Theory of Production Processes

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Lecture - 50
Brazing, Soldering and Adhesive Bonding

Welcome to the lecture on Brazing, Soldiering and Adhesive Bonding. So, after discussing the fusion welding processes and then also we discussed about the solid state welding process we will discuss about the process that is under the category of solid liquid state welding. And in that you have mainly the 3 processes which are known as brazing, soldering and adhesive bonding.

So, let us see what are these processes and where they are used what are the main principle behind these processes. So, as we discussed that this type of process these 3 processes are under the category of solid liquid state welding. And here it is solid liquid state because you will have these adherence or the 2 parent metals which are in the solid state itself, they do not melt.

And the medium with which it is bound that is in the liquid state so, that comes in liquid state or that is converted into liquid state and then it is joined. So, that is why it is under the category of solid liquid state welding.

Now in these processes the physical phenomena are normally same way they develop a bond between the 2 parent metals. And then they resist against the stresses or forces which are each are applied to them, but then they are differing metallurgically, because in these cases because in other cases you have completely a bond between molecules of the filler metal as well as the parent metal here that does not. So, in that way they differ.

Now, coming to the first case of brazing, so you know brazing and soldering. So, both and now in both the cases as we know that you have the filler metal which is you know not the same as the parent metal. So, normally the filler metals are different. So, brazing and soldering in both the cases their melting points are normally smaller than the melting point of the filler metals.

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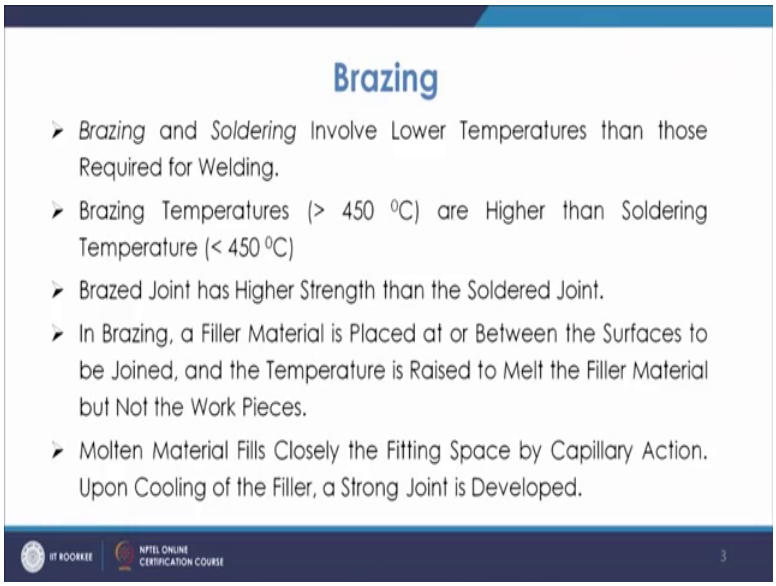

Now, the differ only by the property of the filler metal which is used like in the case of brazing it is braze alloy. So, for that similarly in the case of soldiering it is solder alloy. So, depending upon the strength or depending upon the melting temperature of these alloys you have either category as brazing or soldiering.

Now, in case of brazing where melting point is more than 450 degree centigrade in general. So, and in case of soldering it is less than 450 degree centigrade. So, I mean quite emphatically or quite; obviously, the braze joint since they have a higher melting point. So, they will have the higher strength than the solder joint.

Now, in both the cases the filler material will be placed between the surfaces to be joint and then they will be heated. So, at that localized position there has to be some mechanism of heating. So, what happens that in these cases the cavity which is there in between them or the clearance between the 2 surfaces which are to be joined they are basically to be filled and normally the filling is by the capillary action.

So, what you do is you are providing the metal in between them and then you are heating and then that way once they melt then they go into the cavities or wherever the joint is to be made by the capillary action. So, first of all you have to there are certain steps in which we follow this process and this is steps are like you have to first clean that and then you have to place the material which is to be which will be the binding medium between the 2 parent metals.

And then you have to heat so, that by capillary action they go into the space between the 2 parent metals which are to be added. So, this way the joint is developed. So, once you heat then it will convert into liquid state and then you know you have further once you cool then the joint is developed. So, this way brazing takes place.

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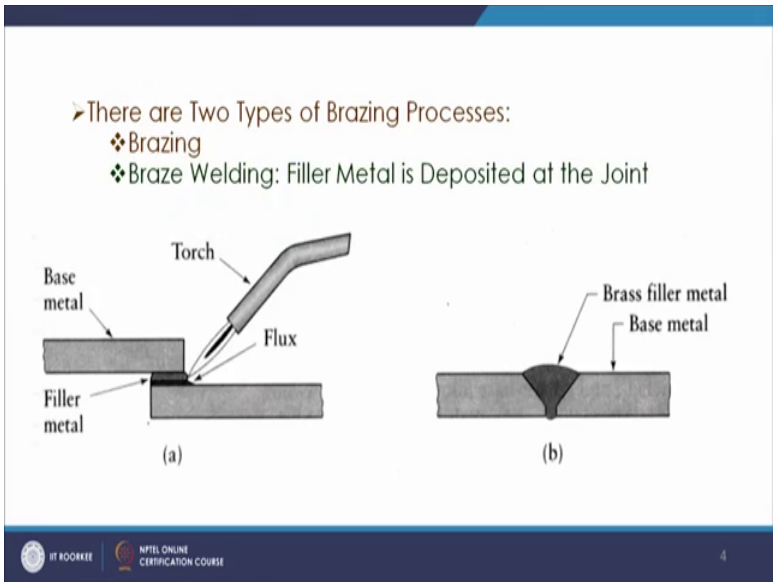

Now, there are 2 concepts one is that in which case the filling is by the capillary action. So, that is your brazing and in the case b here this is known as braze welding. So, similarly here just like in fusion welding what we do you are making the filler metal into the joint. So, this way in this way you are giving that filler metal which is deposited into the joint so, that is known as braze welding. So, that is how brazing and braze building is classified.

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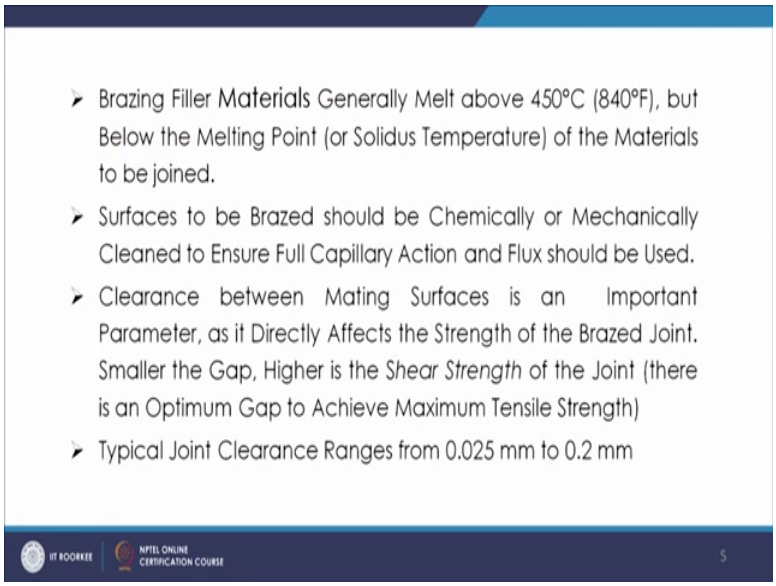

Now, as we discussed that brazing filler materials are generally melting about 450 degree centigrade and below the melting point of the materials to be joined means the join to join the 2 materials the material which are joined by the brazing filler metal it is melting point is higher than that. So, that the 2 will be only solid and then in between the joint will be developed.

Now, surface of the brazed to be brazed so, has to be chemically or mechanically cleaned to ensure the full capillary action and flux should be used. So, first of all to have the proper contact between the 2 surface and also between the material which is to be between the parent material and also the filler metal you need to have a proper bond for that you have to do the proper cleaning.

Cleaning can be done by mechanical means or by the chemical means. Mechanical means you can have the wire brushes or you may have other mechanism by which you can mechanically clean it we can you can just rub the top surface, remove the oxide layers and you remove the impurities grease or whatever it be. So, that way or by chemical means that implies that you can use the acids by pickling you can remove it or you can use some chemicals you can use some detergents. So, that you are making the surface clean.

So, that you have to ensure that the capillary action is quite you know active, quite efficient and. So, for that even fluxes are used so, you have fluxes for that action. So, that

you know these fluxes are in different same you know forms may be there may be in the form of paste, glues or so, powders so, these fluxes are also used.

Now, clearance between mating surfaces is an important parameter because it directly affects the strength of the braze joint. So, how much these that should be the clearance between the 2 parts which has to be you know attached by using the brazing process.

So, that is important you know parameter because if the gap is small then the shear strength of the joint will be higher. So, you have to have the proper joint to have the optimum value of the tensile strength or maximum of the tensile strength. So, normally as reported the joint clearance is ranging from 0.025 to 0.2 mm.

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Now, coming to the different types of brazing filler materials; so you have different you know range of brazing you know materials and with a range of brazing temperatures you have different filler materials. And also the different shapes like wire, strips, rings, shims, preforms or powder this way you may have different you know forms of these materials are available choices of filler metal and it is composition is important because to ensure that there is no Embrittlement. So, for avoiding the Embrittlement of the joint, formation of Brittle Inter-Metallic compounds at the joint. So, because what happens that when you are putting that metal in between the 2 parent metals so, there may be inter metallic compounds formation.

So, that may lead to the brittleness many a times. So, that also you have to have what type of material you have you choose that. So, that does not do the reaction and create or form undesirable type of phases or brittle phases and also the galvanic corrosion in the joint.

So, typically you when you talk about the materials and also the filler materials you have these are the typical material and their filler.

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Base Material	Filler Material	Brazing Temp (°C)
Aluminum and its Alloys	Aluminum-Silicon	570-620
Magnesium Alloys	Magnesium-Aluminum	580-625
Copper and its Alloys	Copper-Phosphorus	700-925
Ferrous and Nonferrous Alloys (except Al & Mg)	Silver and Copper Alloys Copper-Phosphorus	620-1150
Iron-, Nickel-, and Cobalt-Based Alloys	Gold	900-1100
Stainless Steel, Ni and Co Base Alloys	Nickel-Silver	925-1200

Materials and whose brazing temperature will be varying like this. So, like you have aluminum and it is alloys for that filler material is Aluminum-Silicon, it is brazing temperature is about 570 to 620 degree centigrade. Like for Magnesium Alloys Magnesium-Aluminum which has the brazing temperature of 580 to 625. Copper and Alloys for Copper-Phosphorous 700 to 925. Ferrous and Nonferrous, Silver and Copper Alloys 620 to 1150 alloys except Aluminum-Magnesium, Copper-Phosphorus then Iron, Nickel and Cobalt base for Gold and then Stainless Steel, Nickel Silver.

So, all these are the filler materials and it is brazing temperature and you can see that this brazing temperature is normally less than it is melting temperature of aluminum suppose 666.7 degree centigrade is the melting temperature of aluminum. So, it is quite less I mean it is less considerably.

Similarly, in any case what we see is that this brazing temperature is normally having a smaller value as compared to the base materials melting point. we use the fluxes in the case of brazing.

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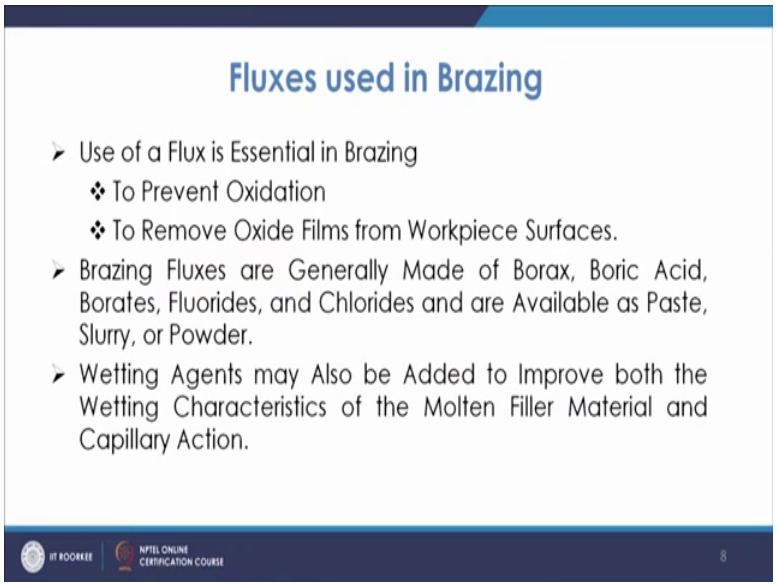

And this is that is to use that is used for preventing the oxidation and to remove the oxide films from workpiece surfaces. So, what we have seen that once you have the oxide surfaces or you have impurities that will be preventing for the formation of a good contact you know when or the bonding which develops between the filler metal and the parent metal.

So, basically we use the flux which prevents this oxidation and removing the oxide films. So, normally in brazing we use the borax or boric acid, borates, fluorides and chlorides which are basically available as paste slurry or powder. So, they are used as the flux material and we also use the wetting agents which are added to improve both the wetting characteristics of molten filler material and capillary action.

So, what is the meaning of this the thing is that this activity of either brazing or soldiering in all these cases you need to have a proper wetting. So, for that proper wetting means the surface which is must become comp quite wet in that case the wetting angle or the angle which is used for the surface tension calculations. And all that that angle that angle must be I mean if it is completely wetting means that angle is 0 and if it is more it means it will not be wetting.

So, for the increasing this wetting characteristics you know we also add the wetting agents which are improving that wetting characteristics of molten filler material and the capillary action. So, once the wetting is into a wetting characteristic will be more the capillary action will be quite better. The surfaces so, once we had come to the steps of doing the brazing so, first of all the surface which has to be brazed has to be first clean and free from the rust, oil, lubricants and other contaminants.

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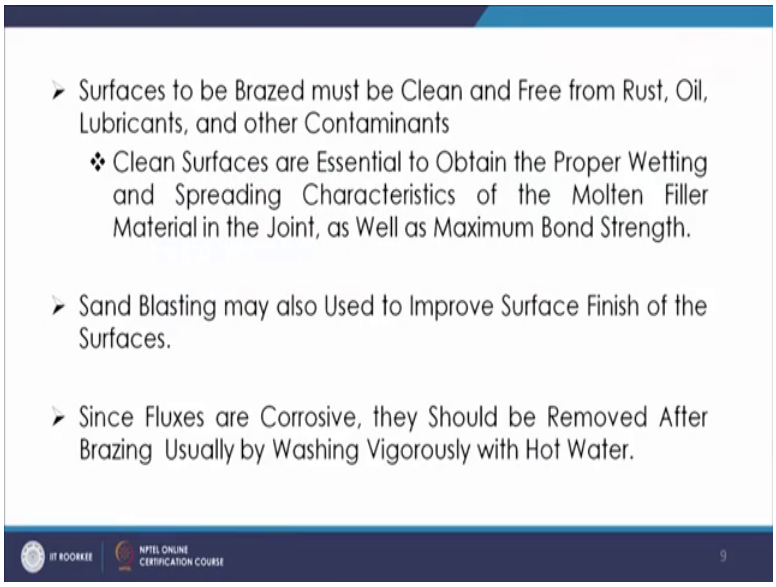

So, you can have the proper methods of cleaning and then they must have the proper wetting and spreading characteristics of molten material because they have to be wet and also they must spread properly. So, that the proper bonding takes place it gives you maximum of the bond strength.

So, there are many you know methods of having proper surface finish of the material and in that you may have the sandblasting and then as we discussed we can have the use of brushes, you can have the use of the chemical agents and also. So, for that and fluxes many a times fluxes are corrosive in nature. We have different types of fluxes that we will discuss. So, these fluxes many of fluxes are corrosive in nature.

So, basically once the process is done then you must remove these fluxes because otherwise they will create undesirable effect they may be corrosive in nature. So, normally you try to remove them you have to wipe off them you are also watching them rigorously with hot water. So, that these fluxes or their residues they are removed.

Now, we talked about the different types of brazing methods now different type of brazing methods are basically depending upon the how you are heating. So, according to the heating methods in brazing the different methods will be based on how you are heating. So, basically you have the placement of you have to you are making the joints, first of all you are placing the braze material and then you are further heating.

So, based on the different methods of heating itself you will have the different you know brazing methods like torch brazing. So, now in this case there is a Torch.

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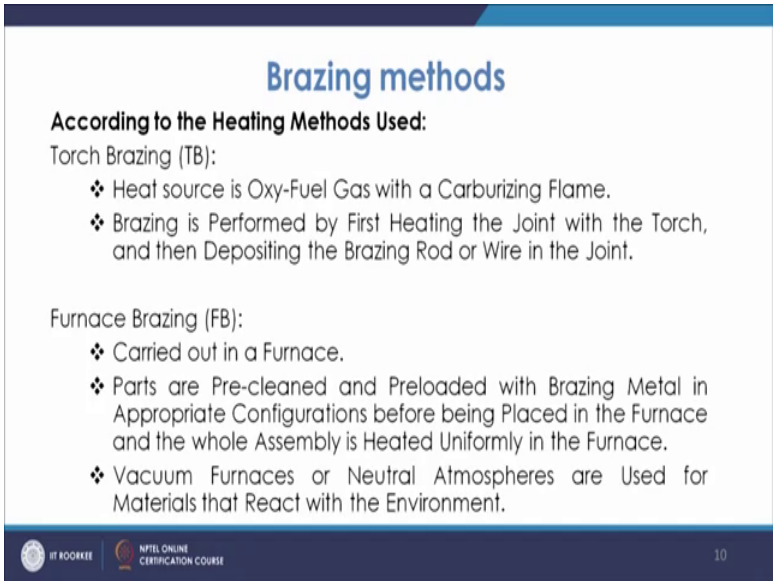

So, you will have a Oxy-Fuel gas with a Carburizing Flame and then you will have that that as a torch. So, in that flame will be coming up and from that you will be heating the joint there then temperature will be increased and that way the brazing will be carried out. So, it is performed by first heating the joint with torch and then depositing the brazing rod or wire in the joint. So, this way you are heating and then depositing that brazing rod or wire in that joint. So, this way the brazing takes place.

Similarly, furnace in the furnace what we do is that first of all we are cleaning pre cleaned and preloaded with brazing metals you are already putting first of all and then put in the furnace and then in the furnace the temperature will be increased. So, and then in that case whole assembly once the temperature becomes more in that case at that particular temperature the welding or braze brazing will take place.

So, many a times for reactive metals you will have to control the atmosphere of the furnace. So, you may have the inert atmosphere or you may have the neutral atmosphere, vacuum also is many times used for very reactive type of materials when you are brazing them.

Another effect I mean method is induction brazing where the source of heat of heat is induction heating by high frequency arc current. So, that way heating will take place and then at that temperature the brazing will take place. So, thickness normally has to be less and induction brazing is normally suitable for brazing parts continuously. So, continuously you just go on and then that brazing will go on continuously for larger parts or for continuous parts that type of process is suitable.

One more thing which must be you know in the mind of you all that normally when you have very thin type of seats the welding is a challenge or joining is a challenge. But in these cases the brazing or soldering or so, in these cases if it is thinner than that way it is advantageous because the temperature involved is less. So, the chances of deformation or fire or heat affected joint areas they are little less I mean it is they are lesser as compared to the normal fusion welding processes.

Similarly, the next type of method is resistance brazing.

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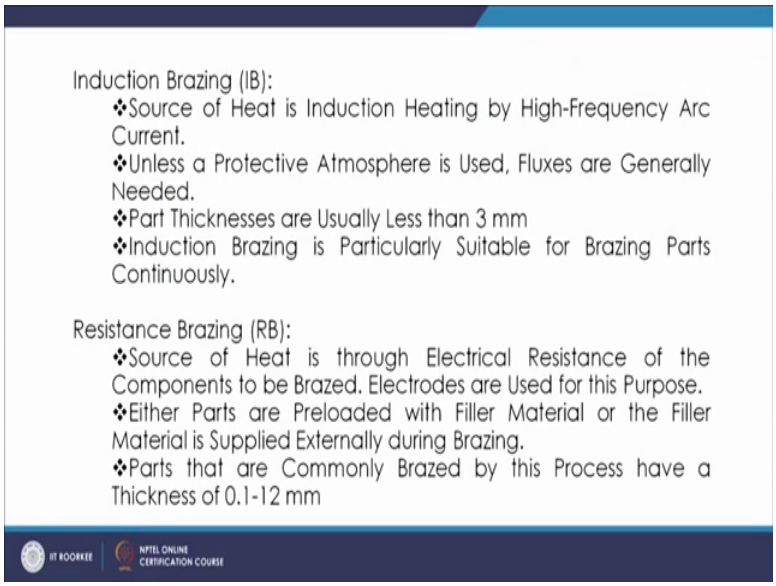

So, in the resistance brazing basically the electrical resistance of the component will be used for the heating purpose. So, you will have the use of electrodes and in between since there will be resistance because of that heating will be taking place and because of that heat the preloaded filling filler material will be melted and then the joint will take place.

So, you have parts to have thickness of 0.1 to 12 mm of thickness. Another method of brazing is dip brazing where you are dipping it in a bath. So, you may have the molten filler material bath or a molten salt bath at a temperature just above the melting point of filler material.

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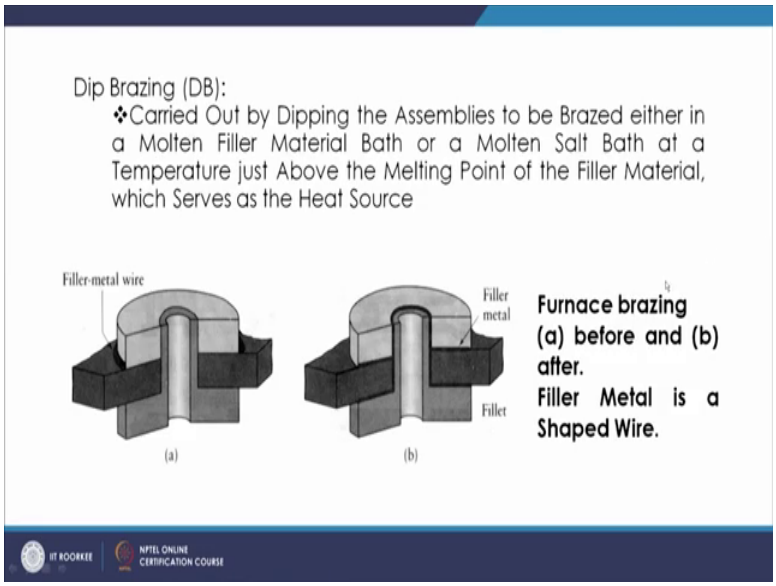

So, you are dipping it and at that temperature, that melting takes place and then the joint develops. So, you can have you can see that how you are putting this in the basically furnace you can put in the furnace, this is the filler metal wire and after that once it comes out you see that whereby capillary action it goes into it.

So, like that dips brazing you are just putting in the bath which is maintained at certain temperature and then it is taken out. So, this way your this brazing takes place. So, these are the different methods of you know brazing which is being carried out in the practice.

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These are the different joint designs which are commonly used in the case of brazing operations as you see you have lap joints or so,. Normally you have different types of joints you can see there you have interlocking of the joints going on, lap type of joints going on we have different you know types of joints in different way you can join them.

Now, we will discuss about another process that is soldiering. So, as we discussed that in the case of soldering the filler material will be melting below that 450 degree centigrade. So, again here also the joint is filled by the capillary action and here you have the different sources of soldiering that is soldering iron torches or ovens. So, based on that you would have different soldiering methods and it is used to join various metals and parts, thickness. you have different types of solders and normally you use the tin lead.

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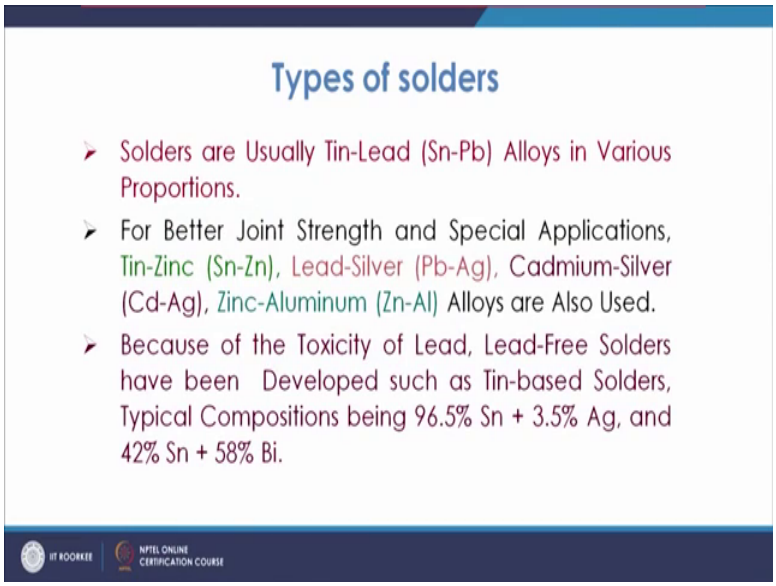

Solder in most of the cases because of it is quite low melting point and that too. If you look at the phase diagram of tin and lead you will have this eutectic which is which has even the quite a lower of lower value of melting temperature. So, that way it is quite popular for using as the solder material because with very small temperature increase it can be melted.

Now, you have for better joint strength and specific applications you may have the as we discuss Tin-Zinc, Lead-Silver, Cadmium-Silvers, Zinc-Aluminum Alloys also used as this solder material. However, because of the toxicity of the lead toxicity of the lead free solders have been developed like tin based solders.

Normally 96.5 percent of tin plus 3.5 percent Ag or 42 tin plus 58 percent bismuth; so they are used for basically ensuring that there is not you know much of the presence of lead because of the environmental concerns.

Now, in this case you have soldering fluxes also the soldiering fluxes are normally inorganic.

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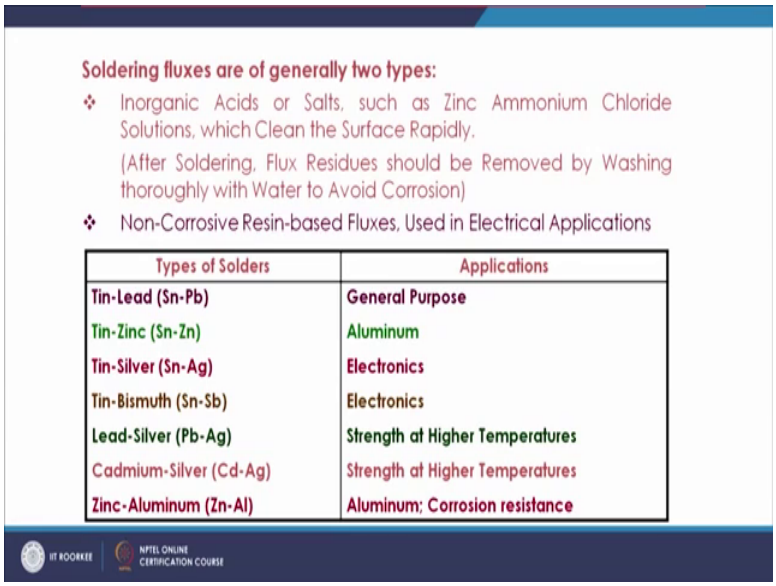

Acids or salts such as Zinc Ammonium Chloride solution and then you may have the Non-Corrosive Resin based fluxes which are used in the electrical applications.

So, as we see that in this case in the case of soldiering also you have the same mechanism, the mechanism of first is it is wetting then you will have alloying and spreading and then further you have the joint filling will be there by the capillary action. So, same thing is you know followed in the case of soldiering.

As far as this fluxes are concerned so, the fluxes will be the liquids or solid or gaseous product and when they will be heated then the there will be promotion of wetting of the metal and then there will be 2 solders will be there. So, they will be wetting characteristic improvement, they will be removing the oxides and other surface compounds.

So, that is the basically basic purpose of using the flux and normally they have the lower specific gravity than the solder. So, that what happens that after heating they will be coming up. So, you have to just remove the fluxes or it is residues from there.

So, you as we know that you have the different types of you know fluxes and as we discussed that you will have inorganic type of fluxes which will be consisting of normally the inorganic acids plus salts. So, normally Zn Cl2 also is used as the flux for steel.

Similarly you have the Ammonia based also compounds are used and the precaution which is taken in the case of these fluxes are that normally they are corrosive. So, they must be removed you know in these cases.

Then you have organic type of also fluxes which uses the organic acids and bases and normally they are the hydro halides in that form they are used. And they normally decompose at the higher temperatures of about 90 to 320 degree centigrade and then they do not leave any residues. And then you have other varieties of also fluxes so, they are used for the special applications.

Then as we discussed that you have the different types of solders and different applications like you have Tin or Lead solder so, you have it is use in the general purpose. You have Tin-Zinc which is used for Aluminum, Tin-Silver for electronics, Tin-Bismuth for electronics, Lead-Silver for strength or higher temperature, Cadmium-Silver for strength or temperature and Zinc-Aluminum for Aluminum and corrosion resistance.

So, this way you have different types of solders for use in different applications. These are the different soldering methods just like a we discussed in the brazing methods.

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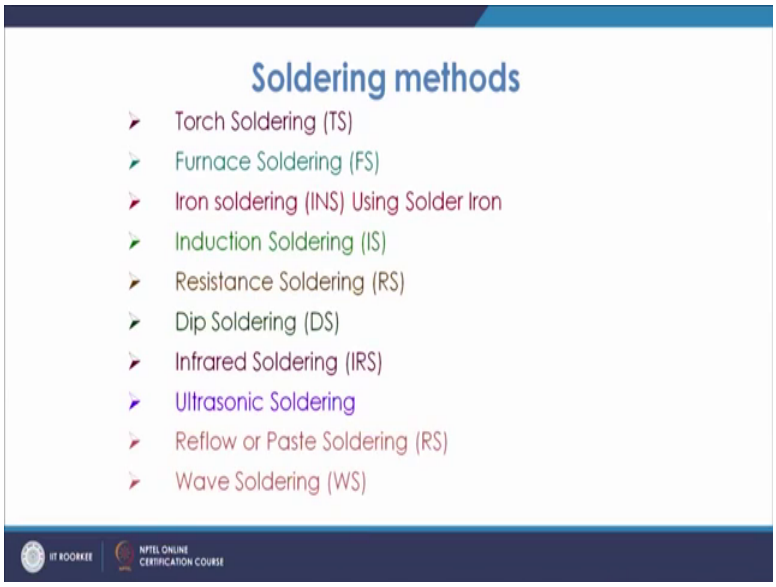

Here also you have the different types of soldering methods for different applications and depending upon the different way they are heated the specimen is heated and soldering takes place.

So, just like you have torch soldering where again the flame will be used a torch will be there, furnace soldering, iron soldering where we use the soldering iron or sometimes we also copper iron also because the copper in the tip is with copper. So, that is also having another name, like you have induction soldering, resistance soldering, dip soldiering infrared ultrasonic reflow or paste and wave soldering.

So, these are the different methods of soldiering which we need to know maybe just because others are like based on the normal mechanism of heating. And some of the methods like paste soldering or wave soldering so, they are special type of in wave soldering you have it is the heated one and it is wave we are coming in contact, so because of the pump and then that way soldering takes place.

So, normally there is a special kind of soldering processes they are used for electronic applications. So, we when we are using the printed circuit boards and that in those cases these wave or the flow and post paste soldering that is used in the case of those methods.

Then after the soldering there is another mechanism of bonding that is adhesive bonding. Now, adhesive bonding is the one where you will have the 2 adherents you are using the adhesive in between the 2 materials. And then one adhesive is kept in between so, again here some is a metallurgical bond is not taking place, my adhesive may be in the form of cement, glue or paste.

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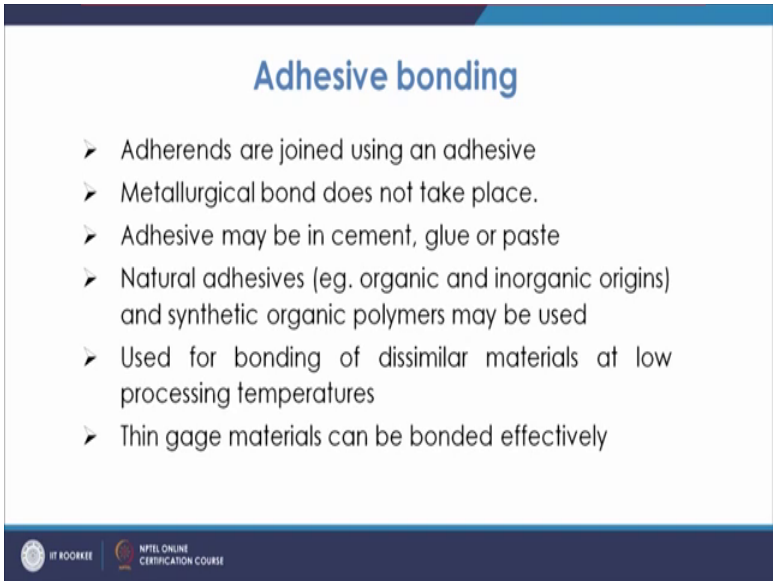

Then you may have the natural adhesive like organic and inorganic origins or synthetic type of organic polymers which are used. this is normally used for bonding of the similar materials at low processing temperatures and there is thin gauge materials which can also be bonded effectively.

So, they are effective quite effective when the gauge material is quite thinner. So, which is normally not in the case of other you know welding processes or joining processes when it is very quite thin then the application of heat in that case may distort or may create undesirable effect.

Now, if we talk about the adhesive bonding here the forces are developed because of 2 kind of forces which are developed 2 kind of you know attraction forces, one is the polar forces which are because of the dipole forces.

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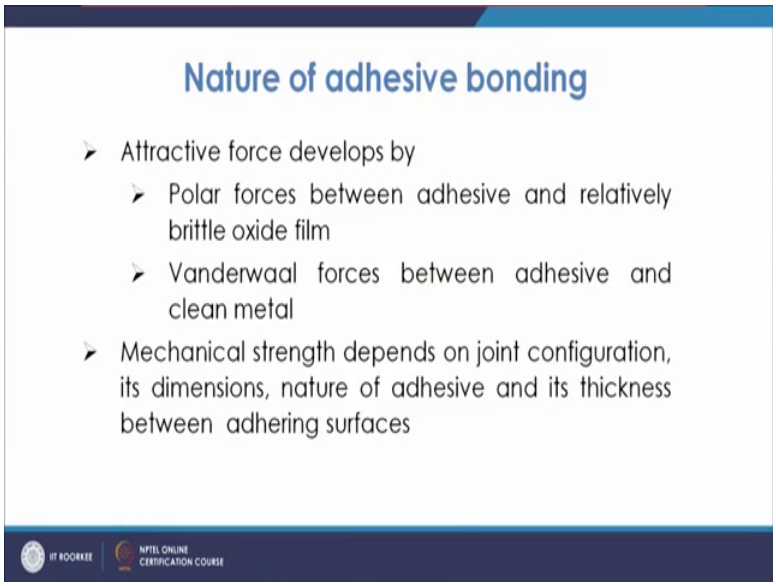

So, dipole creation that is between adhesive and relatively brittle oxide film, another is the because of the Vanderwaal forces which are generated between the adhesive and the clean metal. So, that is the concept of the strength which develops in the case of these adhesive bonding.

Now, mechanical strength will depend upon the joint configuration, dimension, nature of adhesive and it is thickness between the adhering surfaces. So, normally these additive

adhesive type of bonding is normally between the dissimilar type of materials Like whenever we are having the joining of one metal with another nonmetal.

Similarly, normally in the case of making the breaking shoes for automobiles; so you will have one metal and one nonmetal they are to be attached. So, they are to be you know joint in those cases these type of bonding methods are more popular.

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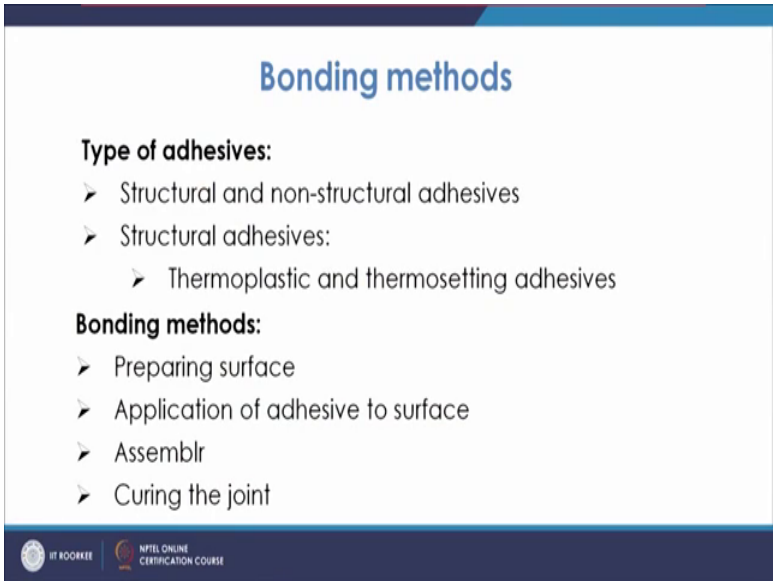

Now, bonding methods like we have type of additives as we discussed that it is a structural and nonstructural relatives depending upon what is the how much force it can resist or it can sustain. And in that structural adhesives you have thermoplastic as well as thermosetting additives. So, you have different varieties of thermoplastic and thermosetting materials which are used as the adhesives.

Similarly, if you talk about these steps in of bond creation; so in that you have first of all you have to prepare the surface then you have to apply the additive adhesive to the surface then you have the assembly and then further you have the curing of the joint. So, this way the joining takes place in such cases. So, this is how the adhesive bonding is developed this is all about these three kind of methods.

Thank you very much.