tells you know to ensure that whether you know preheating is required or not. So, for that there is a test for that and what we do in that. So, that test is normally known as the clip test. So, in that test normally what we do is we have a clip you know or lug.

So, that it will be attached you know that will be welded so and then you try to hammer and you try to break it. So, depending upon you know type of breaking, the way it breaks you can

say that whether the preheating is required or not. So, normally what is done is so you have basically you know this way you have a welding of a clip or lug is done. So, you have such geometry, so and then you have on this what you do is you are attaching this.

So, this is attached and so this will be attached to it and now this is you know welded. So, here it will be coming as the welded part. So, this will be your, this is the weld bead which is welded here and then it will be. So, what you do is in this case, this is your clip you know this clip is welded, clip or lug is there. So, this is you know now in this, this dimension is taken about 13 mm and this area is you know this area which is taken this is about 50 or 75 mm^2 so that area is there and that will be attached to a steel plate.

So, this steel plate is there and this is the mid of say low carbon steel and this is the convex fillet weld that is you know in that pattern you are welding this material. This material is made of you know alloy steel, so this is a steel plate you know made of alloy steel and on this you are you know welding this low carbon steel you know clip which is of that requisite dimension.

Now, on this you will have you will be doing the welding to normal conditions and then you will be allowing this weld to cool you know at to room temperature and then what you do that you are trying to break it. So, you will be breaking by hammering. So, what you will do is so suppose you have you know this specimen. Now, this is welded specimen which you have formed.

So, now you will be you know breaking that with a hammer, so that you will be breaking you know. So, now you have the welded you know this is your bead which is looking like. So, now if you so what you do is you are going to break this you know, you are going to hammer you know with you know number of blows to cause the failure in that you know weld bead. Now, what happens that the failure may be in different way.

So, now what we do is that you know there will not be much of the underbead cracking. So, the failure may be you know if you look at the failure modes, so it may fail you know so that may go you know into this you know that way and so this it may fail or what it may do also in some case. Now, in some case that this will completely come out you know, so this will be

completely coming out and you know this way your bead will completely come out from here, your material will be there.

So, there may be two ways by which this you know what you will see that it will be failing. So, if you see that you know the failing is through the lug, then in that case there is no serious threat but if it takes out some parent metal from here, so if there is you know if there is some parent metal coming out and there is depression caused here, so in that case you know there is need of the preheating you know in those situations.

So, that you know indicates this is the test which you know ascertains whether there is preheating requirement or not. Now, coming to the post weld heat treatment, so as we discussed that the post weld heat treatment is mainly the stress relief treatment in that case. We try to relieve the stresses which are generated you know during the cooling of the you know welded specimen you know while it gets cooled.

So, you know the stresses which are there inside, these stresses need to be you know removed and unless they are removed you know that may result into the formation of cracks. So, for that you know these stress relieving treatments that is done after welding. So, that is they are known as post weld you know heat treatment methods.

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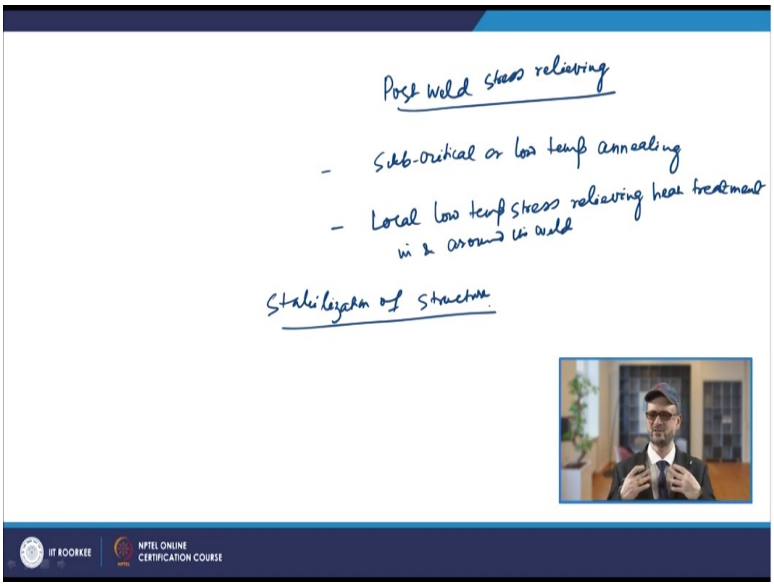

So, in that what we see is you have the post weld stress relieving. So, we will talk about the residual stresses also and what happens that after the welding is complete, then the residual stresses may be you know they are inside the specimen to a very high level and you know

that may lead to the cracks in the you know material. So, what we do normally is that we to remove you know the residual stresses, the most simple operation is to anneal the you know specimen.

So, many a times the most simple solution is to anneal the weldment but then many a times it is not the practical solution because of the different shape of you know the fabricated component. Also, what happens that when you do the full annealing, in that case that may lead to the grain growth of you know the grain growth inside the material and the grain growth basically will lead to the deterioration in the mechanical properties of the material.

So, many a times we have alternative practices for the post weld stress relieving and these are like you go for subcritical you know or low temperature annealing and we also do the annealing locally. So, we can go for local low temperature stressful relieving, you know a heat treatment in and around the weld. So, that is normally done you know using the portable hand torches. So, torches are used for doing you know these things.

But they are normally cheaper and they are normally not very much you know reliable. So, you have otherwise other you know methods for you know doing that. So, you have automatic traversing torches and you have you know special burners so with that we do. Another you know purpose of the post weld heat treatment is the stabilization of structure.

So, what happens as we know that during the welding process, you know the structure which is you know obtained is normally metastable because of very large you know cooling rate and also it may change with time, it may whether may be subjective aging or so. So and then you know so normally we have to stabilize the process you know so that so what we do is you homogenize the structure.

You know using the proper you know annealing operation or the normalizing operation. So, you know and then apart from that you also have the reformation of the structure, so that is you know they are you know there is you know full solution treatment is given. So, this way you know the structure basically are required to be you know modified many a times because you have metastable structure.

So, you give those you know solutionizing treatment or you give the proper heat treatment. So, that the stable structure is formed. So, we will talk about you know the methods of you know the preheating and post weld heat treatment methods and also apply to the different materials how it is applied in our coming lectures. Thank you very much.