Theory of Production Processes

Dr. Pradeep Kumar Jha
Department of Mechanical Engineering
Indian Institute of Technology, Roorkee

Lecture - 54
Control of welding distortion

Welcome to the lecture on Control of Welding Distortion. So, in the last lecture we discussed about the distortions which take place during the welding process and you have different types of welding distort some like you have longitudinal or and transverse shrinkage you have angular distortion, you have buckling and twisting and all that.

Now, the thing is that whenever the distortion is taking place in a welder specimen; that means, that the specimen becomes out of shape, then it does not work satisfactorily for the intended you know service and in that case it may affect the productivity of the process and you try to minimize the distortion that is why and. In fact, you would like to have no distortion.

So, but that is not possible maybe many a times, so we need to look those methods by which you can control these welding distortions. So, for that you may have to select proper operating parameters, proper working variables so that the distortion is minimum. So, as we discussed that since the distortion leads to unacceptable deviation, distortion means being out of shape, so the deviation which is there from the standard dimension.

So, that may lead to many a times a lot of negative results and that may lead to many kind of losses. So, we need to see that how this distortion is to be minimized. Now many a times that is residual stresses and distortion to a large extent behave in a contrary way, this means that many a times when you try to see that the residual stresses should be made smaller or it should be removed.

So, many a times it also happens that you do that method which the distortion becomes more or you try to remove the distortion maybe by um. So, suppose you have a distortion of specificity twisted or so and if you try to use the press or you use certain load and try to remove the distortion. So, this distortion may be minimum, but then the residual stress maybe during that process may suit up.

So, many times they behave also in a very contrary way, but then ideally we would like to have both the values to be on the lower side, we also want to have residual stress also on the lower side and distortion as well because, both are in most of the cases they are not desirable that way especially to I mean it is if it is value is higher.

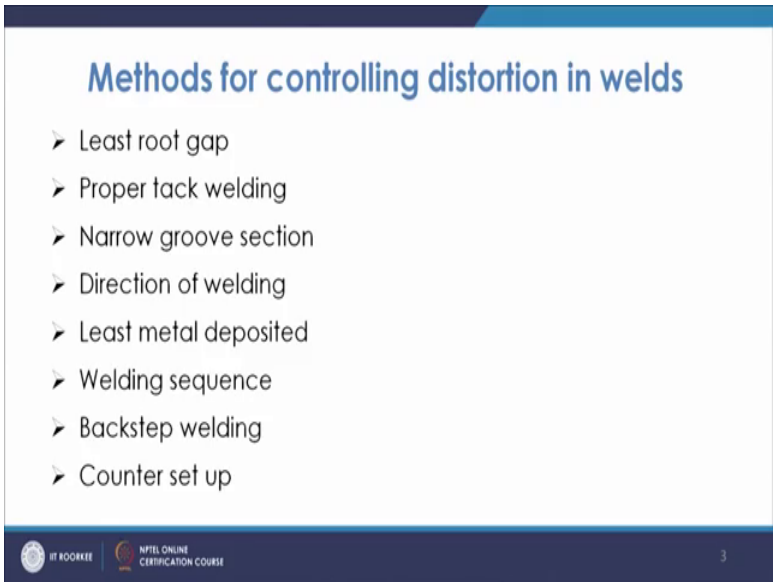
So, residual stresses in certain sense may be beneficial, but in most of the cases they are harmful. Similarly distortion any way is not desirable because desirable once you have distortion you would like to minimize it or you would like not to have distortion at all.

So, we feel that we must have the minimum amount of the residual stress as well as distortion. So, annealing is there a process which basically will be you know reducing the residual stresses, but then if you do not practice the annealing in a proper way. If you have not a proper and controlled annealing process, that may also lead to work piece or distortion because, in annealing you are heating to a certain temperature then holding at that temperature then further in you know cooling. So, if you are not heating at a proper rate you are hitting very fast or cooling fast. So, or you know holding time is also not proper or so in that case also although you may get somewhat the removal of stresses.

But that may lead to add pace so you will have to such I mean control these you know variables or the processes. So, that the you have controlled value of residual stress or the value of residual stress as well as the distortion within a limit so that you can take use of the component.

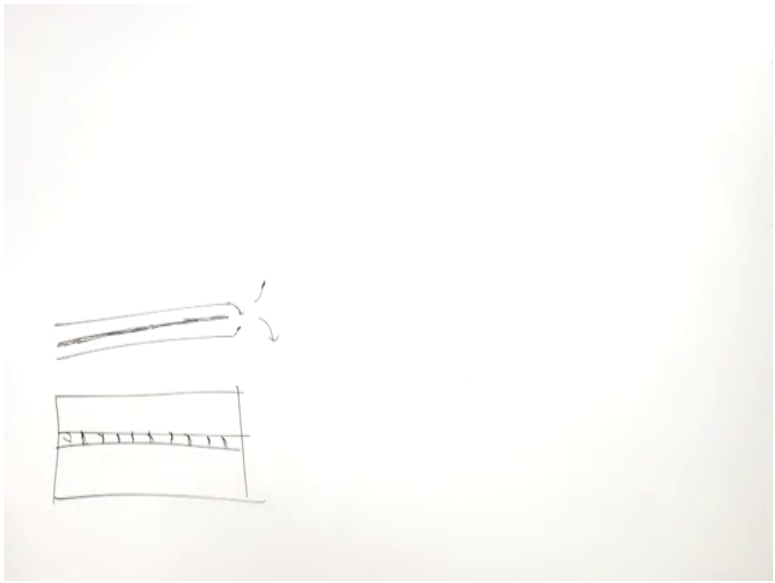
Now there are many methods of controlling these distortion in the welds and the common methods which are implied are least root gaps root gap is, when you are you are must be conversant with the welding terminology. So, you must have minimum of the root gap, then proper tack welding tack welding is something which you must have the idea that when you have the thin portions to be welded you we use the tack welding. This is basically to do to control the distortion because, we have seen that specially in the rotational distortion areas where we see that you are welding along a line and.

(Refer Slide Time: 06:05)



As you reach towards the end then when you are welding like this. So, if suppose this is the weld line and this is the longitudinal direction.

(Refer Slide Time: 06:15)



So, the think that it either this may go like this or you know this may go like this. So, basically what we do a normally is a tacking is done. So, that you are fixing you know these points by using the tack welds. So, that way once you put the tack weld at different locations and then you are doing the welding process. So, that is way to control the distortion of that type, so that we will discuss.

Narrow group section is basically that we must have a group session, so you should be narrowest to be possible because that will minimize the amount of weld metal in that and we discussed that as the amount of weld metal is you know more and more it is its more likely to give you the larger value of distortion, so the narrow group section is another important parameter. Similarly direction of welding in what direction you are welding, what is the restraint where is the restraints what way you are welding that is also important and what direction you should weld. So, that you have the minimum distortion of I mean generated.

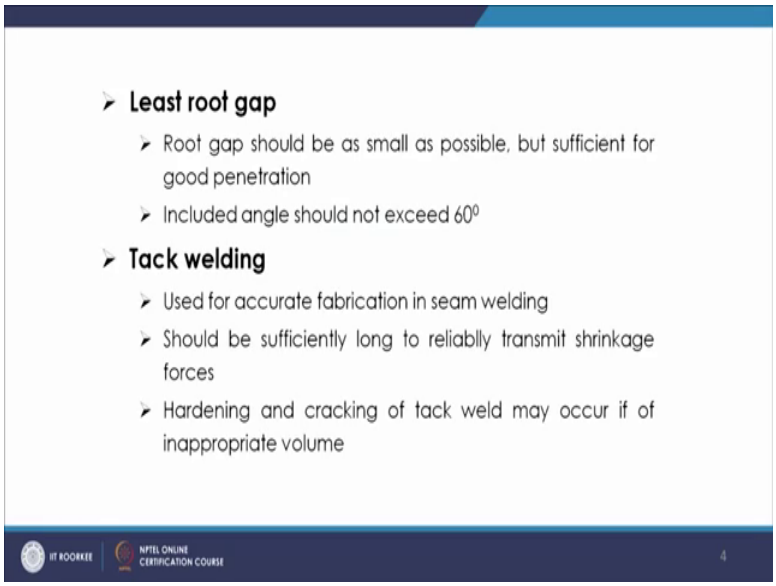
Then least metal deposited again this is supporting thus the same principle that if you have a least metal, which will be supporting the joint then you will have least distortion; larger will be the metal larger is will be the likely distortion. So, least metal deposition is another you know parameter which is important. Then you have welding sequence welding sequence means how you have to proceed in the welding, what we suppose you have a similar a particular type of welding structure.

Then in that case suppose you have transverse welds or you have longitudinal welds. So, if you have plate type of weld structure cylindrical type of structure which is to be welded, in that case what way you should proceed how the transverse welds. So, whether should be welded first or longitudinal welds should be welded first, there are certain you know defined steps which should be followed. Similarly a Backstep welding process is also there where the welding should be in the Backstep manner.

So, Backstep welding tells you that how you have to proceed the welding in the longitudinal direction you have to go, but then you have to go in a Backstep manner many a times you have counter setup. So, you many a times what happens that the welded structure bows or it has a sagging type of you know tendency in 1 direction. So, you are trying to have a counter setup suppose it bows in this direction, so you put the specimen itself in the opposite direction.

So, that even if there is bowing or so in certain direction then it will be flat one even after the welding. So, this way you have the different types of you know methods which are there for controlling that distortion in the welds. So, we will discuss 1 by 1 all these methods. So, the first method is having the least root gap.

(Refer Slide Time: 09:42)



So, we would like to have the root gap as small as possible, but sufficient for the good penetration. So, you know excessive gaps must be avoided and for that it is also advised that the included angle should be you know not more than 60 degree. So, in that way you will have the minimum amount of metal.

So, also include I will increase the included angle then you will have that will be adversely affecting, the distortions and all that because there will be more of the weld metal and accordingly the design does not support that. So, that may lead to the larger amount of distortion.

Now it is also suggested that even you have a heavy section, in those cases the double v type of you know preparation should be preferred. So, like that you have certain you know principles which should be followed and so that the distortion. So, that will try to minimize the distortion then second is the tack welding. So, tack welding is used normally for the accurate fabrication in case of seam welding.

When you are welding along the seam and for larger lengths, that in those cases normally you use this tack welding and it should be sufficiently long to reliably transmit the shrinkage forces.

So, you know it should be when you are putting the tacks, you must have the tack of certain length and normally this length is a function of the thickness of the seat which

you are welding or the thickness of the plate and this tack weld length is normally kept as about 2 to 3 times the thickness of the plate. So, that it can reliably transmit these shrinkage forces.

Then hardening and cracking of the tack weld may occur if of inappropriate volume. So, if there is an appropriate volume of the you know tack weld metal, then in that case there may be hardening of the tack weld because that has to you know transmit the heat. So, it will transmit the heat it will cool fast, so in that way there will be hardening and then there may be crack developed.

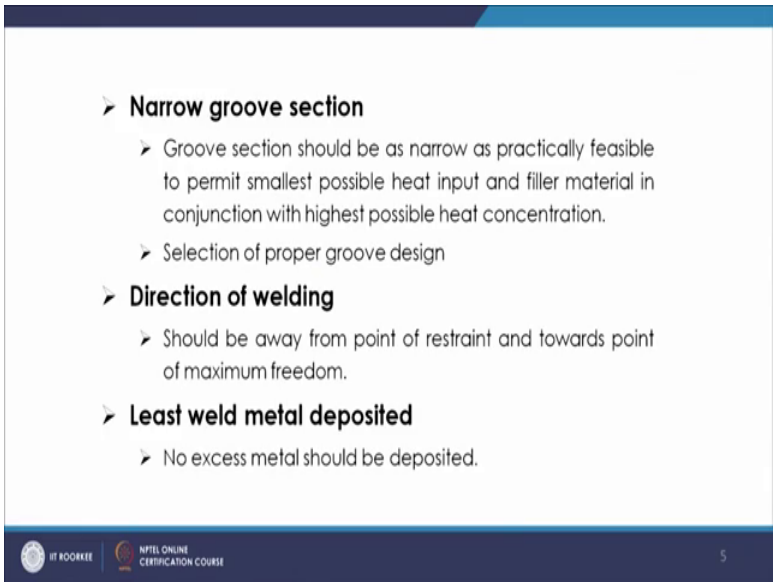
So, especially when you have you are using the small you know volume of tack weld, so and that 2 in the very you know large weld volume. So, you have you have the plates of larger thickness and if you are putting the small amount of tack weld metal. So, in that case that the heat dissipation will be very fast, so in that case be the heat dissipation rate being faster, the chances will be there that it will be extremely hard and it there may be cracks.

So, what we do normally is that we normally preheat that material, before is you know when you are tacking. So, then in that case preheat the plate so that when we tack the heat extraction rate will be not that from fast and it will avoid any kind of hardness or cracking during that process.

Then as we discussed that there may be cracked formation and as well as there may be other even welding defects. So, you know for that we do we can do the preheating or when we are doing the tack welding, then at that time you must also you know take care of removing the slags. So, it is just like a welding process, so you must remove that otherwise when you are doing the further welding process in that case the slag surface is there, you know prior to that. So, that may lead to another slag inclusion or other type of welding defects.

So, you have to be careful for having the appropriate tack welding, so that the destroy and if you are you are choosing appropriate tack welding by using the appropriate process, in that case the distortion is likely to be smaller.

(Refer Slide Time: 14:49)



Next is the narrow groove section, so groove section should be as narrow as practically feasible, to permit smallest possible heat input and filler material in conjunction with highest possible heat concentration. So, that is what the you know requirement is there you feel that, it should be as narrow as possible and you give the heat input you know smallest possible heat input and also the concentration of that heat source should be highest one.

So, that will basically reduce the chances of distortion. If your heat source having is having poor concentration if it has large you know spread or so in those cases the chances of distortion will be more.

So, we think of having you know narrowest to groove section. So, that the minimum of the distortion is taking place, we also try to see that the fusion zone and the plastic deformation zones these are they are smallest as possible. So, in that case the chances of distortion will be minimum or so, then we normally try to see that we should have such kind of groove selection where you have a smallest possible cross section is there.

So, in that case the heat extraction rate will certainly be depending upon the area. So, if you have a smallest possible cross section then in that case the chances are very fast cooling will not be there. So, if you have some grooves which are very larger cross sections of the same for the same volume, in those cases the chances of heat extraction will be fast because heats extraction is depending upon the cross section.

So, you would like to prefer such kind of grooves which have the minimum kind of areas like you prefer the square type of groves, then many a times you prefer u type of groove as compared to v type of groove. So, they give the more satisfactory results and if you have symmetrical weld grooves then, they produce less shrinkage and although they increase the residual stresses.

But then the shrinkage is normally small and there are certain you know practices like you use the double v groove instead of single v or y groove and then similarly you prefer the double sided fillers joint instead of single filled joint to reduce the distortion.

So, if you go for double sided fluids joint you try to prefer that as compared to a single sided. So, that will single solid will is likely to give you more distortion. So, these are the precautions which we must follow, when we are going to have the proper selection of the groove section.

Now coming to the direction of welding, so in that we in what direction the welding should be carried out depending upon the welded structure. So, it should be we have to keep the precaution that; it should be away from the point of restraint and towards the point of maximum freedom.

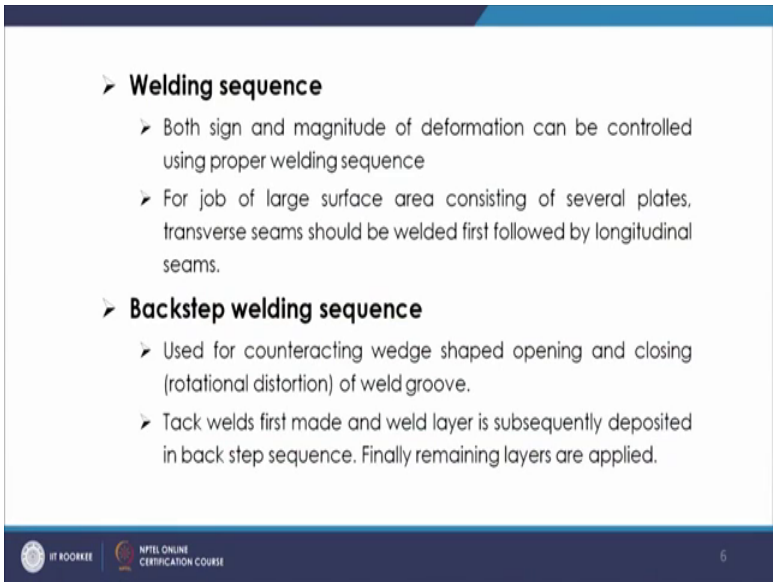
So, that should be seen otherwise, if you are moving towards the point of restraint then certainly there will be larger chances of the distortion taking place because, stresses will be more there will be restrained reaction stresses which are generated they will be larger and larger and in that case the chances of distortion will be larger.

So, you try to follow the welding in the direction in which you have maximum degree of freedom. So, that way that is the better practice of controlling the distortion, and then you have least weld metal deposited. So, basically we know that as the quantity of weld metal deposit will be more and more the amount of contraction will be more. So, that will lead to more of the distortion.

So, you should see that you are not putting any excess metal, so that is why no excess metal should be deposited and you should see that when you are making the weld deposit the proper weld drawings should be made and there should not be any increase in the weld section.

So, that there is increase in the weld metal deposited. So, that way if you have a minimum amount of weld metal to be deposited which will suffice to the condition or which will be sufficient for the structure to be considerably stronger then in that case that is better.

(Refer Slide Time: 20:17)



Then comes the welding sequence now welding sequence is that, if you use the proper welding sequence both sign and magnitude of the deformation can be controlled. So, what is there that how you are doing the welding you have transfer seams? you have longitudinal seams. So, how you are approaching when you are welding a certain type of structures?

So, when we are welding the job of large surface area consisting of several plates, of suppose we have a structure which is consisting of many plates in that case you have the transverse seams as well as you may have you may have the transverse seam as well as the longitudinal seam. So, if you have a longitudinal structure you may have the seam on the transverse direction as well as on the longitudinal direction.

So, in that large surface you know idea consisting of several plates, you try to seam in the same sequence that first of all you try to seam weld the transverse seams and then in the ones that all the transverse seams are welded, then you are welding the longitudinal seams. So, that is the welding sequence so and how you are you know welding. So, sequence means 1 2 or 3 that also is ha among the transverse also. Now if you are going

now in that case you are basically telling that 1 2 and 3. So, it is not that we are also doing if you have many reasons of tack weld. So, you are also going in the same like from 1 to 2 or 3 or so in one direction. So, there also you have to follow certain sequence. So, that the distortion is minimized.

So, similarly for other structures in many cases, when you have circumferential type of joints you go for circumferential first longitudinal seams and then the circumferential type of n joints. So, especially in the case of cylindrical vessels that we follow that we in those cases we try to weld first the longitudinal seams and then n in the end we go for welding the transverse seams. So, that is the proper welding sequence which we follow in the case of this proper welding sequence then the next point is Backstep welding sequence.

So, this Backstep welding sequence is, it is a very important measure it is a very good way, for contracting wedge shaped opening and closing of weld grooves as we discussed that many a times you when you are welding then we have rotational distortion cases where the edges either they move towards each other or they are moving apart from each other. So, for such you know occurrences to avoid. So, those type of you know processes or happenings we normally use these Backstep welding sequence.

So, in that case what is there that normally the groove opening, if the groove opening is suppressed by the prior tack welding or by rigid welding you know restraint, then there may be you know roof shaped type of you know arcing of weld joint occurs.

So, what we do is we first put the tack welds, you know that also we feel that what should be the spacing between the tack welds that depends upon the welding speeds. So, if you have low welding speed then the there has to be low spacing between the tack welds and then the first weld layer what we where we put that is you know subsequently deposited in the Backstep sequence.

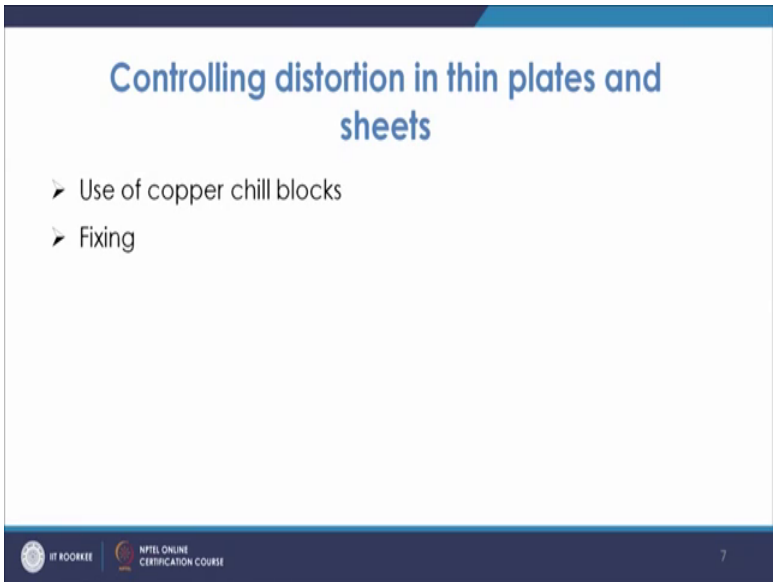
So, what is there that once you have suppose you are welding 2 plates like this? So, what is there that if suppose you have to go like this? Now you have put the tack welds like this and this or so these are the tack welds. Now tack welds we have discussed that tack welds what should be the length of the tack weld and that way you have different reasons and it will depends upon the thickness of the plate which you are welding.

So, now you have so if so we do the welding in this sequence. So, we go for Backstep like this from here to here or from here to here then here to here like this. So, then next here will be here and then here and here and then finally here and here like that, so we go in that sequence. So, it is a known as a back step welding sequence. So, welding direction is same, but we are moving in this fashion. So, this is known as the back step welding sequence.

So, what we do is we tack weld from 1 to opposite end we are moving to 1 end to the opposite end and we are basically first we do the ends and then we are finding the remaining layers also are basically on that also it is applied alternating the direction. So, we do from here to here then we go from here then we are going from here to here or. So, so this way the tack welds are applied.

So, basically this is one of the very important you know process parameter, which is used for demonizing the you know transverse as well as longitudinal shrinkage of the weld joint as a whole and widely used in the case of manufacturing of large structures like ships or tanks or so then other you know you have other, methods also for controlling like many a times you are using the you know counter or opposing setup.

(Refer Slide Time: 26:58)



So, that is that, in this case what we do is sometimes certain members like the vertical members you give somewhat is slight reverse bends. So, they bend in certain direction,

like in a tea joint. If you take the example of a t joint, so it there will be warp is due to the contraction of the weld.

So, what we do is we give somewhat reverse bands. So, that the re distortion is reduced. So, once you have reverse band then it will further bend in the opposite direction, so ultimately we will get a flat type of you know structure. So, this is about the other you know methods for controlling the distortion. now many times we also put the backing strip in case of you know butt welds, so that there is another way for reducing the distortion.

Now we will discuss about something about distortion control in thin plates and seats, so when we do the thin plates and seats welding the thing is that basically because, of the intense heat which is applied because of that distortion takes place. So, what we do is normally we also use the copper chilled blocks. So, we use these copper chilled blocks under these joints. So, that maximum of the heat is extracted by these copper chill blocks.

So, the chances of work piece or buckling because, of the intense heat content that will be reduced and we can also use the water cooled jig also many a times. So, that you know copper tubes are braced to the copper helding chamber and then water is circulated through these tubes and the most of the heat is taken away by this water.

So, this way I mean the purpose is that when you have thin seat it is very difficult for it to carry that much heat is this much of time and so because of the heat it may have it may buckle or distort. So, we place some conductive material so that that may allows the extraction of heat fastly and the distortion will be the minimum.

We can also have the fixing in many cases. So, by proper you know fixing in the frame, so that you have the more rigidity to the structure. So, so this way you can avoid this bending and angular distortion. So, that is another way of controlling the distortion.

There are other also ways of controlling the distortion like you may have the mechanical method of using presses then you may have the use of oxy acetylene methods like torches or so this way you have the different methods by which you can control the distortion you can have different type of burners or oxy acetylene flame or so.

So, they are also used, but then you have to have the precaution that when you use these thermal methods, you have must see that they do not they do not change the property of the material because, they will be acting on the surface of the structure. So, that precaution has to be taken so these are somehow they talk about the different you know methods of controlling the distortion in the welded structures.

Thank you very much.