Equipment Design: Mechanical Aspects
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Lecture 12
Design of Flanges

Welcome to the second lecture of week 3 and in this lecture we will discuss the flanges. And discussion on flanges will be covered in four lectures that is lecture 2, 3, 4 and 5. In lecture 2 and 3 we will discuss theory part of the flanges; however, in third part we will see the design procedure and in fourth part we will solve a few examples for design of flanges. So let us start the discussion on flanges.

First we will discuss that what is flange. So basically if you remember different components of pressure vessel, there we have not discussed the component flanges. However, flanges can be used to join the two parts. For example, if I am having shell and shell length is significantly high, it is difficult to transport from one place to another place, so usually we prepare that shell in different parts and then at the site where it needs to be installed, those parts will be connected.

So, flanges are the integral part of the design. So, it is not a separate component than the pressure vessel it is the part of pressure vessel only. So what is flange. First of all we will discuss that and then what are the types of flanges that we will discuss. So let us define flanges.
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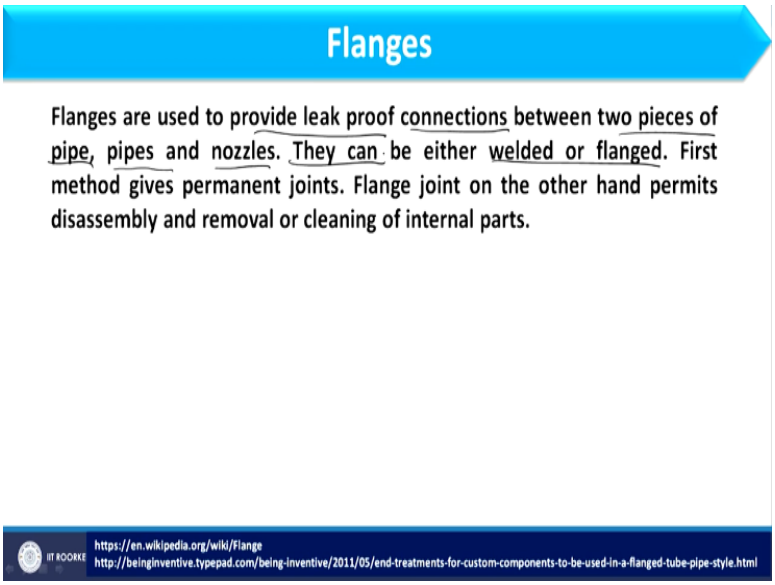

So flanges are basically used to provide leak proof connections between two pieces of pipes and nozzles, okay. So flanges are used to connect either two pipes or pipe with nozzle or nozzle with cover, okay. So in all that stages, we need flanges. Now if I am saying that I have the two pipe of different diameter, okay. So a smaller diameter pipe can be inserted in larger diameter pipe through screwing it, okay.

It is easily joined, but what happens when diameter of both pipes are equal, okay. So flanges are basically used to connect the pipe of equal diameter or pipe with the nozzle because nozzle is the accessory and that will be connected with the pipe, okay, or if I need to cover the nozzle. For example, if I am preparing a site glass, okay, for seeing that what is happening inside the vessel, so that nozzle whip for site purpose we prepare the opening and then that opening will be inserted with the nozzle and over this nozzle that nozzle will be covered with the flange, okay.

So for all this purpose we need the flange. However, when I connect the pipe, the pipe diameter should be equal, then only flange will work. So these can either welded or flanged. These means the pipe sections or pipe and nozzle, these can be either welded or flanged. So welding means what, when I am having two pipes of same diameter I can easily weld, there is no problem.

But welding gives me permanent joint, however, when I am using the flange because it is provide leak proof connection that connection can be separated, okay. So flanges will be used

when we have to go for maintenance purpose and for repair purpose, for all that cases flanges are more advised in comparison to welding, okay.

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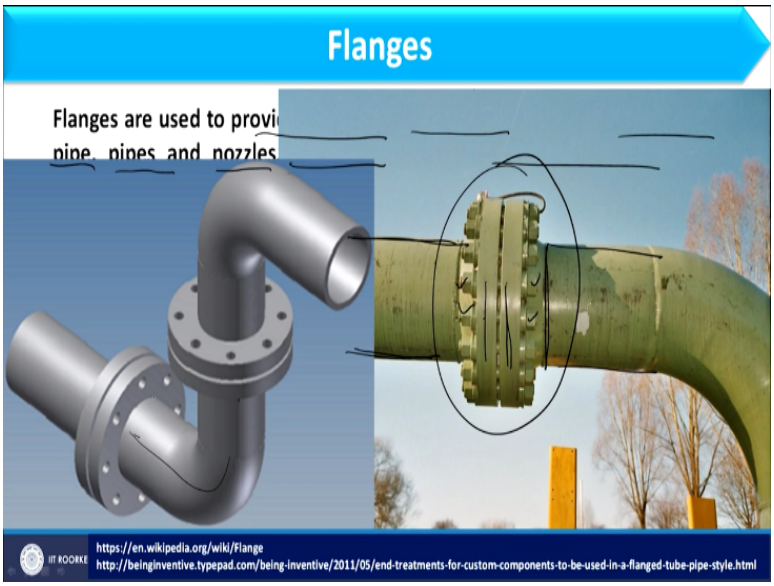

So if you focus on this image. Here you see the image. This section of pipe as well as this section of pipe both are having same diameter and this connection is basically called as flange. So what is flange, flange is basically disc type of structure, which is welded over the pipe and usually flange are prepared or flange are made with a pair. If this is one disc, this would be another disc.

So these discs should be aligned to each other to prepare a leak proof joint, okay. So flanges will usually come in pair, so one flange will be welded in this pipe, second flange will be welded to this pipe and then these disc will be connected through bolts, as you can see these are the bolts. So through these bolts these discs are connected and the whole assembly we can call as flange.

As you can also observe from this image, here all diameters are equal, so we have to connect this elbow through flanges. So for connection of pipe or different sections of pipe, we can use flange very easily. But as far as pipe is concerned, it is specifically used when pipes are having equal diameter that you need to keep in mind.

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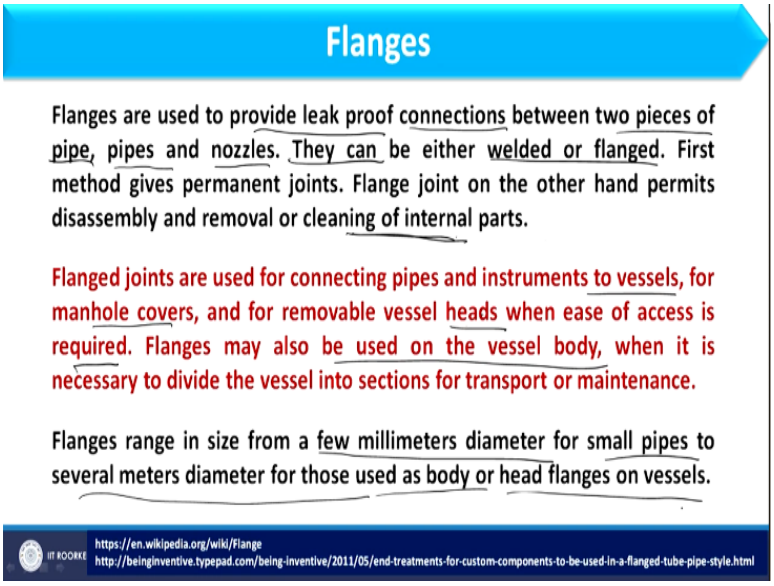

So flange joints are used for connecting pipe and instruments to the vessel for manhole covers and for removable vessel heads when ease of access is required, okay. For ease of access means when maintenance is required, when repair is required in that case we use flange, okay. And flange may also be used to connect the vessel body that we have already discussed.

If one particular component, let us say shell is having very high length or very large length that will be prepared or transported in part and then those parts will be connected using flange. So flanges ranges in size from few millimeter diameter for small pipes to several meter diameter for those used as body or head flanges on vessel, okay. So it is used in different sizes depending upon where we need to attach, okay.

It may be smaller size, it may be very large size when I am connecting that. When I am connecting the shell sections or when I am connecting shell with head in that case, flange diameter will be very high.

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Here you see this image, here we have, this image shows different types of flanges made of stainless steel, okay. So here if you see this particular flange and this particular flange, this flange, all these flanges are having different shape, so this will be more clear when we will focus on types of flanges, but what I need to tell here that whatever flange you are considering for example this, so it is having four holes, okay.

And in this flange we are having 1, 2, 3, 4, 5, 6, 7, 8; 8 bolts I have used over here, similarly 4 are there, 4 are there. So what is the point that whenever I am designing a flange, we consider bolt in multiple of 4, that is the guideline that it is either used 4, 8, 12, like this, so it will always be the multiple of 4 to have a tight joint, okay. That is the guidelines to design a flange. So let us discuss flange joint, how it is connected.

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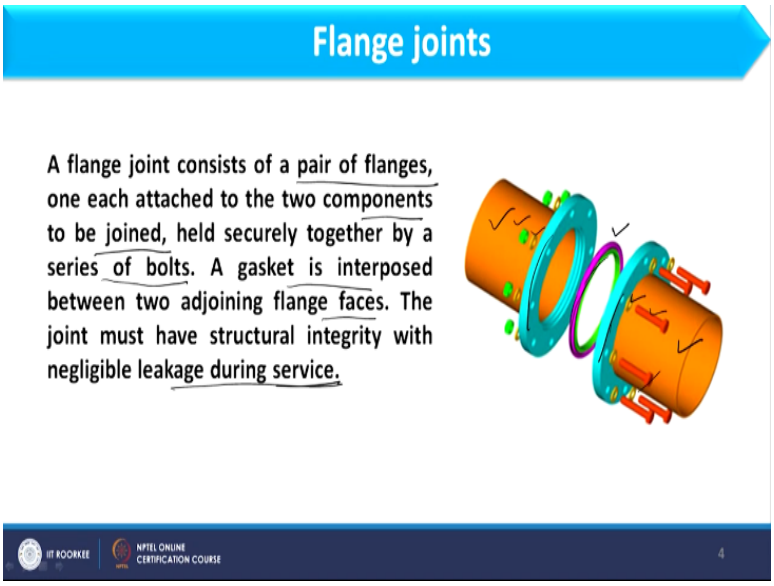

So here I am having the connection, where this is the pipe and this is the pipe of equal diameter, now if you consider this blue part, okay, this blue part or blue discs, these discs are basically flanges, okay. And when we are joining these two flanges, we usually put a metal or rubber ring and that ring is basically called as gasket. So gasket is the integral part or internal part of the flange and it is placed between two faces of flange, okay.

And each flange will have different holes and these holes will be connected through bolts and nuts and here I am again having this, you can say washer or gasket. So in that way we have that full connection. So, a flange joint consist of a pair of flanges, what we have discussed that it is always come with pair, okay. So each attached to two components to be joined, held securely together by series of bolts.

So when I am designing flanges, I will calculate number of bolts and that will depend on how much load it needs to carry. Number of bolts will be decided accordingly, but it always be the multiple of 4. A gasket is interposed between two adjoining flange faces. The joint must have structural integrity with negligible leakage during the service.

So, all these parts are so connected so that chances of leakage will be minimized and that is the beauty of flange that it provides so tight joint, but at the same time it is easily replaceable, easily removable for maintenance and repair purpose, okay.

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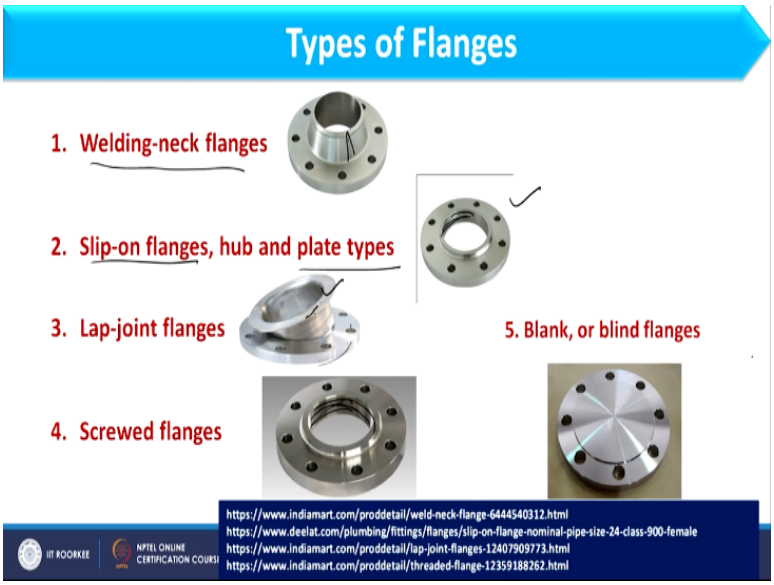

Now, we will discuss different types of flanges. The first type of the flange is welding-neck flange, okay. Its image is given over here. You see here we have the disc and here we have the tapered section, okay. Inside section will be vertical; however, outside section is slightly tapered. So that is why it is called welding-neck flange. Second flange I am having is slip-on, hub or plate type, okay.

So in this flange, here I am having this plate type flange and it is slip-on basically, so what happens when we consider this type of flanges it slips over the pipe. For example, if this is the pipe, its diameter is slightly higher than the pipe outer diameter, so that it slips over it, okay. So it is usually called slip-on flanges. What is the purpose of this, why we are considering this type of flanges that we will discuss in detail.

Next, I am having is the lap-joint. And lap-joint has two part, first is the disc, another is the connecting section where this section is particularly connected to the pipe, and this will move, this will slip over this assembly. So in that way it is lap-joint. Next, I am having is screwed flanges. Screwed flanges means it is almost same as slip-on, but here at inner surface we have the screws instead of plain surface as we have used in slip-on. And fifth flange I am having is the blank or blind flange, where opening is not done.

So it is basically used for closing purpose. Now we will discuss all these flanges one by one in detail. So let us start with welding-neck flanges.

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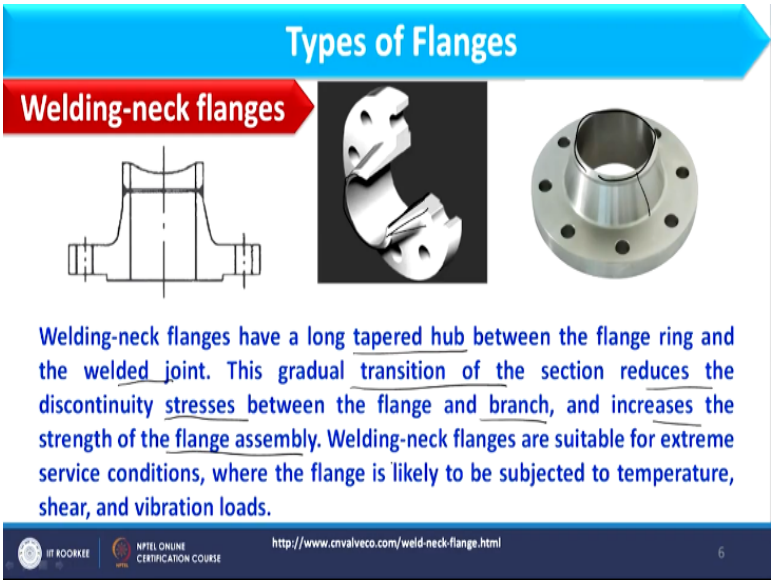

Welding-neck flanges have a long tapered hub as you can see from this image here. You see this image, here we have long tapered hub, this section is basically called as hub and vertical and internal part of this is plain. It means it is vertical; however, outer part will have some tapering, okay. So it has tapered hub between flange ring and the welded joint. Welded joint means at this section it is welded to the pipe, okay. So it is basically coming at the mouth of pipe, okay.

So at mouth of pipe it is welded and then it has the tapering section and then we have the flat plate. So this gradual transition of the section reduces the discontinuity stresses between flange and the branch and increases the strength of the flange assembly, okay. Now what happens when I am connecting flange with the pipe at the mouth of the pipe, then what happens after that diameter suddenly disc appear, okay, suddenly we have the disc. So when I am having that disc it means it has some discontinuity in the stresses.

So that can be mitigated while providing the tapering section or welding neck. And therefore these welded-neck flanges are used for extreme condition because it can easily sustain the shocks as well as variation in stresses due to operational point of view and due to continuous operation. Welding neck flange are used for extreme condition, where it can sustain, it can bear the shocks, discontinuity in the stresses because of that tapering section.

So in extreme condition, these type of flanges are recommended. However, as far as manufacturing cost is concerned these flanges are very costly.

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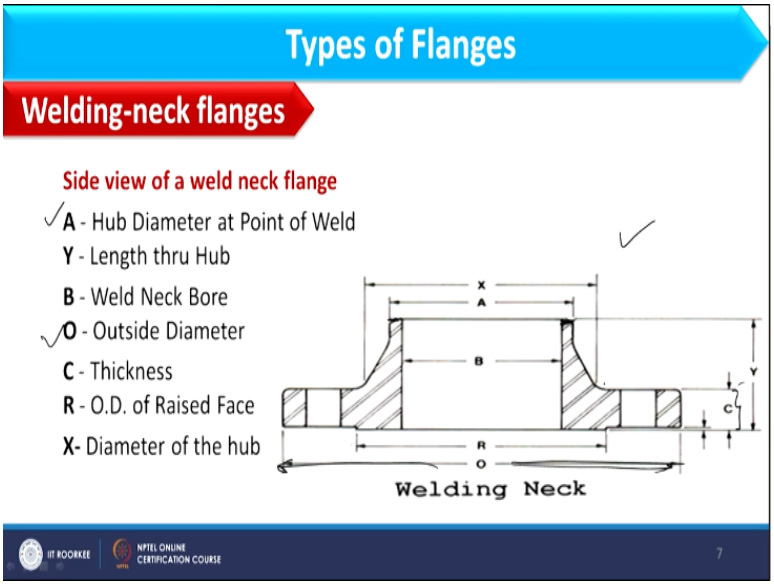

In this slide, I am having the side view of flange neck, where I am having different parameters and these parameters will be used in designing and therefore I have shown the schematic. If you consider what is A, A is basically hub diameter at the point of joint. So if you consider this section we usually weld with the pipe and its outer diameter of this hub is called A. Y is the length through hub that is Y is the total height of the flange including hub and B is the weld neck bore.

Weld neck bore means this is basically B or we also called this as bore diameter, so bore diameter are basically based on how it is connected. For example, if I am considering slip-on bore diameter will be equal or slightly greater than outer diameter of pipe and if it is connected at the mouth of pipe, bore diameter will be equal to inner diameter of pipe.Next, I am having O, which is basically outermost diameter of the flange. You see, this is O, which is the outermost diameter of flange, C is the thickness of flange, R is the raised face.

If you consider this is R, this is raised face and it will be more clear when we will speak on raised face in detail and X is basically the diameter of the hub. So in this way all these parameters are defined, so that you can use these parameters in designing.

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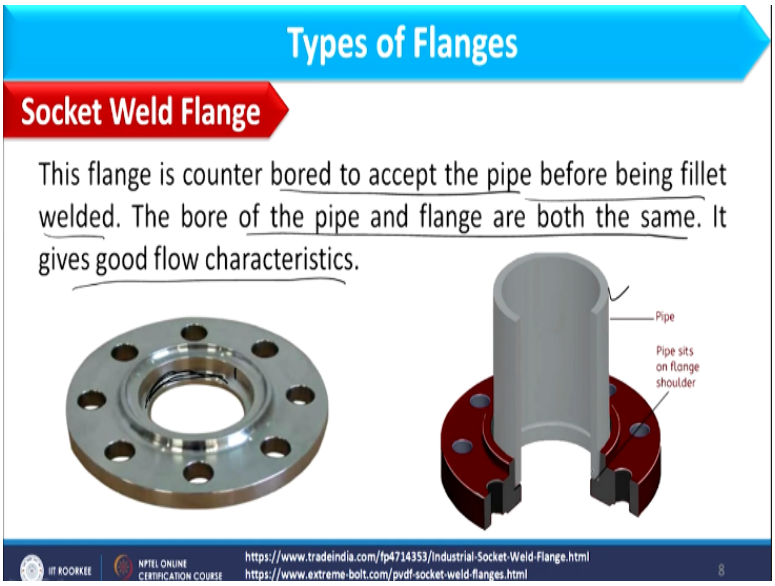

Next flange I am having is the socket weld flange that we have not discussed in type of flanges because it is very unique type or specific purpose it is used and this flange is counter bored to accept the pipe before being fill-it welded. And in this case bore of the pipe and flange are both same and it gives good flow characteristic. So what is basically socket weld flange, if you consider this is the disc and this section is basically connected to the pipe.

So this is basically the disc and if you consider inner part of this flange, this inner part is slightly deepened in comparison to this part. So why it is so because it used to place the pipe where pipe sits, okay. As you can see in this diagram, here you can see this socket is there and over this socket this pipe sits. So what is the advantage of this that when we weld the pipe with the flange, it has welding. So that welding joint will give some irregularity in the flow.

If I do not want if the operation does not require that, we can use for socket type of flange, where pipe sits in the flange and flow characteristic between pipe and flange will not be disturbed due to any connection. So in that connection we used socket weld flange.

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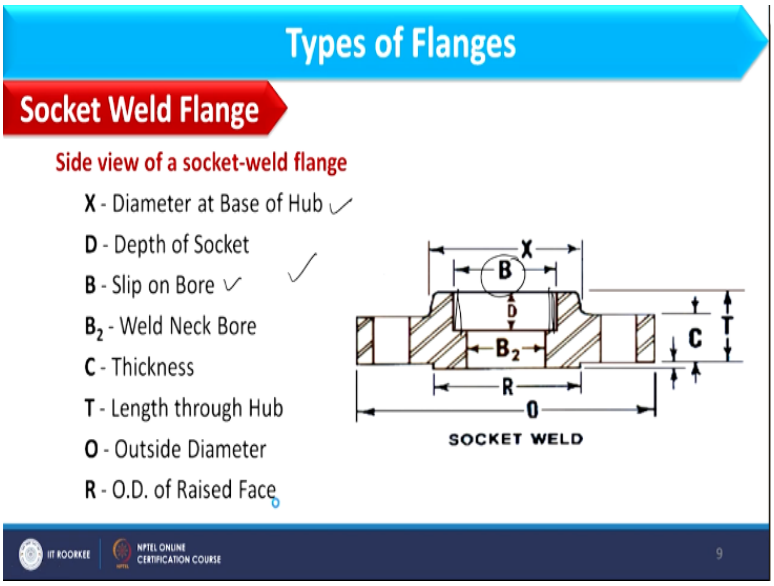

Here I am having the schematic of socket weld, where different parameters are there and other parameters we have already discussed. Here I am having T, which is total height of the flange. Now in that case we have two bore diameter, here B is basically slip-on bore, it means pipe basically sits over here. So pipe basically slips over this. Therefore it is called slip-on bore and B2 is basically the bore diameter where flow will occur. So that would be weld neck bore. Other parameters we have already discussed in previous flange, so you can correlate that.

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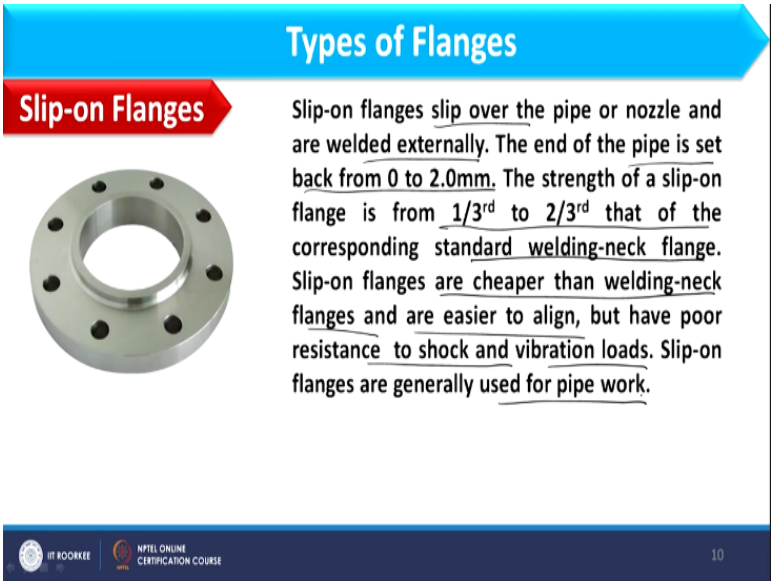

Next I am having slip-on flange. Slip-on flange means what, it slips over the pipe. So in this case, if you see this is basically the plate section of the flange and here this is the bore diameter

and bore diameter will be slightly higher than the outer diameter of pipe, so that it slips over the pipe. So slip-on flanges slip over the pipe or nozzle and are welded externally.

So when such flanges slip over the pipe what happens, how it will be welded, it is welded external to the pipe. It cannot be welded at the mouth of the pipe, but external to the pipe. So in that case, again we do not have irregularity due to weld joint. The end of pipe is set back from 0 to 2 mm, what is the meaning of this that when it slips over the pipe it moves slightly higher than the pipe mouth, okay. So pipe is usually kept 0 to 2 mm back to the flange.

So strength of slip-on flange is from 1/3rd to 2/3rd that of corresponding standard welding-neck flange because it slips on so it cannot sustain shocks or vibration or very high operating condition. So slip-on flanges are cheaper than welded-neck flanges and are easier to align, but have poor resistance to shock and vibration loads. Slip-on flanges are generally used for pipe work.

So these are used where extreme conditions are not faced or not allowed. So use of this type of flanges should be limited to moderate services where pressure fluctuation, temperature fluctuation are not severe, so that we have already discussed.

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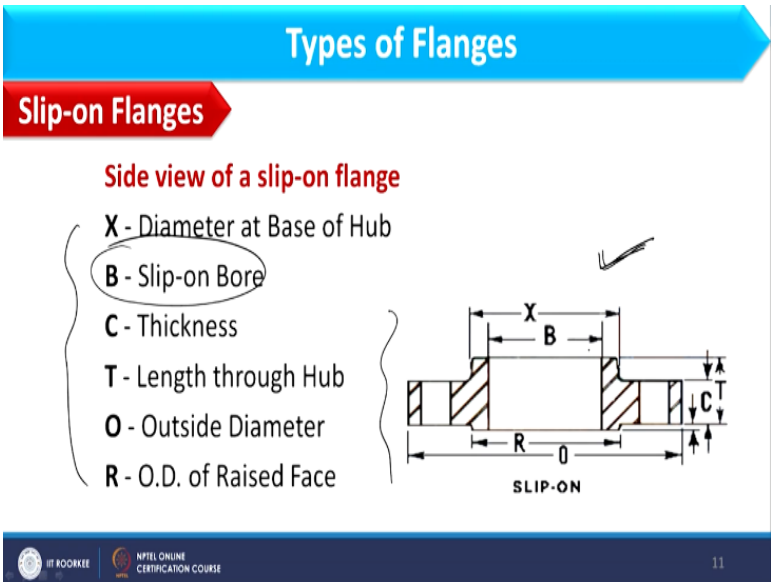

So in this slide I have shown the side view of flange, where different parameters are mentioned over here and these are also shown in this image, so I think all these parameters we have already

discussed. Only thing you need to keep in mind b is basically slip-on bore, okay. So that would be slightly equal to the outer diameter of pipe.

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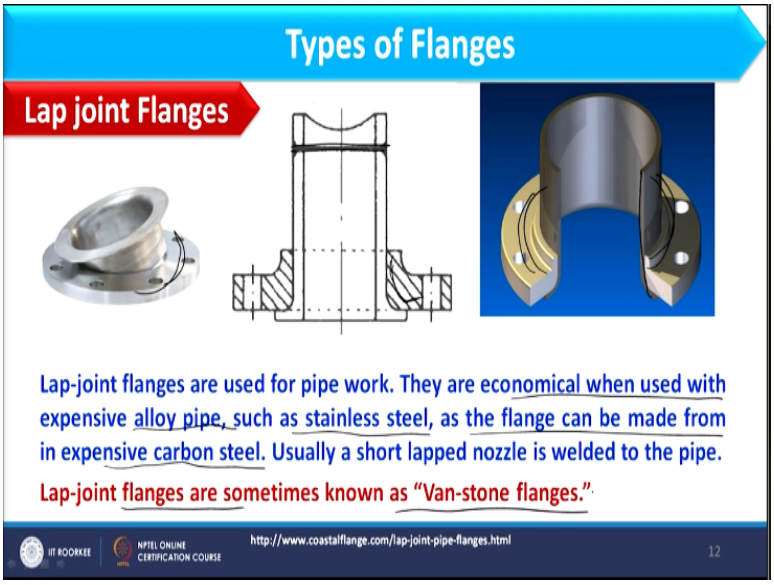

And now I am having lap-joint flanges. This type of flanges have two different sections. As you can see from this image that this is basically the disc and this is another section which we call as lap. So with the pipe this lap is connected as you can see from this schematic that here we have the connection of this lap as well as pipe, and this disc basically slips over the lap, okay. So it is more clear in this image. Here you see this lap and here we have the flat section of the flange.

So lap joint flanges are used for pipe work, they are economical when used with expensive alloy pipe such as stainless steel as flange can be made from inexpensive carbon steel. So what happens, till now whatever flanges we have discussed it has single material, and if I am using flange of very specific material or very costly alloy in that case lap as well as flange that can be kept of different materials in that case only lap joint will be applicable. Lap joint flanges are sometimes also known as Van-stone flanges, okay. So this is the use of lap joint.

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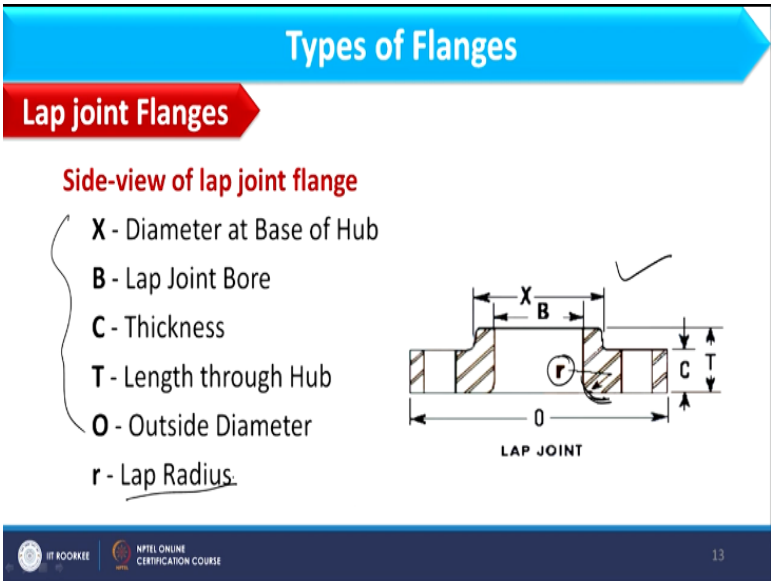

Here we have this side view of this where different parameters are there and here apart from all these parameters we have this knuckle part or we have this round section also. Because of this round section lap as well as plate of flange can be connected nicely, which is also called as lap radius.

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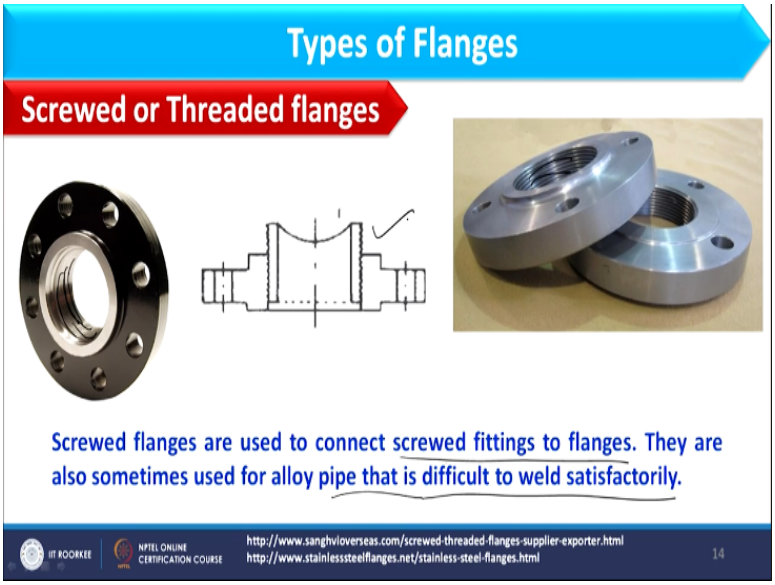

Now we have screwed or threaded flanges. Screwed flanges are used to connect screwed fittings to the flange. They are also sometimes used for alloy pipe that is difficult to weld satisfactorily. So it is basically used when we have a specific alloy which has difficulty in welding, you can understand in that way, which has difficulty in welding, so that flange can be joined with the pipe through screwing it. Only screwed fitting will be required at that condition.

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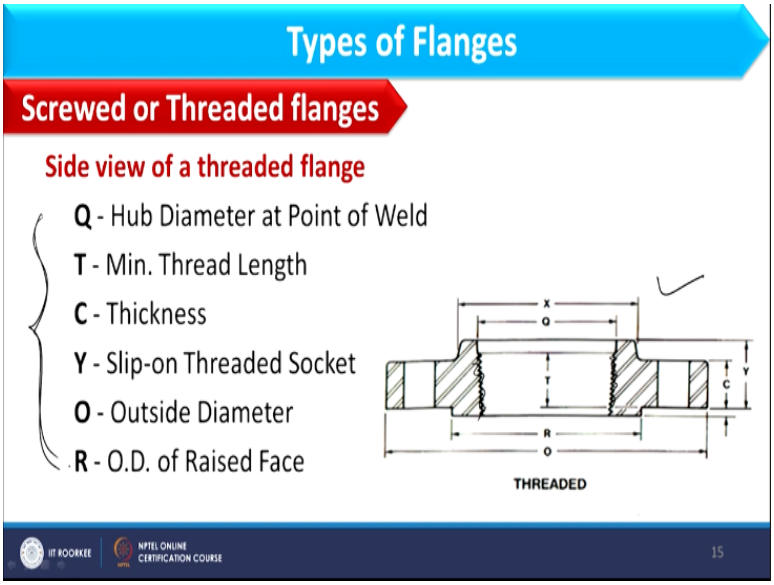

So here we have this flange, it is simply like slip-on, there is nothing different in design except that screwing part. Wherever it is connected to the pipe there we have the screw as it is shown over here and in this schematic. And here in this diagram again I am showing the side view of screwed or threaded where these screwed are shown and parameters are almost similar as we have discussed in previous slides.

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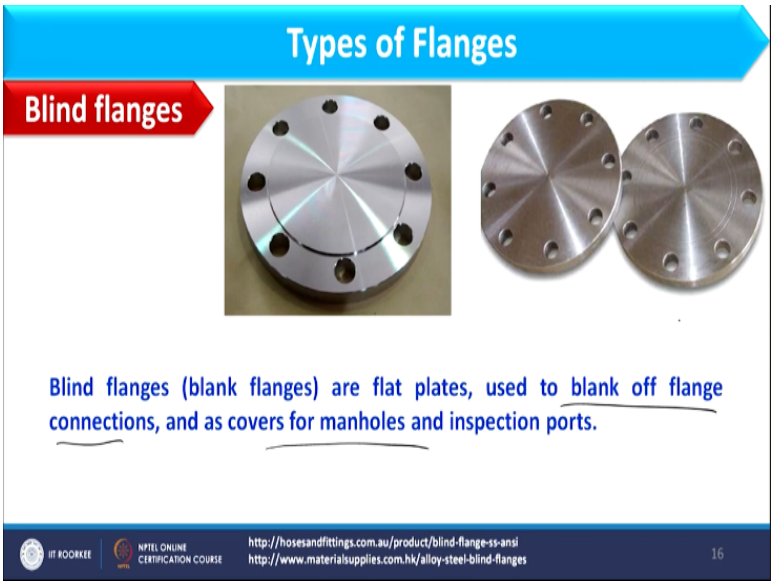

And now we have the blind flanges. So blind flanges are basically those flanges which does not have the provision for fluid to flow or fluid to pass through. So these are basically used for covering things. So blind flanges or blank flanges or flat plate used to blank of flange

connection and as covers for manholes and inspection ports, so these are basically blind flanges, okay, which does not have provision for flow, okay.

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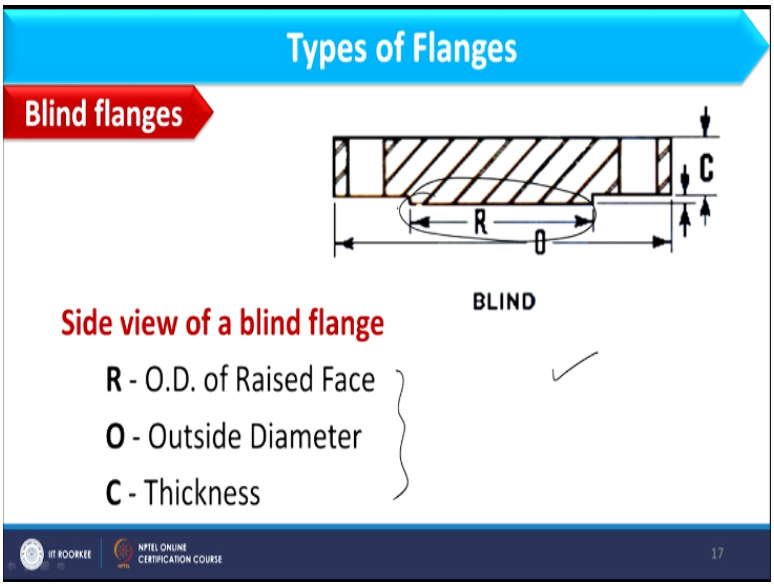

Here we have this schematic of blind flow, side view of blind flow, where different parameters you can understand. In all these flanges you must have seen this R that is raised face and I have not spoken anything on that, that we will discuss in detail when time comes. So till now please bear this raised face as it is. Here I am stopping part 1 of design of flanges, and this is also the end of lecture 2 of week 3 and that is all for now. We will continue discussion on design of flanges in upcoming 3, 4 and 5 lectures of this week. That is all for now. Thank you.