Welding Metallurgy
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Lecture No 45
Control of Distortion in Welds

Welcome to the lecture on control of distortion in welds. So, we have studied about distortion, which is caused in the weld and the reasons for those distortions. Now in this lecture, we are going to have discussion about those methods, which should be adopted to control or minimize the distortion in the welds. So, coming to the distortion of welded specimen.

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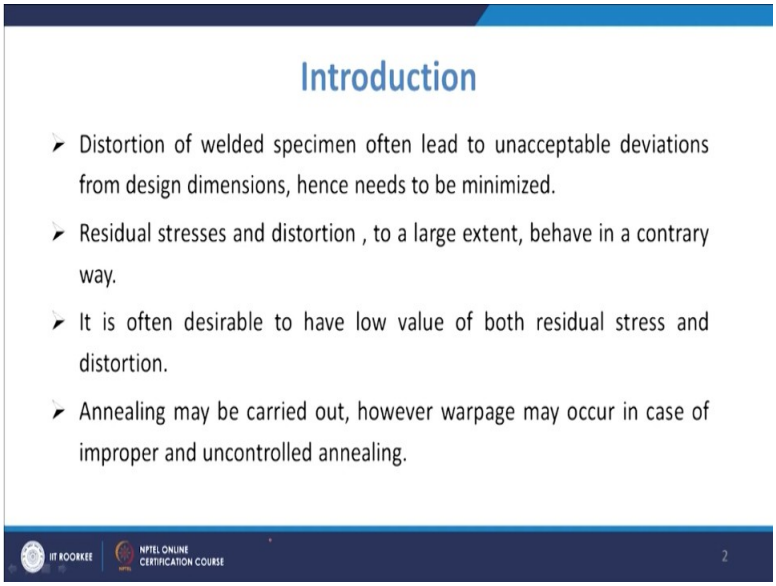

As we know, that the distortion of welded specimen often lead to unacceptable deviations from design dimensions, so, that is to be mentioned and residual stresses and distortion, to a large extent, behave in a contrary way. So, many a times, it is desirable to have the low value of both residual stress and distortion because otherwise you need to, you have a lot of loss or you can have decrease of the productivity, which take place in the case of, distortions or source.

That we have already studied. Now, we always feel or we always desire to have condition of no stress and no distortion and for that, the best method is the annealing process, but if there is improper method of annealing, if there is no proper technique is there or proper temperature is not chosen, then that may result into some other undesirable effects like

warping may occur or so. So, there are many methods which should be adopted there are many techniques which are required to be followed to reduce the distortion.

Now, the mostly apart from the, annealing, because many a times, we go for the annealing but if you take the proper temperature or if you do improper way of, annealing, that involves the heating rate or cooling rate or holding. So, that is also certainly one of the way, but then apart from that, you have other methods also to control the distortion in the welds. So, the first method is the least root gap.

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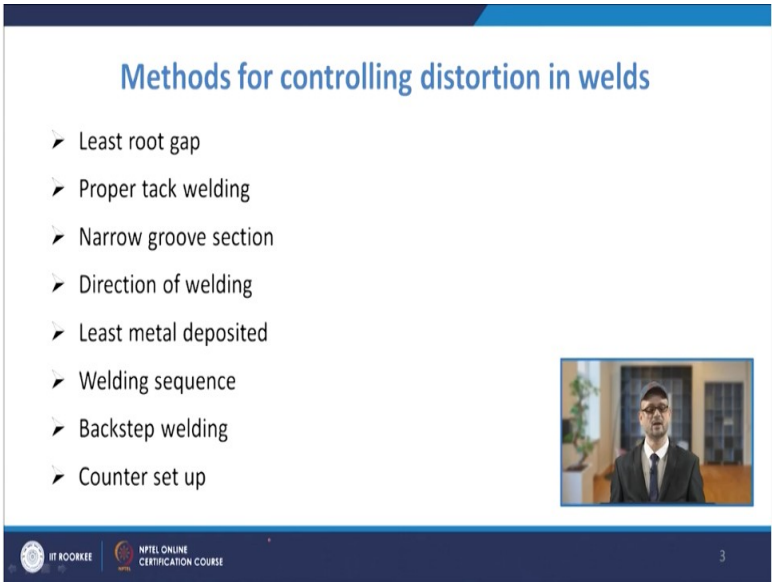

So, these are the methods, which are used for the control of, distortion in the welds. Now, these methods include the least root gap as we see, you have proper tack welding, you have narrow groove section, direction of welding, least metal deposited, welding sequence, backstep wielding, counter set up. So, all these methods are the ones, which should be, followed, which these should be practiced to ensure that there is a minimum amount of distortion that is taking place.

Coming to the first point, that is least root gap. So, we know that while we, I hope that we all are conversant with these terms like root, or gap or I mean, then you have the angles included angles type of joints and all that. So, one of the step which should be followed is the maintaining least root gap. So, the root gap should be as small as possible and basically, although you keep it small, but then it has to be, sufficient for good penetration, so, criteria you have to keep in mind that the penetration should be good enough.

Then, what we do normally is that, so, that is why we try to avoid these excessive gaps excessive value of the root gap. So, normally the practice is that included angle should be not more than 60°. So, that way this practice needs to be followed to avoid large distortion. Now, this is a common practice that when we use the, heavy section in those cases, we try to have double V type of, instead of having single V, try to have the double V type of, section which is preferred over the single V.

Then the next way to control the distortion is the tack welding. So, tack welding is basically used for the accurate, fabrication in seam welding, many a times we do that seam welding, where you have to do the welding continuously for the larger length. And in those cases, as we have studied, depending upon the welding conditions, there may be distortion, taking place, the ease may come closer or that may go apart. So, that may lead to, distortion of the specimen.

So, that depends upon many conditions, but then to avoid, one of the method is the tack welding. So, you make the tack welds. So, especially in the seam welding process this tack welding is of much use. So, this would be sufficiently long to, reliably transfer the shrinkage forces. So, certainly that should be should be sufficiently long. Now, normally what we do is the normal practices that the tack weld length, now that is normally kept at a value of about 2 to 3 times the plate thickness.

So, that is the normal practice of having the, tack weld. However, the there may be hardening and cracking of the weld also and that may occur if a small volume tack welds are applied, as compared to especially for the large, volume components, if you put the small tack volume in that case, there may be hardening and cracking of the tack weld. So, that because of the heat transfer phenomena or so.

So, that is likely to happen in those cases. Now, for those cases, when you have the chances of hardening and cracking of this small tack welds. Now, in those cases, what we do is we normally do the preheating also. So, when we do the tacking, so, that time we also do the preheating, so, that avoids this hardening and cracking of the tack weld. So, also there are possibility of the formation of cracks also and other defects due to when you weld over the tack welds.

So, that is another possibility which is coming. So, it means, to counter that, you have to have different processes to be adopted like you must have the cleaning mechanism, you must have the preheating mechanism. So, these needs to be, practiced to avoid any kind of problem or defect because of the tack welding. Next comes the narrow groove section.

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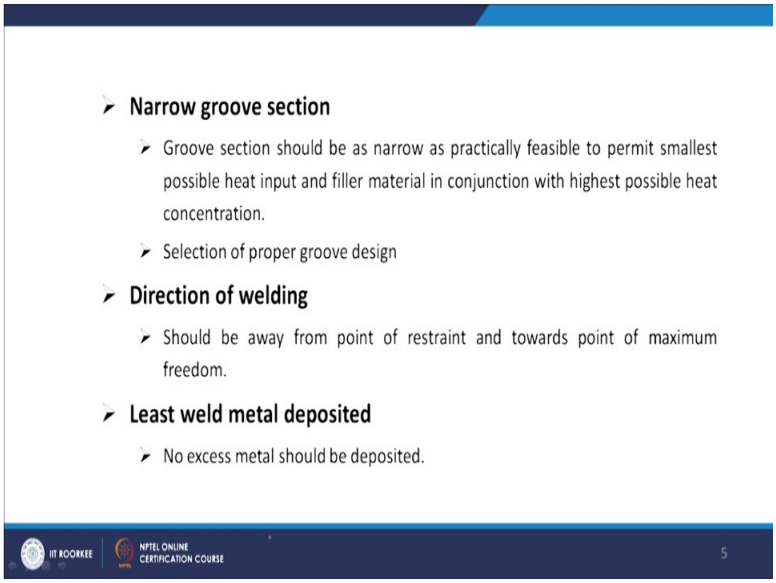

So, the groove section as you see, so, the groove sections should be as narrow as possible, and that is practically feasible to permit the smallest possible heat input and filler material in conjunction with the highest possible heat concentration for welding methods. So, that way you have, certainly there is a limit to everything, so, the groove should be as narrow as the possible. Because we know that the higher will be the heat input, larger will be the heat content, so, that way, larger will be the chances of distortion because of the heat.

So, normally we try to have the narrow sections and we try also to have the highest possible heat concentration. So, so for that we take that kind of the welding methods. Then in those cases basically fusion zone and plastic deform zone are small when you take these, these methods or these practices are adopted, in those cases, your fusion zone and plastic deformity zone, they are a small, so, that gives you lesser the distortion. So, you have to have the proper groove design to be selected.

And normally, what you do is that, you take the square groove which has the smallest possible groove cross-section, so, that you normally take. You also take one of the groove section preferable as compared to other like U shape will be preferred as compared to the V shape. So, that way, we have certain guidelines which should be followed. Then, if you have

the symmetrical weld groove, so, that is preferred, because that will reduce the shrinkage, but then there may be induction of the residual stresses.

So, there are many, some practices followed like you try to use the double V instead of single V or double sided fillet weld, preferred instead of single sided fillet weld. So, normally you go for the symmetrical weld groove. So, this is, as far as the use of the narrow groove section is concerned, these practices should be followed. Then comes the significance of the direction of welding, so, in what direction the welding should be, promoted.

So, normally, the condition is that or the preferable way that the direction of welding should be away from the point of restraint. And it should be towards the point of maximum freedom. So, wherever and whatever direction you have maximum freedom, in that direction, your welding should move. Then another other point which needs to be kept into consideration is the least weld metal deposited. So, normally you have to see that there should be least weld metal because larger will be the weld metal.

So, that will induce more and more contraction, because, you know that every metal when it solidifies, it will contract to a certain extent. So, if for any joint, if for joining any particular 2 component, you are having a joint and one of the joint takes more metal in that case and there is likely to have more contraction in that case. So, whenever you use the excess metal that will increase the probability of having distortion more. So, weld should be made to drawings.

So, you must have a standard set of drawing which is supplied to you design and then amount of weld metal is that will define. So, you should not give you extra amount of weld metal, which should basically increase the chances of distortion because of the larger metal being present there. Then comes the significance of welding sequence. So, basically, what sequence should be followed for the welding. So, what is important is that if you properly control the welding sequence properly select the welding sequence.

Then you can control both the sign and magnitude of the deformation. So, by having the proper welding sequence basically, you can have the control of both the sign as well as the magnitude of the welding deformation. Now, if you have the job of a large surface area, so, consisting of several plates then in that case the transfer sections should be welded first and

then that should be followed by the longitudinal seam. So, normally that is the practice which we follow that when you are dealing with those.

Last surface, surface areas, which is consistent of different plates. So, in those cases first you go for the transverse sections and then you move towards the, you move for the longitudinal layers, so that is for that kind of structure.

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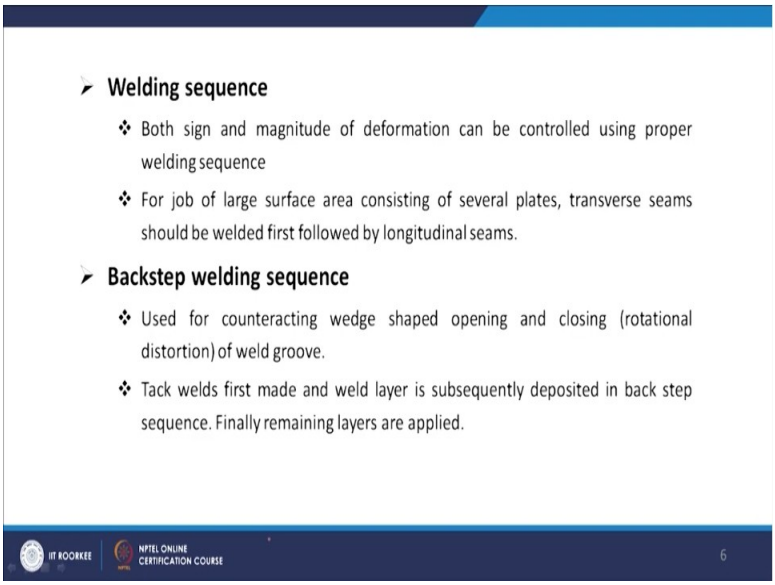

Then when we are dealing with the welding of I or H beam section, then first to be welded are joints within each web plate and the flange, and then we do the butt joint between the web plate and the flanges of the beam. So, that is, when we do for the I and the H section beams. And when we talk about the cylindrical vessels, many a times we are doing the welding of the cylindrical sections. So, in those cases, where you have different tires, so, in those cases as compared to the contrary to the plates.

So, here what you do is, we do the welding of the longitudinal seams first and then then we go for circumferential seams, so, that that type of welding sequence has to be practiced for, when we are talking about the welding sequence depending upon the structures. We should first do the longitudinal one and then move towards transverse or opposite way we have to move. So, that depends upon what kind of shape or structure you are welding.

So, this is the practice or the significance of the proper welding sequence, then, you have the next point which is further important is the back step welding sequence. So, this is normally used to contract the wedge shaped opening and closing. So, that is the rotational distortion of

the weld groove ahead of the weld pool. So, it is normally occurring, with regard to the long welds and at low welding speed. So, normally, for those cases, we use this backstep welding sequence. So, what we do in this case that we are doing the welding in a back manner.

So, in this case, the groove opening is suppressed by the prior tack welding or by rigid lateral constraint or restraint. So, this may result in permanent roof shaped, arching of the weld joint. So, that is, happening in these cases. So, what we do, normally in this case, is that we normally make the tack welds, so tacks welds are first made.

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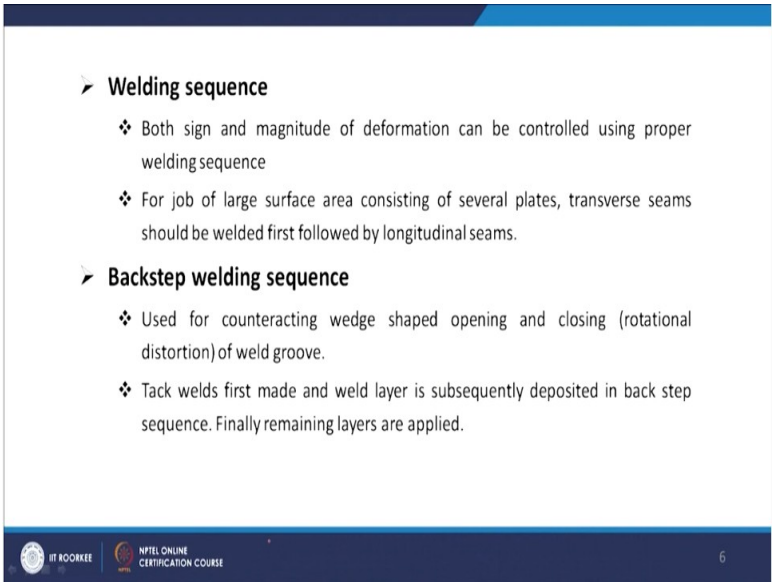

And so, now, that also depends upon what is the welding speed. So, if your welding speed is low, in that case, low spacing between tack weld has to be there. So, if you are moving at a slow speed, in that case, there should be spacing between the tack weld that should be smaller one. Then first weld layer, what we do is subsequently deposited in the backstep sequence. So, you are moving in the in the backstep, this is a welding direction. So, you are moving in that backstep sequence from tack weld at one end to the opposite end.

So, that way, we do the welding sequence and then you go for the after that you apply these layers continuously and alternating so, that way you move. So, in these cases, what is happening is that there will be good melting through of initial sections of the welds. And the warp piece warpage that will be diminished using this backstep welding sequence. It also results into the reduction of the transverse and longitudinal shrinkage of the weld joint as a whole.

And normally, this is very much a practice for the manufacturing of large structures like ships or tanks. So, there, that is this backstep welding sequence is very much a practice to control the distortion. Next, if you go for the other matters, which is also followed, that is your counter or opposing setup.

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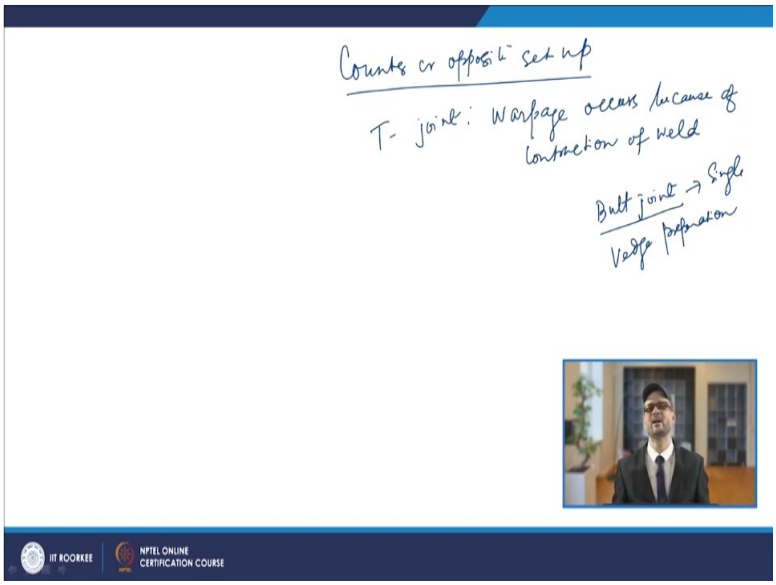

So, sometimes that also is being used. So, you can have the opposite effect on the, distortion, so, warping, which is caused by the internal stresses, so, that can be controlled effectively by these counter or opposing effect on. So, normally, what happens if you look at a T joints, so, in those T joints, you have the, so, if you take the example of a T joint. So, here, warpage will be occurring because of contraction of weld. Now, as you know, you might have some idea about the camber allowance in the case of casting.

Where, what is happening that when you have a joint you know horizontal portion which is you know, which is likely to sag, and that is distortion in those cases, so, what we do is, we normally given an allowance. So, we give that upward bend, so, that even after sagging it becomes straight, so, that is camber allowance in case of castings, so similar concept is here also. So, we normally give a slight reverse bend, so, the vertical member if you are giving the slight reverse bend, or counter camber.

So, normally that will lead to control the distortion in those cases. So, basically counter or opposing setup is also very, one of the efficient way to control the distortion, and if you take about the butt joint, with a single, so, if you take the butt joint welding of 2 plates with single V as preparation, now, in that case, so, what we do normally is that, we provide a, backing

strip also, under that joint, so that the increased opening is formed. So, far for that we normally provide a backing strip.

So, accordingly you know, after the welding the plates will align themselves. So, that also helps you to control the distortion. So, that is one of the way also, to control the distortion in those, butt welded plates. Then, another way also so, if you come to other methods. So, normally, we also many a times we have to deal with the distortion of you know, plates, thin plates and sheets. So, that is a challenge, you know, to control the distortion, but because in those cases we know, that, you know, in those sheets.

You know, the warpage probability is maximum. So, one of the very, you know, method which is normally adopted is the use of copper chill blocks. So, whenever we are, you know, welding the thin, you know, sheets, in those cases, what we do is we are keeping these copper chill blocks, because in those cases, in the case of thin sheets, the transfer of heat, so rapidly through the sheet itself a challenge. So, placing that, we place those copper chill blocks under the job, so that what it does is it will try to extract the maximum heat from the weld.

And if that the heat is extracted, then that will certainly reduce the chances of warpage or the distortion in that sheet. So, that is one of the very popular method then, we also use the water cooled gig also many a times.

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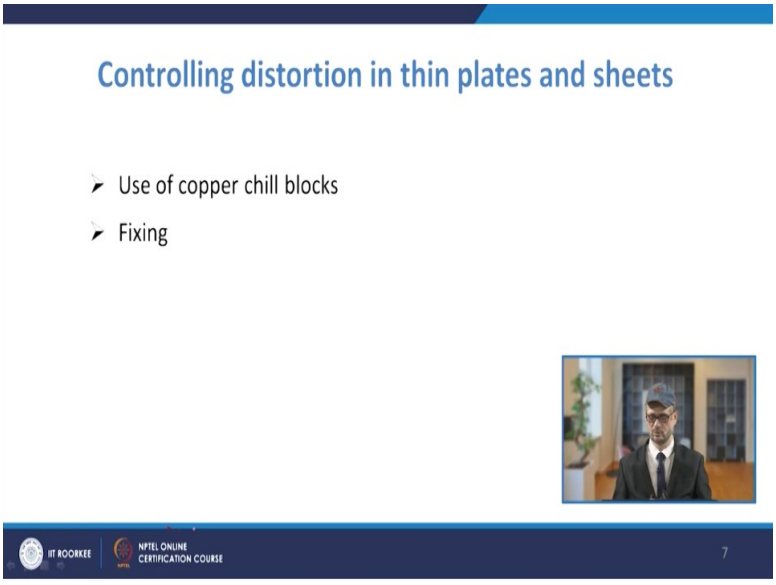

So, you know, you have the copper tubes braced to the copper holding clamps and then water is circulated through that, tubes, so, during the welding. So, that way, if that basically

decreases the temperature in those cases, it is likely that your distortion will be smaller. Then you have some other way also, to reduce the distortion in the case of plates and one is the method of fixing. So, you try to have the frame as rigidly as possible to avoid the bending and angular distortion.

So, that way, we go for, these are the different methods of controlling the, distortion. Then, once there is a distortion, then there must be certain way also, because some there is some amount of distortion, which has occurred in weldment, then there are also certain ways to correct these distorted elements and for that, there are many methods also. So, you can do the, correction of these distorted weldments.

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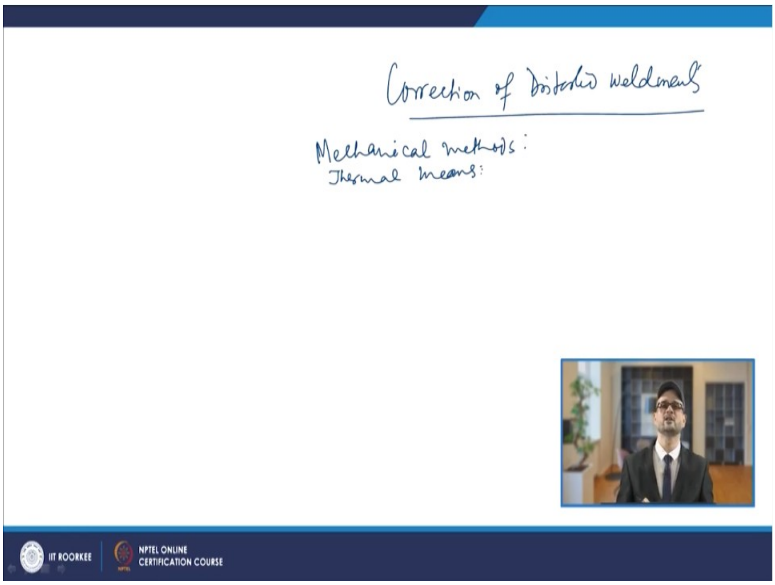

So, there are different mechanical means also there, you have thermal means are there. So, suppose you have mechanical methods are there. So, among the mechanical methods like once many a times when you do that, you when you look at the welded specimen, then they are somewhat deformed, somewhat welded, somewhat you know, warped or so. So, you can use the heavy machines like press, or you may use the rollers, straightening rolls you can use, the jack screw.

Also sometimes in case of minor deformations, you can use these methods to basically reduce the distortion in the weldments. Apart from that, there are also thermal means, so, you know, you use the thermal source. So, you use different type of arc or torches, like you may have oxygen lance torches or carbon arc or you may have the powerful oil or gas burners. So, you know, you will have to use these thermal means only for those materials, where it is, these

property is not affected because of the increase in the temperature.

So, in those cases, we also use these thermal means to control the distortion. So, these are basically the different ways to control the distortion of the weldments. So, this is in nutshell, talking about the distortion which occurs in the welded specimen mainly due to the thermal imbalances relating to the properties of the material, relating to the heat transfer through the material, relating to its improper fixing in presence of restraints, many a times the expertise of the welders.

So, these are the different so, because of that the distortions can occur and how can you control, so, we have got some idea about the correction about the distortion of the weldments. Thank you very much.