Manufacturing Process - I
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Module - 3
Lecture - 3
Brazing Soldering and Braze Welding

Welcome students. This is the third lecture on welding, and this lecture is based on the brazing, soldering, and braze welding techniques. This lecture covers the following aspects like: need of brazing, soldering, and braze welding.

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The principle, materials, methods, and applications of the brazing; principle, materials, methods, and applications of soldering; principle, materials, and applications of braze welding; advantages and limitations of these processes for producing the joint.

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The need of these techniques is due to certain specific reason, and because of which these processes were developed. And the main reason is inability of the conventional welding processes to produce the sound joint. And that inability of the conventional welding processes to produce the sound joint is because of the following factors like: the metallurgical incompatibility - it is practically difficult to weld the metal combinations like aluminum and steel using the conventional welding techniques, because of high reactivity of the aluminum, and significant difference in the melting point of the two metals. In addition to the melting point, high difference in thermal expansion coefficient of the two metals also imposes significant problems in welding of the aluminum and steel. So, the metallurgical incomparability is one of the main reason, because of which it becomes difficult to produce sound joints by the conventional welding techniques.

Another point is cracking: the metals like cast iron, high carbon steels, and other hardnable steels. During the welding high residual tensile stresses are developed, and if the material in the weld metal or in the heat affected zone is hard and brittle, and having very poor ductility, then it shows tendency for cracking. And the materials like cast iron - which is very hard and brittle - and the high carbon steels and a hardnable steels which develop very hard and brittle HAZ shows the cracking tendency. And if cracks are developed either in weld metal or in heat affected zone, then joint becomes useless. And because of this cracking tendency of the hardnable ferrous materials particularly, it is required to use the soldering, brazing or the braze welding kind of processes where load during this service will not be significantly high.

The sensitivity to high temperature - the many metals like a aluminum gets oxidized rapidly at a high temperature and the metals like steels - hardnable steels - subjected to weld thermal cycle, and that weld thermal cycle leads to the hardening of the heat affected zone. So that hardening and softening in some of the cases is observed in heat-affected zone, which leads to the non-uniformities in mechanical properties of the steel weld joints or are of aluminum alloys.

So, the another factor is that like entire different combinations have to be welded, then conventional welding techniques also fail to produce the sound joint. For example, the glass is to be welded with the aluminum; such different natures of the materials are very difficult to weld by the conventional welding techniques. So, for producing the joint which can perform successfully, for the different applications, under somewhat lower load and the lower temperature conditions these - the brazing, soldering, or braze welding - techniques are found useful.

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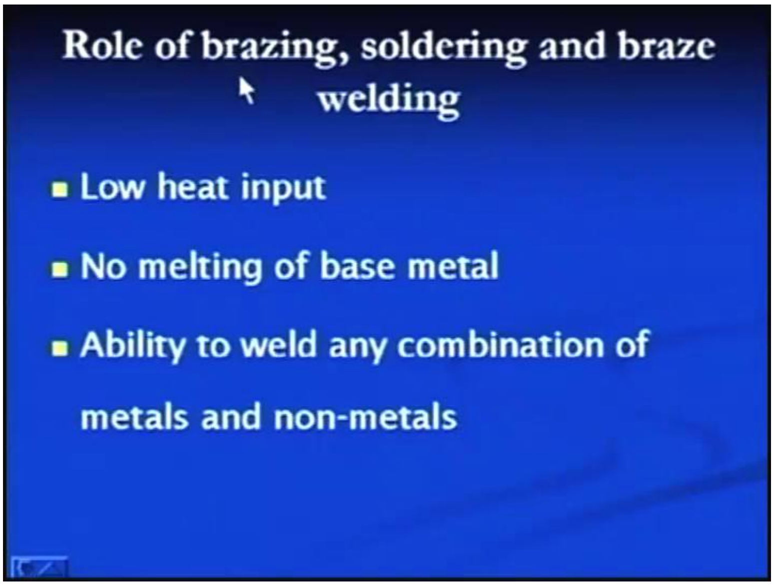

The role of the brazing, soldering, and braze welding is significant in producing the sound joints for the difficult to weld metals as described above. These welding processes are found useful, because of very low heat input is used for producing the joint. Base metal is not allowed to melt, and very little amount of the heat is supplied to the base metal for producing the joint, so that the high heat input related adverse effects are not produced in the base metal like residual stresses or distortion. The no melting of the base metal takes place in this process; this is a major advantage, particularly when joining the metallurgically incompatible materials like aluminum and glass, or aluminum and steel.

The ability to weld any combination of the metal and non-metal - this is possible only because no melting of the base metal is required for producing the joint by these processes – brazing, soldering, and that the braze welding techniques.

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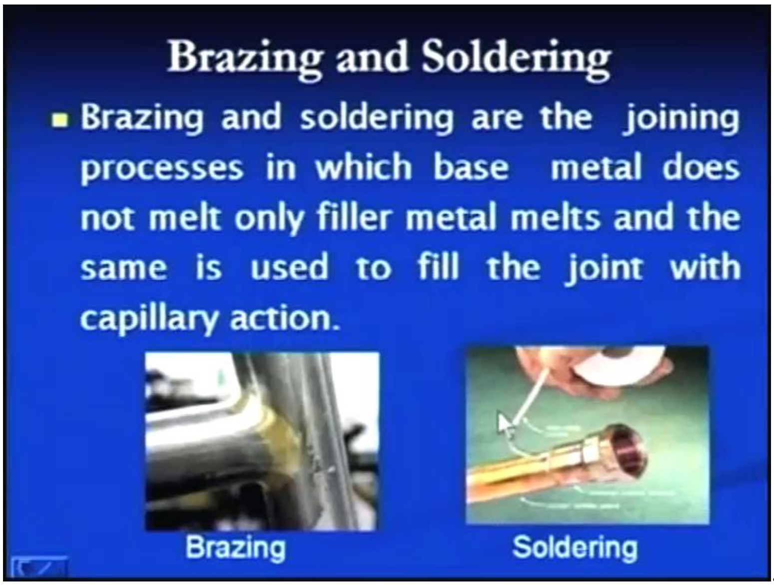

We will see that - what is the brazing and soldering? The brazing and soldering are the joining processes in which base metal does not melt; only filler metal melts, and the same is used to fill the joint gap by the capillary action.

You will see, here, in both these processes base metal is heated to a temperature below the melting point of the base metal and above the melting point of the filler metals. And that molten filler metal is used to fill the gap between the parts, which are to be joined. The filling of the gap takes place by the capillary action. One typical application of the brazing can be seen in joining of the parts in car body by the brazing. Here, this is the brazed joint which has been used to join these two components.

The same way soldering also can be seen here. The tube pieces are being joined by the soldering process here. This particularly - this process - produces the joint which is somewhat of lower strength than that is produced by brazing.

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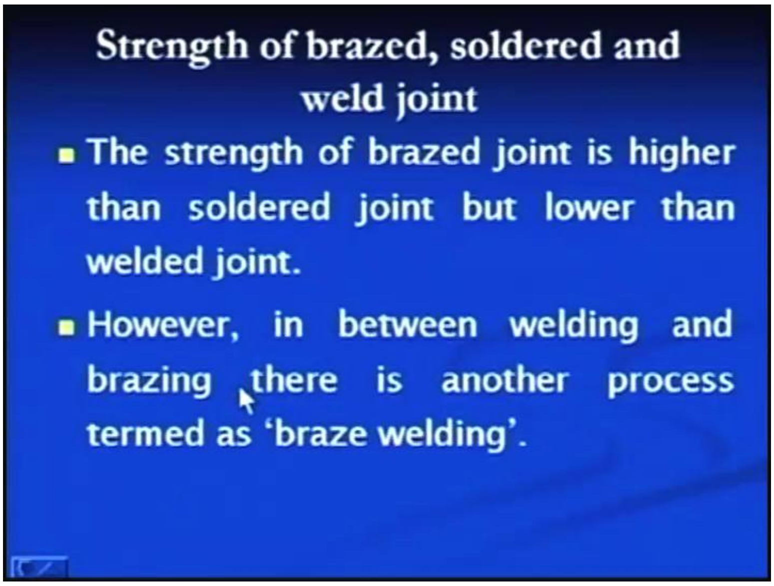

So, the comparison of the brazed, soldered, and the welded joints is like this here.The strength of the joint which is produced by the brazing, soldering, and the braze welding becomes different. And that difference is because of the mechanisms which are responsible for producing the joint, and the difference in the filler metal which is used to produce the joints in these processes.

The strength of the brazed joint is generally found higher than the strength of the soldered joint, because soldered material or soldered filler metal becomes of the lower strength compared to the filler metal, which is used in brazing process. In brazing process, we will use copper-based alloys; the copper-based alloys are used; while the solders are used for producing the soldered joints. Well, the strength of the braze welded joints, come somewhere in between the joints produced by only welding and that produced by the brazing. So we can say that the strength of the braze welded joints becomes in between the welding and the brazed joints.

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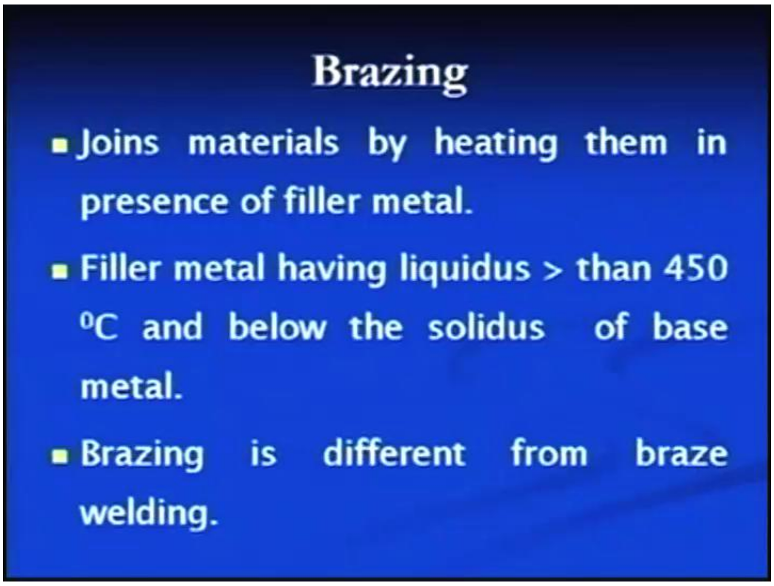

Because strength has to decide - strength of joint produced by either brazed joint or soldered joint or braze welded joint, has to decide - that which process will be more suitable for a given application. Now, one by one we will see the principles, and the methods, and materials, which are used in these joining techniques.

We start with the brazing one. The brazing joins the materials by heating them in presence of the filler metal. The base materials, which are to be joined are heated by the external heat source, and then filler metal is brought in contact of the hot base material portion. Filler metal which are which is used for brazing operation generally has the liquidus temperature more than 450 degree centigrade. and below the solidus temperature of the base metal.

Liquidus temperature is the temperature above which the whole of the metal or the alloys becomes in the liquid state, and the solidus temperature is the temperature below which the whole of the alloy or the metal comes in to the solidus state. So, the solidus temperature of the base metal, means the no melting of the base metal below that particular temperature.

The brazing is different from the braze welding process, because in brazing we use capillary action to fill the gap between the parts to be joined, while in braze welding that capillary action is not used for filling the group between the parts to be joined, although filler metals may be same in both the cases. And the temperature, the melting point, of a the filler metal is in general greater than the 450 degree centigrade and below the solidus temperature of the base metal; however, in braze welding, melting of the braze metal may take place or may not take place, but in brazing, melting of the base metal does not take place.

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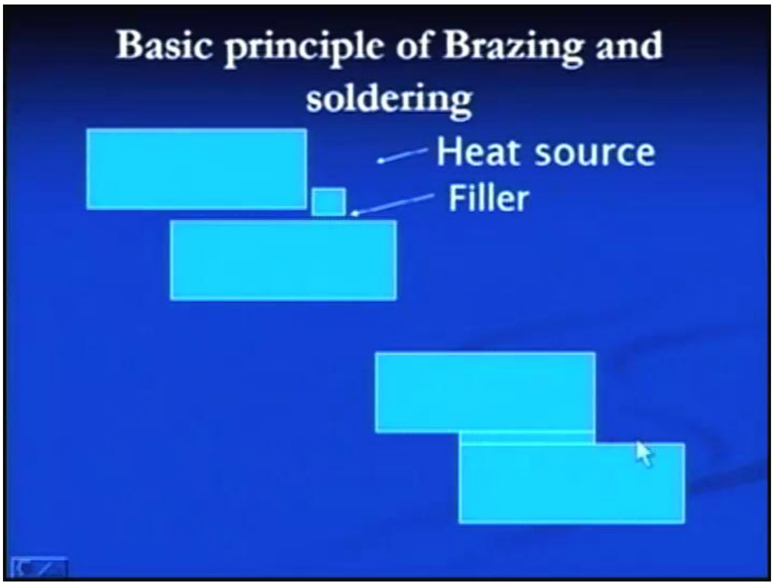

Now we will see the basic principle of the brazing and soldering operation using these schematic diagrams. The two components to be joined here are heated using the external heat source. Heat source may be the some furnace or gas flame or any other heat source can be used for heating the components to be joined. And then, filler metal is brought in contact of the metal pieces to be joined. As a new one filler metal is brought in contact this melts and it is sucked in by the capitally action in the gap between the two pieces to be joined.

So, here the two pieces in joint condition, where the filler metal has filled the gap between the two plates, ultimately leads to the joining of the two plates. So here, this filler metal has melted and filled this gap in this joint, which has been produced by either brazing or soldering. Schematically, we can see.

For effective and uniform distribution of the filler metal, it is necessary that the surfaces are cleaned and free from the impurities. And for that, proper fluxes are applied which helps to increase the fluidity of the molten filler metal and helps in uniform distribution of the filler metal between the gap by capillary action. This heat source can be seen and this is the filler metal.

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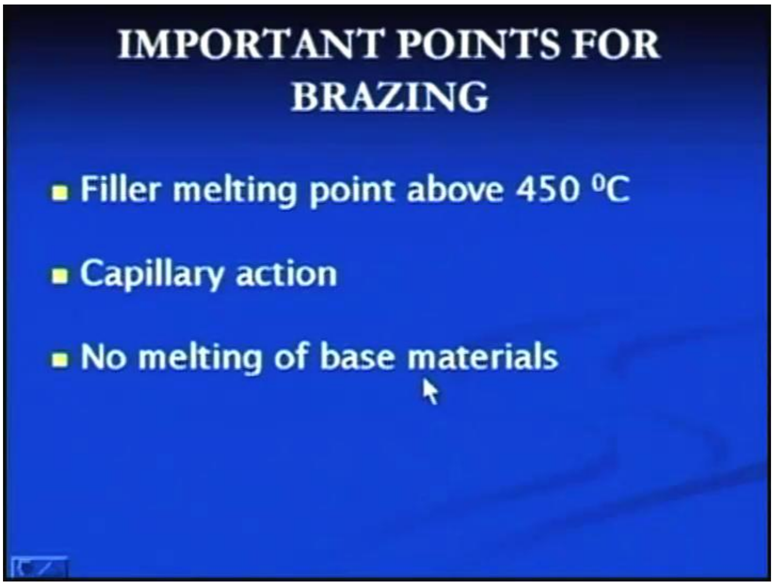

The important points related to the brazing are like the melting point of the filler metal which is used is normally above 450 degree centigrade, and the metal - filler metal - in molten condition is sucked in between the pieces to be joined by the capillary action. And another important feature of the brazing process is that the no melting of the base materials takes place; this is a very important point, because of this only, the brazing process has so many advantages related to the low heat input, and it does not create problems related to the metallurgical incompatibility.

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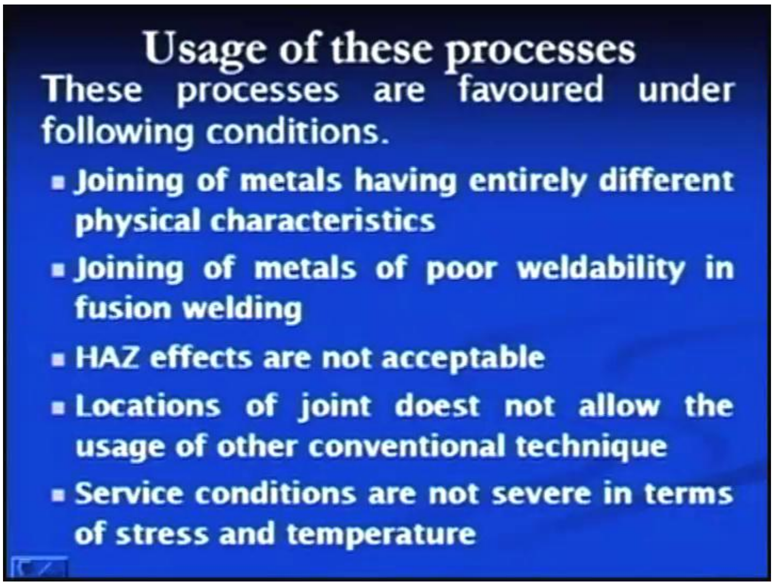

Use of these joining processes is carried out or these processes are used in number of engineering applications, particularly where the conditions are very different; metallurgical compatibility of the materials to be joined creates problem, and the conditions under which these processes are normally used are like joining of the metals having entirely different physical characteristics - like the very high melting point of the one base metal and low melting point of the another base metal, like aluminum and steel; very low expansion coefficient of one metal and high expansion coefficient of another metal also creates problem.

So, the metals having entirely different kind of physical characteristics can be successfully welded by these welding processes, because these processes use very low heat input, and no melting of the base metals takes place, the joining of the metals of the poor weldability in fusion welding. Joining of the many metals by fusion welding processes becomes difficult, because of the hardening of the heat-affected zone, cracking tendency, porosity formation. So, the poor welding will take by the fusion welding processes and leads to create so many problems in joining of the some of the metals in which are hardenable or which are more reactive to the environmental gases. So, these metals, which are difficult to weld by the fusion welding processes, can be successfully welded by these brazing, soldering or braze welding techniques.

Heat-affected zone is not acceptable. Many times either very hard or very soft heat affected zone is produced after the welding, and due to the weld thermal cycle experienced by the weld metal and the base metal near the fusion boundary, and that weld thermal cycle leads to the hardening in the hardenable metals, and hardenable steels, and the cast irons; and the softening in aluminum alloy; and so this variation in mechanical properties, particularly in heat-affected zone if is not acceptable, then these processes are found useful.

The location of the joint does not allow to use the conventional techniques. Many times access of the joint becomes difficult or access of the plates to be joined becomes difficult to weld by or joined by the conventional techniques. Under those conditions, these processes are also found useful to produce the joint. If the service conditions are not very severe, then this process can be used effectively to produce the joints of the entirely different physical characteristics materials.

But, these processes are successful, particularly under the conditions when loading conditions are not severe, and that the service environment temperature is also limited generally below 250 degrees centigrade, because these - the filler metal - which is used to produce the joints in these processes, generally has the low melting point; and that is why the filler metal is not able to withstand at a high temperature conditions, and that is why the joints produced by these processes are quite good enough for the low temperature service conditions and the lower stress conditions.

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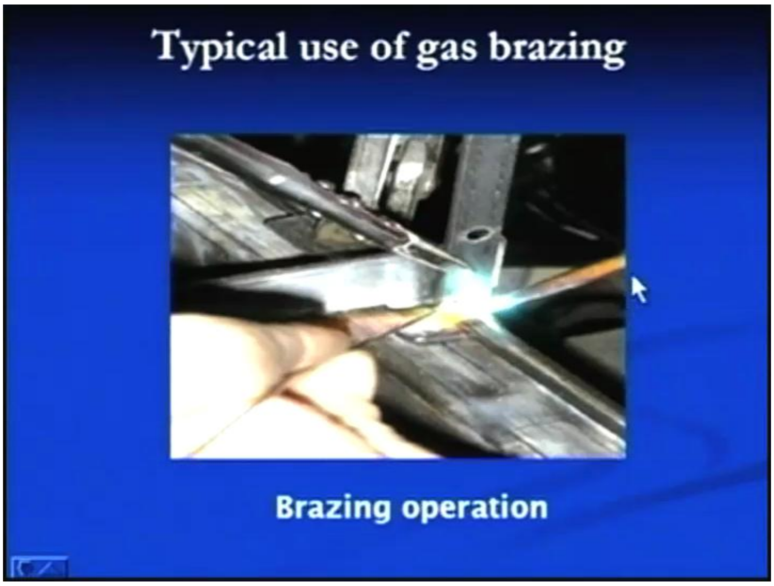

Typical uses of the gas brazing can be seen in this diagram, where in gas brazing oxyacetylene flame is used for heating of the base metal, and when melting of the filler metal bringing the filer metal in contact of the pieces to be joined. So here, this typical diagram shows the brazing operation by using the oxyacetylene flame.

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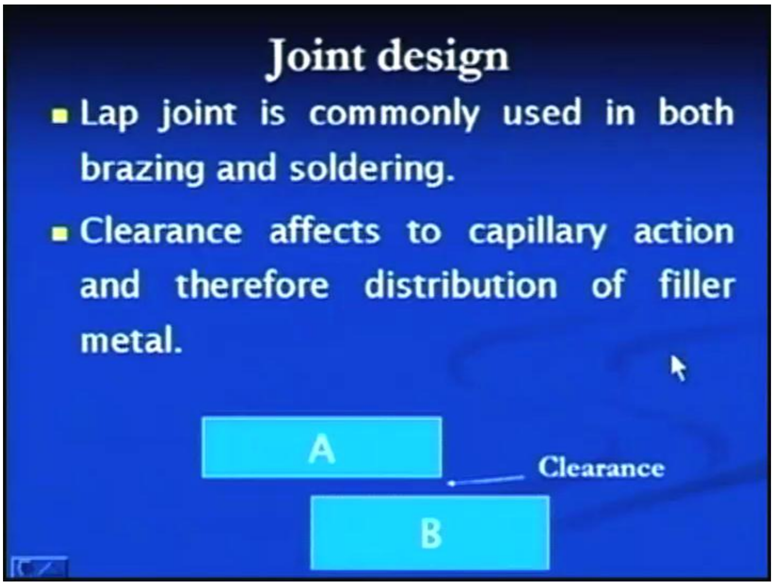

The joint design is very important aspect for producing a successful joint in the brazing and soldering operations, because even your method is perfect, but if the joint has not been designed properly, the distribution of the filler metal between the plates to be joined will not be uniform, and that in turn can lead to the non-uniform distribution of the filler metal and so the poor a strength of the joint.

Generally the lap joint is used for producing the joint in brazing and soldering operations. And in the lap joints, the gap between the parts to be joined, which is known as clearance, plays a very important role in obtaining the uniform distribution of the filler metal. And the uniform distribution of the filler metal between the plates to be joined or in the gap depends on that how successfully capillary action is achieved.

If the clearance significantly affects the capillary action, and therefore, the distribution of the filler metal. There has to be an optimum level of the clearance for perfect capillary action, and obtaining the uniform distribution of the filler metal. If the distribution is not uniform, then the strength of the joint is reduced significantly.

You can see here, example, that the plate A is to be joined with the plate B. And this typical arrangement shows the lap joint, and the gap between the two is known as clearance. This gap has to be an optimum one; not very close and not very open, because it finally affects to the capillary action, and in turn, the distribution of the molten filler metal.

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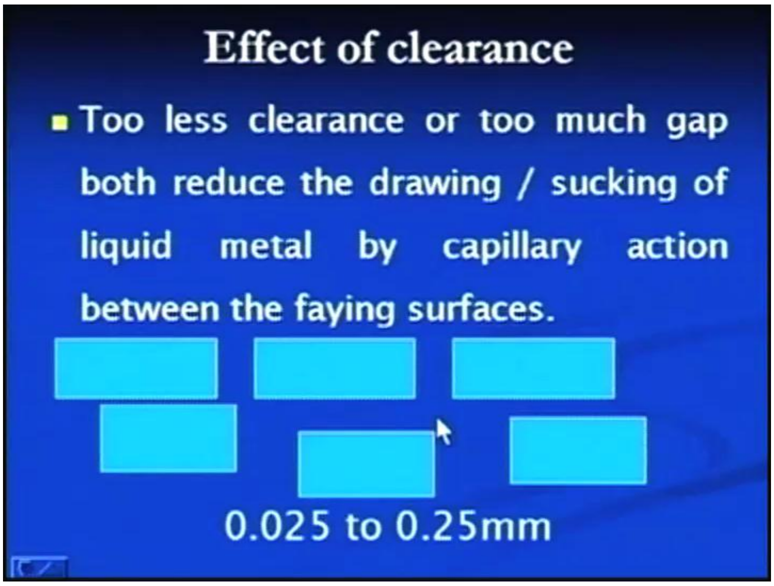

The effect of clearance on the capillary action can be seen using these diagrams, because capillary action significantly governed by the clearance. So, the clearance has to be maintained properly.

The too less clearance or too much clearance, both are undesirable from the capillary action point of view, as both - the either too less clearance or too much clearance - reduce the drawing or sucking capability of the liquid metal by capillary action between the faying surfaces. And that is why there has to be an optimum clearance depending upon the temperature of the filler metal or the type of the filler metal which is being used; because fluidity of the filler metal plays significant role in effective sucking of the liquid metal by a capillary action between the faying surfaces.

We can see here, the two plates to be joined are having very close gap. And this is the another case, where the two plates to be joined are having very large gap; it is clearance is very less and clearance is more - in both these cases that sucking by capillary action will not be that effective, which is required for uniform distribution of the filler metal between the faying surfaces.

That is why it has to be an optimum one, which because of the surface tension force generates enough drawing capabilities in the liquid metal, so that it is sucked by the capillary action between the faying surfaces, and result in uniform distribution, and good strength of the joint.

An optimum range of the clearance varies from 0.025 to 0.25 mm. There is a range of the clearance, because that fluidity for uniform distribution of the filler metal is governed by the temperature and the type of filler metal, which is being used. In addition to that the fluxes which are being used and cleanliness of the faying surfaces also affects the fluidity. So, the optimum clearance in this range will be governed by so many dynamic conditions which are taking place during the brazing or soldering process.

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As I have said, that for effective capillary action, and to have the uniform distribution of the filler metal, it is necessary that the surfaces are cleaned and free from the impurities, and to remove these impurities, and obtain good capillary action, it is required to use fluxes.

There are many other factors, which also force to use the fluxes like if the surface is contaminated with impurities, and if oxides are present at the surface, and the presence of oil or grease oxides having formed at the surface of the base metal, oxidation of the filler metal, and the fluidity of the molten filler wire.

It is always desired to have the good fluidity of the molten filler wires, so that uniform distribution of the filler metal between the faying surfaces can be obtained. And oxidation of the molten filler metal is also to be - should also be - avoided to produce the sound joint.

And oxidation of the base metal due to the heating by the external heat source should be avoided to have the sound joint. And the grease oxides and surface contaminants should also be removed. And to remove these impurities present at the surface, and to avoid the oxidation of the filler metal and the base metal, and to have the better fluidity, the fluxes are frequently used for brazing and soldering operations.

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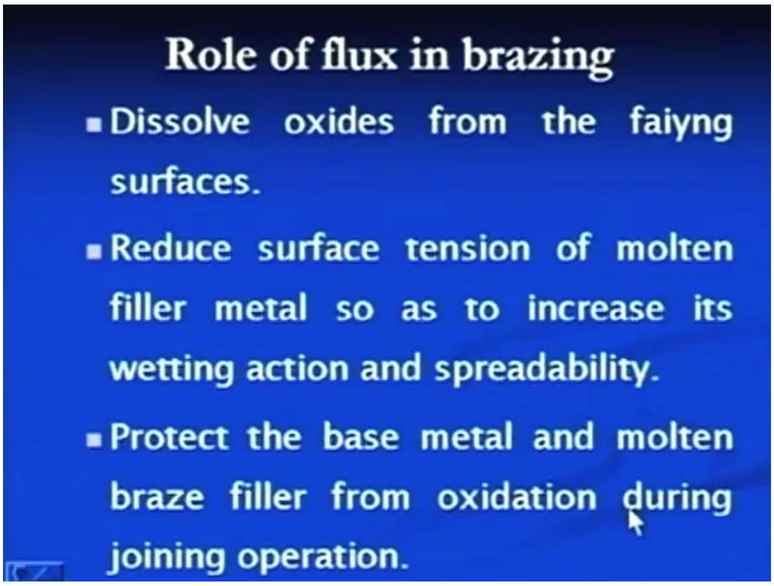

The role of the fluxes in brazing is very important as it performs the number of functions. The fluxes are normally used to remove the impurities present at the surface and prevent the oxidation of the base metal and the filler metal, and improve the fluidity of the molten filler metal, so as to get the better capillary action, and uniform distribution of the molten filler metal in the gap between the components to it.

The first point it says is it dissolves oxides - the fluxes dissolve oxides from the faying surfaces, and to have oxides are removed, that is present at the surface. And removal of the oxides present at the surface helps to improve the fluidity of the molten filler metal.

Reduce surface tension of the molten metal, ao as to increase the wetting action and spreadability ah. So, this is another important role played by the fluxes, which has to reduce the surface tension of the molten filler metal, which in turn leads to improved spreadability and the wetting action. Wetting action is important for better flow of the molten metal between the plates to be joined.

Another important point is that protect the base metal and the molten metal from the oxidation during the joining process, because most of the metals tend to oxidize at a high temperature. So, if the fluxes are used properly, then they will help to reduce the oxidations of the base metal and the molten metal, and that of molten metal.

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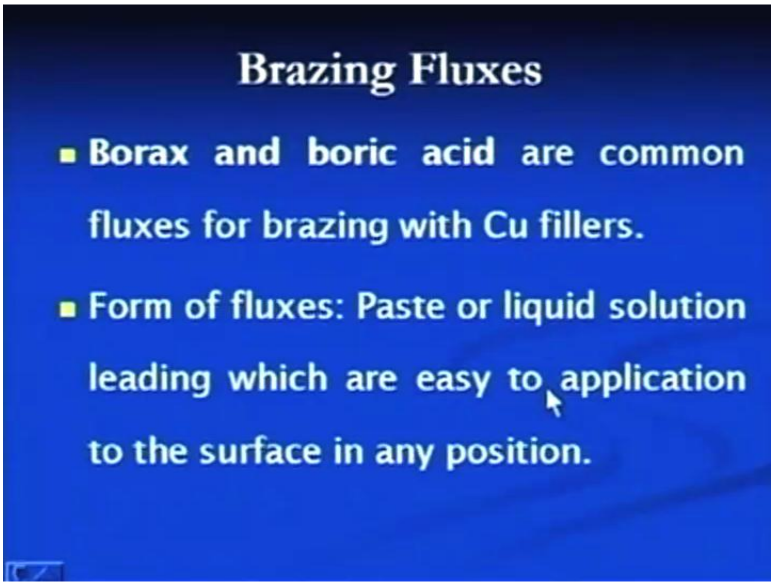

There are various types of the fluxes, which are used in brazing operation to perform above-mentioned functions; like borax and boric acids are the two common types of the fluxes, which are used for brazing by the cobber base alloys as a filler metals. And these fluxes are generally used in form of the paste or liquid solutions, which can be applied easily at the desired locations, so as to get the desired effect from the fluxes - that is related to the protection of the base metal and molten metal from the oxidation, and improve the fluidity of the molten metal, and removal of the impurities present at the surfaces.

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The brazing filler metals - various types of the brazing filler metals are used. The copper based alloys are the most common one. The most commonly used filler metals for the brazing is the copper base zinc alloys, which are known as brass. It generally consists of 50 to 60 percent of copper, approximately 40 percent of the zinc, 1 percent nickel, 0.7 percent Fe, and some amount of the silicon and manganese. This kind of alloy is also known as a spelter, which is used for the brazing operations. Nickel sometimes is used to increase the high temperature properties, particularly high temperature strength of the brazed joint; the nickel can be added up to the 10 percent to attain these specific properties.

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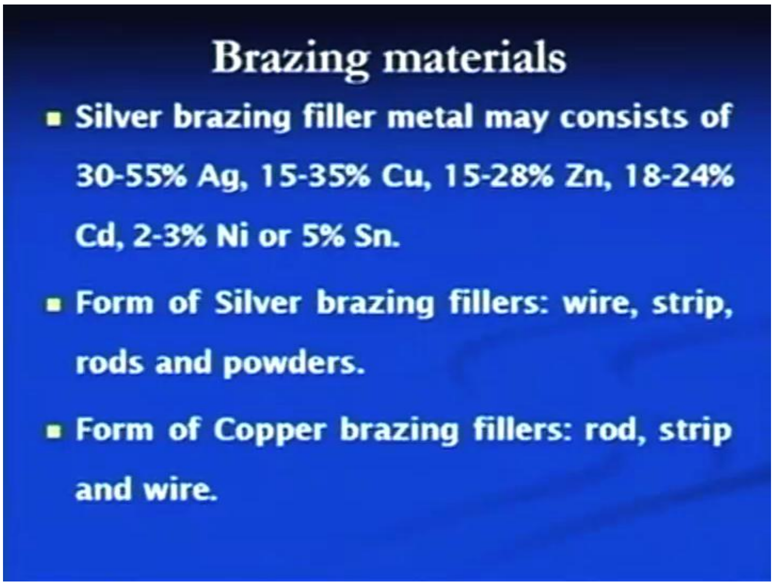

The common brazing materials are like, in addition to the copper base alloys, the silver brazing filler metals are also used, which contains 30 to 55 percent of the silver, 15 to 35 percent of the copper, 15 to 28 percent of zinc, 18 to 24 percent of cadmium, 2 to 3 percent of nickel, 5 percent tin. The copper base filler metals are found in form of the rods strips and wires, while the sliver based filler metals are found in form of powders also, in addition to the wire strips and the rod forms.

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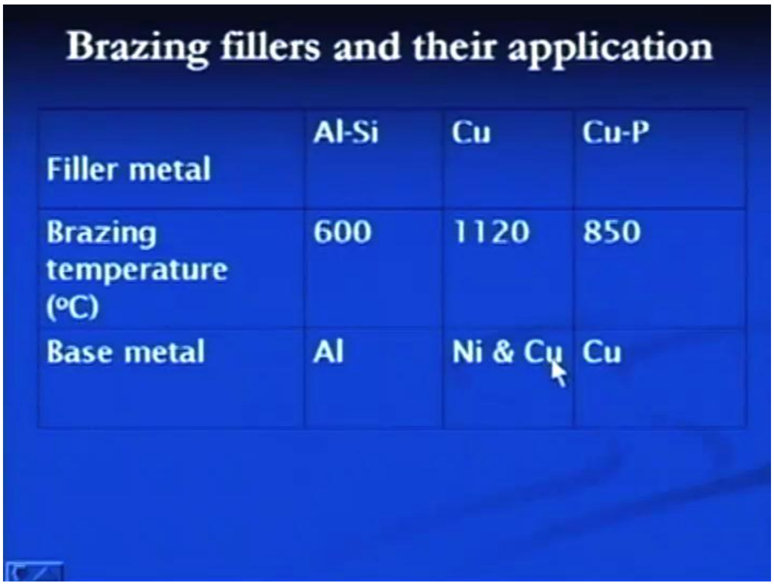

The brazing filler metals along with their applications and brazing temperatures are shown below. And the depending upon the kind of the filler metal to be used, depending upon the kind of applications, like the base metals to be joined, different filler metals are found suitable. And for the different filler metals, the different brazing temperatures are also used, which can produce the joint successfully. Like for aluminum silicon filler metals, the brazing temperature is 600 degree centigrade, and this aluminum silicon filler metal is used for joining the aluminum plates by brazing.

For nickel and copper-based metals, and nickel and copper-based alloys, brazing temperature is 1120 degrees centigrade and for that copper base filler metals are used. Copper phosphorus based filler metals are used for the brazing of the copper, and the brazing temperature is 850 degree centigrade.

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Some other combinations, some other filler metals and their applications are like copper zinc filler metal; for this brazing, brazing temperature is 950 degree centigrade and it is used for joining of the steel, cast iron, and nickel-based alloys.

The Au and Ag - sliver and cold - combination filler metals for brazing purpose are used by using the brazing temperature of 950 degrees centigrade, and it is used for producing the joints - brazed joints - of stainless steel and nickel alloys. For stainless steel and nickel alloys, also nickel copper based filler metals are also used and brazing temperature for that 1120 degrees centigrade is preferred.

There are many methods, which are used for producing the brazed joints, and the difference in these brazing methods mainly lies in the way by which heat is developed and applied in the components to be joined by the brazing process.

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These brazing methods are like in torch brazing, oxyacetylene torched is used for heating of the base metals. In dip brazing, salt bath or molten metal bath is used for heating of the base metals. In furnace brazing, the electrically heated, the furnace is used for heating the components to be brazed in pre-assembled condition. Infrared radiations are used for heating the joints - heating the components - to be joined by infra-red brazing method. And induction brazing, means induced current is developed at the surfaces of the components to be joined by brazing - in induction brazing - so that melting of the preplaced filler metal takes place.

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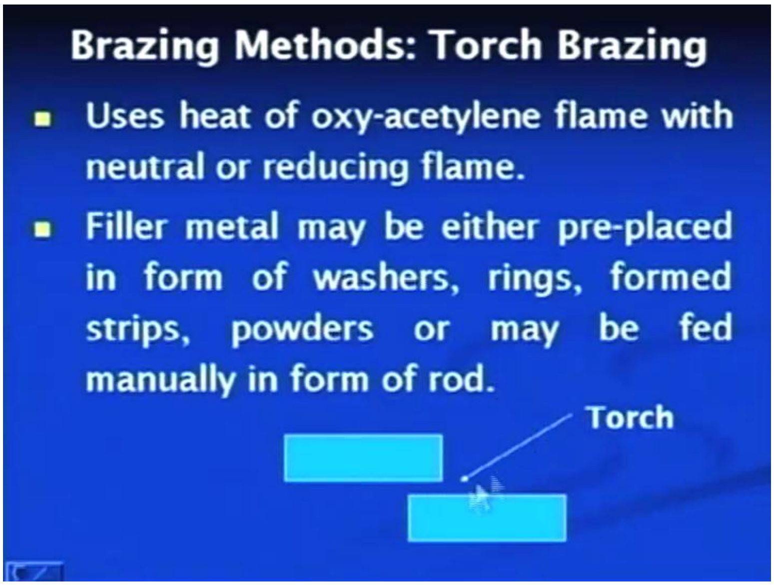

The brazing methods in detail we will discuss. Like we will start with the torch brazing. In the torch brazing, as I just told you, that oxyacetylene flame is used for heating of the base metals to be joined by brazing. And for this purpose, either neutral flame or reducing flame can be used, so that oxidation of the base metals is avoided and the surfaces are remain free from the oxides and other impurities. The filler metals may be either pre-placed in form of the washers, rings, strips, powders, or may be fed manually in form the rods.

So, depending upon the kind of the components to be joined, the suitable filler metal either in powder form, a strip form, or ring form can be either pre-placed or it can be applied with the help of the rod form of the filler metal.

For example, the two plates to be joined will be heated by the gas flame to a temperature - suitable temperature - depending upon the kind of filler metal to be used, and then, filler metal is applied here.

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In the torch brazing, this shows the typical way of producing the brazed joint by the torch brazing. This is oxyacetylene flame torch, which is being used to heat the surfaces to be - surfaces of the component - to be joined. And this is what is the filler material is being applied at the area of where joint is to be produced.

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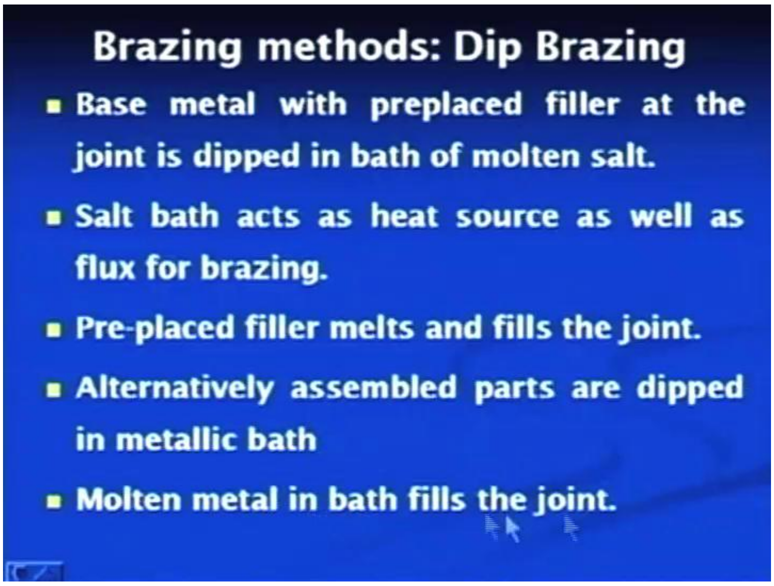

In a dip brazing, the heat is applied at the faying surfaces, with the help of salt bath or with the help of the molten metal bath. The base metal with the preplaced filler metal at the joint is dipped in the salt molten bath, and which transfers the heat required for heating the base metal, and that heat leads to the melting of the preplaced filler metal. So, salt bath acts as heat source as well as flux for the brazing operation. Preplaced filler metal melts, because of the heat transferred by the salt bath and that the molten filler metal fills the joint, fills the gap to produce the joint.

Alternatively, the assembled components can also be dipped in the molten metal bath. So, in that case, there is no need to provide the preplaced filler metal, but the molten metal from the bath enters in between the faying surfaces to produce the joint and the molten metal in the bath fills the joint.

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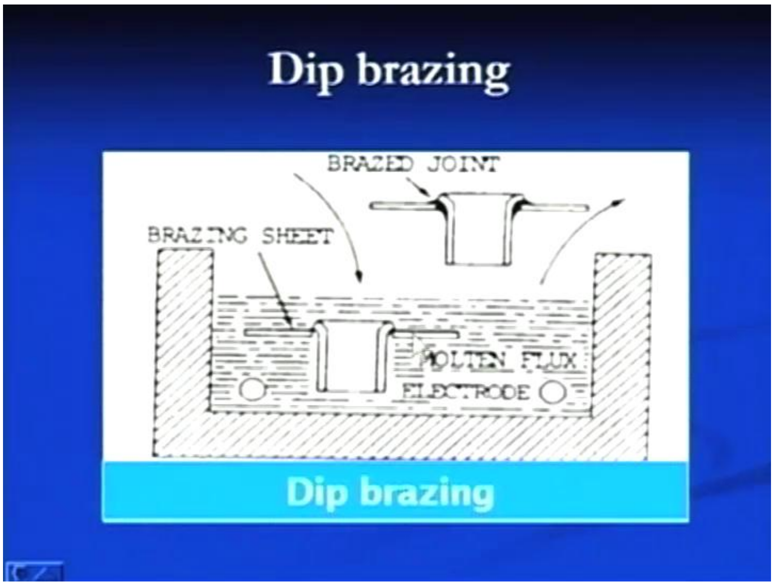

Dip brazing method can be seen here with the help of this diagram. Here, these are the two components to be joined in the preplaced condition, and this is the molten salt bath, and it is heated using the suitable electrical heating system, and the preplaced, preassembled components are dipped in the bath, so that it gets the heat desired and leads to the melting of the preplaced filler metal to produce the joint.

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In the furnace brazing, furnace brazing also the preassembled parts to be joined are passed through the furnace. Here the filler metal is preplaced between the parts to be joined. And then, it is passed through the electrically heated furnace, where melting of the filler, and filling of filler metal, and the filling of the gap takes place to produce the joint. Many times to avoid oxidation of the faying surfaces the controlled atmosphere is also developed in the furnace by using either argon or helium. So, this is particularly used in case of the reactive metal components brazing.

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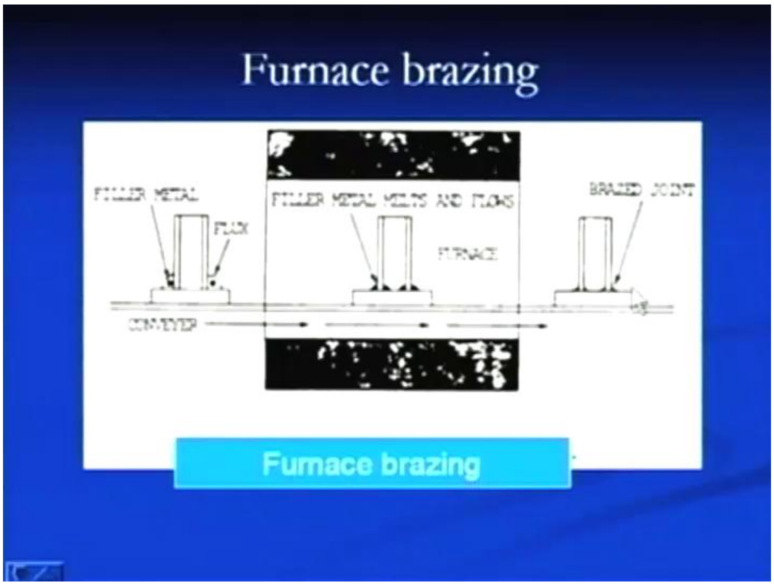

Then schematically we can see that how furnace brazing works. Here, this is the furnace, where high temperature is maintained and controlled. This is conveyor, the preplaced components, preassembled components with the filler metal and fluxes are placed like this. And then, this entire assembly is passed through the furnace. And in the furnace, the fluxes melts; the filler metal also melts; they perform their functions and by the capillary action the gap is filled by the molten metal, and at the end we get the brazed joint here.

So, the preplaced, preassembled components with the desired amount of the fluxes and filler metal are passed through the furnace to produce the joint. This is a very quick method, but needs proper automation for high production rates.

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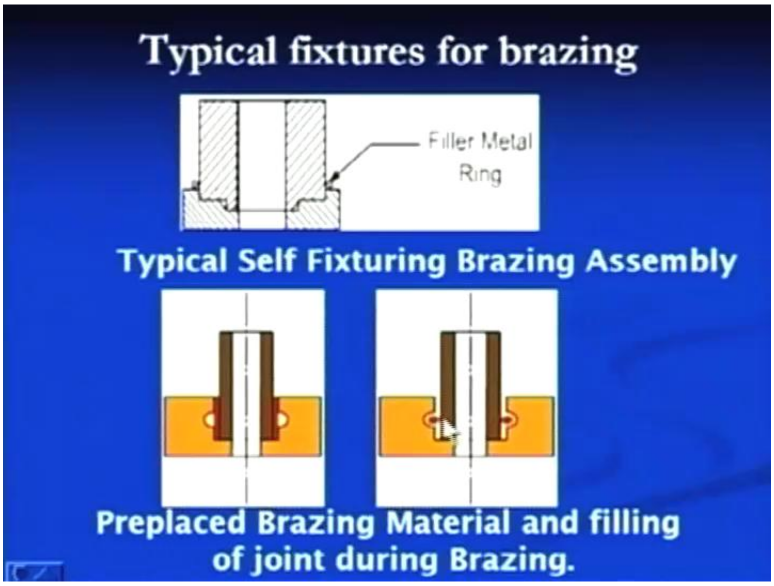

Typical fixtures, which are used for the brazing operations can be like this, where the two components to be joined are preplaced with the filler metal ring, and this entire assembly can be passed through the electrically heated furnace. In the same way, here, the preplaced brazing material and the filling of the joint can be seen in this diagram. This is your preplaced filler metal, and after brazing, it fills this, after passing through the furnace it fills this gap to produce the joint.

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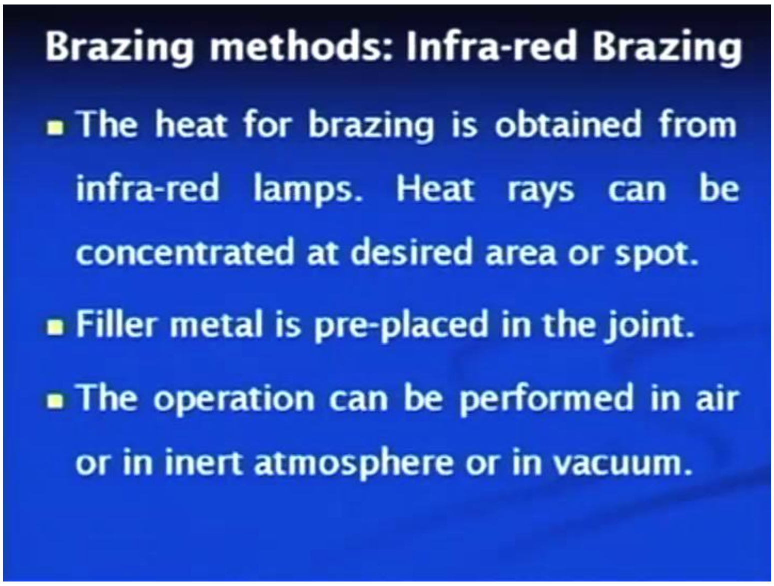

Another brazing method is the infrared brazing where heat desired for producing the brazed joint is generated from the infrared radiation. These radiations are focused in the areas where heat is to be generated using the optical lenses. And then the preplaced filler metal is melted and to produce the joint. And this operation, can be carried out in either controlled atmosphere or in the vacuum conditions to avoid the contamination of the joint from the atmospheric gases.

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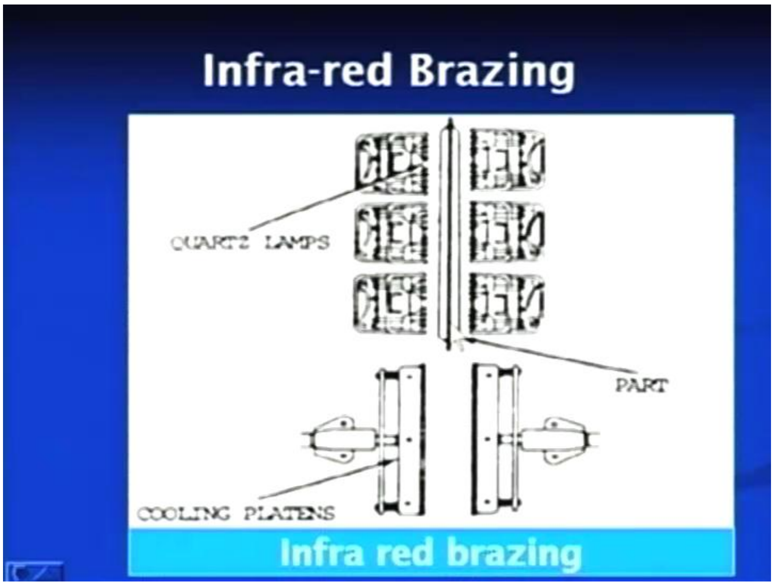

The schematic diagram shows the infrared brazing process here. From these sources, from these areas lamps will be getting infrared radiations in this, near the components to be joined with the filler metal desired heat is there. These radiations are focused at these areas, so that heat is generated to melt the filler metal and produce the brazed joint.

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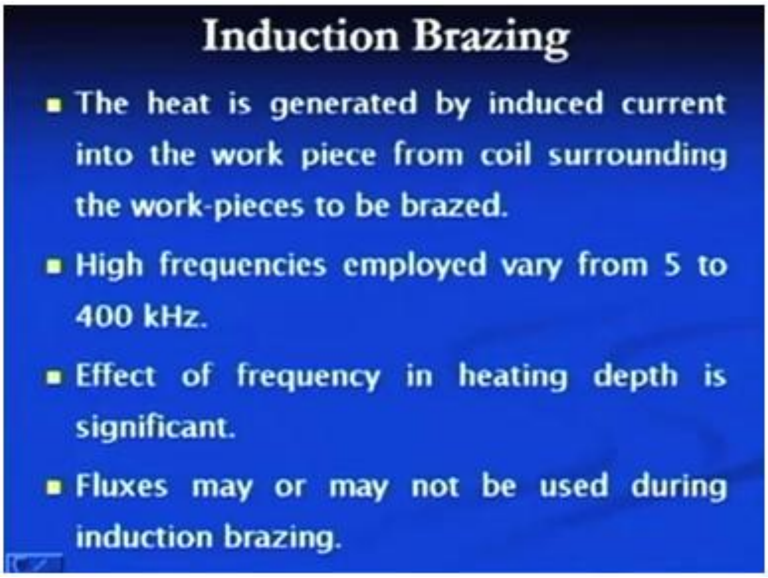

In induction brazing is another brazing method, in which a high frequency current is used to develop the heat in the area where joint is to be produced, and the frequency of the current which is used for producing the heat varies from 5 to 400 kHz.

The frequency of the current, which is being used to induce the current for brazing purpose, significantly affects the depth up to which the heat is generated. Now low frequency is used for generating the height, for generating the heat up to the greater depth. The fluxes in this process may be used or may not be used depending upon the kind of the metal combinations being joined of the filler metals being used.

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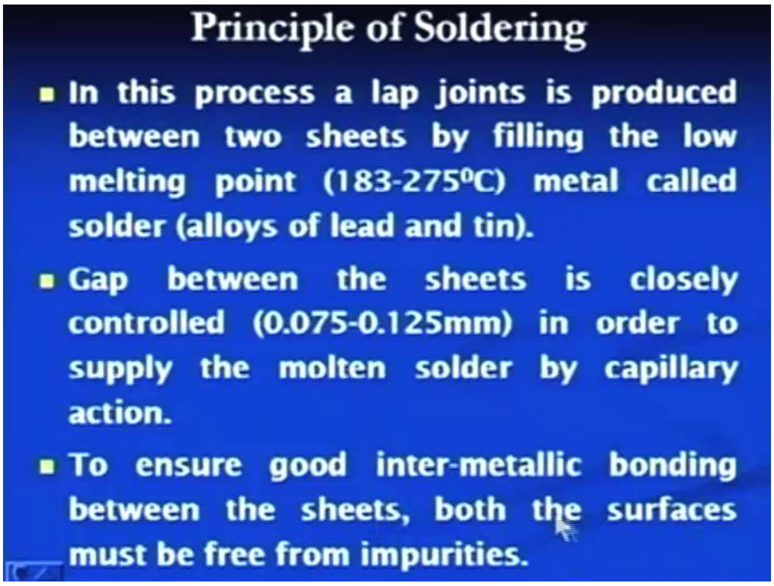

The principle of the soldering process is largely similar to that of the brazing process. Only difference is there in the filler metal, which is used for the soldering operation.

In this process, the lap joint is produced between the two sheets by filling the low melting point material, which is called solder. And the solder is basically an alloy of the lead and tin.

The gap between the sheets to be joined is controlled very closely to get the benefit of the capillary action, and this gap varies from 0.075 to 0.125 mm, because this capillary action is very important for uniform distribution of the filler metal between the plates being joined.

To ensure that sound joint is created, it is necessary to ensure that good inter-metallic bonding between the sheets takes place, and for this purpose, both surfaces must be free from the impurities.

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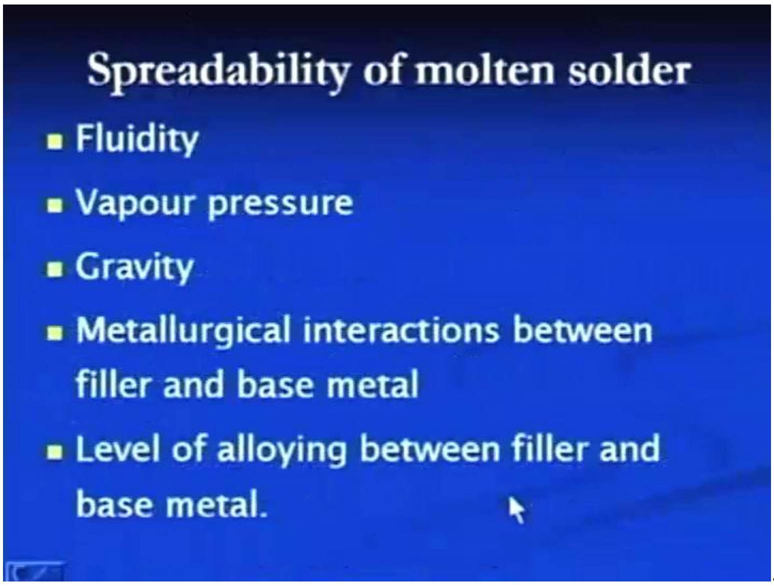

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The spreadability is very important for producing a sound joint in soldering, because the spreadability is poor, then distribution of the filler metal between the faying surfaces will not be uniform. And this spreadability is significantly governed by the number of factors like fluidity - high fluidity helps to improve the spreadability; vapour pressures that will help to push the metal in the gaps where it is required; the gravity - the gravity will affect the spreadability depending upon the location where the joint is being produced. The metallurgical interactions between the base metal and filler metal - like higher alloying ability of the solder and the base metal leads to the reduced spreadability and if they form some sort of intermetallics then that also reduces the spreadability. So, the level of alloying between the filler metal and base metal affects the spreadability.

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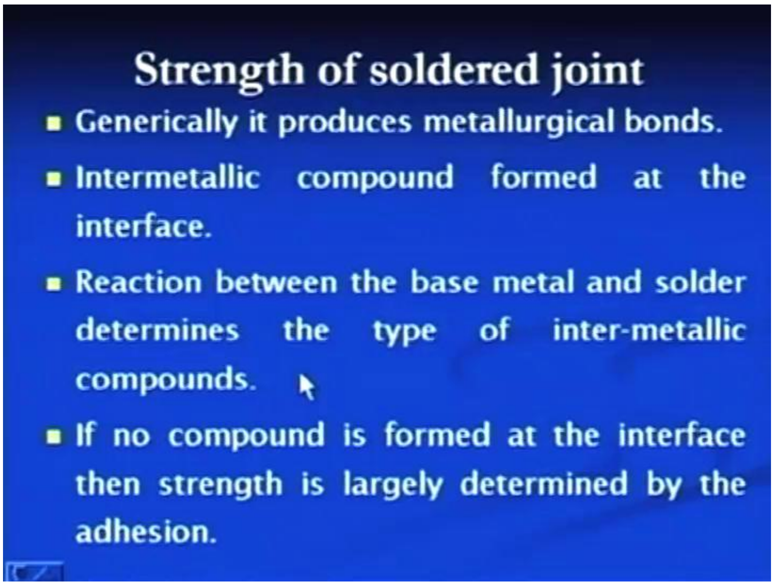

The strength of the joint, as I told, that is significantly governed by the spreadability, uniform distribution, and the filler metal, which is being used for producing the joint. The joint, which is produced in the soldering is the metallurgical type, and it forms the intermetallic compounds at the interface. It means the base metal reaction with the solder metal to from the intermetallic compounds. If this intermetallic compound is formed, then the strength of the joint is formed is good. And if the reaction between the base metal and solder determines the type of the compound, which will be formed, and if the no compound is formed at the surface, then bond strength is largely governed by the adhesion.

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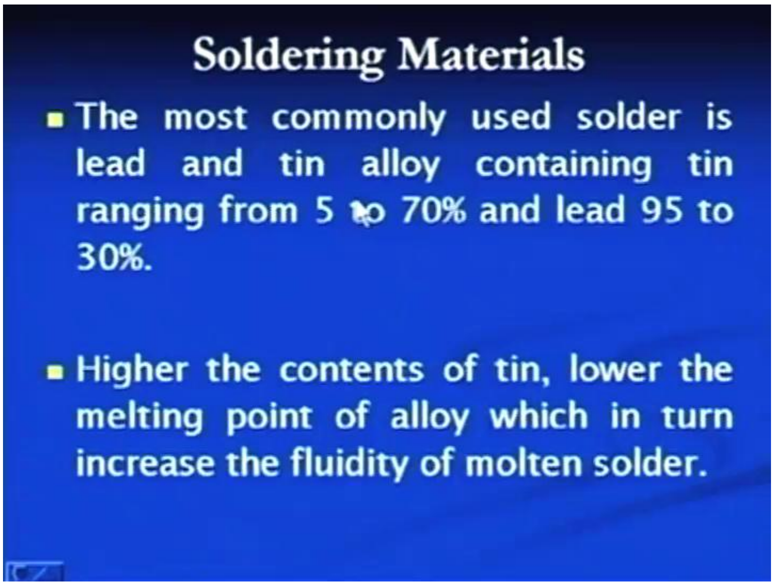

And the strength, if is being determined by the adhesion, then it will not be as high as that is generated by the production of the intermetallic compounds at the interface. Soldering metals, which are commonly used for the solder soldering purpose, are the alloys of the lead and tin containing the tin from 5 to 70 percent, and lead 95 to 30 percent.

And higher contents of the tin lowers the melting point, which in turn increases the fluidity, but depending upon the percentage of the lead or tin, or depending upon the relative amount of the lead and tin, and the strength of the soldered joint, then the melting point of solder will be affected.

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Other soldering materials, which are used for soldering purpose, are like tin-antimony solder, tin-silver solder, lead-silver solder, tin-zinc solder, cadmium-silver solder.

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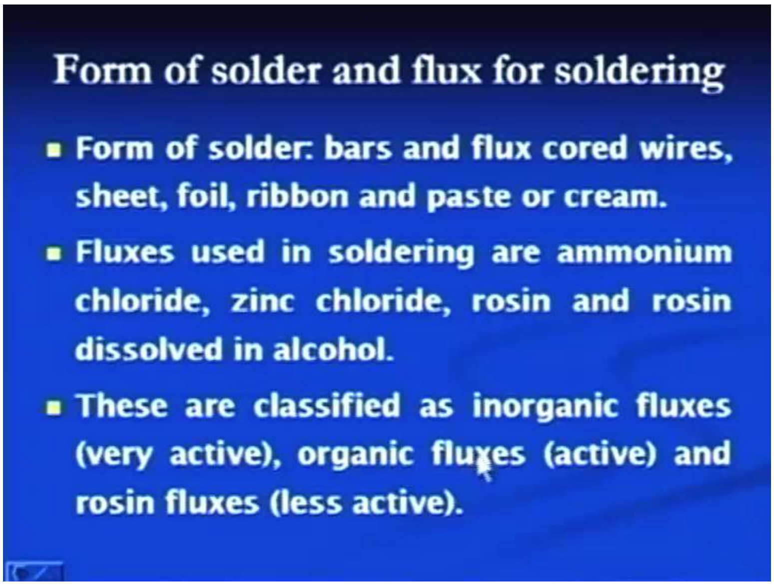

And the forms and fluxes, which are used for the soldering purpose… normally solders are used in form of bars, and the flux cored wires, and in form of sheets, foils, ribbons, paste, and creams. And fluxes for soldering purposes are normally used in form of ammonium chloride, zinc chloride, rosin, and rosin dissolved in alcohol. And these fluxes used for the soldering purpose are classified in three groups like: inorganic fluxes, which are very active; organic are active; and rosin fluxes are somewhat less active.

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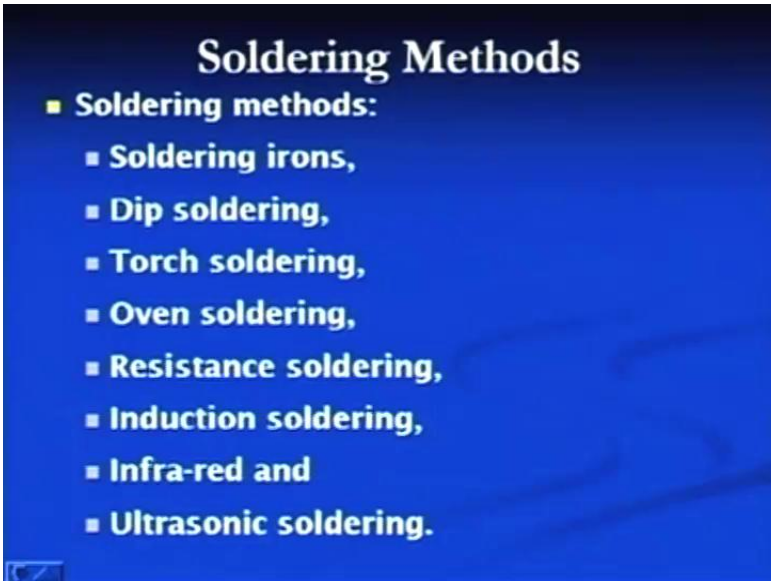

And depending upon the methods, which is being used for heating, the base metals to be joined by soldering, there are a number of soldering methods and these are: soldering by irons, dip soldering, torch soldering, oven soldering, resistance soldering, induction soldering, infrared soldering, and ultrasonic soldering. Main difference in these methods lies in the way by which it is being generated at the faying surfaces to produce the joint, and melt the solder material.

Ultrasonic soldering is different from the other soldering methods in the way that ultrasonic energy is introduced in a bath to produce the joint successfully of the materials, which are entirely different in nature like glass and aluminum combinations, which are otherwise difficult to weld by other soldering methods. Here when the ultrasonic energy is introduced in the bath, it acts like the fluxes, helps to remove the impurities.

And now, I would like to summarize this lecture. Students you have seen that what is the need of using these soldering, brazing, and braze welding techniques, because many times the conventional welding techniques fails to produce the desired joints.

And you have seen that what is the principle of the brazing operation, soldering operation, what are the materials used for the brazing and soldering operations, and the methods which are commonly used for the brazing and soldering operations. And now in the next lecture, you will see that the braze welding and the importance of removing the residual - the fluxes - from the joint which is produced.

Thank you for your attention.