Welding Metallurgy
Prof. Pradeep K. Jha
Department of Mechanical and Industrial Engineering
Indian Institute of Technology Roorkee

Lecture No 56
Introduction to Welding Defects

Welcome to the lecture on introduction to welding defects. So, we talked about the welding processes, we have studied about different aspects about the metallurgy of welding. And we will have the discussion on the welding defects and try to have the knowledge about the defects which arise because of many reasons. What are the different defect types and certainly, as the lecture goes on and subsequent lectures, we will have the different aspects about the welding defects and we will try to correlate it with this metallurgy of the welding.

So, as you know that, the performance of the welded structure depends on the quality of fabrication, that is whether there is presence or absence of defect in the weld joint. So, any departure is there from the specified requirement that basically tells you that you have the defect in that particular component. Now, principal causes, which causes for the failure are to failure to follow the requirements of welding specifications.

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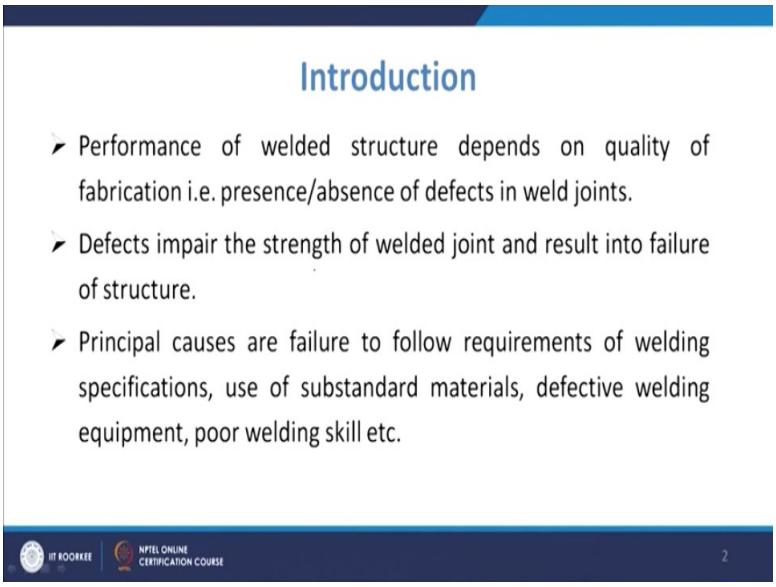

The main reason, which is there for these welding defects are that you are not able to follow the requirements of the welding specifications. Then, many a times we use the substandard materials, then we also have the defective welding equipment that also many a times we use. Then, many a times we have the poor welding skill is there. So the manpower which is there

that has not adequate workmanship. These are the reasons and then it may because of fault of the designer.

So, that is design or drawing errors that may be also one of the reason because the joint design or the gap or all that which you are trying to give, so that may not be the proper one, so that may also lead to the generation of defects. So, that way, you have the chance of having the defects. So, if you talk about the classification of the defects, then you have the defects are classified as the cracks.

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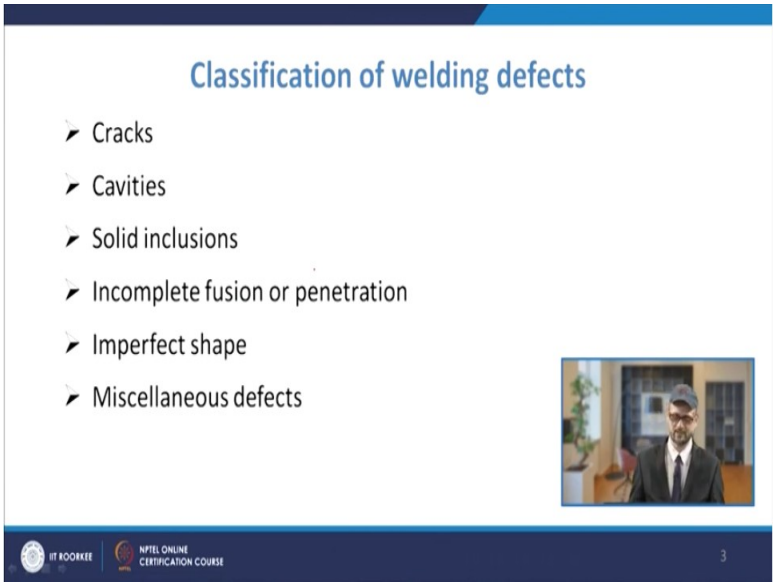

These cracks are different types of cracks like you have the cold cracks, you have the hot cracks, you have the crater cracks, you have toe cracks, on the track we have a lot of we have the understanding in our earlier lectures we talked about different types of tracks and its generation. Then you have the cavities. Cavities are also very important type of welding defect because as we have understood that when we are doing the welding, during that process actually because of the high temperature.

And if there is no proper shielding from the environment, in that case, there may be gaseous pickup or there will be dissolution of gases in the weld and many a times some of the gases has very high solubility at very high temperature and very low when the temperature drops. So, if they are not able to go out so, that they are also going into it, so, cavities may be because of these gases.

So, in those cases you can have the blow holes in the case of welding where the holes are

there inside the weld pool. Then you have the you may have the chance of having porosities, you may have the shrinkage, so all these are the different kind of cavities which may be generated. Then you have the solid inclusions, solid inclusions will be like you have the slag will be there or flux is there, so there may be slag trapment or flux that may be trapped inside.

Many a times you have the metal oxides or when we use the tungsten electrodes, so in those cases, you may have the trapment of the tungsten also in those cases. So, that also may go and that may be seen in those cases. So, these are basically coming under the solid inclusions, then you have the incomplete fusion or penetration.

So, that is further seen because when you are doing this building process, in that case, you may have the improper fusion may be there, there may be lack of fusion, there may be lack of penetration, its not able to penetrate properly, then you have the suck back effects. So, that phenomena may also be there. So, these are the results because of the incomplete fusion or penetration.

Many a times you have the imperfect shape. Imperfect shape means the contour which you are getting that is unacceptable. So, the way it looks that is basically not acceptable. So, you will have the dimensional deviation may be there in those cases. Then you have the undercut or you may have the under feel, then there are also chances of overlap. So, these are the different kinds of defects, which are structurally you can see when you are doing the welding.

Then many a times what we do is we give the excessive reinforcement also so that may be also coming in this category. Then excessive penetration is there or the bead shape which is not proper. So, all these are under the category of imperfect shape or maybe unacceptable contours. Then also we have the other miscellaneous kind of defects.

So, that is like you have the arc strike is there, you have the excessive spatter is there, then you have the rough surface generation, that is another kind of defect which is likely to come in the case of the welding and you have uneven ripples and then you have the pock mark. So, these are the defects which are coming, which are under the category of miscellaneous. Now, the thing is that when we are going to discuss about the welding defects.

So, in this lecture or in the coming lectures, we are going to have the discussion of the

welding defect basically under two categories so the category will be one will be visual or surface defects.

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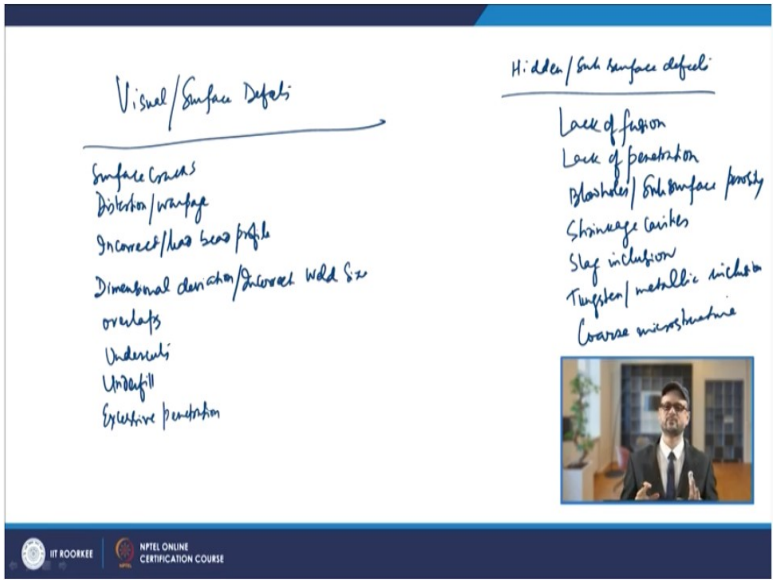

And in another category, you will have the hidden or subservice defects. So, in this case **is** the defects which are you are able to see that they are the visual or surface defects and where you cannot see them, so they are inside below the surface that is your hidden or subsurface defects. If you try to have the example of these visual or subsurface defects, so, in that category you will have the surface cracks.

Then you have the distortion or warpage which is created because of the surface crack means the crack which is exposed to the surface on which it is appearing at the surface crack. Distortion or warpage which is created because of the residual stress values or the restraint which we have studied earlier. So, there that you can see visually that is under the visual crack. Then you have incorrect shape profile, bead profile, incorrect or bad bead profile.

So, this profile which you are able to see that may be incorrect, so, that is if any kind of overlap is there, undercutting all that is there. So, that we will see later on. You will have dimensional deviation or incorrect weld size, so they are basically coming under the visual surface defects, then coming to the overlaps, then you have undercuts. So, on the bead you can have the look that how they are overlapping going over the surface or there is undercut on the side. So, you will have undercut that is seen, so, that will be undercut.

You have the underfill so that is another thing which is being shown, then you will have the

excessive penetration. So, about these defects we had studied, so this is your excessive penetration, then apart from that, you have the unfilled craters, that is also among these visual surface defects, where the crater is not getting completely filled. You have the defects like interruptions are there, so that you can see, so that is among that visible type of defect.

You have surface porosity, you have surface oxidation, these are among these defects which are visual or surface like surface spattered is there many a times that effect creates the unevenness on the surface of surface finishes, we basically gone. These are the examples of the visual or surface defects. If you talk about the hidden our subsurface defects, now in these cases, we have the lack of fusion shape, so this can be defect which is under this hidden or subsurface, because the fusion is not proper.

Now, inside that you cannot see visibly from outside. So, this lack of fusion, that is a defect basically, or lack of penetration. So, it has not penetrated inside and you are not able to see it from outside. So, that is lack of penetration. You have blowholes or subsurface porosity, so these as porosities which are there below the surface. So, basically that will give you these problems in the case that you have to have another means to see it, so that is hidden.

Then you have shrinkage cavities, so, that is again, this you have to find it using special means that what are the shrinkage cavities, you have slag inclusion. So this is among the hidden or subsurface defects, then you have tungsten or copper inclusions or metallic inclusions you can say.

Then, you have the coarse microstructure, that also you cannot see, so, that is also a defect and coarse microstructure will be one of the defect which is a type of hidden defect or you have the subsurface defect, which needs to be controlled and there are reasons for these. So, when we will discuss about these defects, and we will have some, in depth we will be talking about it.

So, further if you come to the sources of these welding defects, now, we will talk about the general sources, which are there, when we are talking about the welding defects. So, the first is that improper selection of the welding process.

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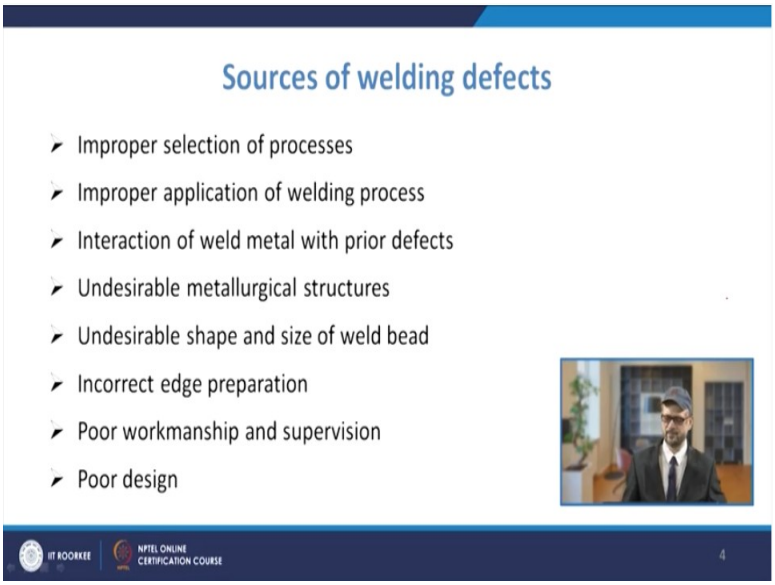

Now, if you take improper session of welding process, the end result may be not very rewarding, like if you are taking a process, which has a very deep penetrating heat source and if you are putting on the very narrow V angle, so, that basically will cause the crack in the route because of the very large depth, to width ratio. So, in those cases you will have to have the improper selection of the process of the welding, so, that you get the desired results after the welding. Then the next point is the improper application of the welding process.

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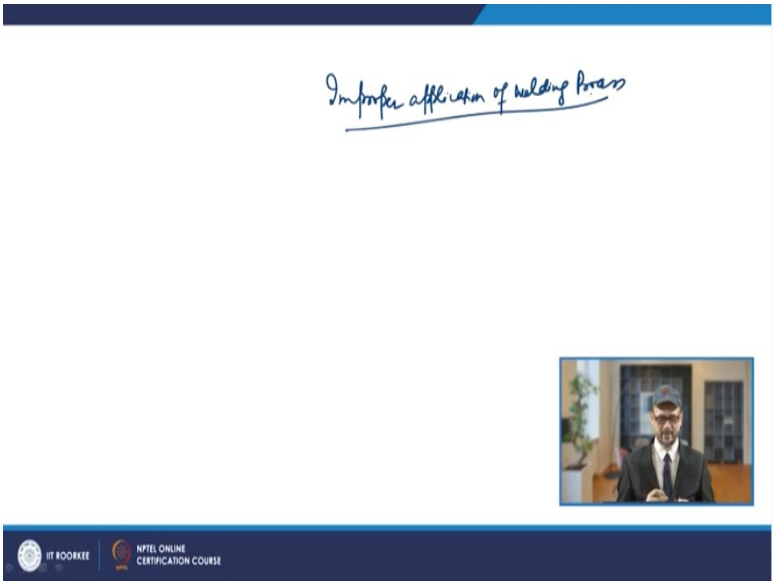

So, you will have improper application of welding process. So, in this case, what we mean to say that you are using improper application like improper shielding gas, you are choosing not appropriate the welding current which you need to select, because depending upon the dimension of the plates to be joined or depending upon the different processes you do not have the proper current setting. Or maybe the gaseous shield is there that is not adequate or

maybe that you have done improper weld deposition.

So, these things basically will be leading to improper results or the defects in the welded specimen. Then the next point is the interaction of weld metal with prior defects. Now, many times this weld metal that will be interacting with the defects which is already there in the base metal. So, like you have the laminations and you have the impurities like phosphorus is there sulfur is there or silicate is there.

So once you will have their interactions, then that may result into undesirable structures and you will have the brittle zones formed and that may result into the lamellar tearing. So, if you have suppose, you have the laminations and that will be interacting with these impurities, which are there. So, we have studied about the lamellar tearing, and their interactions may result into that kind of tearing which is observed that is lamellar tearing.

So, that is because of the interaction of the weld metal with the prior defects. Then you have undesirable metallurgical structures, now, that is related to the grain size and hardness. Because, many a times you have undesirable metallurgical structures with respect to the grain sizes. Suppose you wanted certain grain size and grain size is coarsened so, in welding, it is very, very likely if you do not control properly, then your grain size will be coarsened, so, that will have the implication on the properties of the structure.

So, you will have, with respect to that grain size and hardness you may have the undesirable microstructural or metallurgical structures and maybe because of the inclusion such as the tungsten oxide or slags. So, these inclusions will also going to have the effect, because they are undesirable microstructure, undesirable metallurgical structures, and that is going to be detrimental for the quality of the weld.

Similarly, the hydrogen is another principle constituent material, which is very undesirable type of inclusion, and most of the time as we have studied that hydrogen is very much responsible for the cold cracking. So, you will have to have a control on the presence of hydrogen inside the weld. Then apart from this undesirable shape and the size of the weld bead you have the incorrect edge preparation. First of all, before that you have undesirable shape and size of the weld beat.

So, here again, you will have to look into the weld profile which you are getting. There may be many reasons, you may have, the overfill, you may have overlap, you may have the undercut. So, this is under this category that you have undesirable shape and size of the weld bead. Basically, you want a particular for having the ideal, properties you have an idealized shape of the weld bead.

If there is more deviation, so, deviation may be in many forms, like there may be overlap, there may be undercut. So, that is basically the presence of the weld bead**,** not in a very proper shape. So, that is your undesirable shape and size of the weld bead. Then you have the incorrect edge preparation, so many a times, the edge preparation, which is done that is not proper, that is not very correct.

You have poor fit up, that is also there. So, in those cases, you are not likely to have basically the properties, proper welding characteristics. So, when you do the welding, it will not give you the optimum properties. So, that will lead to many kind of defects like there may be lack of fusion also there, because of the improper fit up or improper edge preparation. Then you have the cracking, many types of defects have the originations from these incorrect edge preparation that is possible.

Then you have the poor supervision, poor workmanship. So, basically, if you do not have the proper trained manpower, then that may result into poor quality of the welding because the workmanship will certainly talk about many output parameters being affected that may result in to stray arcing, so arching may not be even, there may be stray arcing.

Then you may have the tool marks on the job, so, that is another example of poor workmanship or the presence of the unskilled labor that can be detrimental for the external appearance of the specimen. Then, there may be undercut and inclusions, poor finishes very much possible that is what we talked. So, that is very much directly the outcome of the poor workmanship or the inefficiency of the welder.

Lack of fusion, lack of penetration, then incorrect weld shape, all these are basically the results of the poor workmanship or not having proper expertise of the welder, which is doing the welding job. So, basically, these things, it will not be able to create proper surface profile, proper finish and all that, that will be ultimately affecting the properties of the

material that will be affecting the fitting life of the component.

So, that is why they are basically important, I mean it is important to have a proper, trained welder who should be doing the welding in a proper manner and also that will be giving you a proper joint strength also, so joint strength, fitting life these are very important. Then inferior design, that is also very important parameter which has to be looked into. So, if you have the inferior design, then that basically will not allow us to do the inspection properly.

So, that we lead to inaccessibility in the welded specimen and we will have inaccessibility in the welding as well as in the inspection and we will have the hard spots and stress razors will be there, if you have the improper design then that may be formation of hard spots or stress razor points which will be basically responsible for leading to cracks and that may lead to failure of the material.

Then, you have the difficult welding position, suppose, you are having that difficult welding position from where you are welding, so, that may lead to many kinds of problems and may be quality wise as well as the safety issues are there. Then, you have the poor weldability many a times we take the welded material which has very poor weldability, which is not the notch ductile, so, in those cases, when you are making the weld, then it is more likely to have the defects.

So, these aspects need to be looked into when we are going for assessing the weldability of the material. Then so, when we talk about the notch ductile material basically, which will be continuing to form plastically, that is deform plastically that is not as the notch ductile. So if it cracks in a rapid brittle manner, it is not the notch tough or notch ductile material, so, based on that basically we are defining this property of the material, notch ductile or so.

So apart from these aspects, we may have another aspect also may be many other reasons for the occurrence of the specific type of defects, these are only the defects which we discussed, so among them, the reasons which we have cited, for most of the defects however, there may be specific reasons for some specific kind of defects also.

Now, there may be causes for these defects and there may be special remedies of the defects that can be discussed later and that will help you understand that what may be the possible

reasons for the onset of these defects. And how they can be removed by changing of the process parameters, operating parameters and so, on and other conditions, which are there when you are doing the welding like choosing of proper environment, the proper machine has to be there, proper heat source has to be there.

So, there are many reasons that can be the remedy for many specific kind of defects. So, in the coming sections, we will be having the introduction about the defects, because of the different processes may be due to arc welding or they are specific kind of defects which may arise. So, in the coming lectures we will have the discussion about those kind of defects and also I will be talking simultaneously about the causes and the remedies of these defects.

So, that is what about the lecture on this introduction to the welding defects. Thank you very much.