Manufacturing Guidelines of Production Design

Prof. Inderdeep Singh
Department of Mechanical and Industrial Engineering
Indian Institute of Technology-Roorkee

Lecture-28
Design Guidelines for Mechanical Fasteners

Namaskar friends, welcome to session 28 of our course on manufacturing guidelines for product design. So, as you were well aware now that we are trying to discuss the various guidelines which have been established for various manufacturing processes. Now 2 various I have used in this sentence, so we have seen that the manufacturing processes can be classified into different families.

Now what are these families, we have to shape the metal or the plastic, so there are few shaping processes. Then we have some joining processes where we try to join the 2 parts together to make the complicated product and third one are the finishing processes. So, till now we have not discussed anything related to the finishing processes but we have discussed numerous guidelines related to the forming processes.

If you remember we have discuss the guidelines related to the sand casting process that when the product is to be made by sand casting what are the important guidelines that we need to take care of. We have also taken care of the die casting or the permanent mould casting processes, so these are 2 processes which give shape to the metal. Then we have discussed the processes that give shape to the plastic where we can give shape to the different types of plastics.

We have seen compression moulding, we have seen extrusion, we have seen injection moulding and we have try to understand that what are the various design guidelines that must be kept in mind when we are designing a product which has to be ultimately manufactured by any of these plastic manufacturing processes. In the current week our target is to focus on the joining processes because for any product it is very difficult to be made as a modular product or as a near nut shape.

So, what we usually do we divide the product, we blast the product into it is individual components or subcomponents or parts. And then these parts or subcomponents are assembled together to get the final product which is fairly complicated. So I have taken an example of the camera which is recording this session and the camera is made up of as I can very easily see maybe 50 to 100 different parts together.

So, what these parts are manufactured by any of the processes that we have already discussed maybe by some of the parts maybe made by die casting process or some of the parts plastic parts may have been made by the compression moulding process or the injection moulding process. So, the shape has been made by any of the forming processes either for plastic forming or for metallic forming but now we have to join these parts together.

So for joining we have to ensure that the parts are designed in such a way that they are easy to assemble, many a times it may happen there the individual parts are designed keeping in mind the guidelines for the individual processes. But when the two well designed best designed parts have to be assembled together we find it difficult to assemble why because the designing or during designing process the joining guidelines have not been taken into account.

So joining of 2 different parts either made of the same material or made of the different materials of different geometries. So when the 2 parts have to be joined together we must be very careful that how the parts are going to mate to each other or how the parts are going to join with each other. So that is the basic purpose of discussing this week or discussing this week the sessions that we have planned or the overall discussion for this week.

So the target is to understand that what are the various joining processes which we have already completed in session number 26 where we have covered the review of the various joining processes wherein we have seen that we have adhesive joining, we have mechanical fastening and we have welding which gives us a permanent joint.

So, in session number 27 we focused on the adhesive joining that if the 2 parts have to be joined by using an adhesive what are the various precautions guidelines that we must take to account,

what are the steps involved in adhesive joining, what are the different types of joint configurations that we can use very easily for making the adhesive joints. As well as we have also seen that how we can modify the joint configuration depending upon the type of load that the adhesive joint is going to bear.

That how we can improve the bond strength between the various adherents especially in case of the adhesive joints. Today our target is the mechanical fasteners, so regarding mechanical fasteners we have already seen in session number 26 that what do we mean by mechanical fastening. So in mechanical fastening we can have either rivets which can be used for joining the 2 parts together or we can use the screw type of fasteners. So let us first quickly have a look at the various types of mechanical fasteners.

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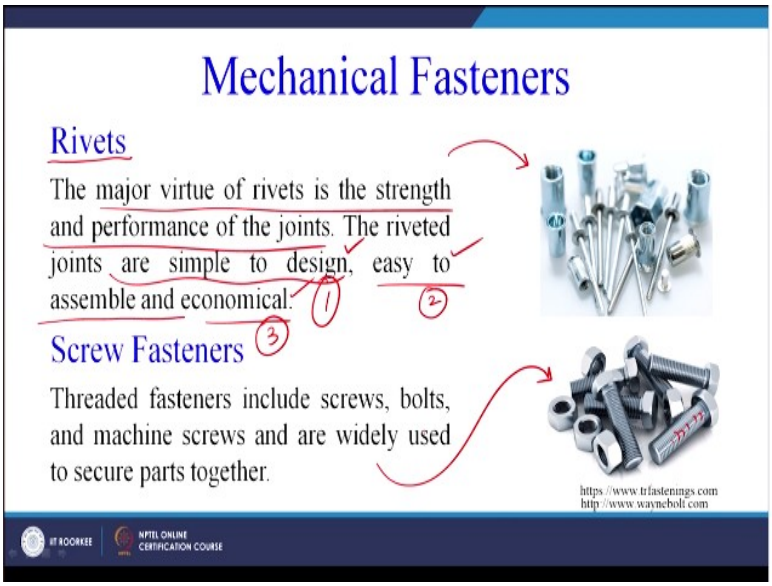

So, we have the rivets which we have already covered, the examples are given here, these are rivets we can see. The major virtue of the rivets is the strength and performance of the joints, so the rivets will give us very good performance of the joints. One of the examples of the rivets that we can usually see is when we cross the railway bridges over the river. So many times we will see strong round metallic rivets that are used for joining the various truss members of the railway bridge.

So, those are examples of the rivets, so we can see that bridge can take the load of a complete train. So which means that the joints are very strong, so the major virtue of the rivets is the strength and performance of the joints. The riveted joints are simple to design this is one advantage we can say one advantage that they are easier to join, easy to assemble and are economical, so simple to design easy to assemble and are economical.

So, somebody may ask us that what are the advantages of the riveted joints, so we can very easily tell that they are simple to design, easy to assemble and are economical. Whereas the screw fasteners are normally the threaded fasteners which include screws, bolts and machine screws under widely used to secure the parts together. The examples are given here, so where we can see the threads, so these are the threaded or the screw fasteners.

So depending upon the requirement we will choose the type of fastener that we are going to use. For example the rivets are semi-permanent type of fastening process. So using rivets if we feel that the fastening that we are doing need not require the disassembly of the joint maybe for a long period of time we may go for rivets. Whereas to ensure the maintenance and serviceability of the parts many times we may go for screw fasteners also which we can unscrew and we can disassemble the structure in order to facilitate the process of maintenance.

So depending upon the application we will choose that which type of fastener we are going to use. So first thing is depending upon the application, second thing is maybe the kind of strength required the kind of performance required from the joint will also define that which type of threaded fastener we should use or which type of rivet we should use. Because in the subsequent slides we will see that there are different types of rivets also which can be used.

Now depending upon a number of criteria we can very easily decide that which type of fastener we must employ for a specific application.

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So, let us now quickly see what are the various design guidelines for the rivets, so once we have to see once we have decided that among the rivets and the mechanical fasteners our joint has to be having a very long term good performance or we expect a long term application for this particular structure. So we have decided that we are going to use the rivets for our application, now let us try to see that when we have chosen rivets what are the design guidelines that we must keep in mind.

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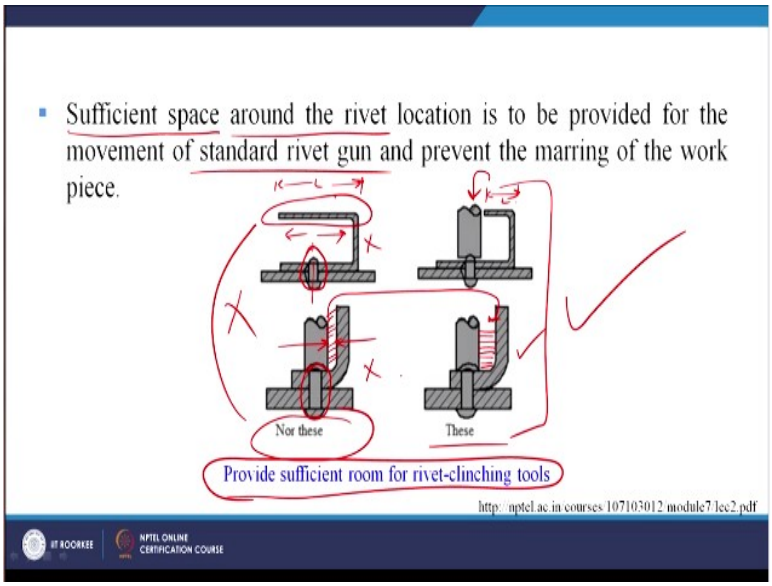

The first guideline you can see on your screen is not these, so this is something which is not required. These are the appropriate designs which are actually required, now what is the meaning of these I will try to explain. So sufficient space around the rivet, so this is the rivet in our case

here, this is the rivet. So, sufficient space around the rivet location is to be provided. So, around the rivet we must provide appropriate space in both the directions is to be provided for the movement of standard rivet gun is used for maybe fastening the rivet or maybe fixing the rivet at it is proper position.

And prevent the marring of the workpiece. So we have to decide that how much space around the rivet we must provide. So here we can see maybe there is no space for the rivet gun to complete the process, so here we can see by modifying we can change the position. So, here we can see what is the distance between the 2 the distance is this distance specially this distance is not adequate, whereas this distance has been modified here as per the design and we have more distance here.

So this is something which is a right design, here also we see because of this structural member we cannot use the rivet gun. So, if we can modify the design and position our rivet at a place, so that the gun can be used properly, it will be a better design. So we have modified in this is the length of this member whereas here the length has been significantly reduced. So we have to provide sufficient room for the rivet clinching tools.

So the tools which we are going to use for the riveting process or the rivet clinching process those have to be provided with the sufficient room and it is very very clear from these 2 diagrams. Here also there is no room available, here also very less room is available for the rivet clinching tool to perform its function. But here sufficient place, here also the distance is adequate and the rivet clinching tool will be able to perform it is function without any problem.

So these are the design modifications we can see in the product design which will help us to facilitate the riveting process for the assembly of our some parts. So these design modification because there you see this is a product, this is also product 1 part of the product second part of the product A part of the product, B part of the product. So the product design has been modified to ensure the clinching or the rivet clinching of the rivets, so these are the first guidelines.

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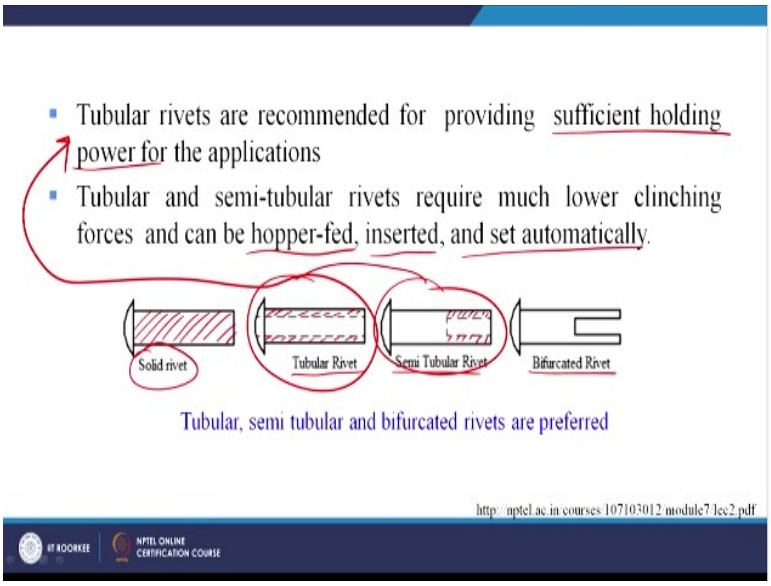

Then second is we can see there are different types of rivets, this is a solid rivet you can see, this is solid portion here. And this is the tubular rivet we can see, this is a section here tubular rivet can be see, then we can see semi tubular, then we can bifurcated rivet. So, we have different types of rivets and their usage will depend upon the different types of application depending upon the application we will choose the type of the rivet.

Now it is given here tubular rivets which one is, this is the tubular rivet, tubular rivets are recommended for providing sufficient holding power for the applications. So wherever sufficient holding power is required there we will go for the tubular rivets. Tubular and semi-tubular rivets say this is a semi-tubular, so tubular and semi-tubular rivets require much lower clinching forces and can be we can see how they can be applied hopper-fed or they can be inserted or they can be set automatically.

So these 2 types of rivets that is a tubular rivet and the semi-tubular require much lower clinching forces as compared to the solid rivet and can be hopper-fed or they can be inserted and can be set automatically. So their application is also quite easer as compared to the solid rivet, so tubular semi tubular and bifurcated rivets are preferred. So in various engineering applications where the rivets have to be use we can do our choice, we can do a selection among the different types of rivets.

Because there as engineers usually we are taught about the solid rivets only, so we can see here the different types of rivets we on usually do discussion related to solid rivets only. But we can have tubular, we can have semi-tubular, we can have bifurcated rivets which can give us different types of various application or different types of applications whereas solid rivets may not be that applicable.

So we can see less force is required specially in case of the hollow rivets that is tubular or semi-tubular rivets and they are easy apply also easy to use during the application.

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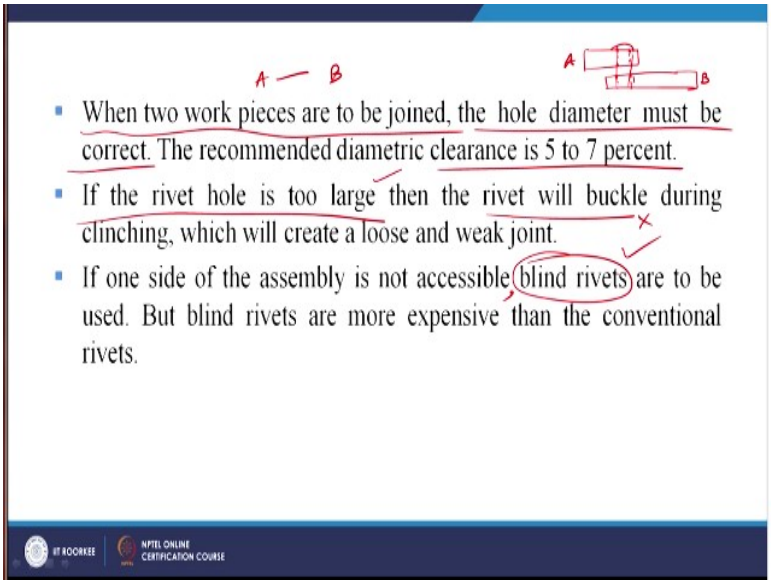

So, we can see when 2 workpieces are to be joined the hole diameter must be correct. So, here also we can see that once the rivet has to be used. We can just take the example this is maybe 1 part, this is other part, part number A, part number B, A and B have to be joined using the rivet. So, when 2 workpieces are to be joined in our case we have taken A and B they have to join the hole diameter must be correct.

Now we need to use a rivet, so we will have a hole here and the corresponding hole here, so these hole diameter must be correct. The recommended diameter clearance is 5 to 7%, so we will provide some clearance here in the hole. So, that we are able to fit our rivet here like this, if the rivet hole is too large, so if this is the clearance value is given here 5 to 7% clearance. But if it is too large if the rivet hole is too large then the rivet will buckle.

So, there are chances that when you are applying the pressure you are doing the upsetting motion, so the rivet may buckle. So, that buckling has to be avoided, so while which will create a loose and a weak joint. So, you are buckling process if there is a space between the clearance is too large and the hole is bigger you put the rivet inside.

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Suppose this is a hole and you put a rivet inside there is all around there is space available and when you maybe upset the head of the rivet there are chances that inside the rivet may buckle. So, buckling may take place which we have to avoid because otherwise it will give us a very very poor joint in terms of the joint strength that we can get. So, buckling has to be avoided therefore the size of the hole plays a very important role when we are doing the riveting operation.

So, if the rivet hole is too large then the rivet will buckle we will see this buckling in the subsequent slides also with the help of a diagram. So, if the rivet hole is too large then the rivet will buckle during clinching operation which will create loose and weak joint. If one side of the assembly is not accessible, now maybe in this case maybe both sides are accessible but in many cases we will see in our applications.

In today's session also towards the and that if there is if the both sides of the part or the assembly are not accessible you are not able to reach to both sides of the joint. Then blind rivets this is another type of rivet depending upon the geometry we have seen that we can have solid rivet, we can have tubular rivet, we can have semi-tubular rivet, we can have bifurcated rivet though those are based on the geometry of the rivet.

But based on the application we can have blind rivets also, where the blind rivets will be used these will be used where the assembly is not accessible from both the sides. The one side of the assembly is not accessible blind rivets are to be used but blind rivets there is one limitation are more expensive than the conventional rivets. So, we have to see that if we are going to use the blind rivets they are going to be costly as compared to our other conventional type of rivets.

Now there is another guideline that we have seen that various guidelines related to what we are currently trying to discuss are the guidelines related to the riveting operations. So, we have seen that the for the tool or the rivet clinching tool there must be appropriate space that must be provided during the design of our parts which have to be finally riveted. So, that is one thing then we have seen that we must provide a proper size of a hole with minor clearance.

So, that the rivet does not buckle inside because if the rivet will buckle inside it will create a loose and weak joint, now the other guidelines in is in case of riveting thick materials.

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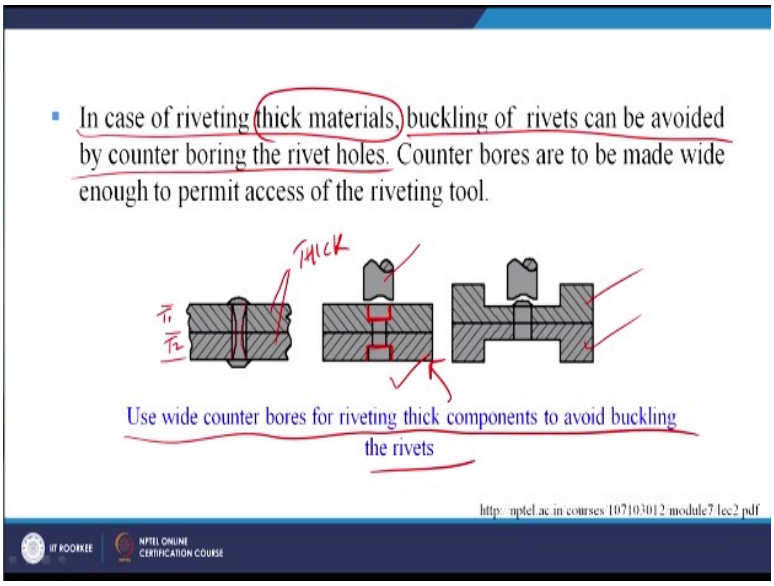

Now let us say another application area, the materials are thick, so in case of riveting thick materials buckling of rivets can be avoided by counter boring of the rivet holes. Now in case of thick materials we can see as we have seen in the previous slide that we must provide adequate dimensions or adequate diameter of the hole where the rivet has to go. If that there is extra clearance the buckling may take place, so here we can see this is the buckling action of the rivet. It may buckling may also take place if the thickness of our parts 2 parts you can see here T_1 and T_2 this is quite large, so which means that these 2 parts are thick.

So, if we are joining 2 thick plates using a rivet there are chances of the buckling of the rivet, so in case of riveting thick materials as we have seen here buckling of rivets can be avoided. The rivets may buckle when you are joining thick plates using the riveting operation but it can be avoided, how it can be avoided by counter boring of the rivet holes. Now this is a counter boring which has been done, this is a counter boring on the other side and this is our rivet clinching tool.

So, we can do this counter boring operation and this will avoid the buckling of the rivets or will avoid the buckling of the rivets. So, this we can see here this is one modification that we can do or the design modification in the parts to be joined using the rivets can also be done. So, use wide counter bores for riveting thick components, use wide counter bores for riveting thick components to avoid the buckling of rivets or we can do the design modifications in our parts to be joined by a rivets.

So that the thickness can be under our control, so the in order to avoid the buckling of the rivets during the operation or during the fixing of the rivets in the plates. So, that is one important guideline that we must keep in mind.

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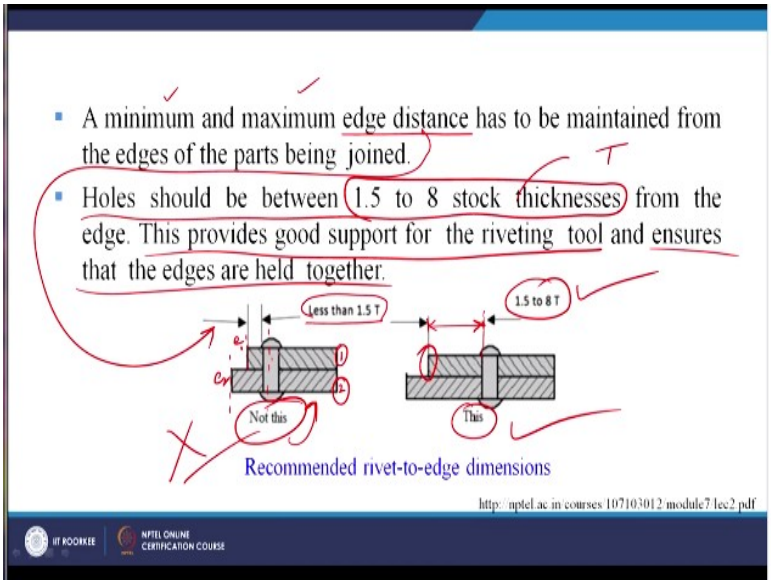

Then we can see here the distance from the edges this is the edge of the plate, this is again the edge of the plate what must be the distance of the rivet from the edge of the plate. So, here edge to edge distance has been calculated. So, this is less than 1.5 times the thickness T is the thickness of the plate. So, minimum and maximum edge distance which is given here, a minimum and maximum edge distance has to be maintained from the edges of the parts being joined.

This is part number 1, this is part number 2, so these are the 2 parts being joined and these are the edges maybe edge 1 and this is edge 2. So, they are saying that a minimum and maximum edge distance has to be maintained from the edges of the parts being joined. So, we have to maintain a minimum and a maximum distance which means that holes should be between 1.5 to 8 stock thicknesses, stock thickness is given by capital T here.

So, the holes must be 1.5 to 8 stock thicknesses, so this is means that this maybe 1.5 times T it is less than 1.5 times T. In this case, so which means it is not this, this is a wrong design because it

is too close to the edges of the plates that we are joining together using the rivets. But yes this is what is recommended you can see the distance between the edge of the plate, this is the edge of the plate and maybe the place where the rivet has been fixed.

So, this must be 1.5 to 8 times the stock thickness, so that will help us to avoid the effect at the edges. This provides good support for the riveting tool that is one and ensures that the edges are held together. So, why we must provide this edge to edge distance between the edge of the plate to be joined and the place where the rivet has been put, it must be 1.5 to 8 times of the stock thickness why?.

Because this provides good support for the riveting tool in the very first guideline we have seen that we must provide adequate working area for the rivet clinching tools. So, that it is able to perform it is function, so this provides good support for the rivet clinching tool and ensures that the edges are held together. Because if we do the riveting too close to the edges, the edges may tend to come up or dissociate or maybe kind of.

There may be the movement of the edges in the opposite direction like this because if we are joining too near to the edges. But if we are joining at a distance 1.5 to 8 times the stock thickness then this maybe movement of the edges or the opening up of the edges of the plates can easily be avoided. So, recommended rivet to edge dimensions are given here, many times we select this distance from the edge based on our intuition only.

But if we look at the standard guidelines we will be able to design our parts properly as well as design our joints properly, this is another guideline that we must take care.

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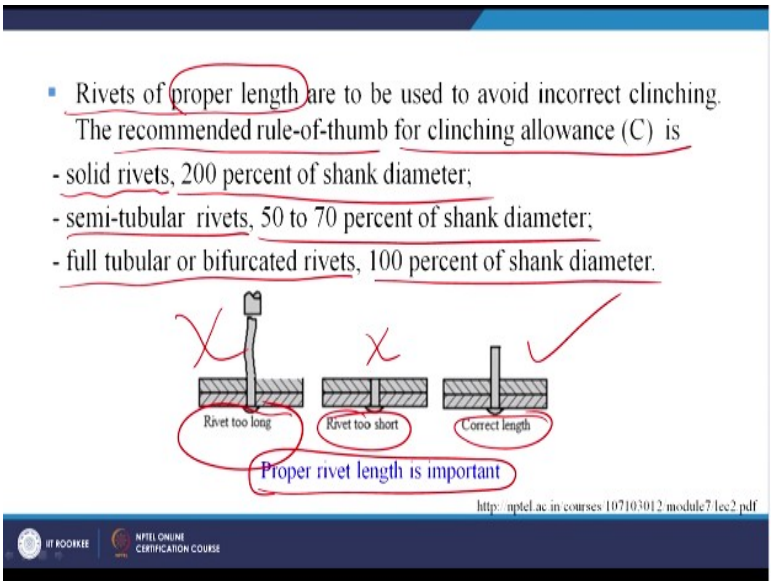

Then this is also very important rivets of proper length are to be used to avoid in correct clinching. Now we have talked about the diameter of the hole in which the rivet has to be fixed. We have talked about the distance of the rivet from the edge of the plate or the sheet, now we are talking about the length of the rivet. The rivets of proper length are to be used to avoid in correct clinching, the recommended rule of thumb.

So, this is a rule of thumb for clinching allowance C, so what is the rule of thumb, now we have seen that there are different types of rivets. So, if a different types of rivets we have different types of clinching allowance, now for solid rivets we can select 200% of the shank diameter. So, where rivet we will have a diameter, so it is length or the clinching allowance must be 200% of the shank diameter.

Then the semi-tubular rivets 50 to 70% of the shank diameter fully tubular or bifurcated rivets 100% of the shank diameter. So, our clinching allowance C that we are proving on the our rivet is indirect correlation with the shank diameter. Now depending upon the type of the rivet that we are choosing. For example this is the rivet we are choosing, the length will depend upon or the proper length of the clinching allowance C will depend upon the shank diameter.

And will be a percentage of the shank diameter also the allowance will changed based upon the type of rivet that we are using, in case of solid rivet the clinching allowance will be different. In

case of semisolid or maybe tubular rivet we can see semi-tubular rivet it will be different for fully tubular bifurcated rivet the clinching allowance will be different. So, we can see that if we do not select the length of the rivet properly the rivets of proper length we do not select what can be the problem.

Here we see the rivet is too long, rivet is too short not able to hold the 2 pieces together, this is the correct length. So, too short rivet is also not recommended, too long rivet is also not recommended appropriate length of the rivet must be selected, proper rivet length is very very important for the proper joining of different parts using the rivets.

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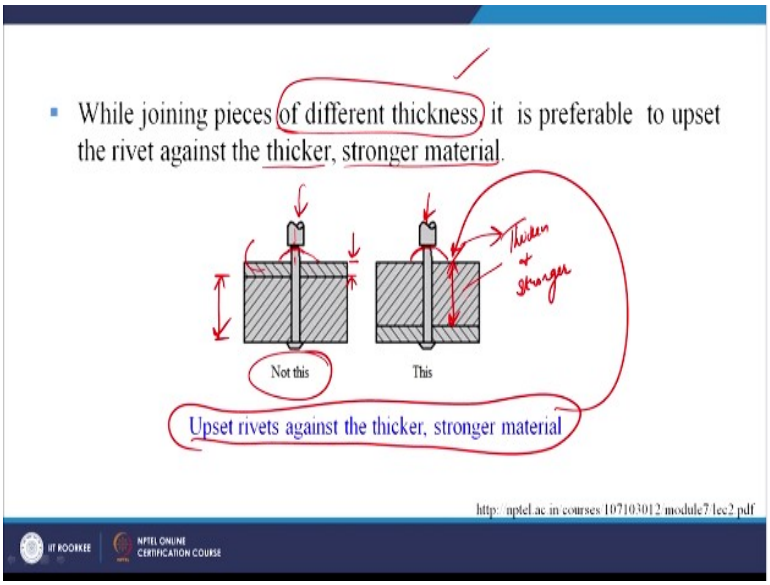

Now while joining pieces of different thicknesses, so we have seen we need to properly control the length of the rivets or suggest the because when we are designing a particular product we have to tell that how the different parts have to be joined together.

If they have to join together with the rivets we have to decide that from the edge of the plate what must be the distance of the rivet or the riveting position that we have to take care, what should be the hole in which the rivet will be fixed, what should be the allowance that we give to that we need to give on the length of the rivet. So, all these things we need to take into account in order to make a proper joint which will join the 2 parts of the product together.

So, when joining pieces of different thicknesses now we take into account the other important parameter that is the thickness. So when joining pieces of different thickness here we can see this is a thicker part and this is a thinner part. So, when we have to join 2 pieces of different thicknesses what are the guidelines we must keep in mind, it is preferable to upset the rivet against the thicker stronger material.

So, thicker and stronger material we must upset the rivet, so this is not recommended because here we are trying to this is the upsetting tool that we are using. So, we will try to upset it like this but we are upsetting it by hitting the head from this direction against a thinner material or maybe a softer material. But this is recommended here this is the thicker as it is written here and stronger, so this is a thicker and stronger material.

So, we must upset this rivet here with the help of this tool against the thicker and stronger material and this is not recommended we are upsetting our this head of the rivet against a thinner and softer material, this is not recommended. So, the guideline is upset the rivet against the thicker and stronger material which is shown here, here it is thicker also, this is a thickness thicker as well as stronger material.

So, there this very good guideline when we have to select our rivets as the joints for joining materials which are different in thickness as well as different in their mechanical properties, this is good guideline.

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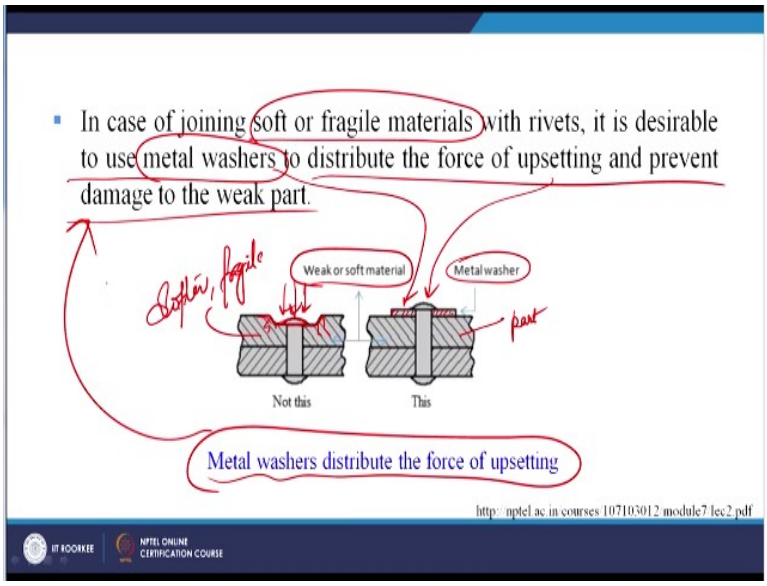

Again in case of joining soft or fragile materials, so we have seen thicker materials joined to thinner materials we have seen that whenever we are joining of same thickness what must be the diameter of the hole. We have seen different types of guidelines, so this is related to soft or fragile materials when we are joining soft or fragile materials with the help of rivets it is desirable to use metal washers, it is shown here.

We must use metal washers why, to distribute the force of upsetting and prevent damage to the weak part. So, when the material is fragile the material is soft you can see and we apply the load here of upsetting this particular head of the rivet see there is a depression which has been created why. Because this is a softer material it may also be fragile it maybe fragile, so softer there are chances that the material may also get develop some cracks here.

Because of the upsetting force that is being applied here because it is a weak or a soft material. So, what we can do we can use a washer this is a washer which is shown here a metal washer, so it will take the force it will distribute the force of upsetting. So, when you are upsetting the head of the rivet here it will absorb the force it will distribute the force and it will prevent the damage as in this case damage has taken place.

Because of the weak or soft material my use of metal washer will avoid the damage to the material of the part which is to be joined together. So, the metal washer distribute the forces of

upsetting and therefore avoid the damage to the weak part. So, we have seen when different thicknesses have to be joined what is the guideline when softer or fragile materials have to be used and the rivet has to be they used for these soft fragile materials, what are the guidelines that must be taken into account.

So, we have seen different types of rivets also, we have seen what must be the diameter, what must be the length of the material or the rivet that must be taken into account. So, we must have avoid the buckling of the rivet inside it may take place because of the plates that we are joining are very thick. So, all these things have to be taken into account when we are designing the parts in which rivets are going to be used as the fasteners for joining purposes. Now here we can see blind rivets though they do not have the strong axial forces of conventional rivets.

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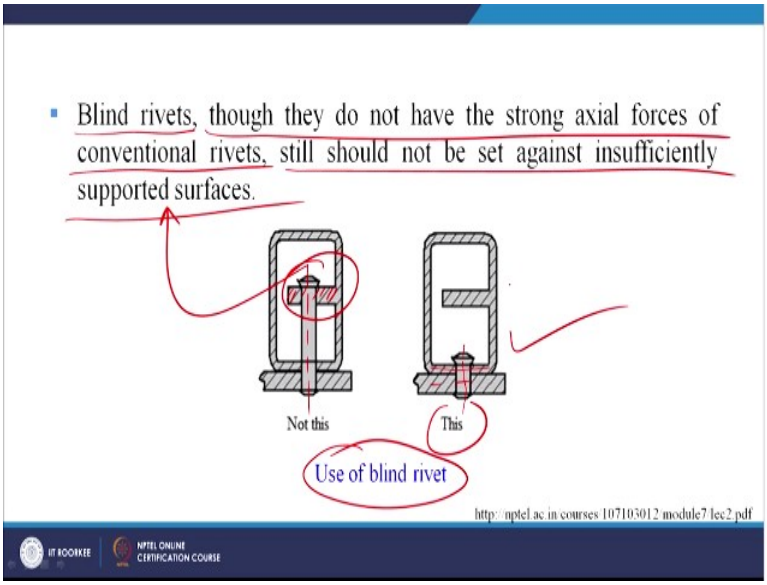

Blind rivets although they do not have the strong axial forces as in the conventional rivets still should not be set against the insufficiently supported surfaces, this is an insufficiently supported surface. So, our rivet must not be set against an insufficiently supported surface, so this is a right design because their both these surfaces in which we are using the rivet are adequately supported.

So, this is giving us the use of a blind rivet, so when we are going to use a blind rivet we must select the surfaces that we are going to or select the sections that we are going to join together

with the help of a blind rivet. Because this type of a joining may create problem during the use but this will not create any problem in the use because we are not supporting our rivet against a surface which is insufficiently supported.

This is a surface which is insufficiently supported, so we must not support or put our rivet against an insufficiently supported surface. So, this is a right design this is not the right design, so with this we can conclude the today's session in which we have tried to learn the different guidelines that we must take care when we are designing our product. So, we have seen that many design modifications can help us to provide ample space for the tools that we use for clinching of the rivets.

Also we have seen that whenever we are joining thick material to a thin material what is the guideline that must be taken care of that from which direction we must upset our rivet. If we are using a soft or a fragile material we must use a washer whenever we are using a blind rivet what are the guidelines that we must take care of. So, now I think as a product designer if I am designing a product and it has to be made in 2 or 3 different parts.

And each of these parts have to be joined together using the mechanical fastener then specially the rivets what are the guidelines that must be followed that is very very clear. So, this will help us to design our parts in a much better and efficient manner, in our subsequent sessions in this week we will try to focus on other methods of joining and try to learn what are the design guidelines?

That we must keep in mind when we are designing our products which have to be joined which have to finalize or assembled from the different parts which are manufactured independently. Thank you.