Joining Technologies of Commercial Importance
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Lecture - 21
Adhesive Joining

Hello, I welcome you all in this presentation, this presentation is based on the Adhesive Joining is one of the techniques for joining the metals with other systems also and metal to metal as well.

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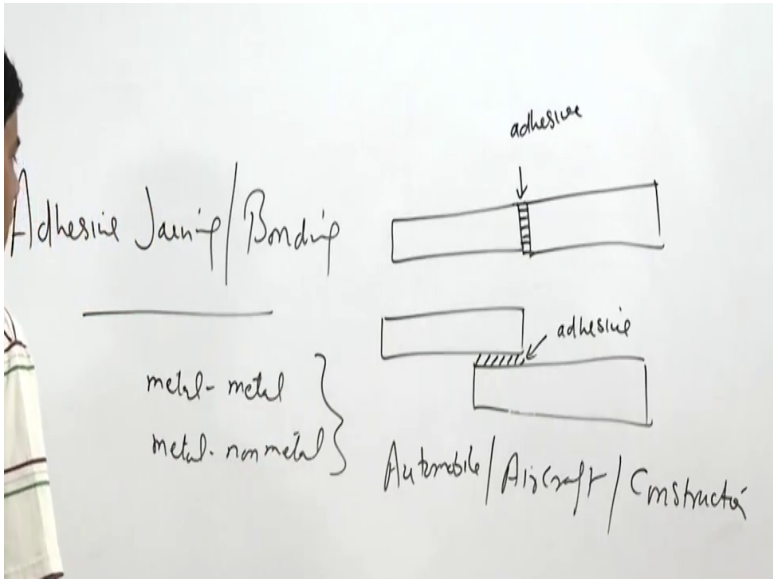

So here the topic goes in like this adhesive joining or this also known as adhesive bonding, so as name reflects that the components to be joined or kept mostly either in the butting position like this or they are kept in the overlapped position, so mainly the lap joint or the butt joints are made and between the - the faying surfaces adhesive is applied. So adhesive is applied and here this is an adhesive.

And after the curing the joint achieve the desired strength to pick up the service conditions to take up the load similarly this is adhesive in the lap joint configuration for developing the - the bond, so since this method is so versatile that it can be used for metal to metal bonding or even metal to non-metal bonding also.

So that is why it is extensively used in automobile industry, aircrafts component joining and even the construction industry for joining of the glass to their steels extra and that is why this finds very extensive application in the engineering industry for development of the variety of components, so this is how the this kind of the joint is developed. And now we will go into the finer details related with the adhesive joining.

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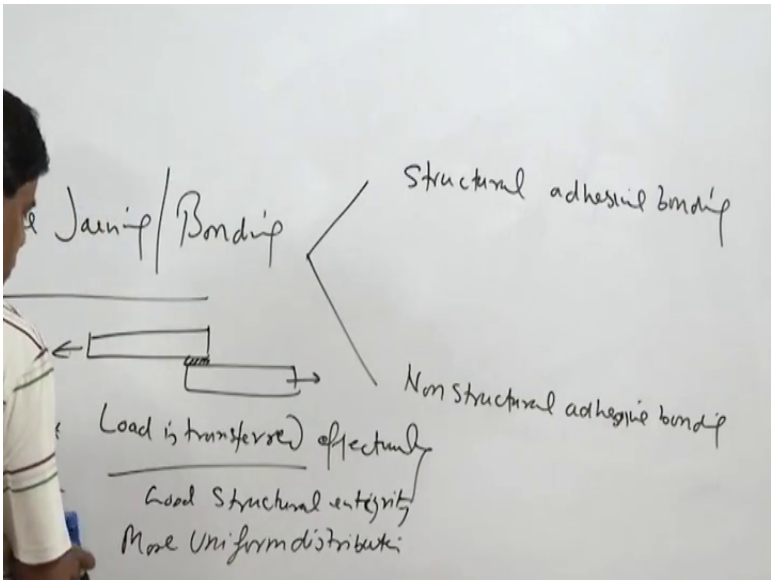

Adhesive joining basically is found to be depending upon the purpose it is of the two types one is like structural adhesive bonding or non-structural adhesive - adhesive bonding. So in case of the structural adhesive bonding the structural members like say the two members carrying the load or they have to support the load and the two needs to be joined with the help of adhesive. So in this case the load is transferred load is carried by the joint.

And it is transferred from one member to another, load is transferred effectively from one member to the another one, so this kind of the joint is basically load carrying joint it supports the load and the unique part is that this kind of the joint serve the purpose without loss of structural integrity, so it offers good structural integrity. At the same time that also offers in this case the bond area is found to be the large enough.

So the stresses are distributed over a larger area, so what will say more uniform distribution of the stresses is observed in case of the adhesive joining as compared to the mechanical joining

which is more commonly used and that is why these experiences somewhat lesser stress concentration or stress localization as compared to the other processes. So it effectively transfers the load.

And the joint becomes the load carrying type good offers the good structural integrity as well as it allows more uniform distribution of the stresses over the larger area and that is why the chances for nucleation of the voids and the growth of the cracks become somewhat lesser as compared to the - the case when the stress concentration is higher stress magnitude is high, so this is what is there in structural adhesives.

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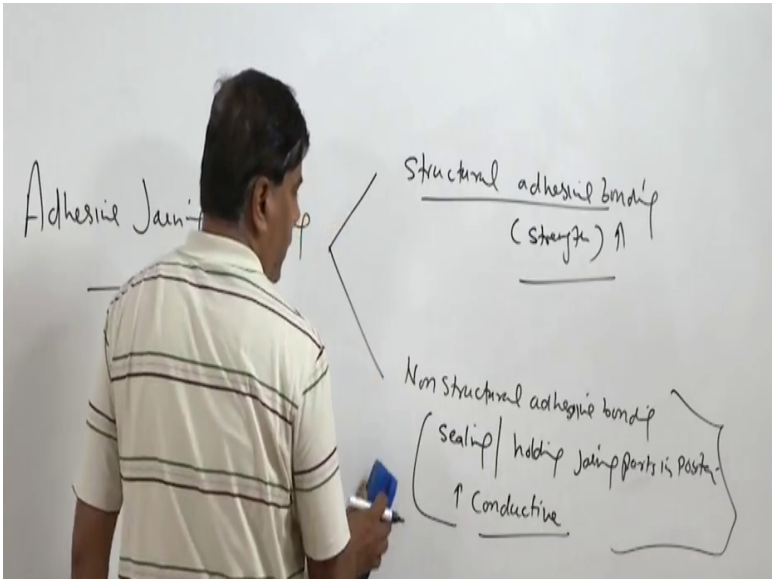

Obviously, the strength of such joint is high and they can carry the load of the service conditions. and on the other hand is non-structural adhesive bonding, basically used for the ceiling purpose or just for holding the component in position holding the joining parts in position, sometimes for the special purposes also like to improve the conductivity thermal or electrical conductivity or thermal or electrical isolation also the adhesive joining can be used.

So, these are the purpose of the non-structural adhesive bonding and they are not supposed to carry the load during the service much mostly these are subjected to either compressive or the shear stresses, so the design of non-structural adhesive bonding is not found to be that critical as

the structural adhesive bonding, so basically will be talking about the structural adhesive bonding and how it is achieved.

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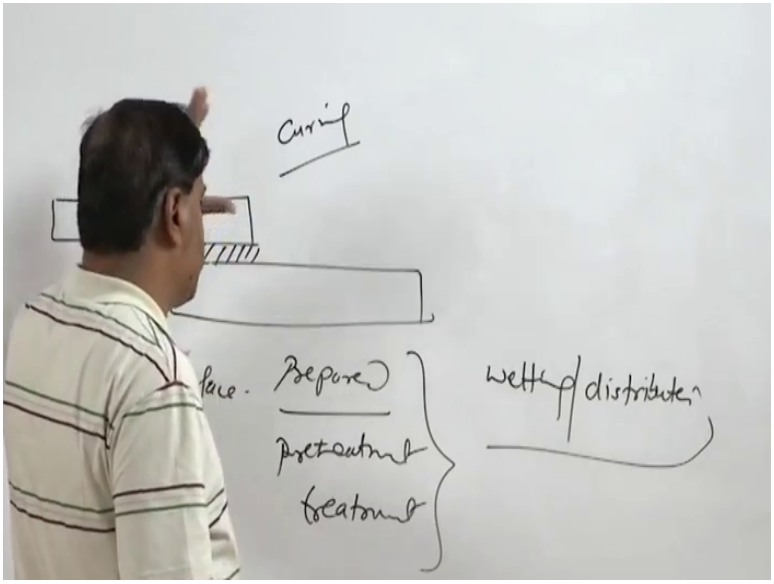

So if you see the how adhesives work like say the members to be joint maybe of the same or the different types when so the first step is that all faying surfaces - faying surfaces are properly prepared preparation is done for to take to remove all impurities like oil, grease, dust, draught etc. from the surface so the surface is prepared and then it is subjected to the pretreatment so pretreatment further help to avoid the oxides, observed gases moisture etc. from the surface.

And then treatment is also done to activate the surfaces to make the surface more nascent so that it really helps in helps in wetting as well as the distribution or you can say spreading of the adhesive between the surfaces, so as a - as a part of preparation the surfaces to be joined or the components to be joined its faying surfaces are prepared pretreated and the treated so that they are more clean and more activated for wetting as well as spreading of the adhesive.

And thereafter adhesive is applied when the adhesive is applied normally after application curing is performed so that the kind of bond being formed can be strengthened further through the interactions between the - the adherent surfaces and the adhesives and under this the various hypothesis have been proposed which help to offer or increase the strength of the adhesive joint.

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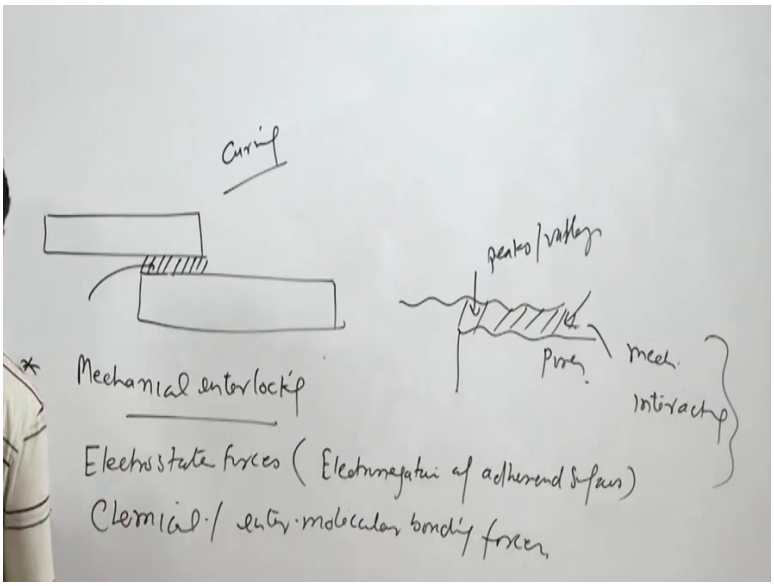

So the three mechanisms are - are there they can work interdependently or the - the role can be interdependent and they in combined way also they offer the strength of the adhesive joint, one is the mechanical interlocking, mechanical interlocking basically uses the concept of like all the surfaces will have the - the ups and downs over the surfaces. And when the adhesive is placed it will be filing the peaks and valleys present at the surfaces.

And all pores are filled in by the adhesive and once this sports are filled in, it offers the mechanical interlocking by the adhesives after filling in the gaps at the surface and filling in the pores ups and downs present at the surface. Second is electrostatic forces it depends upon the electronegativity of the adherent surfaces. And third is the chemical and intermolecular bonding forces.

All these three mechanisms are supposed to work together whenever adhesive joint is made and it is found difficult to distinguish which of these is working how much for strengthening the adhesive bonds.

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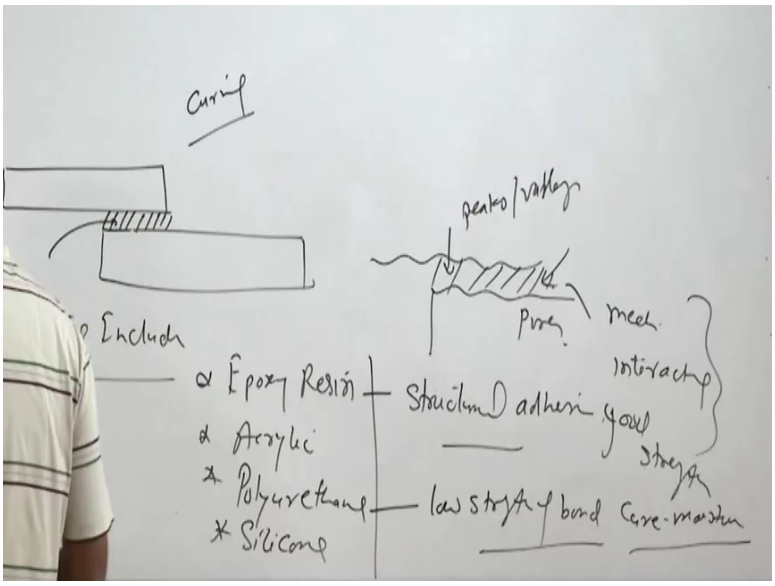

So and apart from this the common adhesives which are used to for the purposes of the adhesive bonding, so includes adhesives includes like epoxy resins this is one, acrylic is another and we will have there is one or two - one or two more adhesive which are commonly used is like polyurethane and silicon. So these are the common adhesives, epoxy resins is a very common structural adhesive which offers very good strength.

But this needs curing to achieve the peak strength while in peak strength at elevated temperature and polyurethane this offers somewhat low strength of the bond and curing happens in this case by the moisture in atmosphere, so it does not require very high the temperature like the epoxy resins for hardening purpose. So these are the common types of the adhesives which are used for adhesive joining along with their characteristics.

So it is common that the epoxy resins are commonly used as a structural adhesives and they offer the desired strength after curing at about 120 degree centigrade so that required strength can be achieved.

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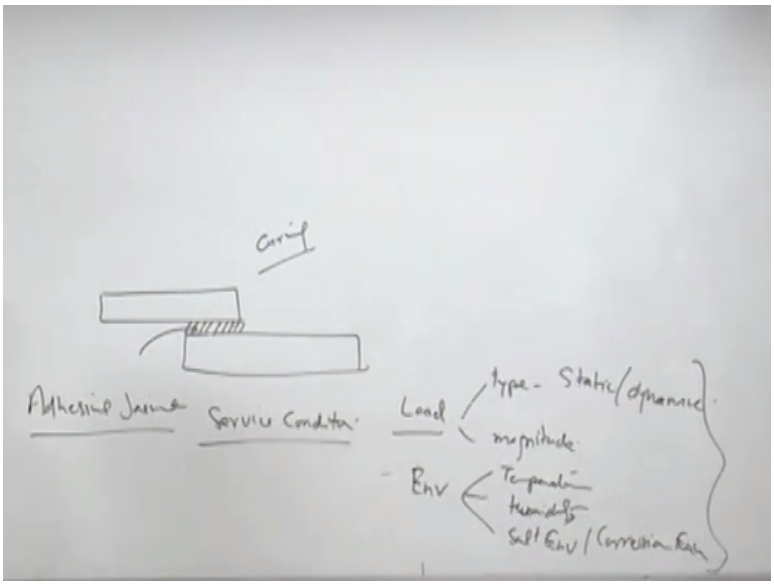

So apart from this for achieving the desired joint or adhesive joint with the desired properties must be designed properly, so the design of the adhesive joint depends upon the service conditions whatever design is there that should satisfy the service conditions and service conditions mainly include the load in terms of the type let that is static or the dynamic and then magnitude the magnitude of the load.

So these are the two factors and apart from this the service conditions, service conditions like environment this includes three aspects, one is the temperature under which the adhesives are supposed to work, humidity - humidity and the third is any salt environment or corrosive environment which may degrade the adhesives and their performance. So this need to be kept in mind considering the load type of the loading, magnitude of the load.

And the temperature humidity and the other special environmental conditions for the service the suitable type of the adhesive is selected and the design of the adhesive joint is made, so the common designs which are developed for adhesive bonding these include the butt and the lap joint configuration.

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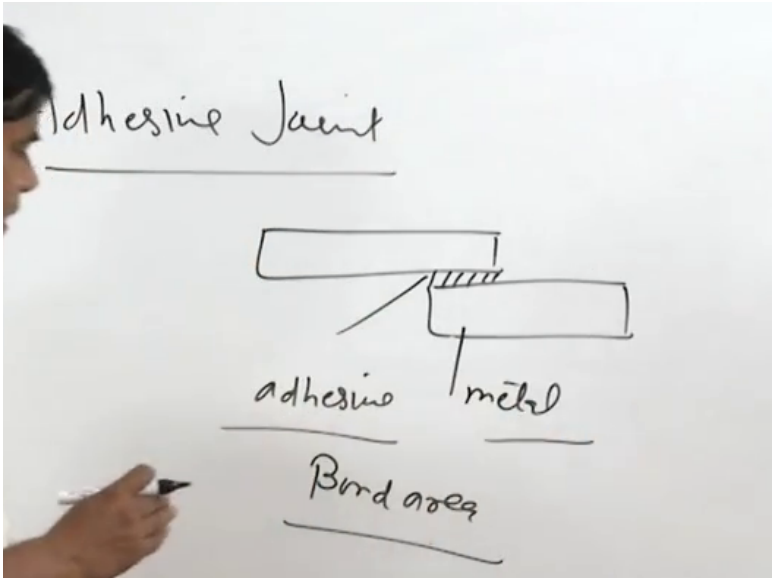

In addition to this, for designing the adhesive joint what we have to keep is adhesive joint design what it includes basically we have like say the members to be joint and what we have in our hand is this the adhesive can be placed between the faying - between the members to be joined since the - the mostly the metals offer much higher strength than the adhesives, so adhesives being weaker than the metals.

And then to achieve the strength of the joint which is matching with the metals it is necessary that the bond area is large, so what we say that due to offset or to overcome the lower strength of the adhesives it is necessary that the bond area being used is large enough, so that the strength of the bond is either equivalent to that of the metals or it is even better than the in terms of the load carrying capacity of the members being joined.

So the bond area place a big role in determining the surfaces - determining the load carrying capacity and capability to carry the service loads during the service successfully, so the bond area must be large enough whenever adhesive joints are made.

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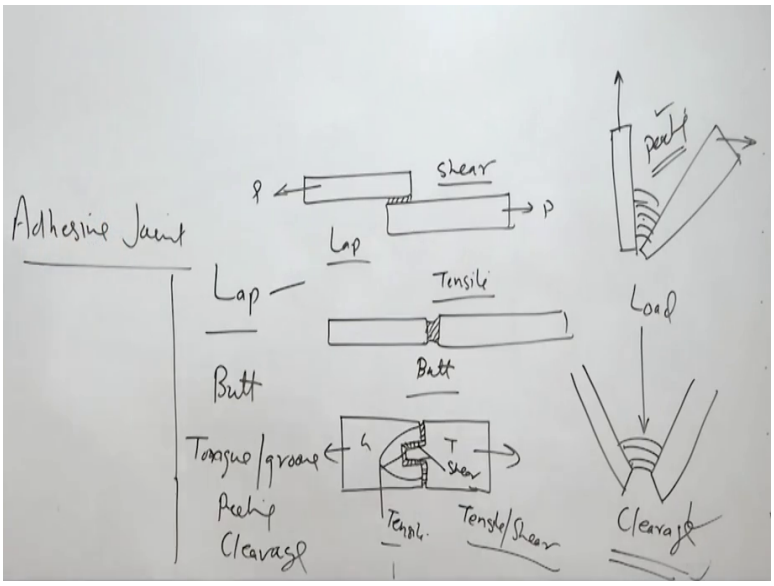

So the common the joints which are made in lap joint configuration and butt joint configuration and there is tongue - tongue joint configuration which is tongue and groove joint configuration, so these are the three, apart from this the some of the joint configurations which need to be avoided includes the peeling situation and the cleavage situation the kind of the loading which adversely affects the capability of the adhesive joints.

So the typical lap joint configuration works like this where in mainly the shear load acts at the joint and the joint area is designed in such a way that it carries the required the load, so this experiences the shear load and this is the lap joint configuration, in butt joint configuration obviously the plates to be joined or the sheets or the members to be joined are kept in butting position and between them adhesive is applied after preparing the edges.

So in this case since the bond area is limited so the strength of such kind of joint may be lower than the other shear type of the joint, therefore special joint designs also are made for this - for the butt joint configuration, so but joint configuration in this case stress is experienced by the adhesive joint are the tensile in nature, then tongue and the grooves. Tongue and groove joint design in this case special configuration is made in the butt for the butt joint like this.

So that load carrying capacity in butt joint configuration can be increased, so here, we make the this is the tongue and this is the groove, so both one side we have a tongue and another side we

have the groove and the area in this case between these two the adhesive is applied for developing the joint. So in this case, if we will see some of the surfaces which are if this is the way by which load is tensile load is applied.

Then, some of the surfaces will be subjected to those which are perpendicular to the external load they will be subjected to the tensile load and some of them will be subjected to the shear load, so the surfaces of the joint or the joint the portion of the joint which is parallel to the external load will be experiencing the shear load. So here these two will be experiencing shear while this surface.

This surface and all these surface this will be experiencing the tensile stresses, so basically a combination of the tensile and shear stresses will be experienced by the tongue and the groove design. In case of the cleavage type we will have like say the orientation of the plates been joint is like this and the component that have been joined using the adhesive in this manner and load is applied through on the joint itself.

So this kind of joint configuration is termed as cleavage and it basically tends to break the joint this kind of the loading tends to break the joint and offers the limited load carrying capacity that is why efforts are made to avoid the cleavage joint as well as the peeling type of configuration is also avoided where in actually the one plate is like this another is in this orientation where in one plate is being pulled like this and another is in another direction.

So this will tend to break the joint easily this is the peeling joint configuration and both these peeling as well as cleavage joint configurations tend to lower down the load carrying capacity of the adhesive joints and therefore efforts are made in such a way that the peeling and the cleavage joint configuration exist in the it does not these two do not exist in the area of the high stresses but they are relocated suitably.

So that they fall in the less critical areas where stresses are low or where the stress nature is compressive or shear in nature rather than peeling or the cleavage type, so these are the three - these are the five types of the joint - joint configuration and their capabilities in terms of the

stresses which are generated and the kind of service conditions under which they support the joint support the adhesive joint.

So the typical joint configurations which are used for the shear as well as the butt joint configuration will be showing that how to develop the adhesive joints so that it can carry the load successfully for that purpose we need to focus on the two points.

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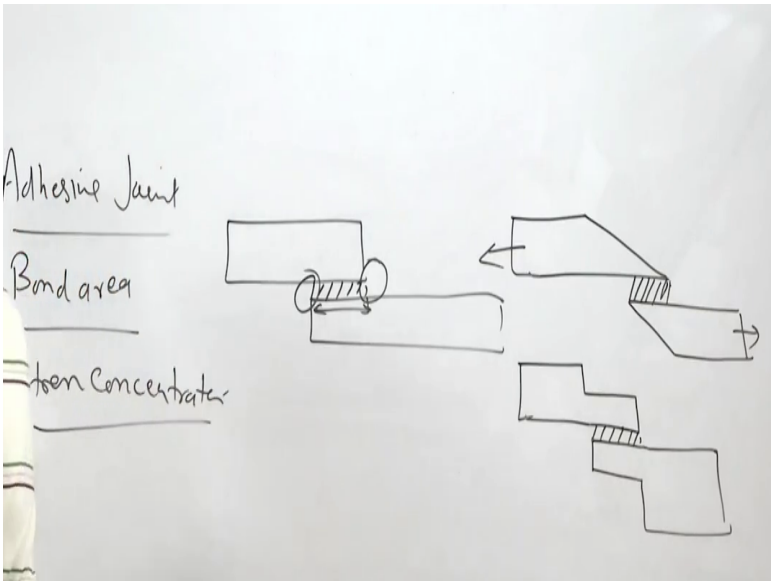

One is our bond area is really large enough and the second is stress concentration is very limited, because it can start the separation at the interface of the adhesive and the sheet being joint, so these are the two factors are kept in mind and therefore considering this in mind the joint configurations one is the simple one, in the lap joint configuration joint area that is the overlap length is selected in such a way.

And the width of the work piece, it is selected in such a way that the bond area is sufficient to carry the external load. But in this case we may have the higher stress concentration at these two hence and therefore the joint configuration is modified little bit where in the section will be having the gradually reducing like this, so here the change is gradual in terms of the section and this will have - this will help to reduce the stress concentration especially in the high stress areas.

So this is one typical for the lap joint configuration. Another we will see for that there is another approach to do the same that instead of having a tapered one where the plates are made prepared like this, so this will also help to reduce the stress concentration at the edges of the plates for butt joint, so this is this two where there for the lap joint configuration which help to reduce the stress concentration at the edges at the same time it also helps to increase the bond area.

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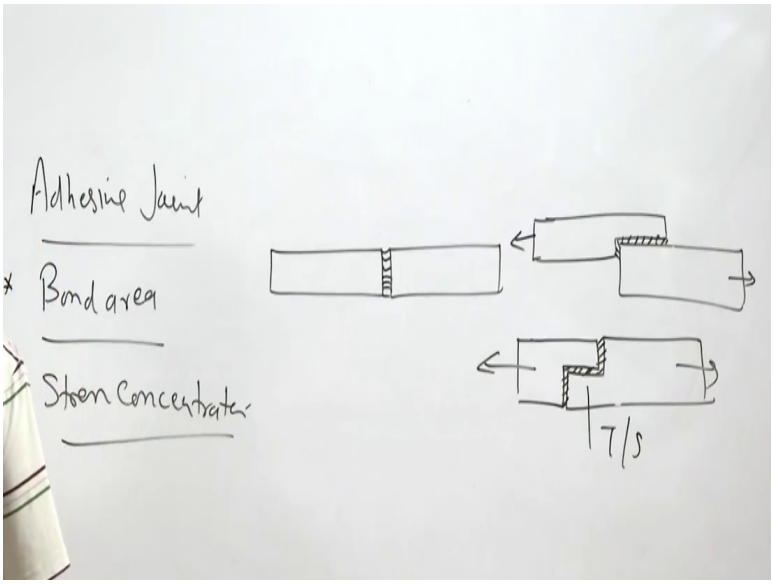

Then we will see the for butt joint configuration the common one is this one but since it offers somewhat lesser the bond area so to increase the bond area like this this is the typical common one, but it is modified in the two ways one is the simple sheet is kept like this and another sheet is prepared this manner, so that the plates and here this area is applied with the - the adhesive bonds, so this is another modification say for the butt joint configuration.

And another one there is one more modification where in like this the plates are both the plates are modified and prepared in such a way with plates are exactly in the butting position and this bond line is used to increase the bond area or this is how the bond is bond line will be perpendicular to the external load as well as the parallel to the external load, so this will be experiencing both the tensile and the shear stresses.

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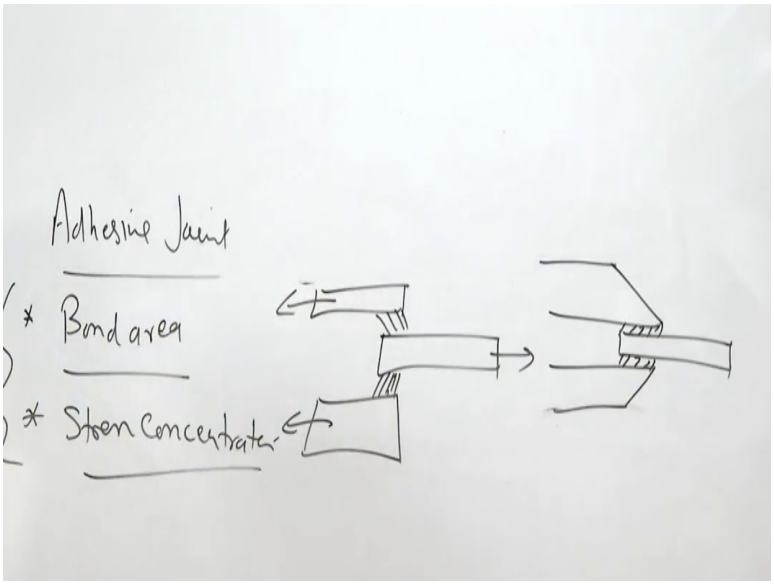

So this is how we can increase the - the bond area as well as reducing the stress concentration, there is one more way to increase the load carrying capacity where in the double sided plates are used, like say this is one plate and then what will be doing another plate is brought in like this, another one is brought like this and between the two the bond is made from the two sides so this bond this is one load carrying capacity and this is this one member.

And there are two other members which will be supporting the joint and the bond area in this case the bond strength will be doubled and in this case for the to reduce the stress concentration we may work in like this and here we will be providing the centerplate and this will be applied with adhesive joint in between. So these are the different joint configuration which can be used for developing the adhesive joints.

Now we will talk about the typical advantages and limitations related with the adhesive bonding, so if you will see - if you will see the typical advantages and the limitations of the diffusion bonding these are many.

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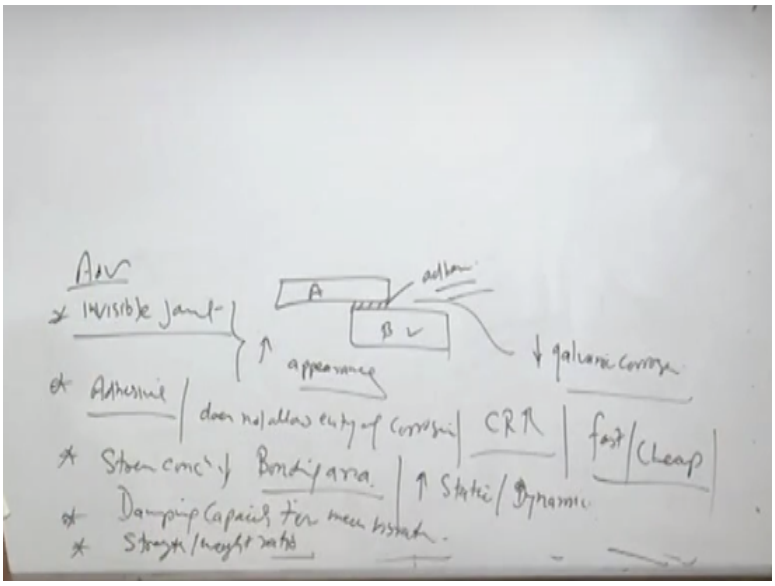

The first one the - the joint advantages the invisible joint, so when just like in welding the - the joint at the surface but in case of the adhesive joint, joint is between the surface is being joint, so the basically the joint is invisible this helps to improve the appearance of the assembly being developed so this is one. And the second is adhesive since adhesive is present between the faying surfaces between the members being joint.

So it does not allow entry of corrosive media or entry of the environment. So the corrosion resistance basically corrosion resistance is improved, further stress concentration is low because the bonding area is very large in case of the adhesive joints this in turn results in the good static as well as the dynamic load carrying capacity of the adhesive joint, further it since the metal A and metal B both are good in transmission of the vibrations.

But when the two are joint with the help of non-metallic adhesive it effectively damps the transmission of the vibrations. So the damping capacity for mechanical vibrations is found to be good when the adhesive bonding is performed further it isolates the A and B, if A is one metal B is another than the two are isolated with the adhesive joints and this kind of separation or isolation results in the reduction in the Galvanic corrosion.

So the Galvanic corrosion tendency is also reduced due to the isolation of the base metals and especially in the corrosive environment. Another one is the strength to weight ratio - strength to

weight ratio of this joint is very good, so the joint is developed even when the load the weight of the adhesive is very little so it does not contribute towards the weight much so that is why the strength to weight ratio is very good, another good point is the process is very fast.

And it is very cheap for the development of the joints so these are the many advantages as far as the adhesive joint is concerned. Apart from that there are limitations are like very good quality surface preparation is mandatory, so proper cleaning, surface treatment and pre-surface treatment are mandatory otherwise adhesive joint will not be good, number two the adhesive can degrade in a special environments or specific environments like we cannot use above 180 degree centigrade or in corrosive environment these can degrade or in humidity this can be degrade.

So there are service limitations related with an environmental condition, further the load carrying capacity of the adhesives become less so this cannot be used for very higher load conditions - higher load service conditions as compared to those of which are associated with the mechanical joining methods or like the welding methods. And one more thing is that the process of the curing of the joint is very time consuming to achieve the desired strength.

So it takes really long to not just for the curing purpose but it needs infrastructure like ovens fixtures etc. for the purpose of the curing so that the required joint strength can be achieved. Now I will summarize this presentation, in this presentation have talked about the importance of the adhesive joining, the factors that matter for development of the successful adhesive joints, as were as the various advantages and limitations associated with the adhesive joining process, thank you for your attention.