Welding Engineering
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Module - 4
Arc Welding Processes
Lecture - 8
Brazing, Soldering & Braze Welding

In this presentation, we will be talking about the brazing, soldering and the braze welding processes. These processes are different from the conventional arc welding processes in the sense that the melting of the faying surfaces is not done. The weld joint or the joint is made using the comparatively low temperature of filler materials without bringing the faying surfaces of the base metal to the molten state. That is why these processes are very common among those metal systems, which are very sensitive to the heat or they are metallurgically incompatible with each other. So, the situations under which these processes are used and what are the factors that led to the use of these joining processes.

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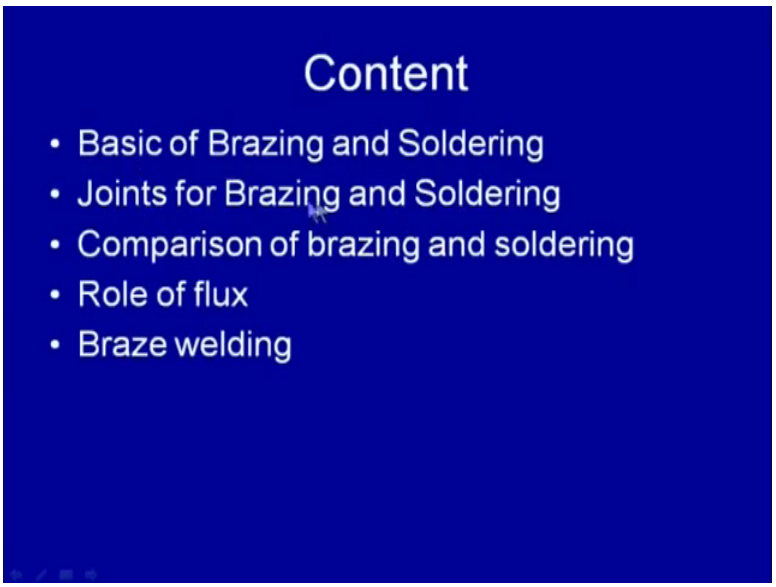

So, we will be going through the various aspects related with these processes in detail which will include the basics of the brazing and the soldering the joints. How the joints are made by brazing and soldering, then comparison of the brazing and soldering. We have to see that the role of the fluxes and how the braze welding is carried out and how it

is different from the brazing and soldering process.

We know that conventionally fusion welding process are more commonly used then this group of the joining processes because they apply the metallic continuity of the same metal, largely same metal and the performance is also performance of the weld joint is similar to that of the base metal to great extent. But in many situations we cannot it is found difficult to do the melting of the faying surfaces for developing the weld joint.

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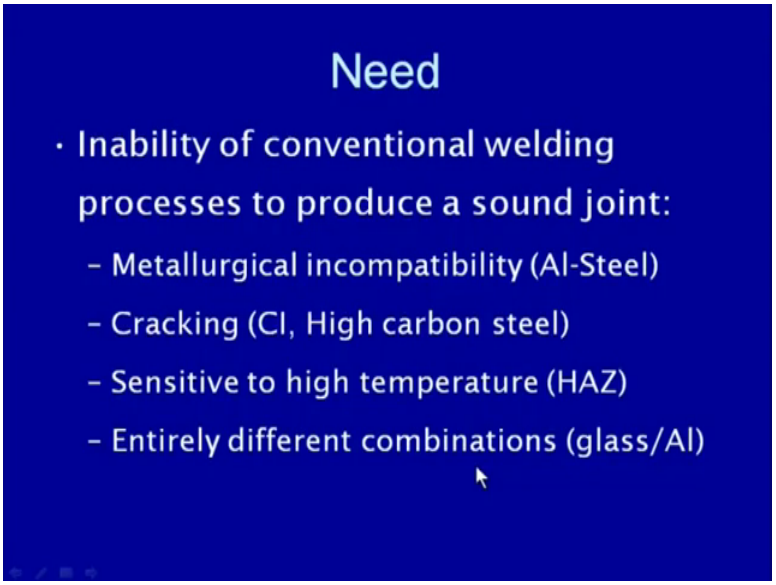

Due to the various problems like metal systems to be joined are metallurgically incompatible. Under those conditions it is required to use those processes where the melting can be avoided, but the joint can be made using some low temperature filler materials by heating the surfaces to be joined. There are certain metal systems which are very crank sensitive on heating and then the followed by rapid cooling during the conventional welding that leads and those metal systems frequently leads to the cracking.

So, to avoid cracking of those metal systems like cast iron, high carbon steels instead of the arc welding processes or the fusion welding processes this set of the joining process are used which can involve the brazing, soldering and the braze welding. Further, the metal systems which are sensitive to the high temperature and significant deterioration in the performance of the region close to the weld zone takes place like the heat affected zone. Then those are also, those also need some alternative processes for joining the metal systems for variety of purposes.

And the entirely different kind of the combinations are required like the aluminum to copper or aluminum to steel etcetera. Then under those conditions also we need such kind of processes where melting of the faying surfaces can be avoided. At the same time use of the low melting point filler material can be done for developing a weld joint for achieving the desired function of having joint between the two component.

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If we see these processes are different from the conventional arc welding processes and other fusion welding process in the sense that these group of the processes like brazing, soldering and the braze welding use very low heat for developing the joint. Especially using a low melting point filler metal and these groups of the process does not, do not involve the melting of the base metal and because of this group of processes allow the combination of the different metal and non metal systems.

So, these are the unique features related with these processes that they use very low heat input for developing the weld joint, for developing the joint between the two components or no melting of the base metals take place. Base metals are the components to be joined and the dissimilar combinations can be joined. If at all we have to carry out the brazing and soldering then what process and what procedures are used. So, step by step we will be looking into the methods and the steps which are followed for developing the joint using the brazing and soldering.

These groups of the process are called the solid liquid processes because the base metal remains in the solid state and the filler metal is brought to the molten state or the liquid state. There and on the solidification of the filler metal leads to the development of a joint. Mainly three steps are used in the brazing and soldering. First, involves the heating of the plates to be joined using the suitable heater source. This heat source can be of any type like the gas flame.

It can be gas flame or induction heating, infrared rays can be used or any other source can be used for heating the plates to be joined. Thereafter, placing the, placing and melting the solder or brazing material followed by heating to the molten state. So, once the plates are heated then brazing or soldering material is applied. So, that it can be brought to them molten state and gets distributed between the plates to be joined out the components to be joined.

So, the filling of the molten filler metal between the faying surfaces of the component to be joined by the capillary action. And thereafter, on solidification we get a complete joint. So, the steps are mainly the heating of the plates then placing the solder or the brazing material. So, that the melting of this filler material takes place and gets distributed between the components to be joined by the capillary action. And thereafter, solidification results joint between the components.

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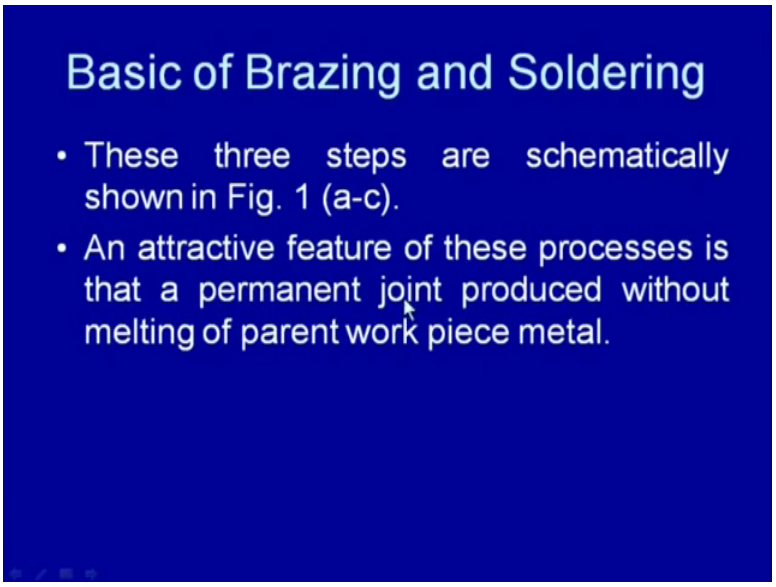

So, if you see these three steps will be shown schematically in the subsequent slide. An attractive feature of these processes is that a permanent joint is obtained without melting of the faying surfaces. And these in turn helps in avoiding many undesirable characteristics which are offered by the fusion weld joints like the differential expansion and contraction leads to the development of residual stresses and the heat affected zone and sometimes distortion in the weld being made.

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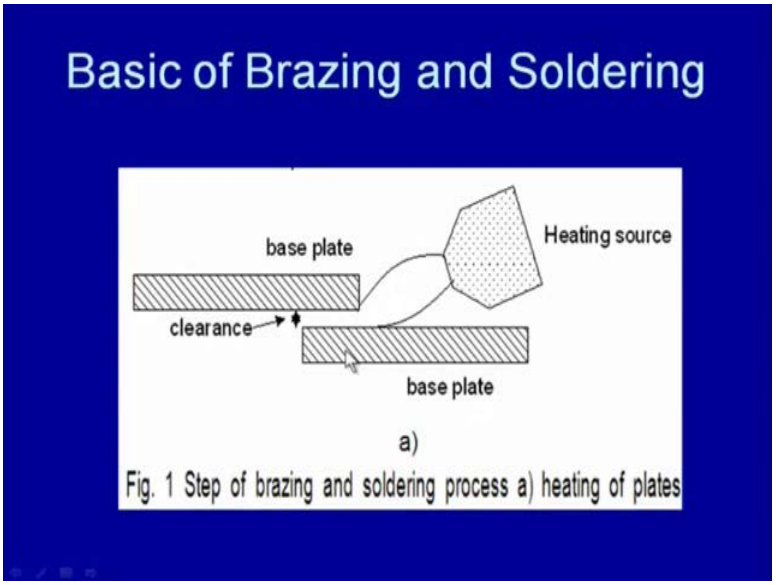

If you see schematically this process if we are using heat source as gas flame, so the plates are and the components to be joined are brought in a particular positions, so that proper clearance is maintained between the plates to be joined. And thereafter, heat is applied. Once, they are heated to the correct temperature then the braze material or solder material is placed in and on melting this place, on melting this material gets distributed between the component to be joined by the capillary action. And subsequently on solidification we get joint between the members to be joined.

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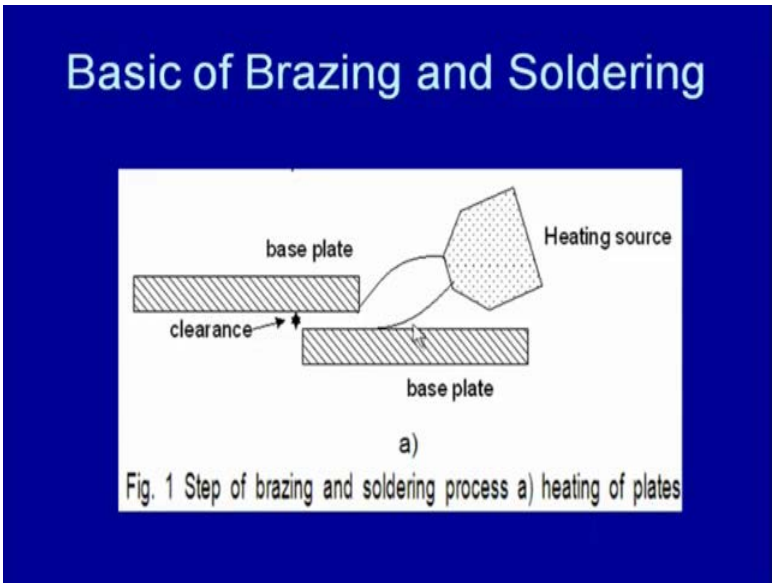

So, here we see the arrangement is the red plates are kept under the, in a particular position with the controlled gap and the heat is applied using a suitable heat source and then filler material is placed near the edges of the plates to be welded are to be joined. And subsequently on melting of this filler material it gets distributed by the capillary action between the, in the gap between the members to be joined.

So, this is how the filler material here it heating, here heating is taking place and once the things are brought to the molten state it gets distributed by the capillary action between the plates to be joined. Under what conditions these processes find their applications that is what will be seeing. Owing to, due to the typical feature of developing a joint by brazing and soldering that it uses very low heat input and the joint is made without melting of the faying surfaces. This kind of typical feature associated with the brazing and soldering helps in application of this processes under the different conditions.

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So, the first one you can say the metallurgical in incompatibility. So, this, these processes are found to very effective under the conditions when joint is to be made between the entirely different, between the metal systems having entirely different physical, chemical and mechanical characteristics. Since, no melting of the faying surfaces or the base materials takes place during these groups of the processes and that is why the metallurgical incompatibility between the members being joined does not play any role. So, the metal systems having the metallurgical incompatibility in respect of the physical, chemical and the mechanical characteristics can be effectively joined using this group of the processes.

The poor weldability, though the joints, joining of the metals having the poor weldability by the fusion welding processes due to the excessive cracking tendency or the chemical reactivity to the ambient gases or some of their problem associated with the fusion welding processes like excessive hardening and softening of the heat effected zone. Under those conditions the, this brazing and soldering is found to be effective for developing a weld joint because it supplies very less heat for developing the weld joint. So, these adverse affects related with the fusion welding processes can be avoided by use of the brazing soldering and the braze welding processes.

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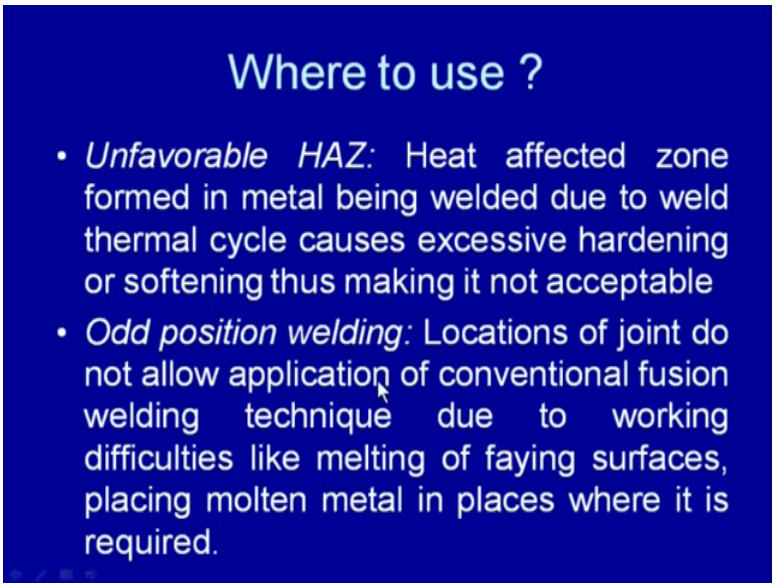

Further, if we see there are other situations like in the conventional fusion arc welding processes rapid heating and cooling in the regions close to the fusion boundary leads to have significant variation in micro structure and mechanical properties. And that leads to the development of zone called heat affected zone where mechanical and metallurgical changes are experienced by the base metal. And sometimes these changes in the base metal near the weld zone which is called heat affected zone leads to excessive hardening or the softening which makes the joint unacceptable for number of applications.

So, if you want to avoid these undesirable effect of the heat affected zone then the application of the brazing, soldering and the braze welding can effectively reduce the heat affected zone which is formed in the base metal by this group of the processes because of the reduced heat input and absence of the melting of the faying surfaces. And further the brazing, soldering and the, braze welding processes can be effectively used in odd positions where welding, odd position welding experience is number of the difficulties. Because the locations of the joint where the common fusion welding processes is not favorable due to the working difficulties like melting of the faying surfaces or placement of the molten metal in the desired location.

Then the brazing soldering can be effectively used because it requires first heating of, heating of the components to be joined. Thereafter, replacing the filler material in the location between the components to be joined and then on melting of this filler material

it automatically gets distributed between the components to be joined by the capillary action. So, under those conditions means under odd positions also this brazing, soldering and the braze welding can be used. However, braze welding is slightly different from the brazing and soldering. About that we will be talking in detail.

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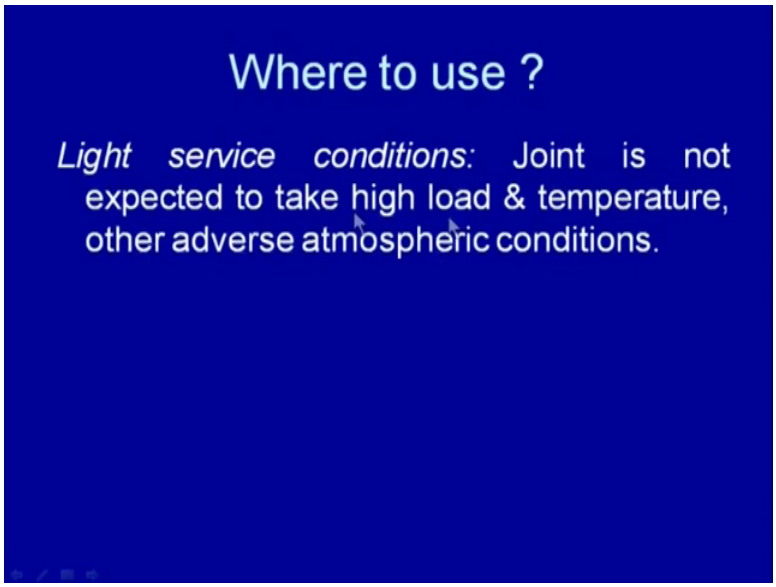

Under the what conditions this kind of joint is preferred? So, the under the light service conditions all the joints which are required not to take very high load or not to, it is not required to serve under high temperature conditions or any other adverse atmospheric condition. The brazing soldering joints can be effectively used for developing the joints between the metal systems, which are either metallurgically incompatible or the common fusion welding processes are not favorable due to the variety of regions. So, under the conditions where the mechanical loading conditions or the temperature conditions or other atmospheric conditions are not severe, under those conditions brazing and soldering can be effectively used.

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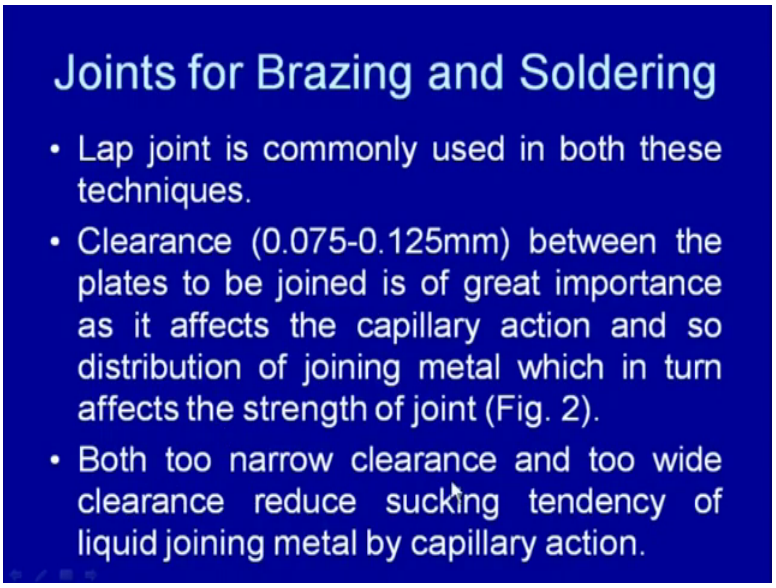

For developing the braze and solder joints it is common to use the lap joint, but other joints like the butt joint and some slanting of the faying surfaces is also done for making the joint between the two components. So, lap joint is commonly used in both these technique that brazing and soldering and the clearance between the components to be joined is controlled very accurately. So, as to get the required capillary action in order to distribute the molten filler metal between the components to be joined because this, the clearance and the thickness of the film of the filler material being formed between the components also effects the strength of the joint.

So, the clearance plays a very important role in developing the braze or the solder joint which can offer the desired strength and the sound joint. And this clearance normally intend between the 0.0 to 0.075 to the 0.125 mm in order to get the advantage of the capillary action. Both, the too narrow clearance will not allow the entry of the filler material and the too wide clearance will reduce the sucking tendency by the capillary action of the liquid metal between the components being joined.

So, both too narrow or the too wide clearance is not preferred for brazing and the soldering purpose. So, the, this gap between the components to be joined indicates clearance and it is, it should be maintained very clearly between the components to be joined. Schematically, I will try to show that how different kind of the joints are used for developing the braze or solder joint.

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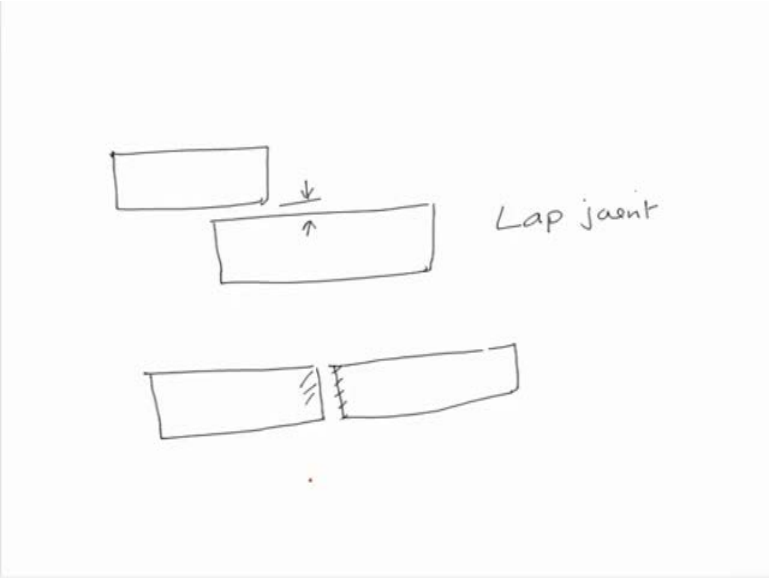

Here we can see this is the common lap joint, which is used. And the gap between the plates to be joined is maintained in very controlled manner which is called clearance. This kind of the joint is called lap joint, but it can also be used means butt joint can also be made between the members to be joined. And here heat will be applied near the edges of the plates to be welded and then the filler material is placed here. So, that it gets distributed between the members to be joined. And one more method which is used in this case, this area will be determining the length and the width, means this length and width of the faying surfaces will be determining the strength of the joints. So, in order to increase the strength of the joints sometimes slanting of the faying surfaces is done.

So, that as compared to that of the simple square edges it, when the slanting edges are formed this helps to have the larger area for the same thickness. And this kind of arrangement is especially used for developing this is scarf joint. So, here this kind of slanting helps to increase the area of the joint which will indirectly help in increasing the strength of the joint. So, but the lap joints are very common with the braze and the solder joints.

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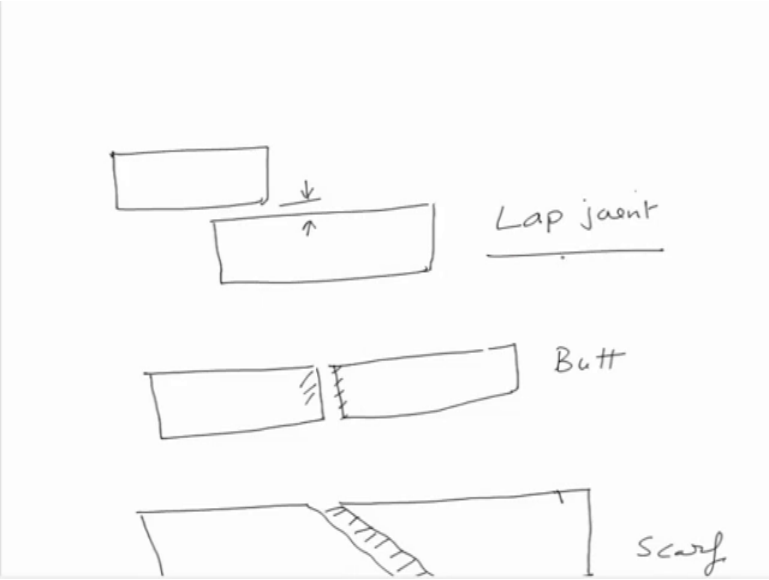

For developing the weld joint, for developing the braze or soldering, solder joint it is necessary that the plates are cleaned first. And the all the impurities, oxides, oil, grease etcetera present on the surface of the plates to be join is removed. So that the proper capillary action can be obtained for uniform distribution of the filler material being applied at the edges of the plates to be joined.

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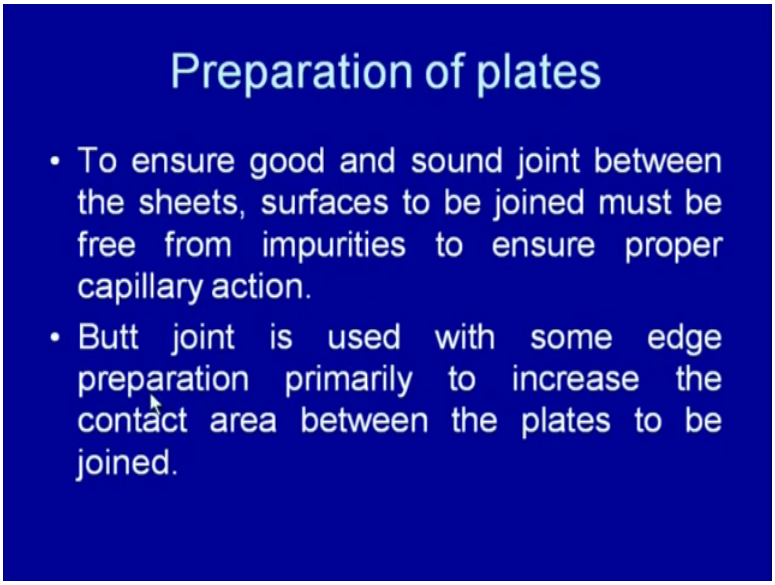

So, to ensure the good and the sound joint between the sheets the surfaces to be joined must be free from the impurities like oxides, oil, grease, paint etcetera present on the

surface. And this is necessary to have the proper capillary action. Butt joint can be used with the some of the, with the some edge preparation primarily to increase the contact area between the plates to be joined. So, this is what I said that some slanting of the edges of the plates can be done for increasing surface area, so that the strength of the joint can be increased.

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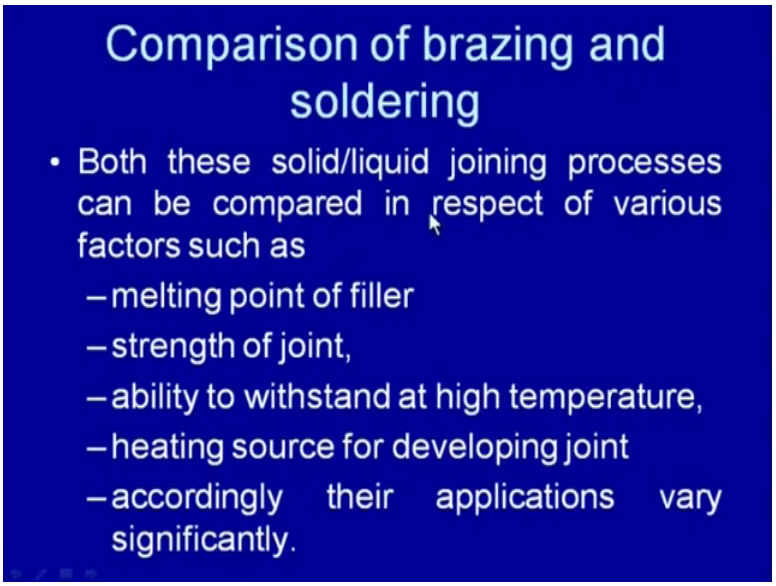

Both these solid liquid joining processes like brazing and soldering can be compared with respect to the various factors with the, each other. The brazing and soldering are different. They have lot of similarities in respect of the, in the respect that both are solid liquid joining processes where the filler metal is brought to the molten state and the base material remains in the solid state. And it is not brought to molten state. No melting of the faying surfaces of the base material is done, but these processes are different in respect of the many ways.

The first is the melting point of the filler material. Normally, the braze, brazing material has the liquidous temperature that is the melting point, complete melting point of the filler material greater than 450 degree centigrade while in case of the soldering, the filler material is lower than the 450 degree centigrade. The strength of the joint in general in case of the brazing joint is better than the solder joints. And the ability to withstand at high temperature braze joints can withstand at a high temperature than at which the solder joints can withstand.

The heating source for developing of the weld joints, there is slight difference in the heat source which can be used for the true processes and based on their ability to take up the load, melting point of the filler material and ability to withstand at high temperature these two processes find applications in different areas. And of the conditions where mechanical load is not much for between the components being joined, the soldering is very commonly used in electronic industry where connection is required mainly to have the flow of current or this flow of this signals from one side to another through the joint.

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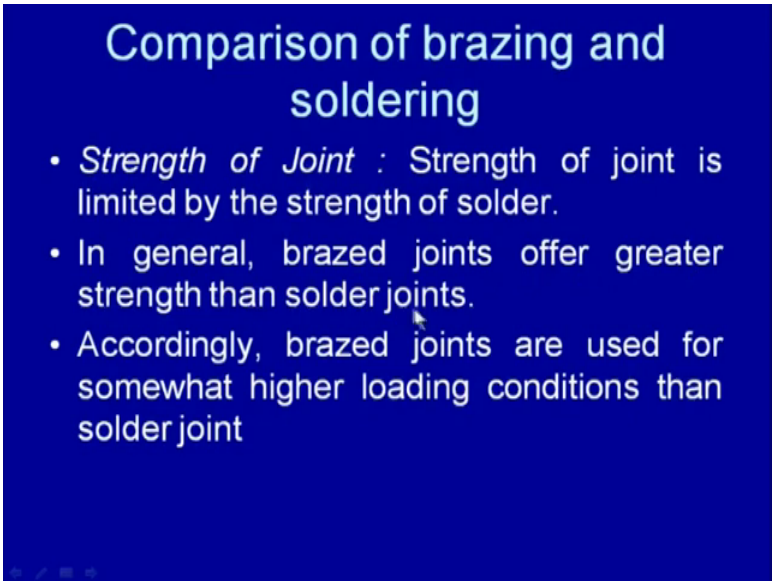

So, detailing with these, the points as far as comparison between the brazing and soldering is concerned melting point of the filler material is the first point where solder uses the low melting point filler material, normally 183 to 275 degree centigrade. These are called the solder, which are basically alloy of the lead and tin while the brazing uses the comparatively higher melting point filler material of the 450 to 800 degree centigrade. And mainly these are the alloys of the aluminum copper and the nickel and accordingly the braze joints are used for somewhat higher load conditions than the solder joint and they can withstand also at the higher temperature.

So, the strength of the joints, strength of the, strength of the… If we compare the brazing and soldering joint in respect of the strength and the strength of the joint in this case is limited by the strength of the solder means in the case of soldering strength is limited by the strength of the solder. Well in case of the brazing it is the strength of the brazing

material which is being used. Since, the brazing materials are stronger than the solder joints, solder material and accordingly the braze joints offer the greater strength in the solder joints. And therefore, the braze joints are used for higher loading conditions than the solder joints.

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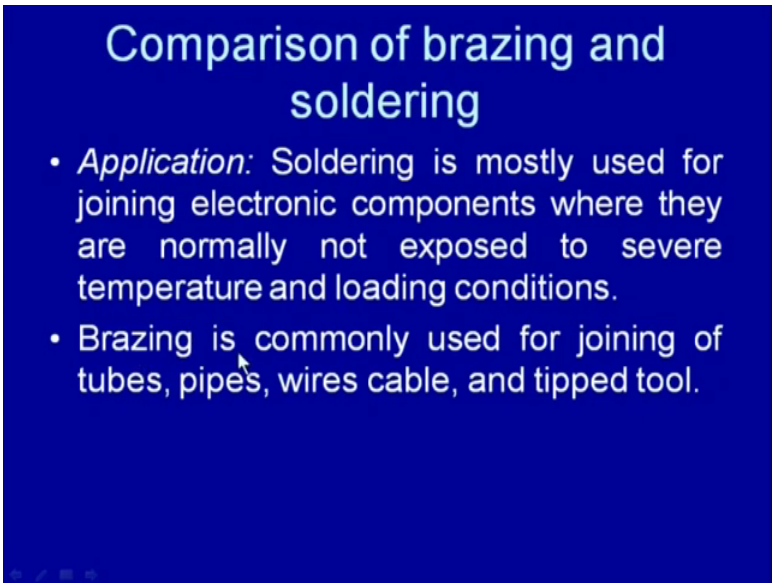

Then the ability to withstand under the high temperature conditions, in general braze joints offer the higher resistance to the thermal load means they can withstand high temperature or under the thermal higher thermal fluctuating conditions than that which solder joints can withstand. And this difference is primarily due to the difference in the melting temperature of the solder and the brazing filler metals which are used. And therefore, these joints are preferred for mainly for the low temperature applications.

Application wise these two processes can be compared in the sense that soldering is mostly used for joining in the electronic components, where they are normally not exposed to the severe temperature and the loading conditions. While the brazing is commonly used for joining of the tubes, pipes, wires, cables, wires, cable and tipped tools, where some sort of load can act on the component or in the joint during the service.

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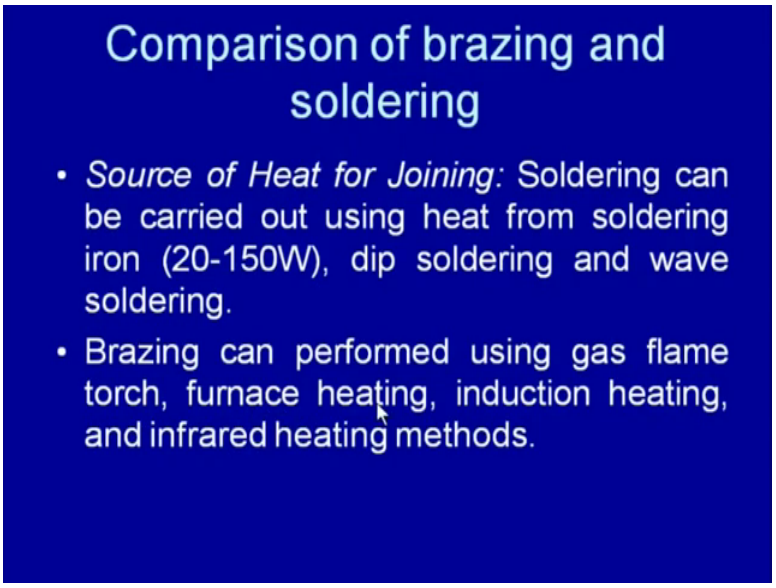

As far as source of the heat is concerned soldering can be carried out using the heat from the soldering iron or dip soldering and the wave soldering. Brazing can performed using the gas flame torch, the flame heating, induction heating or infrared heating methods.

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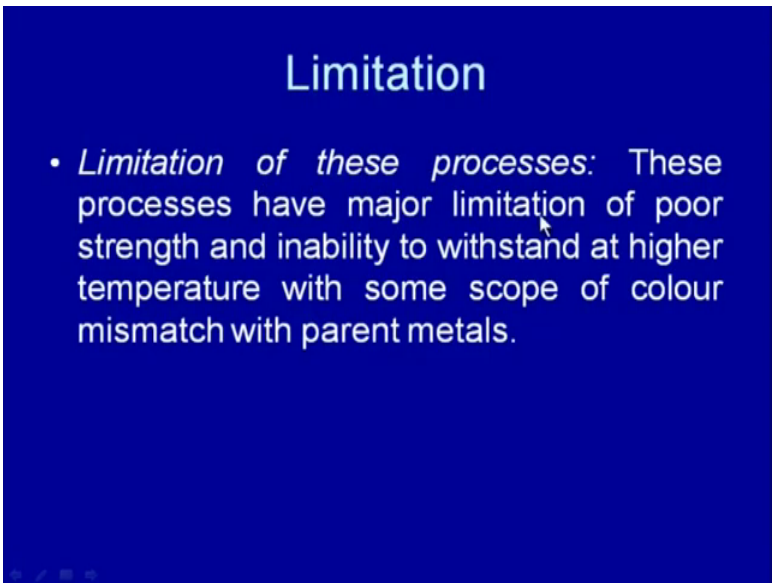

So, but there are certain limitations associated with both these processes; these processes have major limitation of the poor strength and their inability to withstand at higher temperature with some scope of the color mismatch with the parent material. So, the major limitations are they are poor strength and inability to withstand at high

temperature. And there is also possibility of the color mismatch especially when the components to be used under the…

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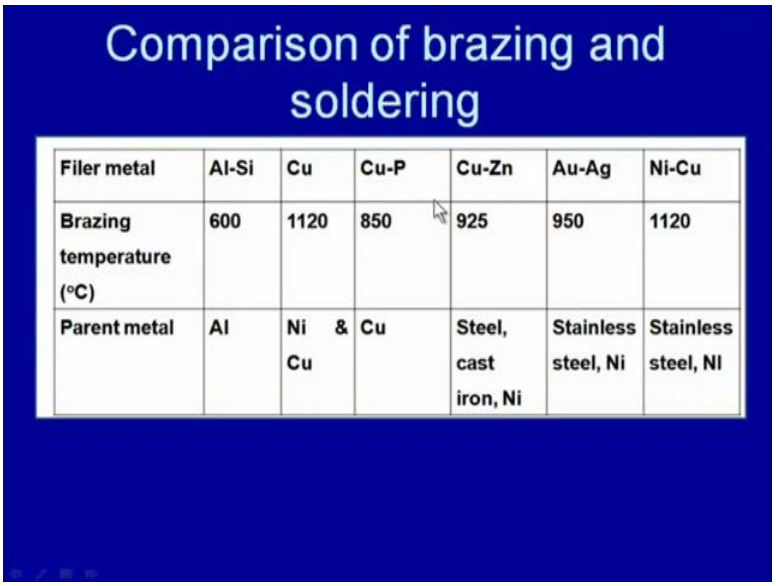

When the joint is exposed and they are direct in line of site especially in the components of like car where the mismatch of the color can decrease the esteem value of the product significantly. So now, if we see the different filler metals and the conditions for which or the base metals for which they can be used. So the base, the brazing materials like filler material aluminum silicon, the brazing temperature 600 degree centigrade for the, for the parent material like aluminum.

And then filler material copper 1120 degree centigrade can be used as filler material with the nickel and copper alloys. Then the copper phosphate brazing temperature 850 degree centigrade can be used with as a brazing material with the copper. Similarly, copper zinc alloy systems having the melting point of 9 brazing temperature 925 can be used with the steel, cast iron and nickel alloy systems. Silver and gold the brazing system, the brazing temperature 950 degree centigrade can be used with the stainless steel and the nickel alloy systems.

And nickel copper fillers metals brazing temperature 1120 degree centigrade an can be used with the stainless steel and the nickel systems as a base material. For developing the sound weld joint which is sound, the braze joint or solder joint it is necessary that whatever joint is being made just free form the impurities, oxides and it is properly

distributed between the components being joined. So, for that purpose like in the conventional arc welding processes to remove the impurities from the molten metal and to prevent the oxidation of the metal during the welding. Here the fluxes are also used. Fluxes are used with the brazing and brazing and soldering in order to have the various favorable effects like the surface contaminants, various impurities and undesirable contents can be present on the surface.

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So, in order to remove them the fluxes are used as they will dissolve the impurities present on the surface and to may, will make them clean. Further, these will also dissolve the oxides present and prevent the further oxidation of the base material. So, after removing the oxides present at the base metal surface the further oxidation is removed, reduced by, prevented by the fluxes when they are used. The fluxes also helps in removing the oil and grease which is present on the surface.

And it prevents the oxidation of the base metal further, prevents the oxidation of the filler material also. So, there are various purposes for which the fluxes are used in brazing and soldering; removes the impurities present at the surface, removes the oxides removes the grease and oil present, prevents the oxidation of the base metal further, prevents the oxidations of the filler material on heating and helps in improving the fluidity of the molten metal. So, that it can gets distribute it can distribute uniformly between the faying surfaces.

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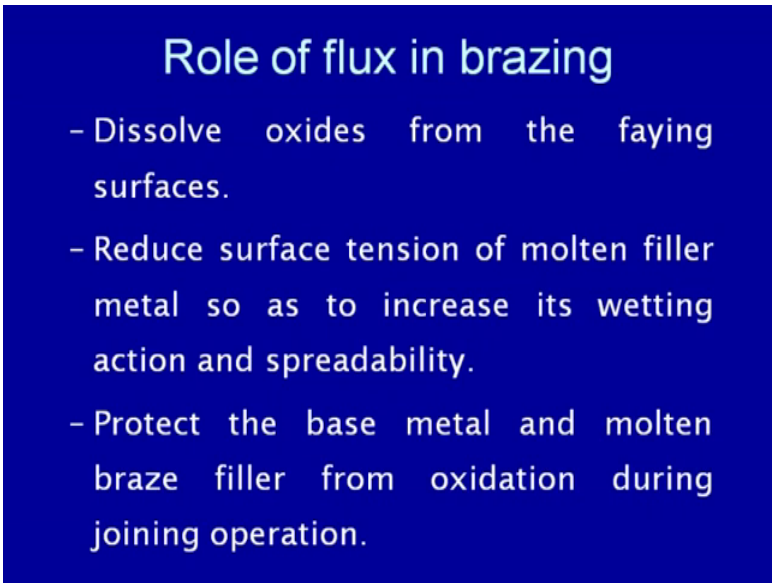

These fluxes basically dissolve the oxides from the faying surfaces and reduce surface tension of the molten filler material in order to increase the wetting action and the spreadability. So, when the fluxes are present and heating of the filler material is done.

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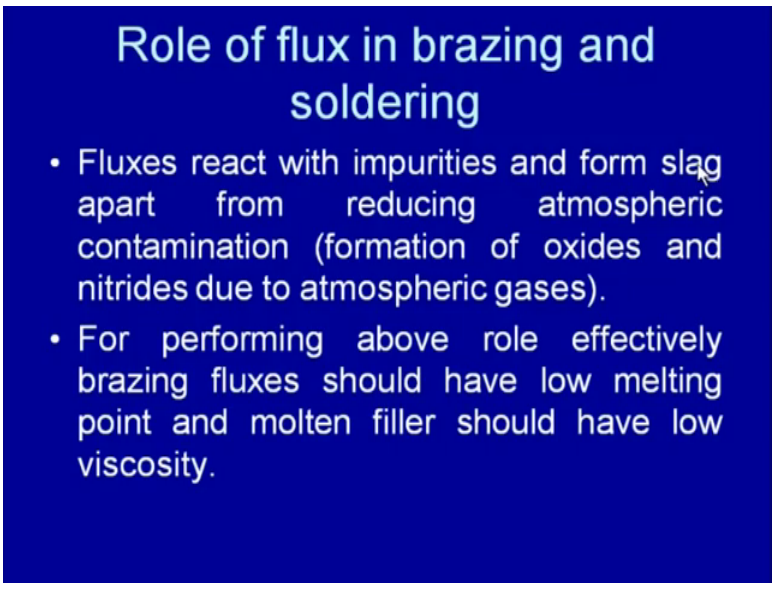

So on melting, these filler material the fluxes helps in reducing surface tension of the molten filler material, which in turn helps in improving the wetting action and increases, which in turn increases the spreadability or the ease by which the molten filler material can get distributed between the faying surfaces. And further, it protects base metal and

the molten braze filler metal from the further oxidation from the atmospheric gases during the joining operation.

So, fluxes these fluxes react with impurities and form slag during the operation from the reducing atmospheric contamination or the formation of oxides and nitrides due to the atmospheric gases. So, when the fluxes are present these fluxes react with the impurities present with the molten metal and it forms slag. So, these impurities can be formed by the reaction between the molten filler metal and the atmospheric gases by forming the oxides and nitrides.

When these are formed the oxides and nitrides are formed the fluxes react with them to form and after reaction they form slag and the slag is removed. And for performing above role effectively the brazing fluxes should have the low melting point and the low melting point and the molten filler material should have the low viscosity. So, that things can react effectively and after getting, after removing these impurities present with the filler material; the filler material can get distributed uniformly between the faying surfaces for developing the joint.

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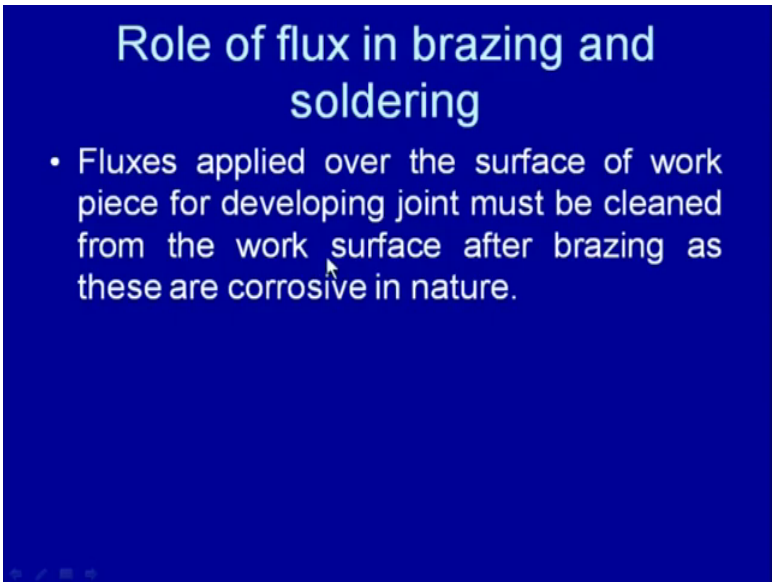

The fluxes are applied over the surface of the work piece for developing the joint must be cleaned from the surface of the work piece after the brazing because these fluxes present on the surface of the work piece are found to be corrosive in nature. Therefore, once the fluxes are applied these must be removed from the surface. The fluxes which

are commonly used for performing their role means reacting with the impurities and removing them in form of the slag.

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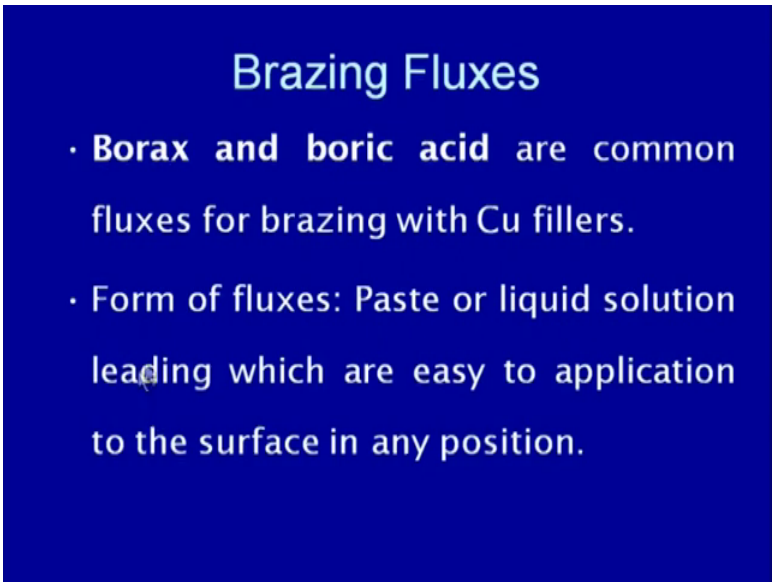

The borax and the borax flux or the boric acid, are commonly used for the brazing with the copper filler metals. And these fluxes can be used in form of paste of the liquid solution which can be easily applied at any position during the joining process. For the brazing depending upon the source of the heat which is being used for heating the base material for developing the braze joint the various brazing methods have been developed.

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The torch brazing uses the flame for heating the faying surfaces of the base material and then application of the filler material in form of braze filler material the joint is obtained. The dip brazing, the salt bath is used for heating components to be joined and the furnace brazing the components to be joined are passed through the furnace. And then under those conditions the filler material melts and gets distributed between the components to be joined. Then infrared brazing where infrared rays are used for heating the component to be joined. In induction brazing induction effect is used for developing the heat for heating the components to be joined. One by one we will be taking up these brazing methods.

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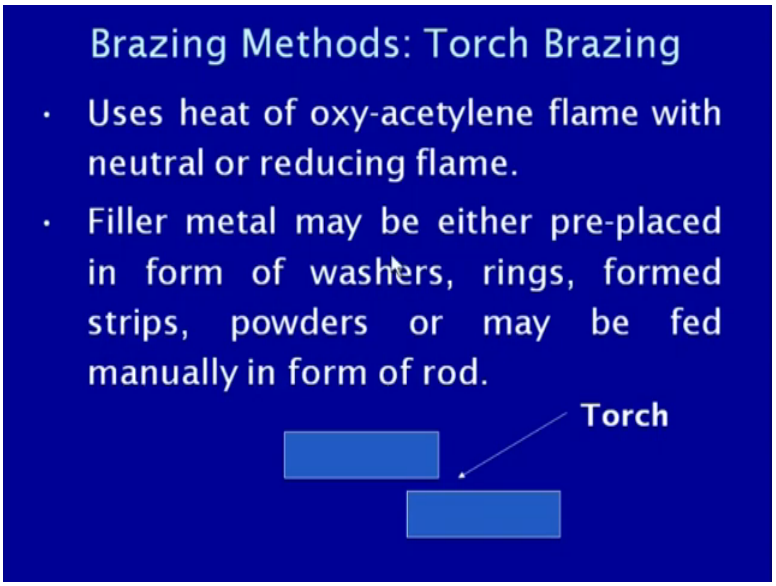

In the torch brazing it uses the flame of the oxy acetylene with the neutral or the reducing flame for heating the components to be joined. And the filler material in this can be placed either in, filler material may be either pre placed in form of the washers, rings or formed strips or the powders or it may be fed manually in form of the rods. Say, the faying surface the component to be joined after putting in particular position are heated using the flame. And once the heating is done either these filler materials can be pre placed. So, on melting these will get distribute or these can, after the heating the filler material can be applied manually in form of the rod.

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In the dip brazing the base material with the pre placed filler material at the joint is dipped in to the molten salt bath for applying the heat onto the component. The salt bath acts as a heat source as well as the flux for the brazing. It avoids any atmospheric contamination of the molten filler material during the joining and in the pre placed filler material melts and fills the joint.

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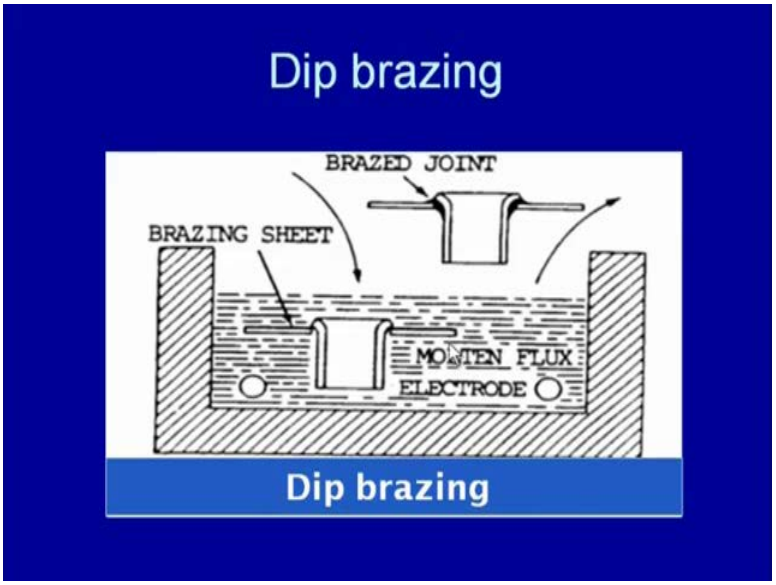

Alternatively assembled joint parts are dipped in the molten metallic bath, so that the joint can be made. And the molten metal in the bath fills the joint. So, the assembled

parts are dipped in the metallic bath, so that it fills the gap between the components to be joined and the molten bath, molten metal in the bath fills the joints. On solidification, we get the brazed joint afterwards. So, here say the components to be joined is one situation where these are the two components to be joined. So, the braze, the braze material is kept between them and then it is just put in the salt bath for applying desired heat. And then it is taken off to get the joint.

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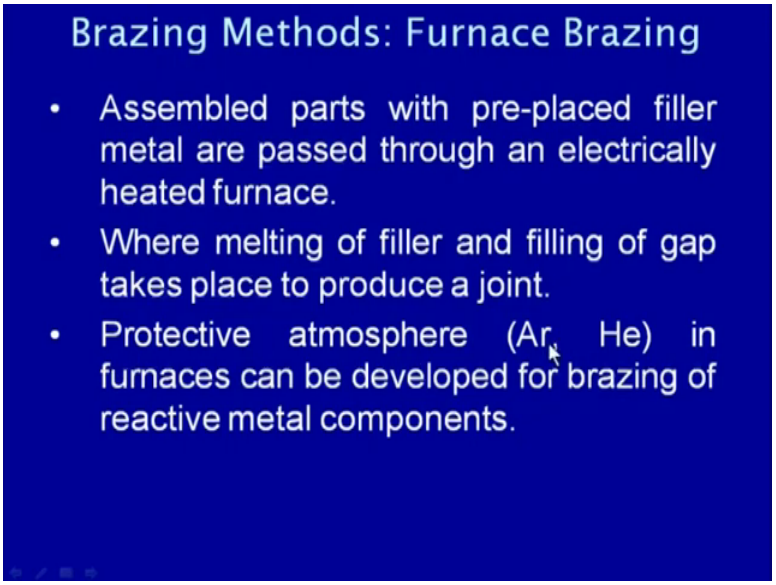

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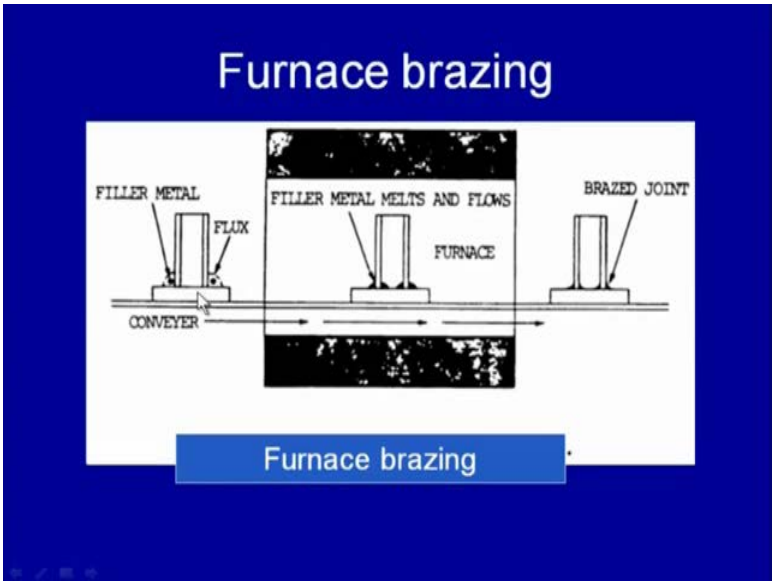

In the furnace brazing assembled parts with the pre placed filler metal are passed through an electrically heated furnace where melting of the filler, where the melting of the filler metal takes place and which in turn fills the gap between the components to be joined in order to produce, in order to produce the joint between the components. Protective atmosphere like helium and argon in the furnace can be developed for brazing of the reactive metal components, so that unnecessary reactions can be avoided.

Here, say if the two components to be joined then we put in the flux, the flux and the filler material and the filler material between them; then the system is passed through the furnace. When it passes through the furnace flux performs its role, and by reaction with the molten metal, molten filler metal to remove the impurities and prevent the oxidation if any has taken place. At the same time the, on melting this filler material it gets distributed between the components to be joined and after coming out complete on solidification of the braze material we get the joint in case of the furnace brazing.

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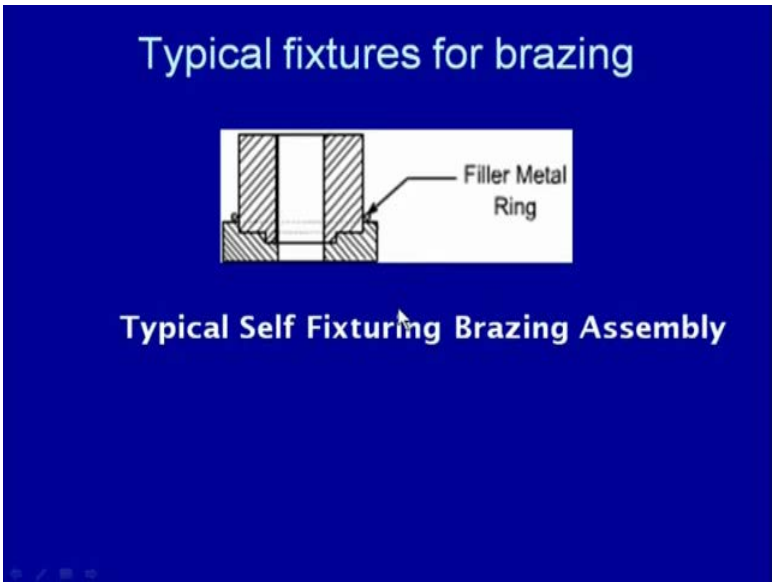

This is the situation where the filler material is, between the two components filler material is placed and then this entire assembly is passed through the heating furnace. So, in this situation like self fixturing brazing assembly here the filler material is placed between the components to be joined and then it is passed through the furnace and after that on solidification we get the braze joint.

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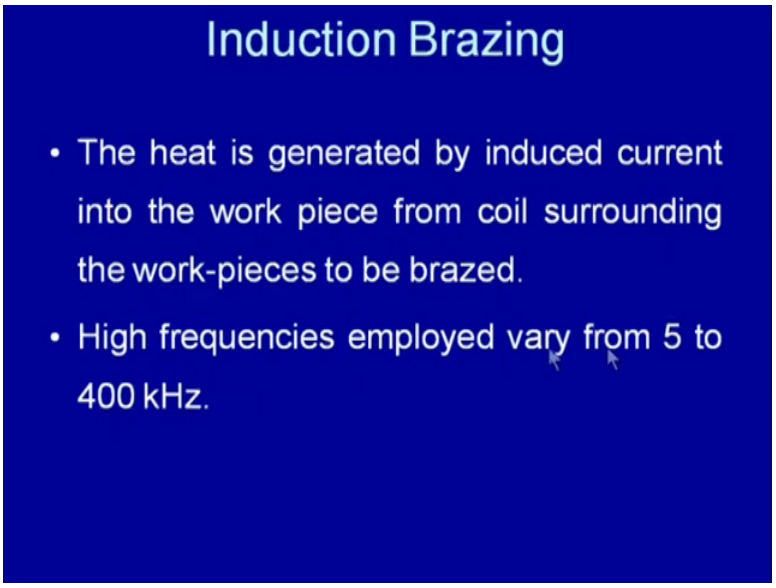

In case of induction brazing heat is generated by induced current into the work piece which is brought close to the coil which is surrounding to the work piece to be brazed. So, basically by the induction effect the current is induced, this induced current helps in electrical resistance heating of the component to be joined by the brazing. And especially the high frequency is a, is used for developing the heat and the frequency can vary from 5 to the 400 kilohertz. Now, we will see the soldering principal, which is used in case of developing, for developing the weld joint or for developing the joint between the components where common fusion welding process we cannot use effectively.

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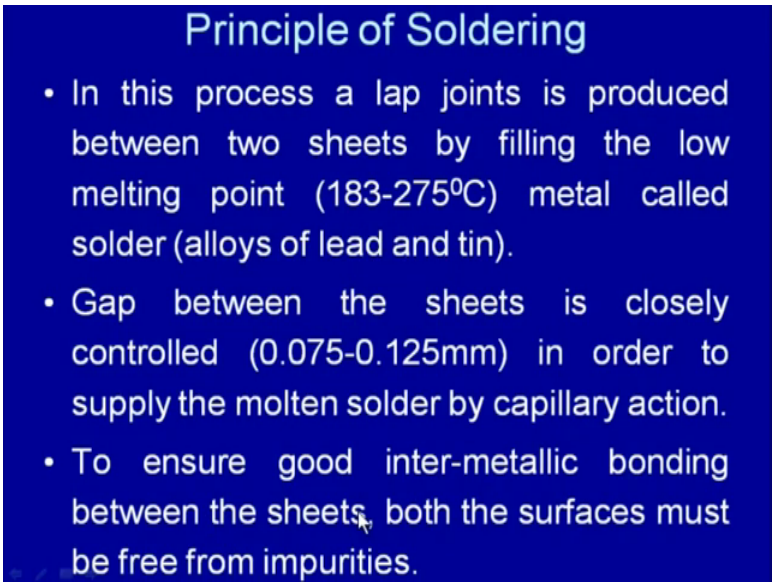

In this process a lap joint is produced between the two sheets by filling the low melting point filler material having the melting temperature range varying from 183 to two 275 degree centigrade metal. And this kind of metal is called the solder which is alloy of lead and tin. The gap between the sheets is closely controlled in this range in order to supply the molten solder by the capillary action. And to ensure the good metallic, inter metallic bounding between the plates or the sheets both surfaces must be free from the impurities.

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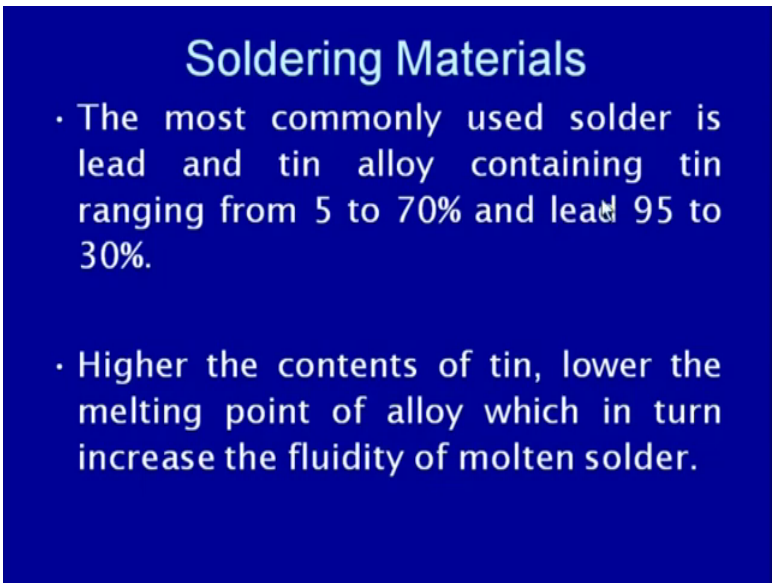

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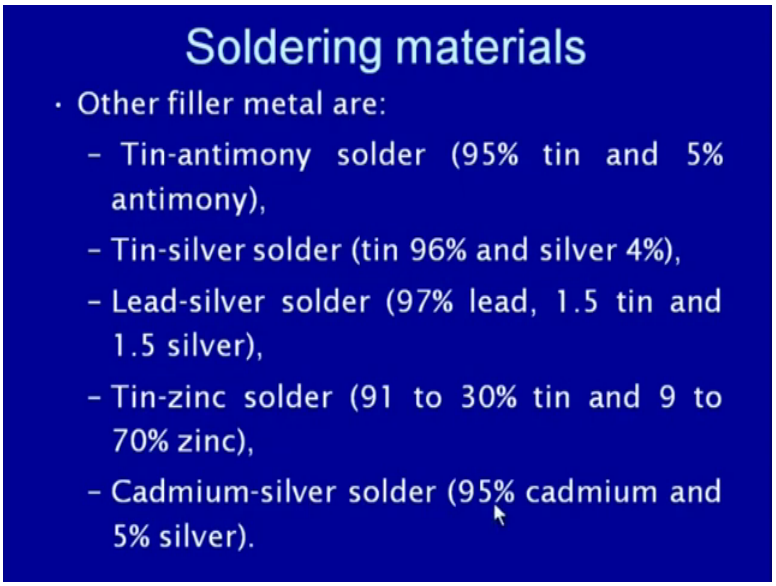

We, the solder materials which are commonly used are the lead and tin alloy containing,

tin can range from 5 to 70 percent and the lead can vary from 95 to 30 percent. The higher content of the tin lower the melting point of the alloy, which in turn increases the fluidity of the molten metal. So, the low tin the solders will be melting at the lower temperature, but at the same they will be offering the lower strength also.

They are many other soldering material which are commonly used like lead, tin antimony solder having the 95 percent tin and 5 percent antimony. Tin and silver solder where 95, 96 percent tin and 4 percent silver. Lead and sold silver solder having the 97 percent of the lead and 5 percent in, 1.5 percent tin and 1.5 percent silver. Then tin and zinc solder 91 percent, 91 to 30 percent tin and 9 to 70 percent of the zinc. Cadmium and silver solder uses the 95 percent cadmium and 5 percent solder. Now, various soldering methods, which are used for developing the solder joints. These soldering methods involve the, like use of the soldering iron where very low power soldering iron is used for developing the heat and applying it between the components to be joined for melting the solder.

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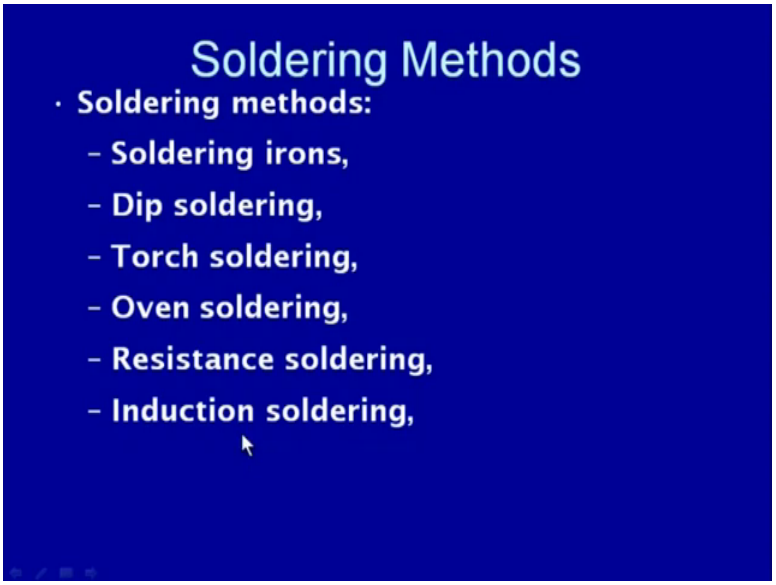

And the dip soldering is another method like we have described in case of braze, dip brazing and torch soldering uses the flame of the oxy fuel gas flame is used for heating the faying surfaces to develop a solder joint. And oven soldering uses the oven for applying the heat between the components to be joined by solder, so that the solder can brought to the molten state. And resistance soldering uses the electrical resistance heating

principal for developing the heat between the components to be joined by soldering.

And then induction soldering the a d current means the current induced by the induction effects between the components to be joined by bringing the induction coil close to the components to be joined. And once the components brought to the desired high temperature the solder is brought to the molten state and then distribution of the solder leads to development of the solder joint. And similarly, infrared radiations are also used for applying the heat and likewise the ultrasonic soldering. In all these methods, these methods are different in the way that how heat is being developed for melting the solder, so that the joint can be obtained between the component to be joined by the soldering method.

Now, I will conclude this presentation. Here in this presentation mainly covered the things related with the brazing and the soldering. We have seen the basic principal of the brazing and soldering, and what is the role of the fluxes in this, in these two methods. How can we compare the brazing and soldering methods with each other? What is the basic principal of the soldering? What are the soldering materials and the brazing materials and what are the common methods being used for developing the braze joint and the solder joints. In coming lecture I will take up first the braze weld and then other, various other aspects related with the other joining methods we will be taking up.

Thank you for your attention.