Manufacturing Guidelines for Product Design

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Lecture-30
Design Guidelines: Brazing and soldering

Namaskar friends, welcome to the last session for our week 6 and today we are going to discuss the design guidelines for brazing and soldering. So just to have a brief recap of what we have discussed in week 6, our focus primarily was on design guidelines for the various joining processes. And if you remember in session number 26 that was the first session for week 6 we have talked about the review of the various joining processes in which we have seen the basic definitions of welding, mechanical, fastening, adhesive joining.

After week number 27 we talked about the various design guidelines or the joint configurations that we must use when we are doing the adhesive joining. There after we talked about the guidelines for mechanical fastening specially we talked about the riveted joints that what are the design guidelines that we must keep in mind for riveted joints. And there after we talked about in the previous session if you remember the welding.

So, we know that when we are designing a product and the product has to be made in 3 or 4 different sub assemblies or parts or components. So these components have to be designed in such a way that they can integrate into one another in a easier manner, easier means that we are able to assemble them properly. And for design for assembly guidelines we have already discussed during our third week of discussion in this course.

So therefore our target is to make the design as simple as possible as easier as possible to be assembled together. And for that we have seen that there are standard guidelines for product designers which must be kept in mind when the product is being designed. So that at a later stage it becomes easier for us to assemble the parts together. Now today our target is brazing and soldering, now some of you maybe wondering that what is the difference between welding and brazing and soldering processes.

So first let us try to understand the difference between that 2, so in welding if you remember the definition there is a source of heat and we try to join the 2 materials together. Now these 2 materials can be similar or dissimilar, so we have a source of heat which can be electric arc or a flame produced by the combustion of gases. So we have a flame or arc which a source of heat it can be sometimes in unconventional welding processes or advanced welding processes.

The source of heat can be laser, it can be electron beams of the source of heat can be anything, there is 1 source of heat, 2 parts to be joined together we bring the 2 parts together in a good fit up and then apply the source of heat. Once the source of heat is applied the 2 parts get fused together maybe after melting in electric arc welding or fusion welding processes the parts will melt and they will solidify at and form a joint.

Now that is the most important difference between brazing soldering and the welding process. In welding especially in fusion welding processes the parts will be melted together at the joint interface and then the molten material or the weld pool will solidify and will form the weld bead. So there are 2 more terms I have used weld pool and weld bead, so the final geometry of the welding that we see is called as the weld bead.

So therefore in case of welding we are joining the 2 parts together by fusion welding technique where the 2 parts are melted and the molten material solidifies to form the joint between the 2 parts. Sometime we may apply pressure we may not apply pressure, we may use a filler material, we may not use a filler material, but definitely most of the cases we will have heat as one of our important input.

So, that is the basic welding process which we have already covered in the previous session. But in case of brazing and soldering the 2 parts that we are joining together. Suppose these are the 2 parts that we are trying to join, these will not be melted, so we will not heat them above their melting temperature. These 2 parts will be brought together and the third material a filler material which can be either a solder or it can be a braze alloy.

So, we will use an additional alloy that will be melted and it will flow in the gap between these 2 parts together. So, these 2 parts we are joining together these are lap joined configuration, during brazing or soldering the additional alloy will melt and will flow inside this gap and we will settle down there and will form the joint between the 2 parts under the lap joint configuration.

So, the material will flow because of the capillary action and will form the joints, so this and this are not getting melted as in case of fusion welding we usually try to melt the 2 parts to be joined together. And then this molten pool solidifies to form the weld joint, so this is the maybe a basic difference between the welding process and the brazing and soldering process and therefore the guidelines will also different.

Because there we are not going to melt the 2 parts to be joined together, so they will remain as they are but we have to melt the additional material and that material has to flow which can be an alloy to form the joint between these 2 parts. So, therefore we will try to understand what is a difference between brazing and soldering also, by now we have been able to differentiate between a fusion welding process and brazing and soldering on one side.

Now within brazing and soldering what is the difference between brazing and soldering that also we will try to understand in the course of today's session. Let us start our sessions as is we are following the basic approach first we talk about the process maybe for 2 or 3 or 5 minutes and then we go to the guidelines. So, let us first talk about the 2 processes that we are going to discuss today that is brazing and soldering.

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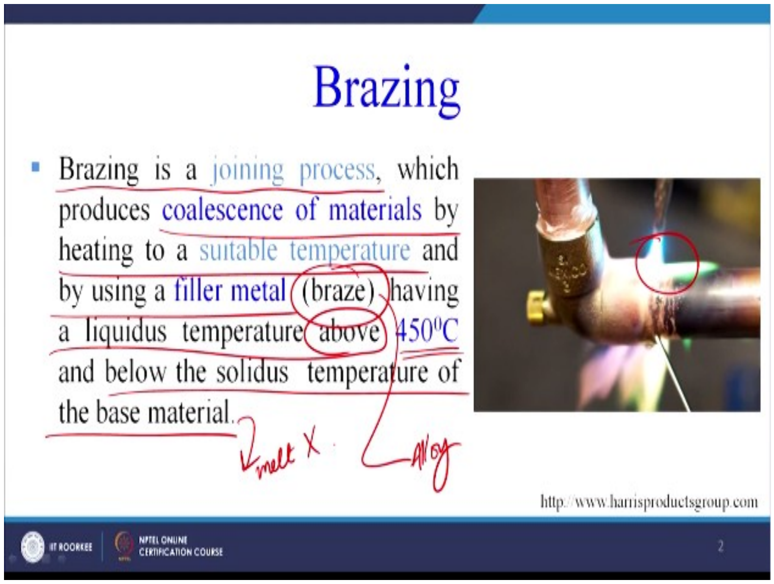

Now first let us see brazing this is you can see a brazing being done at this particular point. Now what is brazing, brazing is the joining process which produces coalescence of materials by heating to a suitable temperature and by using a filler metal. So, we use a braze alloy this is a filler metal having a liquids temperature above, this above you must keep in mind, one thing is we are using an additional alloy here which we are calling as a filler material.

And the temperature is above 450 degree centigrade, this is a liquids temperature of the braze alloy and below the solidus temperature of the base material. So, solidus temperature of the braze material, so braze material we are not going to melt in case of brazing and soldering the 2 part we will see with the help of various diagram. The 2 parts to be joined together will not melt but the alloy will melt and it will go into the joint and will form the joint there.

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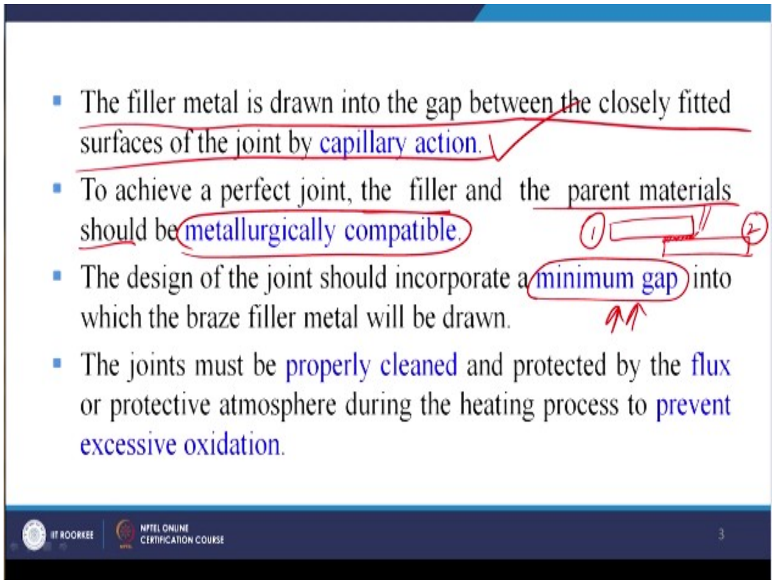

So, this is the basic definition, the filler metal is drawn into the gap which I have already explained the filler metal is drawn into the gap between the closely fit surfaces of joint by capillary action. So, the closely fit surfaces these are maybe in the lap joint these 2 surfaces are closely fit there is a very small gap between the 2 parts to be joined together, 2 surfaces to be joined together and we put or additional alloy into this joint which is a braze alloy.

So we put that alloy into this by the help of a capillary action and this will go and form the joint between these 2 parts which we want to braze. So to achieve a perfect joint the filler and the parent materials must be the filler as we have already seen and the parent materials which we are joining together must be metallurgical compatible, so we have to ensure that they are metallurgically compatible.

The design of the joint should incorporate a minimum gap into which the braze filler metal will be drawn. So, the most important design guideline is the minimum gap has to be ensured between the 2 parts to be joined together. Now let us see these are the 2 parts that we want to join together part number 1, part number 2. Now this is the minimum gap that have to be ensured, so that our alloy can rush into this by the action of capillary and then they it sets there and forms the joint between these 2 parts.

So, the design of the joint must incorporate a minimum gap into which the braze feeder metal will be drawn. The joints must be properly cleaned and protected by the flux or protective atmosphere during heating process to prevent the excessive oxidation. So, we have to do the welding or not for the welding sorry the brazing or the soldering action under a protective environment, so that excessive oxidation does not take place, we can do it under the flux also.

So that a proper joint is formed, in many cases in case of welding we have flux coated electrode which try to create a protective environment around the weld pool. So that the contamination of the molten metal does not take place, similarly in case brazing and soldering we must ensure that we do our operation of brazing or soldering in a controlled environment or under the flux. Now again that is brazing similar is the mechanism of soldering also.

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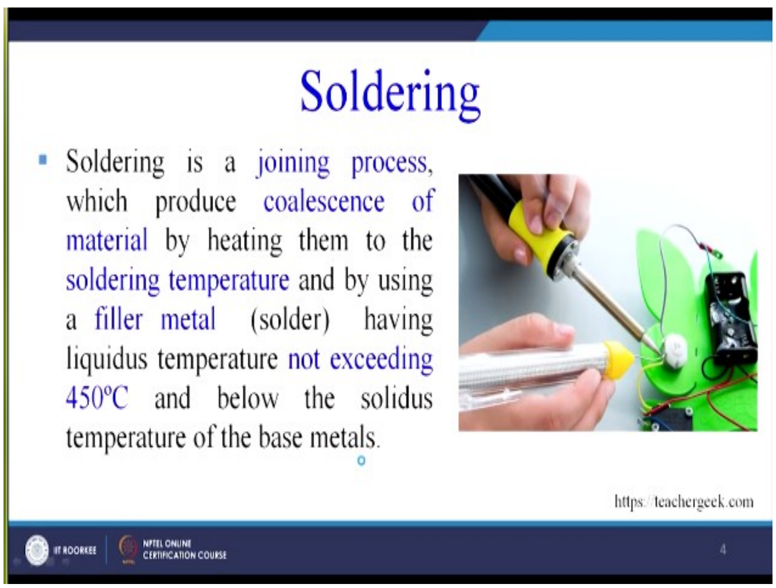

Soldering, a joining process which produces a coalescence of material by heating them to a soldering temperature and by using a filler metal, solder having liquidus temperature not exceeding 450 degree. Now if you remember in case of brazing the temperature was greater than 450 degree here it is not exceeding 450 degree and below the solidus temperature of the base material.

So, this is same below the solidus temperature of the base metal this is same but here this is the difference between brazing and soldering in case of brazing the temperature is greater than 450 degree centigrade. In case of soldering the temperature of the liquidus temperature of the filler metal or the solder is less than 450 degree centigrade. So, here we can see this is a solder and this is a soldering iron, so it is heated and this is the point we are pushing maybe by capillary action the molten solder is pushed into the parts that are joined together.

Now I think the process part is clear what is brazing, what is a soldering, what is a difference between brazing and soldering. And in general what is the difference between welding as well as brazing, soldering.

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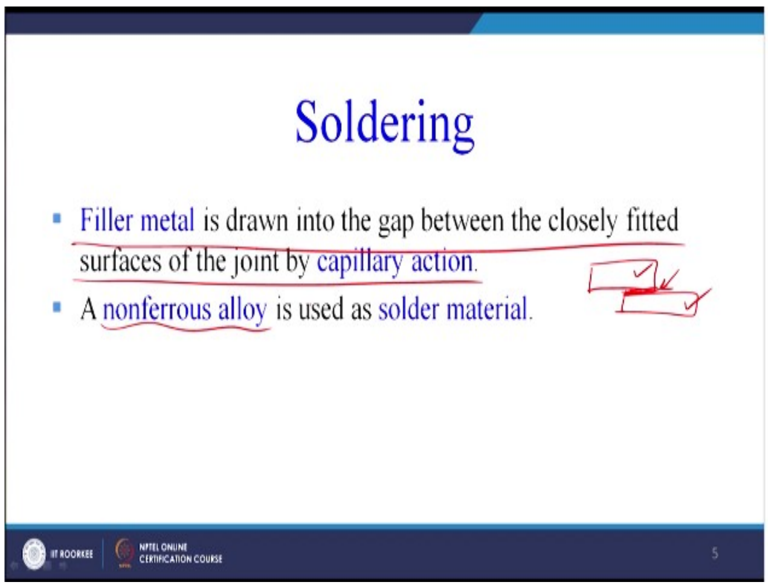

So, let us now try to see what are the design guidelines but before we go to that this is again a reputation of what we have covered for brazing. The filler metal is drawn into the gap between the closely fitted surfaces of the joint by the capillary action. Again same diagram I am drawing, so the metal will flow into this gap using the capillary action. So, this is not going to melt only the filler metal will melt and will move into this gap and form the joint.

A non-ferrous alloy is used as the solder material, so you can check that what are type of alloys we use for solder which can be or for soldering action which can be one of the questions in the examination.

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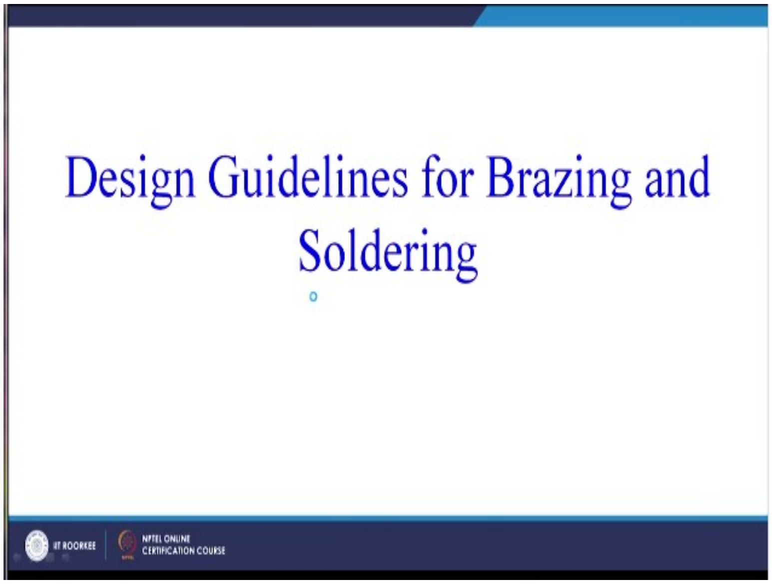

Now what are the design guidelines for brazing and soldering that we can try to understand, brazing and soldering are suitable for broad range of production quantities.

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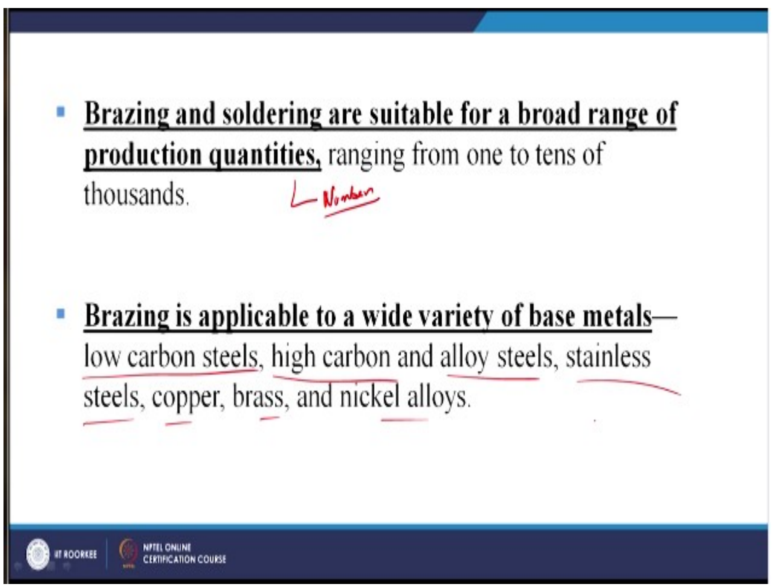

So, one thing is that it the number of parts that have to be made can range from a smaller number of parts to a larger number of parts broad range of quantities ranging from one to tens of thousand. Brazing is applicable to wide variety of base metal, so brazing can be used for low carbon steels, high carbon and alloy steels, stainless steel, copper, brass and nickel alloy. So, we can see it can be use for ferrous as well as non ferrous metals the brazing process can be done.

In case of if you remember in case of machining sometime we use the brazed tipped tools, so we have a sack and the tip of the tool is very very hard, it is brazed onto the shank, so there the application of brazing is there.

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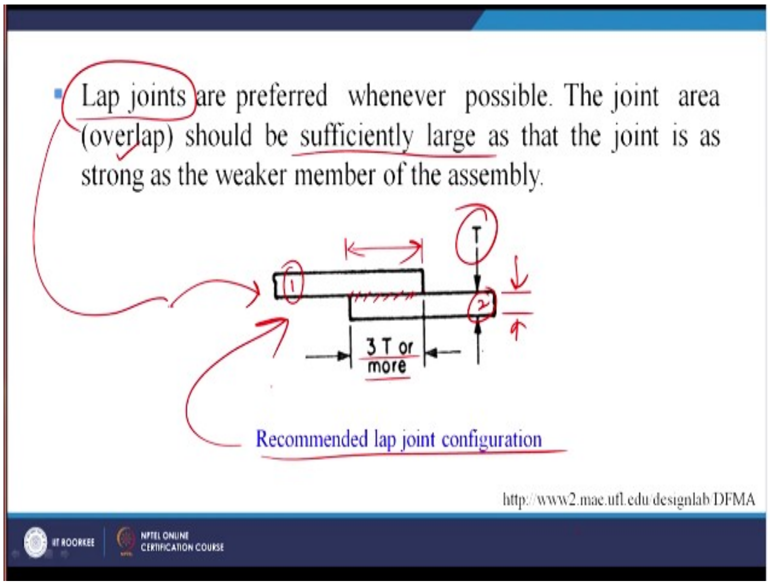

Now this is the first most important guideline we can see, we have seen that we can have different types of joint configuration and this week has been dedicated towards welding, brazing, soldering, mechanical fastening, adhesive joining. So, the joint configuration is very very important, so in case of brazing and soldering lap joints this is an example of lap joint, lap joints are preferred whenever possible.

So, wherever we design our parts which have to be brazed or maybe soldered we must take into account that if possible we must go for a lap joint configuration. So, lap joints are preferred whenever possible, the joint area this is the overlap area from here to here where the adherents, this is part number 1, part number 2. These are being joined at this cross-section or at this section, so the joint area overlap that is joint area specially the talking about the overlap should be sufficiently large.

As that the joint is as strong as the weaker member of the assembly, so the basically in order to have a good joint strength the overlap area or the overlap length must be sufficient or the joint area must be sufficient. Because in that area only our filler material has to be melted and flown using the capillary action and it will settle down there and form the joint between the 2 parts.

So, it is just 1 rough guideline is given if the thickness of this part is given it is T then this overlap area or overlap length must be 3 times T or more. So, if we can ensure that the length of overlap for the brazing or soldering joint is more than 3 times of thickness of the individual or the weaker part. Then in that case the joint strength will be sufficiently high, so recommended lap joint configuration is shown here.

So, whenever our brazing soldering operations have to be done and we have a choice to decide that which type of joint configuration we may choose. We must always prefer the lap joints moreover another guideline there the overlap length between the 2 parts to be joined together must be greater than 3 times the thickness of the parts.

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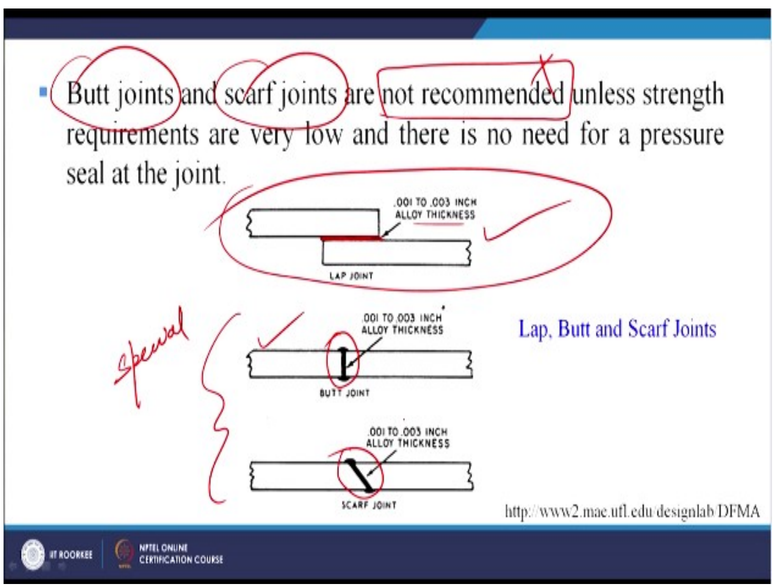

Butt joints and scarf joints are not recommended very very important butt joints scarf joints not recommended unless strength requirements are very low. So, wherever the load there is no load that is going to come on this joint, in that case we may somehow and there is a necessity that we must join the 2 points together under the butt configuration. We can go for butt configuration also but the joint strength will be considerably less as compare to the lap joint configuration.

So, unless strength requirements are very low and there is no need for a pressure seal at the joint, so when you do not need to have a pressure seal at the joint or the joint strength requirements are very low. In that case we can even go for butt joint configurations during our brazing and soldering operation, so we can see lap joints always advisable. So, we can see the gap thickness also is given.

This is a thickness at whichever because of the capillary action our filler material will flow. So, 0.001 to 0.003 inch alloy thickness. So, here we can see this is a butt joint configuration wherever strength requirements are low, we can go for butt joint also and wherever possible we can go for a scarf joint also. So, we can most commonly recommended is the lap joint configuration but in special cases we can go for a butt joint or the scarf joint also and the gap thickness is also mentioned and here.

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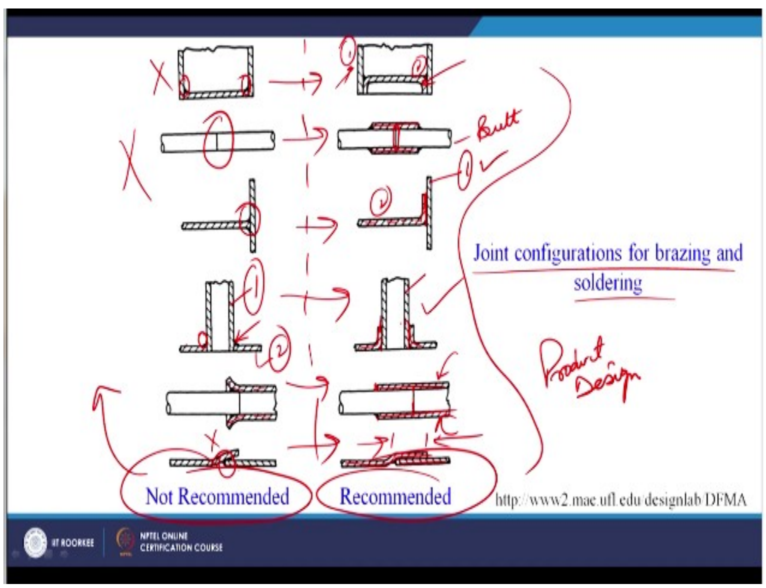

Now here we can see joint configurations for brazing and soldering these are the various recommended. This is the dividing line, this is recommended and this is not recommended, why not recommended we can see here we are trying to do our action here which is difficult to do. So, here if we can modify our parts which have to be joined together, these are the 2 parts this is part number 1, this is part number 2.

So, if these 2 parts can be redesigned, so that we can make a better joint here, so in that case we will be able to produce a better joint strength. So, here we can see this is not recommended because we will not be able to get a good joint strength in this case. But here we can see we can get a better joint because more area is in contact here and here we can see a simple butt joint as already told simple butt joint is not recommended for brazing and soldering.

So, we can make a joint like this and we can make a joint a butt joint configuration under special circumstances. So, we can make this type of a joint configuration, now this type of a joint if we make the joint strength will be very poor. But if we modify our part configuration and we can do the on this surface we can do our brazing or soldering it will give us a better joint strength.

Similar is the case here these are the 2 parts to be joined together, this is patriarchal number 1, this is part number 2 and this is the place where we are doing our brazing and soldering, so not recommended. So, what we are doing, we are converting it into a lap joint configuration only and doing the welding sorry brazing and soldering at these 2 point. So, this will give us better strength as compare to this type of a joint.

Similarly here also we can see these 2 parts can be redesigned they can b made straight and then we can do the welding here or the brazing and soldering can be done at this point where it is not possible. Because both these are solid but we can do our brazing or soldering at these points and these can help us to get a good joint configuration. Similarly here also if you do our brazing and soldering at this section not recommended we may not get an adequate joint strength.

But if we modify the 2 sections like this, this is the overlap area is increasing here and therefore the joint strength will automatically is directly proportional to the joint overlap areas. So, if we are able to increase the joint overlap area with the redesigning of our parts that we are joining using brazing or soldering. In that case our product will perform better our joint will perform better if our joint will perform better the product automatically will perform efficiently and effectively.

So, we can see that with modifications which are possible easily we can certainly improve the product design. All these if you take into account we improve the product design our efficiency of joining will improve our joining process will become easier and once our joining process will become easier. In that case our overall manufacturing of the product will become easier and the performance of the product with these type of joints will be better as compare to the ill designed part or the not recommended part.

But usually what we do when we are designing a product we ignore all these guideline and when we ignore all these guidelines we come up or we end up with the product which is poor at the joint. So, if we know that these 2 parts have to finally joined using the brazing or soldering operation, we must talk about or we must discuss we must look at these type of guidelines which will help us to redesign our part.

Now here we can see little modification in this case let us take this example, the this part, part number 1 remains same no modification. Only in part number 2 we have done a little modification but it will significantly affect the joint strength between part number 1 and part number 2. Similarly here also this part remains same only these 2 parts we have modified and we will get a better joint strength.

So, basically when we are designing our parts and we know that these parts have to joined by brazing or soldering. We must have a look at the guidelines that are available for brazed or soldered joints. So, if we take those joint if we take those guidelines definitely we will be in a much better position during our manufacturing or the assembly of our parts. So, we can further see that there are other guidelines also the higher temperature of brazing can cause distortion.

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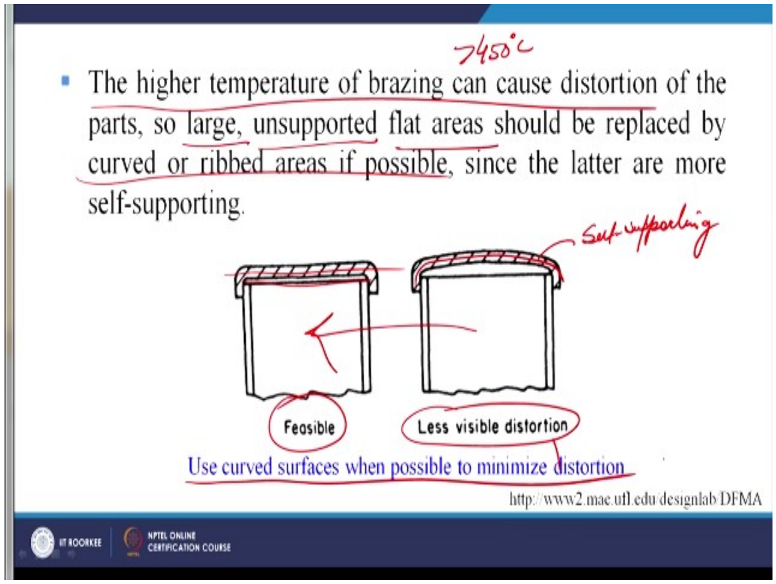

So, we have seen that in case of brazing the temperature is greater than 450 degree centigrade, so the higher temperature of brazing sometime can cause the distortion. So, large unsupported flat surfaces so here we can large unsupported flat surfaces should be replaced by curved or ribbed areas if possible, this is a curved area. Since the later are more self supporting, so this becomes a self supporting part.

So, when we have a self-supporting part it is less prone to distortion as compared to a flat part like this. So, this can also be done it is a kind of a flat configuration as similar to a lap joint configuration only we can do it. But if possible this is more convenient and we lead to less distortion as compared to this joint configuration. So wherever possible we must minimize the use of large unsupported flat surfaces and wherever possible we must change those large unsupported flat surfaces to the curved surfaces with ribs or the ribs areas.

So, that we are able to avoid the distortion because of the higher temperature which is seen in case of brazing, so use of curved surfaces when possible to minimize the distortion.

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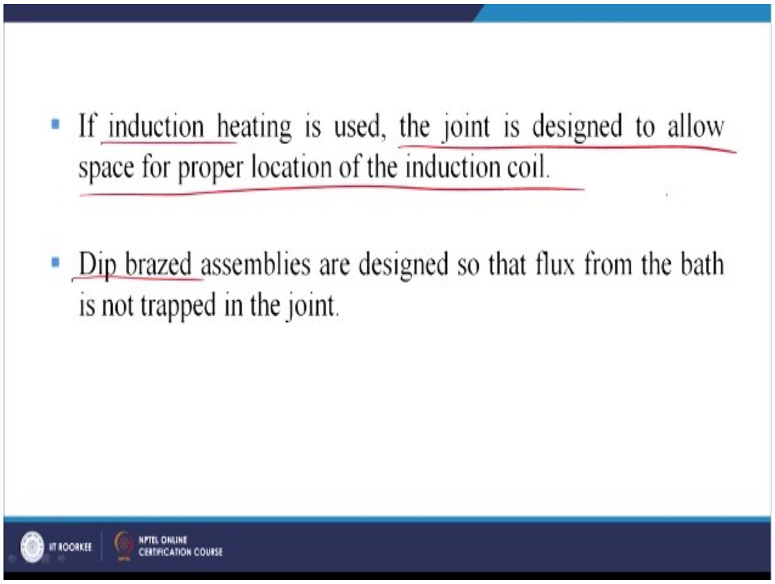

Now this is something related to different types of the brazing or soldering process we are not going to the details of the processes. Because soldering can be done in more than one way and brazing can also be done in 5 or 6 different ways. So, maybe induction based brazing is 1 technique then dip brazing is another technique but there are guidelines related to the processes also, so if induction heating is used.

So if we are going to do induction heating, so the source of heat is induction the joint must be designed to allow space for proper location of the induction coil. So because the heating has to be produced by the induction coil, so we must design our part in such a way that we can use the induction coil to heat the location properly. So, that our filler material can melt and flow into the gap between the joint and may form the joint between the 2 parts.

So therefore a location of the induction coil has to be ensured when we are designing our parts. Similarly in another process dip brazing, so when the dip braze assemblies are designed, so that flux from the bath is not trapped in the joint. So, we have to see that in dip brazing we will dip the complete assembly of the 2 or 3 parts that we own to join using the dip brazing technique in a bath.

So in the bath we have to deign them, design these parts in such a way when we are dipping it in the alloy that is during the dip brazing process. They have to be designed, so that the flux from the bath is not trapped in the joint. So those things have to be taken care of, so we right now I am not having an image to explain the dip brazing process. But such type of guidelines do exist for different types of soldering and brazing processes.

And these guidelines must be kept in mind when we are designing our parts because if this is maybe we have some kind of a flux trapped in the joint. And when we are using this part the part may not be able to take up the designed load for which the part has been designed and at a later stage may lead to the failure of the joint also.

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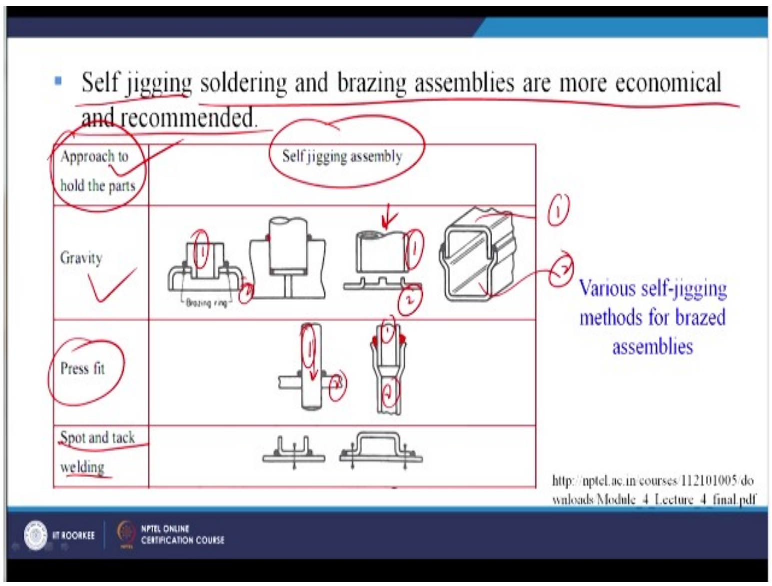

Now this is the last guideline that we want to cover self jigging, soldering and brazing assemblies are more economical and recommended. So we have an example of self-jigging assemblies here, so what is the approach to hold the parts together. So, if we talk about gravity this is part number 1, this is part number 2, so our part number 1 and part number 2 can be assembled using the concept of gravity, this is just 1 geometry, this is another one.

Here we are trying to do our brazing action which it is shown in black color and these are the 2 parts with this one is coming from top and getting fix, this is part number 1, part number 2. They are assembled together and then we do the brazing action and here we can see this is part number 1, this is part number 2 and how they are getting fixed into one another self jigging soldering and brazing assemblies.

So, automatically they will fix with each other and then at the joint interface wherever there is a gap we will try to form a joint with the help of melting of the filler material. And the filler material then moves into the gap areas to form the joint by the capillary action which we have already seen. So, we can have a gravity based assembly of the self-jigging assemblies, we have press fit type of joining for the self jigging where we can see this is part number 1, part number 2 press fit into this.

This is another one here we can do our joining process, this is part number 1, part number 2, so they are join press fit into one another and then the gap which is created as used for making the joint. This is the place where our brazing or soldering will take place then spot and tack welding many times we may try to join the 2 parts together using the spot welding or the tack welding procedure.

So, one small place weld nugget we will deposit at we will join the two parts using a weld nugget or the resistance spot welding. Now these 2 parts are fixed together then we will weld not in the weld but we will braze or sold solder the assembly wherever there is a gap between the 2 parts which we have assembled together temporarily with the help of spot or the tack welding.

So, this is this slide is just showing that when we are joining the 2 parts together first we have to bring the 2 parts together. There will be a designed gap between these 2 parts and then that gap we have to fill using the capillary action of the filler material. After the filler material is melted this material will flow into the gap and will form the joint between the 2 assemblies.

Now how these assemblies have to be brought together and how these assemblies have to be designed. So that they have brought together in the most convenient manner, that is what we are trying to understand here. So here we are trying to see that what is the approach to hold the parts together, in many cases we may take advantage of the gravity. So, 1 part is placed like this other part comes from top because of the gravity it gets fit into this.

And then there is a gap which is created between the 2 parts is filled by the capillary action of the filler material. Similarly we can use press fit the 2 parts together we can do spot or tack welding at 1 or 2 points and the 2 parts are fixed together and then we do the brazing and soldering of these 2 subassemblies, there are other methods also.

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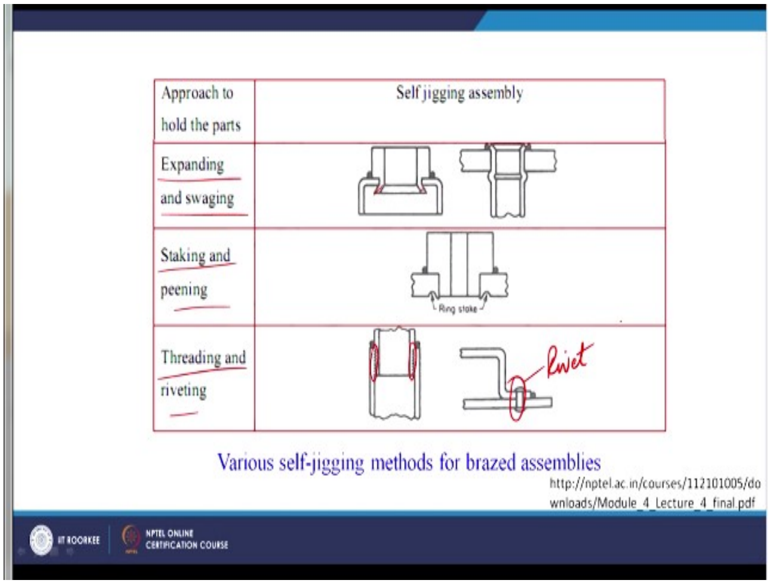

We can do expanding and swaging, so we can see here we expanding and swaging can be done to fix up the 2 parts together. Then staking and peening can be done then threading and riveting can be done, we can see there is a threaded here and this is a rivet. So, you know now what is the rivet and what are the design guidelines for joints which have to be joined using the riveting procedure, so these are the various self jigging methods for the brazed assembly.

So, the basic summary is that we have to bring the 2 parts together, so that we can do the brazing and the soldering action. So, these are the various self jigging methods for brazed assemblies, so when the brazing process has to be done we have to bring these 2 subassemblies together and these are some of the techniques that can be use for bringing the 2 assemblies together which have to be finally brazed.

So, with this I think we will conclude the today's session as well as the discussion for week number 6. So, just to summarize what we have covered in week number 6, we have done the review of the various joining procedures or processes where we have seen welding. We have seen adhesive joining, we have seen brazing and soldering, we have seen mechanical fastening and then in the subsequent 4 weeks sorry 4 sessions.

First session was review of the joining processes, then in the 4 sessions w have covered 4 different processes. In the first we talked about that is session number 27, we talked about design guidelines for adhesive joining, session number 28 we talk about design guidelines for mechanical fastening. In which we have seen the design guidelines for riveted joints, design guidelines for threaded fasteners.

And then we talked about the design guidelines for welding process in session number 29 and today in session number 30 we have discussed about the design guidelines for the parts that have to be joined together by brazing and soldering. And towards and we have seen that how the parts must be designed when they have to be brought together for the brazing operation, some examples have been taken.

And the standard methodology of self jigging that how the two parts can be fixed up together, what are the various approaches we have try to finish up the discussion for week number 6. In our subsequent weeks that is week number 7 and week number 8, our target will be same we will focus on different types of processes and the design guidelines thereof. And if you remember we have already classified the processes and we have tried to cover most of them.

We have tried to cover the primary forming process, we have try to cover the material removal processes, we have tried to cover the joining processes. Similarly we will try to cover the finishing and other processes which fall under the broad umbrella of manufacturing processes. Our target is to acquaint the learners with the various guidelines or the kind of information that is available, we are not able to cover all the information.

But our target is to give you a glimpse of the type of information which is available which maybe in the public domain and as designers we must take care of that information when we are designing our parts or the products. Because this will help us to manufacture these parts or products in a much more efficient effective and productive manner.Thank you.