Fundamentals of Manufacturing Processes
Dr. D. K. Dwivedi
Department of Mechanical & Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture – 50
Joining of Metals: Brazing, Soldering & Weldability

Hello, I welcome you all in this presentation related with the subject fundamentals of the manufacturing processes. And we are talking about the metal joining processes. And among the metal joining processes like in the last presentation, I have talked about the fusion based welding processes.

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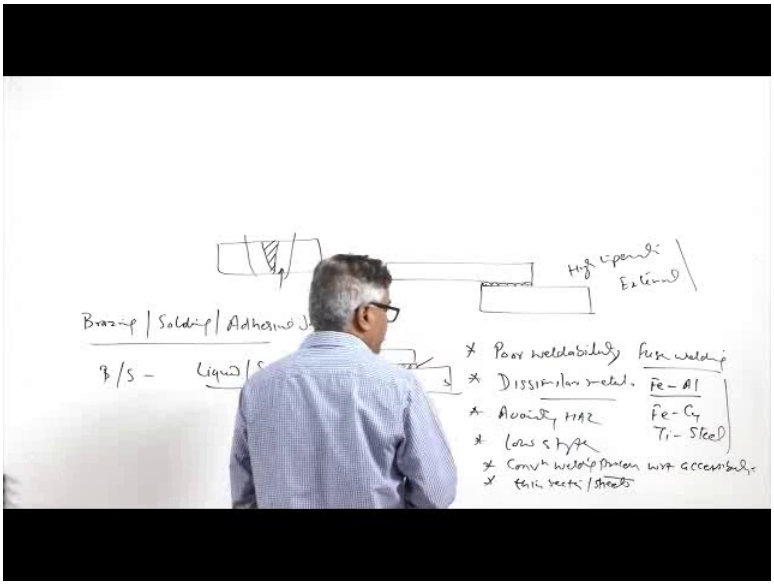

And we will see now the brazing soldering processes and maybe adhesive joining also we try to talk little bit about the adhesive joining processes. Brazing and soldering processes are called liquid solid processes. Because the joints to be made here, between the base metals base metals remains in the solid state, while the filler metal is brought to the molten state between the at the faying surfaces between the joint.

So, liquid is the filler metal and the base metal remains in the solid state. This kind of the processes needs very less heat input and gives the joint. Now strength of the joint is somewhat less or it is poorer than the base metal, but still it is a good for working in number of situations and number of conditions where high strength high load carrying capacity is not a major requirement. For example, like developing the solder joints where

electrical connectivity is more important, similarly brazing joints where compressive forces are acting like in cutting tools. So, the stress and strength requirements are not much high. So, under those conditions the brazing and soldering is found to be very effective.

There is another process which is called adhesive joining wherein the chemical reactions between the adhesives and the functional surface this faying surfaces of the joints to be made in. So, adhesive is placed in that case normally structural additives are free used for high strength joints, but these cannot be used for the high temperature conditions and even for the external environmental conditions. Because these under these 2 conditions that has you tend to degraded the joint is weakened very badly. So, the conditions under which the brazing joints and soldering joints are preferred include like where the fusion welding is not possible due to the poor weld ability fuse due to the poor weld ability, the fusion welding is not a workable option.

The second is completely different metals like dissimilar metal systems are need to be welded, where the compatibility between the 2 does not exist for example, like there may be iron base alloys and aluminum or iron and copper titanium and steel. So, these are the systems which are if they are not metallurgically compatible due to the variety of regions like difference in melting point expression coefficient yield strength. So, they create lot of problem during the fusion welding. That is why the similar metal joining can be facilitated in number of cases through such kind of the joining processes where the base metal remains in the solid state only the filler metal is brought to the melting point.

And then we have the conditions like the heat affected zone you know, we have seen in the fusion welding processes application of heat results in the fusion zone, but nearby a lot of heat affected zone is formed which has the different properties in terms of the metallurgical characteristics and the mechanical behavior even the corrosion properties are adversely affected. So, if the heat affected zone is unfavorable which is produced in the fusion welding.

So, avoiding the heat affected zone avoiding HAZ helps when the brazing and soldering processes are used. And like even the low strength joint is and the conventional welding processes are not applicable as per the accessibility. So, processes with regard to the accessibility and the workability of the joining.

So, these are the some of the conditions wherein it does not work where the conventional welding processes are not working. And like very thin sections or thin sections and thin sheets need to be welded there the brazing and soldering can be effectively applied for developing the joint while the fusion welding may not be feasible and workable effectively. So, for to deal with these the conditions the brazing and solder joints are used. Now you will see the basic principle which is used in these processes in the development of the joints.

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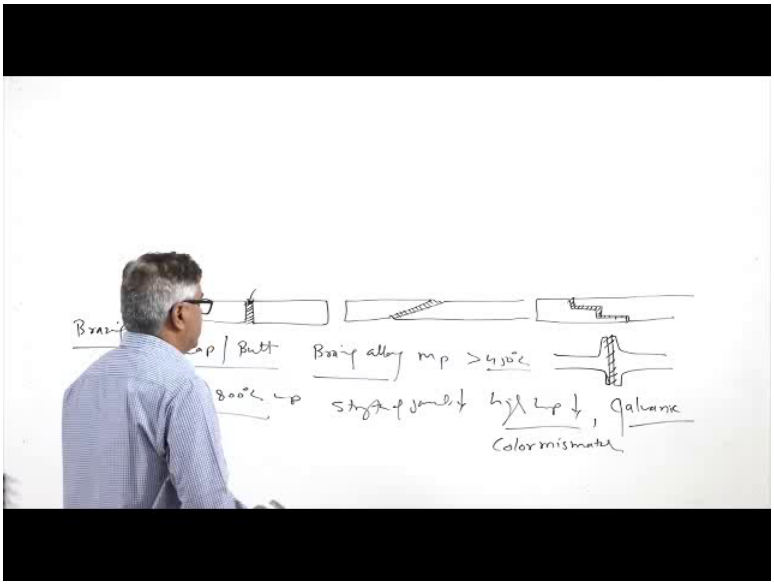

So, we will take first the brazing joints for this purpose like say the plates to be welded are mostly. These there can be the different kind of arrangements wherein like lap joint or the butt joint both can be made, but it is more common to use the lap joint configurations for the brazing purpose and the whatever. So, like say this is the butt joint configuration and the different joint designs have been proposed for the butt joint configuration here this is a square one, but square one will be if very if the strength is not a metal criteria because the weld a area is very limited. So, in order to increase the strength of the joint in this case some kind of the joint is prepared in such a way that the joint area is more. So, such a larger joint area will be increasing the strength of the joint by meti making the faying surfaces at certain angle.

Another arrangement which is which can be made is like this for developing the butt joint like this. So, this is also butt joint and the faying surfaces and in between the faying

surface is the brazing joint, the brazing alloy is applied. Then there is one another kind of arrangement where near the faying surfaces the cross section is increased, cross section is increased like this. So, that larger joint area can be achieved for having the desired strength. And here this is the location where brazing system will be applied. So, increasing the strength in all these designs is based on increasing the joint area for the brazing purpose.

So, for brazing basically, the brazing alloys are used for brazing purpose they normally have the melting point greater than 450 degree centigrade, but the issue with this is that the brazing joint generally they have like the temperature in the ranger of 450 to like say 800 to 900 degree centigrade in terms of the melting point.

So, if we compare like if these are being used for joining of the steels then strength of the strength of the brazing joint is lower, they are ability for the high temperature withstanding is lower they cannot be sustained at high temperature as well as they sometimes because the brazing material is different from the parent material.

So, galvanic corrosion is proposed galvanic corrosion is promoted by this. And even color mismatch is also observed when the brazing is performed. So, these are some negative aspects apart from the benefits which are produced like the joint is made, with the reasonable strength without melting of the base metal limited heat input limited size of the heat affected zone. So, there are. So, many beneficial aspects rel related with the brazing for brazing a special kind of approach is used wherein the surfaces to be joined are cleaned properly and they are smoothened properly. So, that the flow of the metal can be smooth like say in this configuration.

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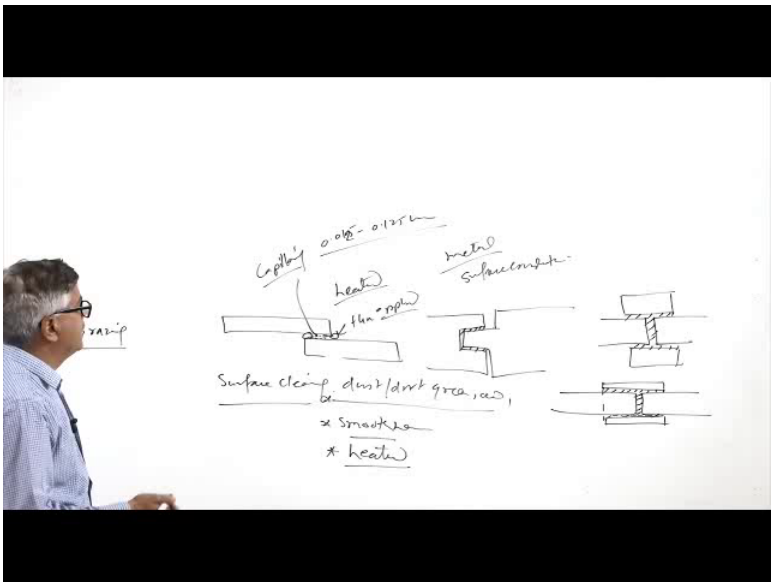

This is the lap joint configuration and various lap joint configurations are used here. One typical one is this one wherein the surfaces to be joined are placed in overlapping position.

Another one is maybe like this, where in the components to be joined or kept in over lapping position. This manner and here this is the overlap portion. And then there may be an arrangement wherein the plates are kept both the sides in this way and the brazing joint is made like this. And then sleeve can also be used in this manner where the like say the rods to be joined in this manner. So, brazing alloy will be placed here then sleeve on both the sides is applied in this manner and here all this area is brazed.

So, for brazing purpose the important thing is surface cleaning. Surface must be cleaned from the dust dirt grease oil paint etcetera. Because these are the impurities which will be hindering the flow of the molten brazing alloy and apart from this this should the surface must be smooth enough. Because the molten metal has to float under the capillary effect between the faying surfaces in order to get uniformly distributed.

So, the smoothness and the cleanliness is important. Thereafter it needs to be heated to the proper temperature. So, the mon ma they can reach to the melting point. So, what we do basically say this is the kind of arrangement which is to be brazed. So, here the plates are to be weld bridged, will be heated the cleaned and smoke and surfaces will be heated and then maybe flux is applied which will help in improving the removing the oxides and

facilitating the wetting of the brazing material. And then brazing material is applied here like this. So, it mesh and due to the and then it flow it is by the capillary action it is sucked inside and gets uniformly distributed.

So, for having this capillary effect what is important that the gap between the 2 is very closely maintained 0.0125; 2.125 mm kind of the gap is maintained? And this will be depend upon the metal of the brazing alloy the kind of the surface conditions which exist at the surfaces and the cleanliness. So, since the flow is here by the capillary action or distribution of the braze a molten brazing metal between the faying surfaces by the capillary action. So, cleanliness is smoothness and a proper fluidity and wetting of the surface by the brazing material is important and flux to some extent helps in removing the oxides and improving the fluidity of the brazing materials. So, that it can spread uniformly between the faying surfaces in order to form the joint when after the solidification the joint is produced.

The common kind of the brazing materials which are used brazing alloys are like copper zinc copper tin then copper phosphorus and the nickel based alloys are used as a brazing material, the compared to the solder joints the brazing joints offer much better strength as compared to the solder joints.

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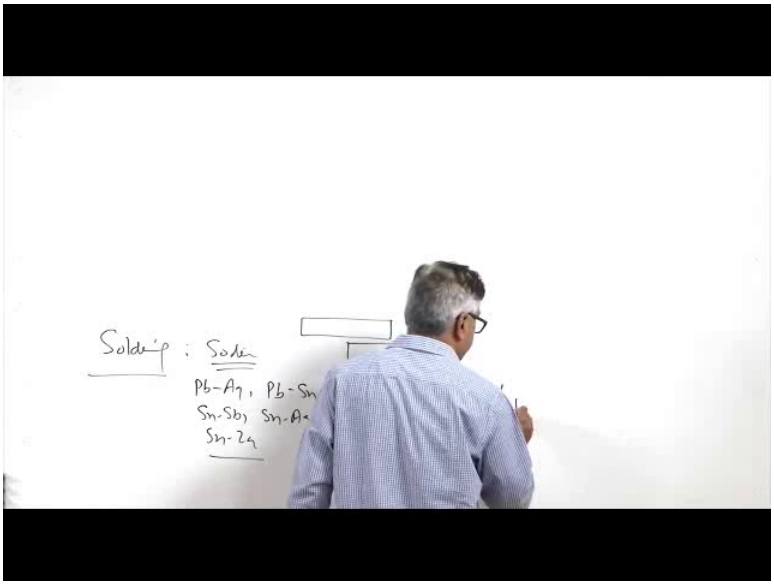

Because the solder joints use the filler metals having the melting point less than the 450 degree centigrade.

So, next is the soldering. So, soldering basically uses the solder for the joining purpose. The principle of this is same as that of the brazing, but it is of the much weaker much lower strength and melts at much lower temperature for the soldering purpose, various kind of the solders are used like lead silver, lead, tin, tin antimony, tin silver, tin zinc. These are some of the soldering systems which are used. And most of these will be melting at the temperature below the 450 degree centigrade for the solder growers because of the lower melting point, they offer the somewhat lower strength and the limited capability to withstand to the at high temperatures. So, they are good for the low temperature conditions.

So, these are low in strength and lower capability to withstand at high temperature just like in brazing surface preparation in terms of the cleanliness of the faying surfaces. And the smoothness is important and the gap needs to be controlled very closely and for this purpose the gap between the 2 is controlled in the range of like say 0.075; 2.125 mm.

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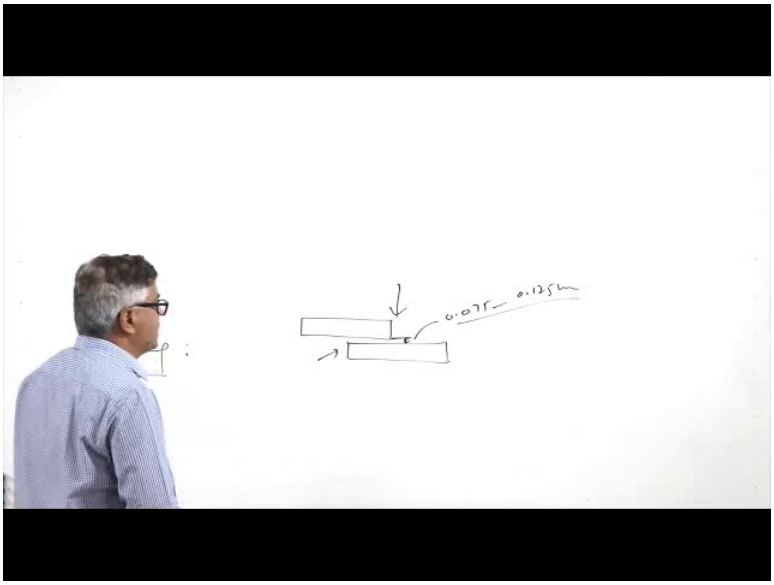

And again this gap will depend upon the kind of solder which is to be used the used and the surface conditions to be used. So; obviously, very low heat input is needed for melting the low temperature mel melting point solders.

So, the this kind of heat can be like a soldering iron can be used for, but likewise there are a number of methods through which heat can be applied for facilitating the melting of

the solder at the faying surfaces. So, through the ca capillary action it gets distributed uniformly across the in the gap between the between the surfaces to be joint.

So, that the joint can be made to improve the wettability and normally the zinc and ammonium chloride is commonly used flux borax is another one, which is used, but these needs to be cleaned properly. So, that and any kind of the corrosion effect on the joint performance can be avoided. Because the residual fluxes can be harmful for the from the corrosion point of view of the of the base metal.

Now, coming to the adhesive joints, adhesive joint is the kind of the involves the chemical bonding.

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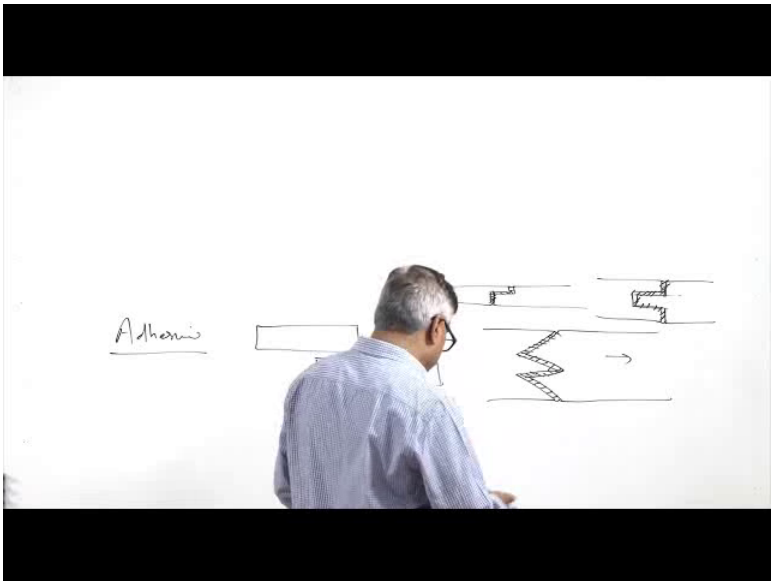

Where in like the plates to be joined or captain probably in the lap joint configuration, but these can also be used in other joint configurations as well. Say for example, the kind of joint configurations for this one for the adhesive joints are also similar to that of the which who are used for butt joint configurations like adhesive placed a in this manner by making for increasing the joint surface area in butt joint configuration. Similarly, that has another joint configuration is like this. And here the adhesive will be placed this is the kind of components adhesive will be placed all around this surface area. So, these are the methods which are used for increasingly the area of the joint.

Like another one is like this the component and another component having the configurations like this and entire this area is applied with the adhesives. So, this increased joint area will be leading to the increased joint strength in the butt joint configuration likewise the number of other kind of the joint configurations are there which can be used for increasing the joint surface area, but it is more commonly used for the lab joint configuration which is more simple like this.

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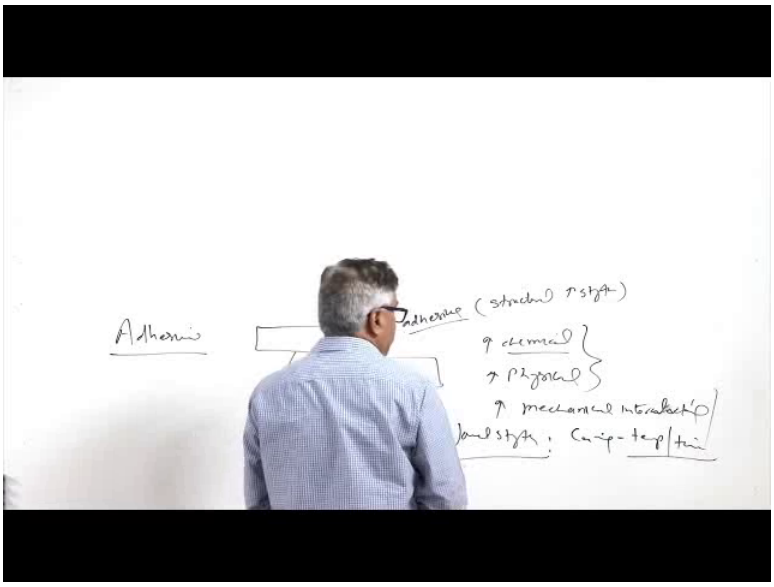

This components to be joined are called adherent and the adhesive which is applied between the faying surfaces is called adhesive or the filler which is applied is called adhesive.

Mostly this is structural adhesives for increasing the strength of the joint and basically the chemical reactions between the adhesive. And the surface and the physical reactions and the mechanical interlocking mechanical interlocking, these are the 3 mechanisms mechanical inter locking these are 3 mechanisms which will be increasing the which will be responsible for the joint strength.

So, some of these like the chemical and the physical reactions which will be occurring after the solidification after the hardening of the after the hardening of the joint and for this purpose normally the curing is performed at controlled temperature and the time both these play an important role in insuring the desired strength of the joint. So, adhesive joint joints are cured properly in order to have the reactions like during the

curing actually curing increases the strength through the polymerization, this is one vulcanization and condensation and condensation.

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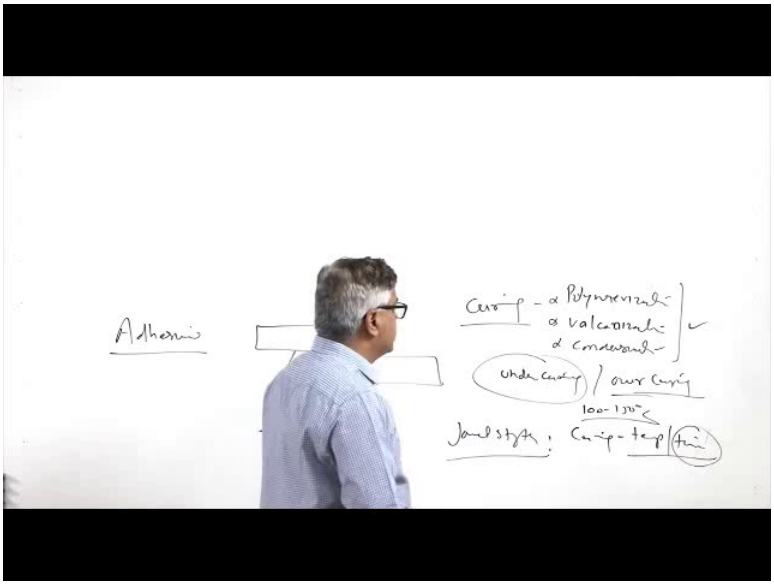

So, these things will be happening during the curing and it is a; it is a prog, it is a important that curing is done under very controlled conditions of the temperature normally like 100, 250 degree centigrade temperature is used and a curing should be done for optimum duration, because otherwise it will lead to the under curing or over curing.

In either case the strength of the joint will be less. So, un in case of under curing when the curing has not been done up to for the proper time then it will lead to the limited reactions which will be occur during the care curing and over curing can lead to the thermal degradation of the adhesives due to the exposure at longer period. So, over curing can also be harmful for the joint strength while as like wise the under curing also adversely affects the joint strength due to the incomplete reactions, and the reactions which will be occurring during the curing like vulcanization polymerization and condensation.

So, the common kind of the re regions which are used for developing the adhesive joints are like epoxies.

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Epoxies and the silicon and then modified acrylics modified acrylics. So, these are the things here as we have said for uniform spreading of the adhesives it is important that surfaces properly cleaned. So, that it wets to the surface and the proper joint strength is realized in order to stre increase the strength of the adhesive joints.

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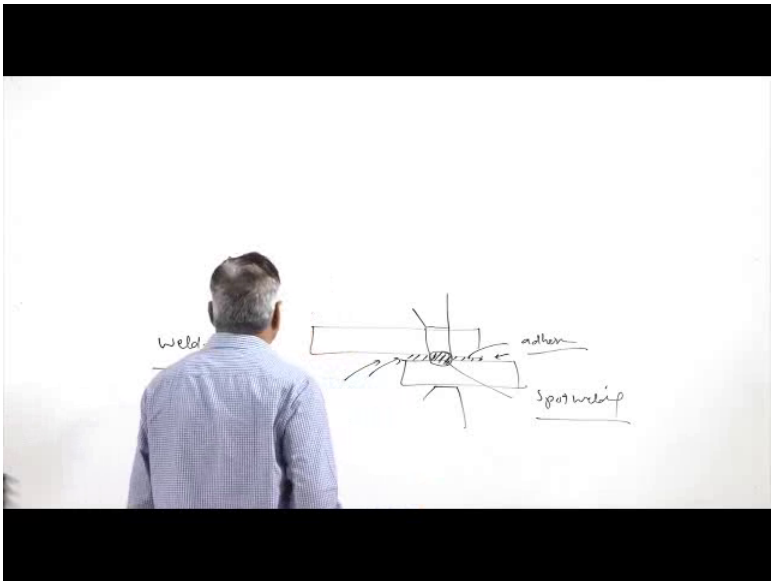

Further like another combination like weld bonding has been attempted wherein the plates to be joined are kept in overlapping position.

So, here the 2 methods are used. Either first the adhesive is applied and then the spot weld is made. So, wherever they there is adhesive due to the flow of current that area adhesive in that area is burn out and weld nugget metallic weld nugget is produced. So, it combines the effect of the adhesive joining and the spot welding. So, there are 2 approaches which are used in like the first adhesive is applied then a spot weld is made. There after curing is done under the in second one first this spot is made then the adhesive is allowed to flow in. And thereafter curing is carried out this kind of the joint offers very good strength as well as the fatigue resistance of such kind of joints is found to be much better than the simple spot weld joints. Because it distributes stresses more uniformly across the joint area which in turn helps in increasing the strength of the joint strength and the fatigue strength of the joint.

Now, we will talk little bit about the weld ability or the ease of the welding.

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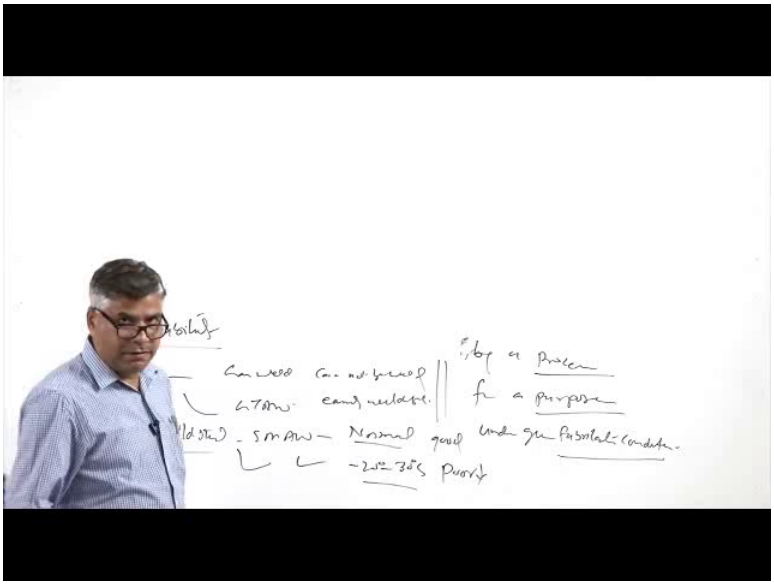

So, weld ability. Weldability is defined as the ease of welding of the metal, but under a in under particular conditions like ease of the welding of a metal for like by process for purpose and under given fabrication conditions. So, how easily, how easily a metal can be welded to produce good quality weld joints by a process for a given purpose under the given fabrication conditions. So, this is basically the relative property like a metal can be easily welded by a process for a given purpose under a given conditions, but it will be very difficult to weld by maybe say by anothy any other process.

So, I will elaborate this little bit for a while to define the ease of welding like if aluminum is welded by the gas welding. So, it cannot be welded, but if the aluminum is welded by the gas tungsten arc welding can be easily welded, whatever purpose for which it is to be used. So, if the process brings in the difference in the ease of welding that is why we specify the process. And then the purpose like say mildly steel welded using the simple shielded metal arc welding process for the normal room temperature conditions, it is weld ability is good, but if the same joint is used under the minus 20 degree centigrade or minus 30 degree centigrade under the impact conditions this kind of the joint is very poor. Because there is a lot of great loss in the toughness of the joint under the sub 0 temperature conditions.

So, it is important that the function for which the joint is to be made the fabrication conditions means the kind of the procedure to be followed that is fixed the conditions and which joint is to be made if all those are faced then probably it will be easy to define the ease of welding for a given metal for defining the weld ability of steels. Normally it is somewhat easier because basically the 2 aspects are looked into the way by which heat affected zone of the steel behaves and the kind of cleanliness of the weld which is obtained.

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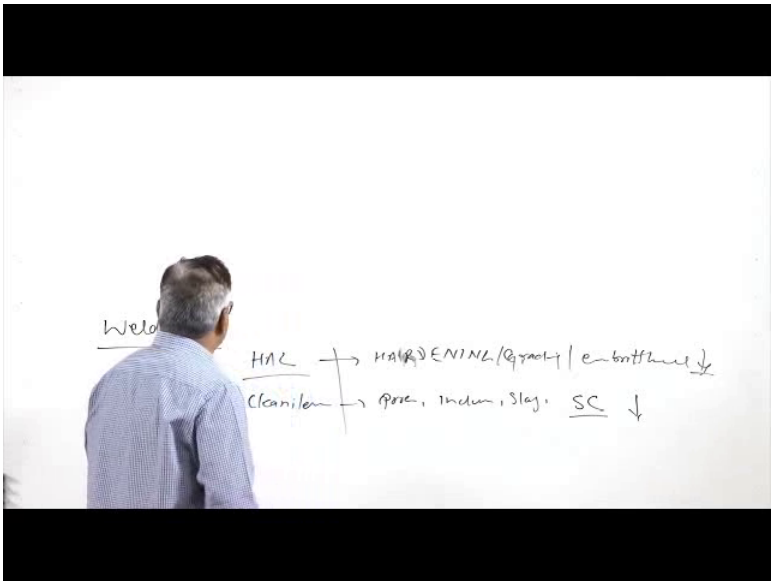

So, if the heat affected zone is more problematic in terms of the heat in terms of the hardening cracking hardening cracking embrittlement. So, all these will be leading to the

reduced weld ability of the weld joint on the other hand presence of the pores inclusions slag like solidification cracking due to the presence of the low melting point things like silicates etcetera all these will also be lowering the weld ability of the steel. So, we need to see in which way during the welding steel behaves with regard to the heat affected zone and the cleanliness of the weld metal.

I will talk in detail about the ease of welding of the steels as well as the factors that affect the ease of welding of the steels. In the next presentation, now here I will I will summarize this presentation, in this presentation. Basically I have talked about the solid liquid joining processes as well as chemical joining process like adhesive joining. So, the principle of the brazing principle of soldering and the fundamentals of the adhesive joining have been highlighted. In today's presentation as well as the conditions under which this kind of the joins are applicable.

Thank you for your attention.