Welding Metallurgy
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Lecture - 36
Preheat and Postweld Heat Treatment for Different Materials

Welcome to the lecture on preheat and post weld heat treatment for different materials. So, in this lecture, we are going to have the discussion about the different methods of preheat and post weld heat treatment and especially preheat you know preheating and then we will also talk about some of the materials and specifically and how you know the preheating is done, what are the you know parameters which are you know set for the preheating of the materials.

So, we studied about the necessity of you know preheating and what we understood that once we do the preheating, then in that case your you know cooling rate which is experienced which will be you know lesser than what it would have been otherwise, so you know there will be avoidance of the hard surfaces formation, you have hard phases formation and you know associated mechanical properties also are affected.

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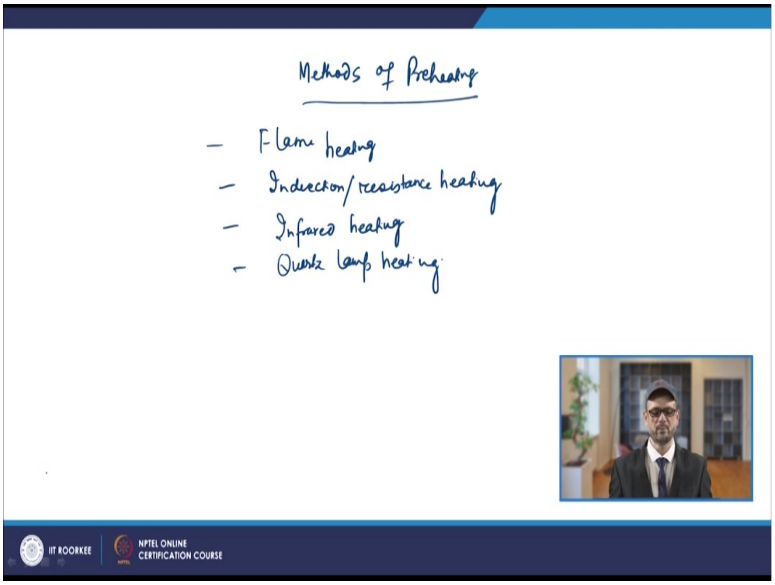

So, if you talk about you know the different you know methods of preheating, so as you know that you have the means like you may do the preheating with flame, so then it is known as flame preheating. So, that is the flame heating. Then, you may do the heating with induction or resistance. So, in that case we call it as induction or resistance heating. So, we can use the electrical means to do the heating.

So, that way it will be induction or resistance heating. Then, you can also go for the infrared heating and we have another way you know to do the preheating that is your quartz lamp heating. So, that way you have different you know ways to do the preheating.

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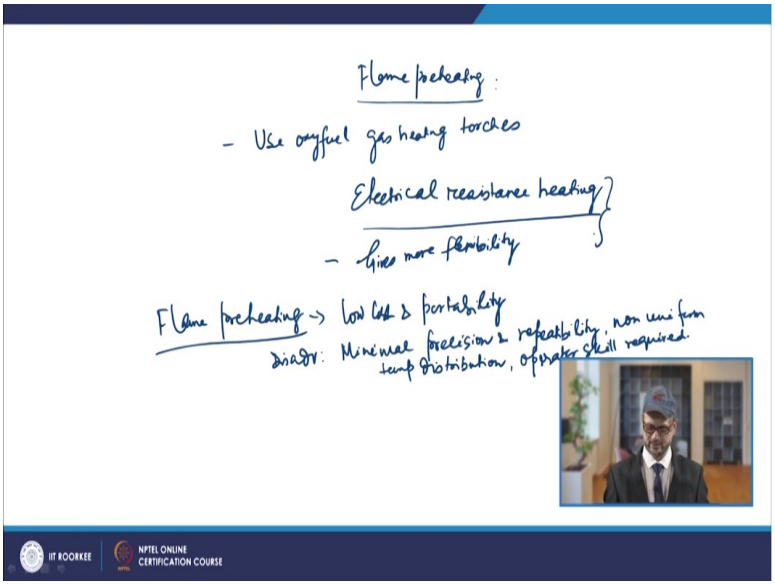

So, if you talk about the flame preheating, so if you go to the you know flame preheating, so in that case what we do is you have the oxyfuel you know gas heating torches, so we use the oxyfuel gas heating torches. So, as you know that in this torch, we have the oxyfuel is there, so hydrocarbon fuels are there normally and then you have the flow of oxygen also you know. So, you can have the control of various flame sizes.

And you have the multi you know flame heating heads will be there in that torches and you know you will have the use of smaller you know tips for the light heating and you will have the larger tips for you know the heavy heating. So, that way you use the you know torches and you know what we do is as we have understood that you have different types of flames that can be obtained by the combination of varying amount of oxygen to the fuel.

So, as we know that you have 3 types of fuel you know flames that is oxidizing, neutral and also the carburizing type of flame. So, you know that you have to adjust the amount of oxygen which is going inside the flame inside that torch so that you can get a particular type of you know flame in those cases. Now, you know when we use the multi-flame heating, so multi-flame heating heads basically they are distributing these you know heat efficiency, heat to a larger area.

So, that way normally we use the adapter or the extension from the mixing chamber. Now, so as we discussed that you will have the control of the flow rate, you can have the proper selection of the you know hose's diameter and you will have other fittings. So, that way you can use these torches to do the you know flame heating. Then, you know flame heating heads normally are you know water-cooled and they have certain you know dimensions.

So, that way you know this flame preheating is done. Another method is the electrical resistance heating. So, you know electrical resistance heating as compared to the flame heating will give you more flexibility. So, it gives more flexibility. So, flexibility in the sense that you can attain the temperature with more uniformity and more quickly you can achieve the you know temperature and the wide ranges of temperature can be achieved using the electrical means in the case of flame heating many a times you know you will have.

Because we do normally with the manual operators in that case or you will have to adjust the you know areas in such a way and also for controlling there are certainly certain bottlenecks whereas in this case you will have more accuracy and more flexibility towards getting this you know temperature and maintaining that uniformity also. So, basically we know we use that resistance principles you know for doing the heating purpose you know in all these you know cases.

So, you can have the electrical resistance, you may have the you know concept of induction heating you know also which is you know based on the electrical concept only. So that way, we do it. So, if you talk about you know the flame preheating and the electrical resistance preheating methods. Now, there are advantages and disadvantages also of these methods.

So, if you talk about the flame preheating method, now its advantages is that if you talk about a flame preheating, now in that case you have the you know low cost. So, this is for low cost and portability. So, these are the advantages of the flame preheating you know preheating if it is done with the flame whereas there will be certain drawbacks. So, the disadvantage is you know in that case you have the minimal precision and you have also repeatability.

So, you cannot have the same repeatability you know better repeatability in such case because you do not have much of the control when we talk about the flames. So, repeatability

will be the issue. Similarly, the temperature distribution in that case of flame preheating will not be uniform. So, you will have non-uniform temperature distribution and also in that case as we discussed that it will very much depend upon the skill of the operator.

Because he only you know will be better do, better to do in controlling that flame, the type of flame which is required, suppose carburizing or oxidizing or neutral. So, he will have you know the more you know he has to be more knowledgeable and more experienced to be able to you know get that particular type of flame you know in those cases. So, you know you require operator skill.

So, this is another you know disadvantage you know in the case of flame preheating or these are the challenges. If you talk about the electrical resistance heating, now in this case, you have basically you know the more you know continuous and even heat you know that is formed.

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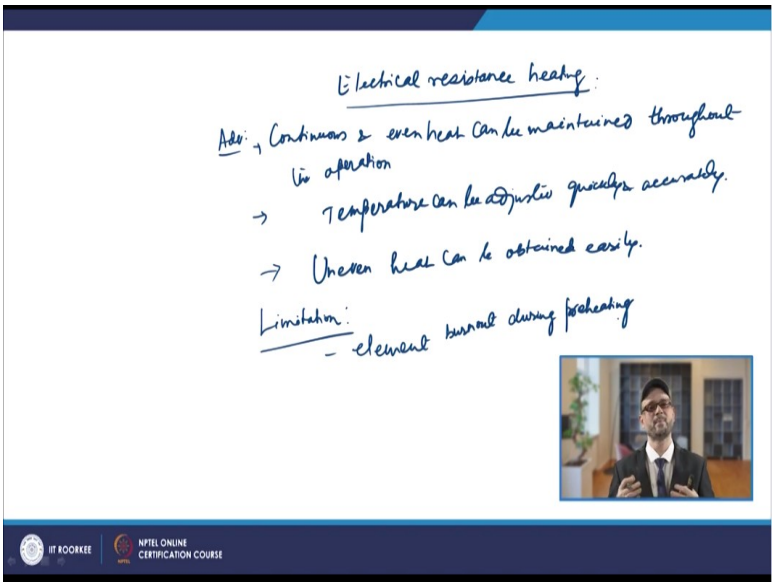

So for electrical resistance heating, so in that case, you have this is the advantage is that they are you know continuous and even heat can be maintained. So, you have continuous and even heat can be maintained throughout the operation. So, that is the you know throughout the operation of welding as well as among the breaks also during the break time also. So, you can have the break and then you can further start.

So, that way you can have this continuous and even heat you know that can be maintained. Another advantage will be that you can adjust the temperature very quickly. So, if you have

to increase the temperature quickly or if you have to decrease the temperature quickly that can be done with very relatively ease, so in those cases, so your temperature can be adjusted very quickly and accurately.

So, in this case, in the case of electrical resistance heating, now you know they have not to, so the welders they basically they will be at relatively at more comfort because mostly you have to have many things you know work by pressing the buttons suppose you know. So, that way the welders will be feeling more comfort in that and they have not to stop you know things because by controlling you know by using the machine itself they can control the preheat temperature, they can increase or decrease it.

So and then you know another advantage with the electric resistance heating is that if you want the differential heating you know, so basically uneven heat so if you have to put some heat mode at some place and some less heat at other place that can be done more easily. So, uneven heat you know can be easy. Uneven heat can be obtained easily. So, suppose many a times what happens that in a certain part, we require more and another part we require less or maybe especially if you talk about the you know take the example of pipes.

So, if on the outer side, on the inner side you require different you know heat. So, those can be maintained you know more appropriately you know in the case of the use of electrical resistance heating methods. However, this electrical resistance heating method also has certain limitation and limitation is that there may be the element you know burn out, so while working. So, you know there may be element burn out during the preheating method.

And then many a times, when we talk about, take the example of you know pipes when we do, so in those cases there may be you know there may be short you know short may happen and that may produce certain spot inside and that may be the you know place of initiation of the crack. So that you know that is you know another possibility of defect you know in the case of electrical resistance heating.

Now, apart from this electrical resistance heating, we talked another heating, another method of you know preheating that was the you know induction method of preheating.

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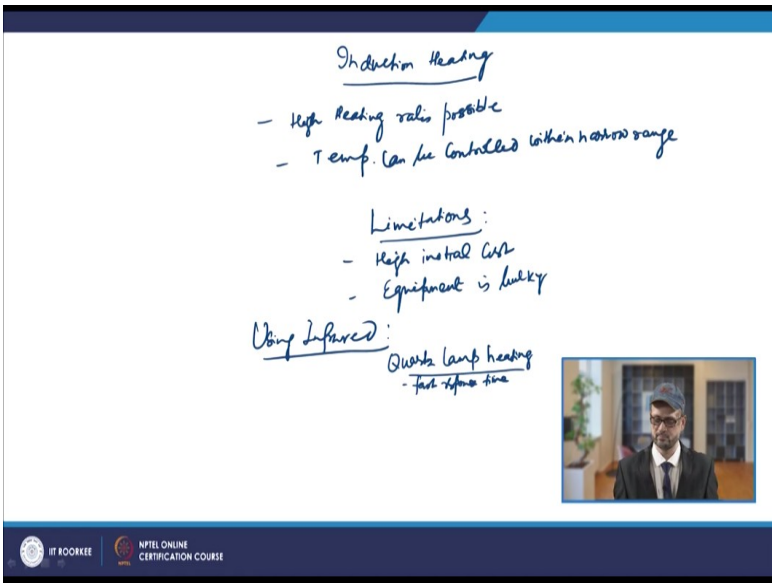

So, what we do you know in the case of induction method, so we do the induction heating. So, in the case of you know induction heating, you can go for high you know heat you know. Higher heating rates are possible when we use the induction heating and you know so you have the high heating rates possible and in this case you can control to a very narrow temperature range.

So, you know temperature can be controlled in a narrow range. So, these are the advantages of the induction heating and you know in that induction heating, those spots which are likely to be formed in the case of electrical resistance heating that is basically not the case in the case of induction heating. However, induction heating also has certain limitations. So, if you talk about the limitations in that case, so the induction heating equipments require large you know set-up cost.

So, you have high initial cost and the equipment is normally bulky, so you know it is not portable. So, that is you know another challenge with you know the induction heating and there are other challenges like you have you know for the non-uniform wall thickness and geometries, there are certainly some limitation so in those cases and many a times you know if you have the need of extra coils, so you have extra setups required.

So, certainly those you know points make it to somewhat discomfort to the you know welders or the person who is handling that. So, that is about the induction heating methods. The other method which is the you know that is your with the gas flame which by an infrared heating.

So, that way you now that is the infrared are the economical means of you know, so using infrared, so that these are economical you know fuel.

And you know in this case, you do not require the insulation you know in the area to be heated. So, that way that is one advantage and in this case you will have the only disadvantage is that you have to have separate furnace which is to be used. So, that is your use of the infrared you know heating equipment and then also you have the you know other method is quartz lamp heating.

So, this quartz lamp heating, so that gives basically very fast response time. So, these are the, so the trait of this is that it is giving very fast response time you know, these furnaces they have good efficiency, good cleanliness and they are fast cooling down and they have the quick turnaround. So, that is the advantage of this quartz lamp heating but the disadvantage again is that you have high initial cost for high equipment cost is there for these you know equipments.

And basically they are very fragile this lamp you know, so quartz lamps are very fragile and also very much sensitive to the contamination. So, that way you know you will have to have the proper care for these you know processes. Now, we are going to have the discussion about the you know preheating temperatures for the different materials.

So, if you talk about you know the materials specifically, the different materials will require the different preheating requirements and it will be depending upon you know the material composition as well as its thickness. So, based on that this preheating you know requirements will be varying and if you talk about the steels, so you have different types of steels normally which we use for the welding applications.

You have carbon steels, you have low alloy steels, you have stainless steels, many a times we talked with aluminum or so. So, you know you have the different requirements but if you talk about you know something like you know the carbon steel.

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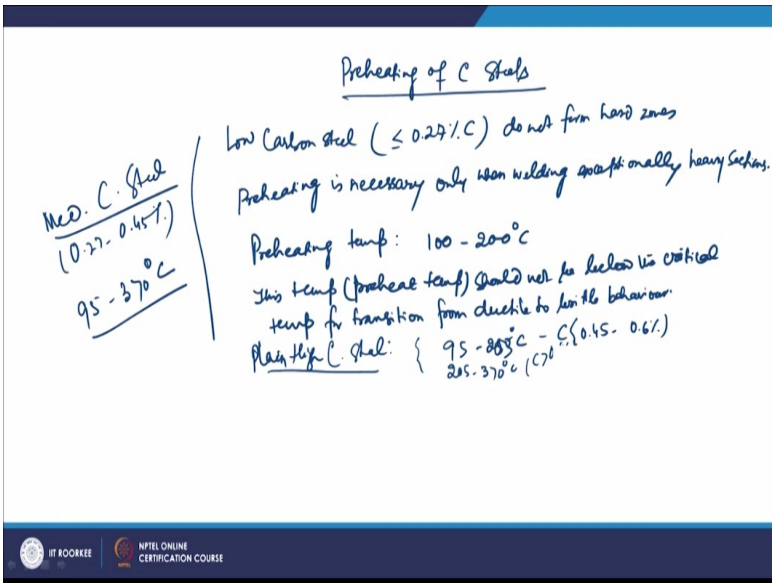

So, if you see the preheating requirement for the carbon steels, so now what happens that if your carbon is you know if your carbon is basically when you have low carbon steel, so when you have low carbon steel where the carbon is you know less than or equal to 0.27% you know carbon. So, these steels they do not form the hard zones, so these steels do not form hard zones.

So, except in I mean you know when you have a thick section with carbon with more than 0.20% you know carbon, so except that it does not make you know the hard zones. So, you know so they are usually not very much hardenable enough, you know to require any heating before welding because otherwise when they are more hardenable, in that case you require to you know to do the preheating.

So, preheating basically so when you have these low carbon steels, in that case you know preheating is necessary only when you are you know doing the very heavy sections. So, preheating is necessary you know only when welding exceptionally heavy sections. So, this is you know for you know when we talk about the carbon steels where the carbon is more than 0.2% for heavy sections.

So, in those cases, we require the preheating and the preheating at temperature, so you know so if you do the preheating temperature if you look at the value, it will be varying from 100 to 200 ^{0}C. So, this temperature will be varying from 100 to 200 ^{0}C but then there is another thing that this temperature you know that should not be below the critical temperature for the you know transition from ductile to brittle.

So, this temperature i.e. preheat temperature should not go below that, should not be below the you know critical temperature for ductile to brittle transition, for transition from ductile to brittle behavior. So, particularly this is important when we are doing the welding in the winter you know winter cases or winter you know during the winter, so we have to be you know careful for that.

And because you know many a times, we are you know we have the danger of having the cracks. So, that is under the influence of these you know welding stress values. So, if the impact strength becomes you know small, so your notch impact values you know so if that is you know under the alarming you know level. So, in that case, it will be you know failing. So, if the notch value goes below the value of 8 to 10 joule, so in that case you know there will be problem.

Then, you know preheating will be also necessary for you know when we are welding the carbon steel with very low you know carbon content. Especially if you have a very thin plate, which is welded to a very thicker plate, now if you talked about the you know thin plate, so you have to have these, if you talk about the thin plate, so for corresponding to that you will have the small electrode diameter.

And if the welding is carried out at room temperature, then cooling rate in the heavier plate, so that will you know that may be sufficiently rapid and that will be hardening even the low carbon steel. So, that is you know, so what we do is in those cases we do the slight preheating. So, we do the slight preheating of maybe about 50 to 100 ^{0}C you know for avoiding this hardening in those cases.

Also, what we do another you know way to overcome this problem is that we do some we give some taper also, you know to heavier section so that you have the section of nearly equal you know thickness which is there. So, that also eliminates the risk of hardening. So, then if you talk about the medium carbon steel, so in the case of medium carbon steel you know the cooling rate so for you know for medium carbon steel, when the steel will be, carbon will be maybe from 0.27 to 0.45%, in that case the preheating requirement will be more.

So, you will have 95 to even 370 ^{0}C of the temperature are required so in those cases and if you go to the plane high carbon steel, so for plane high carbon steels, now this preheating requirement becomes more because in these cases the hardenability is you know quite high, they are very difficult to weld because they can very easily form the martensite and that will cause the brittleness.

So, what happens that normally we have a control system of preheating and in this case, preheating temperature will be varying from 95 to 250 ^{0}C when the carbon is from 0.45 to say 0.6% and you give maybe from 205 to 370 ^{0}C. This is 205 and you give from 205 or 370 ^{0}C when the you know carbon content is more than 0.6%. So, this way you know the preheating requirement becomes more when you go to increase the you know carbon percentage in the carbon steels.

And you know so that way when we if you talk about the multi-run welds, in that case you know the first run will be heating the base metal, so that way the heat of the next run will be basically tempering the base metal adjacent to the weld bead. So, then in every run you will have the enough heat you know so that there is no rapid cooling, so that you know avoids the formation of hard zones.

So, this is about the preheating requirements for the different you know alloys of different forms of carbon steels and as far as the you know post weld heat treatment is concerned.

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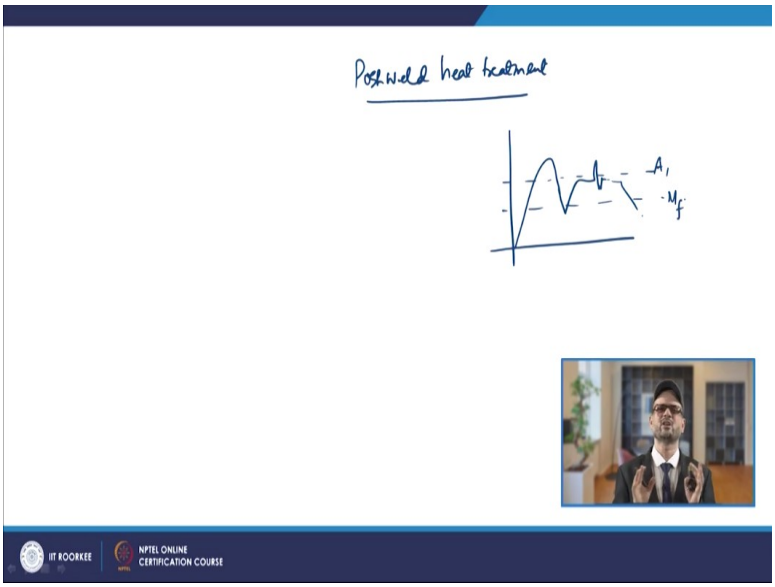

So, normally you have the stress relieving you know methods which are applied and what you do in this case is what you do is you have to go for the stress relieving treatment. So, you are heating you know to a temperature which will be below A_1 and then you are holding it for some time and then further you are cooling. So, normally that is the process of stress relieving. So, this also varies from materials to materials.

And normally what we do is depending upon the you know alloy compositions you have the different you know properties like say what you do is you do the welding and then you know you are coming and further heating and then you are holding for some time and then further you are cooling. So, you do this process close to this A_1 temperature and then this way you will have the M_f temperature here.

So, normally that is a concept of stress relieving that you are going to the temperature around A_1 and then you are holding there for some time and then further you are slowly cooling. So, that way the stress relieving treatment will be done. So, it is different for the different materials and its main purpose is to relieve you know or to homogenize the structure to relieve the material of the stresses. So, that is the main aim of the post weld heat treatment. Thank you very much.