Welding Engineering

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Module - 4
Arc Welding Processes
Lecture - 9
Braze welding and Electroslag welding

This presentation is mainly based on the braze welding and the electroslag welding process. These two processes are completely different from each other ((Refer Time: 00:34)) phase process where the filler metal is brought to the molten state while the base material is largely not melted intentionally to develop a weld joint. While in case of the electroslag welding, the melting of the base material is insured to get the weld joint. In this case, the heat is generated not directly by the arc between the electrode and the base material, but the heat is generated by the flow of current through the molten flux.

So, electrical resistance heating is mainly responsible for melting of the filler material and the base material for developing the weld joint. So, in this process the arcing is used mainly in the initial stage of the welding. Once the small pool of the molten flux is obtained, the electrode is submerged in the pool. Then the flow of current through the molten flux starts for developing the heat desired for developing the weld joint. So, the two processes are different from the each other in the mainly in the way by which in the in the state in which the weld joint is made with respect to the base metal especially.

So, here the overview of the presentation includes the need of the braze welding, then the principle of the braze welding, the basics of the electroslag welding process and the advantages and limitations of the electroslag welding process. So, starting with the braze welding process like in case of the soldering and the brazing the base materials are heated to in the high temperature. Then the filler material is applied, so that the things are brought to the molten state and by capillary action filler material distributes itself between the component to be joined.

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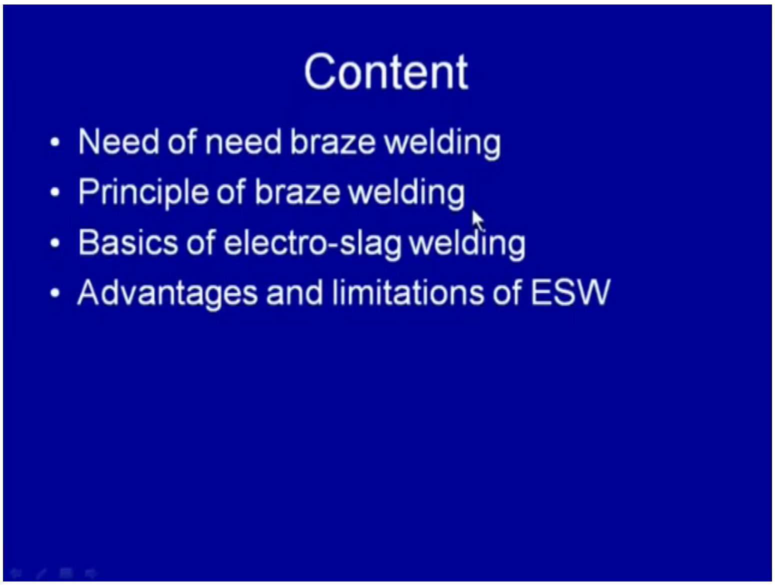

Here capillary action plays an very important role a very important role in distribution of the molten filler metal between the components to be joined. To achieve that uniform distribution by the capillary action the clearance between the components being joined are very that is very important. But in braze welding it is not so because in case of the braze welding. It is similar to the brazing and soldering in one sense and different from the brazing and soldering in other sense.

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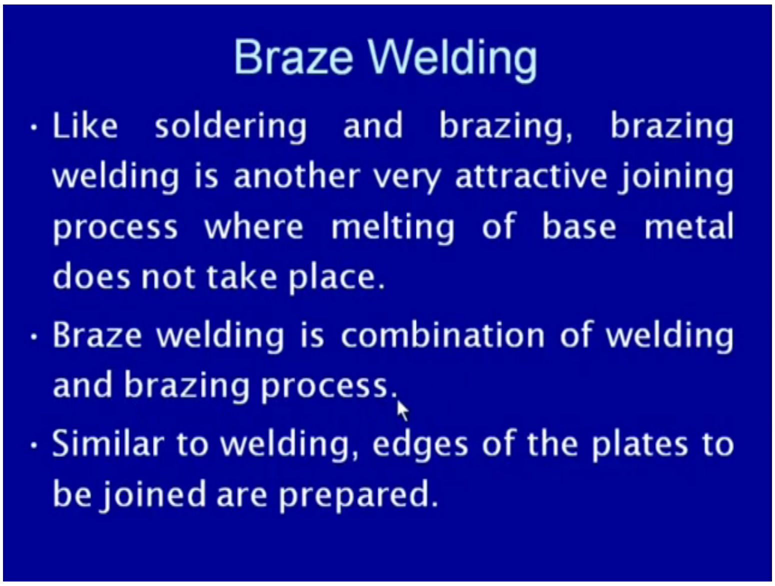

So, what are the various aspects related with the braze welding and how it is different from the brazing and soldering? That we will be looking into the brazing is very attractive joining process, where base material is not melted intentionally to develop the weld joint where only the filler material is brought to the molten state. But for developing a braze weld joint normally the groove is prepared just like in welding. So, the braze welding is a combination of the welding and the brazing process. In case of welding we prepare the edges for filling the molten metal by melting the filler material that is in form of electrode and the base material.

So, the base material is brought to the molten state typically in welding, but here in braze welding the just grove is prepared. So, that the brazing material can be filled in without melting the base material, so thus it is the combination of the brazing process, where filler material is brought to the molten state. But in this case the capillary action does not play any role because the edges of the plates are prepared in form of groove. That groove is then filled with the help of the filler material, which is applied separately and similar to the welding the edges of the plates in braze welding are prepared, which are to be joined.

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So, the plates to be joined are prepared for their edges may be in form of the v groove or some other kind of the groove is made. But as far as similarity with the brazing is concerned only melting of the filler material is done and the melting of the base material is not done intentionally for developing the weld joint. So, the advantage is that the heat is not much applied to the base material and already melting of the filler material takes place.

So, once the grooves, groove is prepared between the plates to be joined the groove is filled using comparatively low melting point filler material without melting the base material. So, our target is not to melt the base material, but only the filler material is brought to the molten state and the melting point of the filler material is normally that is that is always lower than the base material. So, that the groove can be filled in by the heat, which has been supplied to the base material the filler materials are mostly brass. That is the copper base alloys earlier this process was mainly used for the repair of the cracks.

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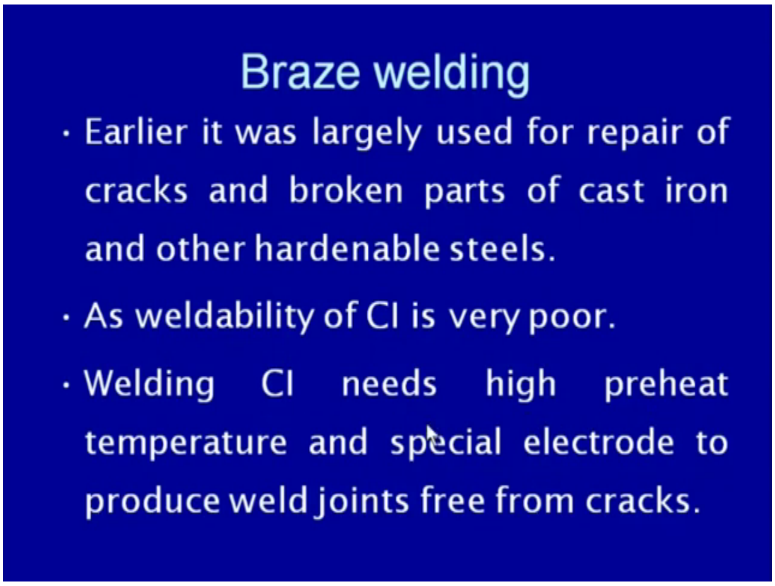

The broken parts of the cast iron and hardenable steels there the thing is that the cast irons and other hardenable steels are known to be very difficult to weld because of the high hardenability. They show great tendency for the cracking due to the high cooling rate and due to the high cooling rate experienced by the, by these materials during the say in conventional arc welding processes. Because of that the high hardenable materials and the high cooling rate associated with these with the welding process of these materials, results in the huge cracking tendency. The increased cracking tendency leads to the simply rejection of the materials.

So, far the repair purpose repair of the cracks and the broken parts of the cast irons and hardenable steels the braze welding is been very extensively used earlier. This is mainly because of the weldability of the cast iron is poor, if we perform welding due to the high hardenability. These will lead to the cracks very easily under the welded component with the cracks cannot be used for any significant mechanical purpose. So, the welding of the cast iron needs, further if we try to weld the cast iron, then it requires the high preheating temperature, which is difficult to difficult to work with.

Because high preheat temperature approaches many difficulties during the welding process to the operator due to the high temperature the handling of the work piece and the application of the welding becomes difficult. That is why the welding of the cast iron using the high temperature makes it difficult. Further, it requires special electrodes to the weld joint for producing the cracks. So, for producing the weld joints which are free from the cracks so then requirement of the high preheat temperature and the special electrodes makes the cast iron difficult to weld, because excessive cost is to be paid for achieving for using the special electrodes, which are mainly nickel base electrodes. The preheating to the high temperature also makes its handling and the welding difficult.

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Because of these two reasons, the cast iron is considered to be difficult to weld. Further many times due to the size and shape it becomes difficult to heat preheat the cast iron components to the too high temperature. Under those conditions, it becomes you see it is very difficult to weld by the conventional arc welding processes. So, to for the repair purpose under those conditions and for minor repairing the repairing of minor cracks, the braze welding is found to be suitable.

Unlike the brazing in braze welding the capillary action does not play any role because in this process mainly the groove is made and the heat is applied after applying the heat when there is desired temperature is achieved. The filler material is applied on the base material, so that it melts and fills the groove. So, here in braze welding the capillary action does not play any role for the success of the development of joint the filler material, which are normally used for braze welding has the liquidus temperature above 44 degree centigrade.

But the temperature below the melting point of the parent material, so this is the normal the temperature range for the melting of the filler materials where liquidus is above 450 and the upper temperature is below the melting point of the parent material filler. Material fills the joint by just like welding with or without melting of the filler material here melting of the parent material is not intentional. However, with the application of the heat due to the careless application of the heat little melting of the base material can take place, but it is not required for development of sound braze weld joint.

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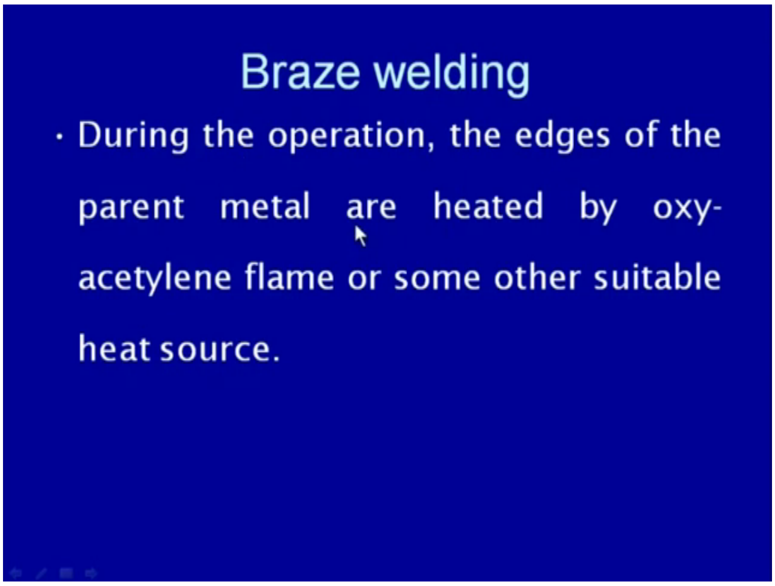

So, during the operation edges of the parent materials for braze welding are heated using the suitable oxy acetylene flame or some other suitable heating source.

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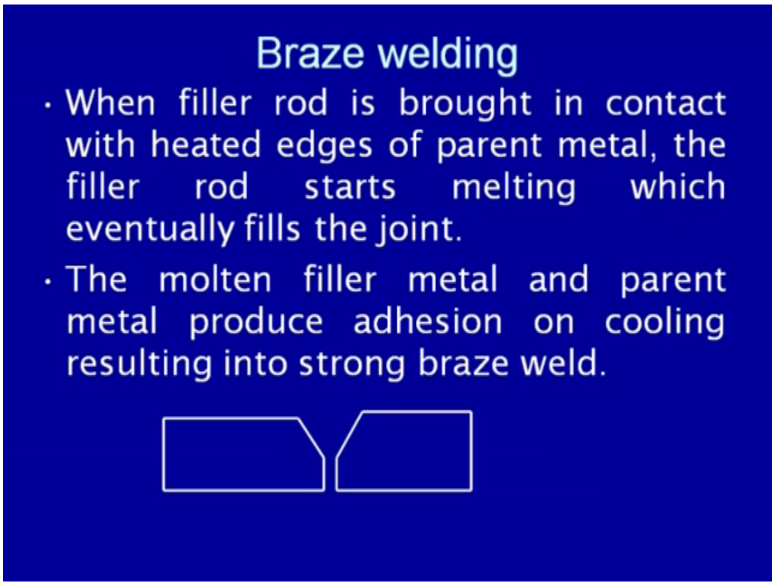

Once the desired temperature is reached here the filler rod is brought in contact with the heated edges of the parent materials to be joined. This and because of this the filler rod starts melting and which eventually fills the joint to be made and the molten filler material and the parent metal produce the adhesion on cooling resulting into the strong braze joint. Say these are the two plates to be joined by braze welding, then the edges are prepared like a typical a v groove form. Then on the application of the heat the filler material melts and fills the groove.

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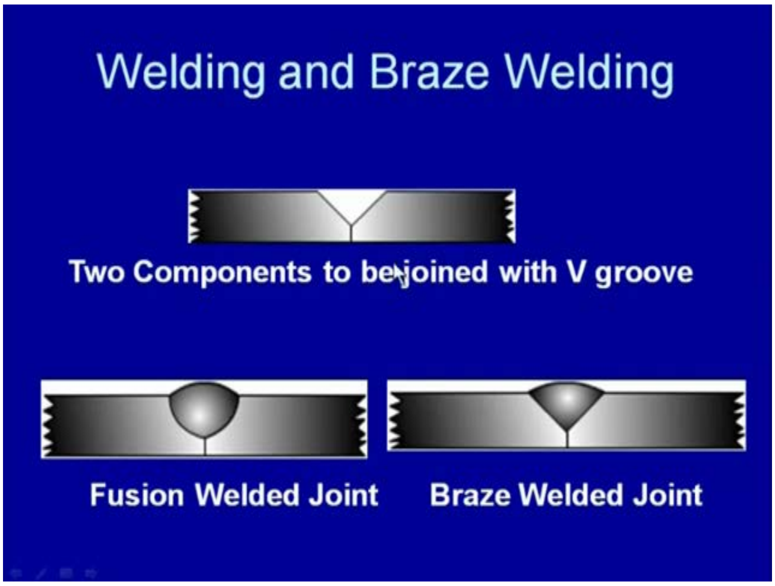

Say the two components to be joined component a and component b and their edges have been prepared. Here in this case here we using the v grooves geometry and once the groove is made the filler material is applied the heat is applied and once the desired temperature is reached filler material is applied. So, that it melts and fills the groove if we see the difference in the kind of geometry, which is obtained by the fusion welding and the braze welding in the two cases.

Then the fusion welding results in this, the straight the faying surfaces of the base material. They become curved because of the melting of the base material in case of the fusion welding processes, while in case of the braze welding the no melting of the base material leads to have the still straight edges only the filler material is used to melt. They fill the gap between the two plates to be joined in for the braze welding purpose.

So, this specific feature where application limited application of the heat to increase the temperature of the base material, but not to melt results in the number of advantages. Because of which it offers, so the reduced heat input associated with the braze welding results in the many favourable advantages, which will be described in subsequent slides like the materials, which are commonly used for the braze welding.

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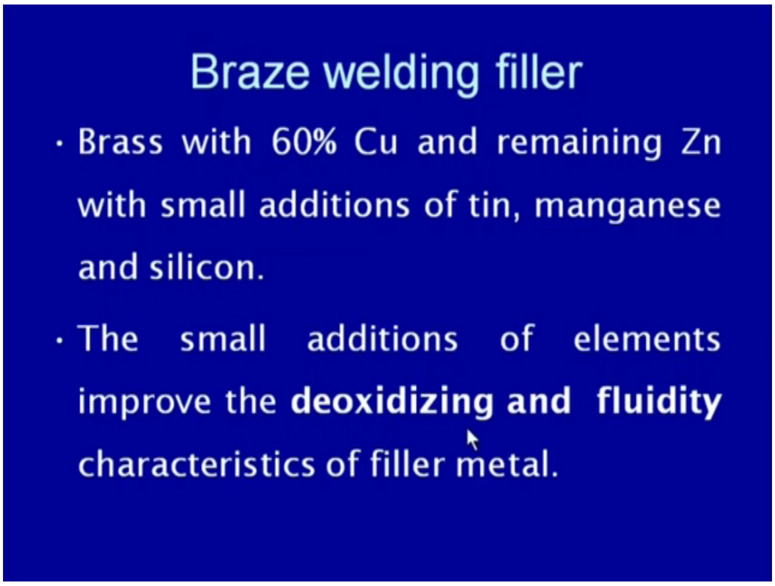

It is in form of the brass which uses about 60 percent of the copper and the remaining amount of the zinc with the small amount of the tin and magnesium and the silicon and the small addition of these elements help to improve in deoxidation, and the improving the fluidity of the filler material. So, that all areas of the groove can be filled in by the filler material being used for developing the braze weld joint. If we see that that key feature of the braze welding as compared to the conventional fusion welding process.

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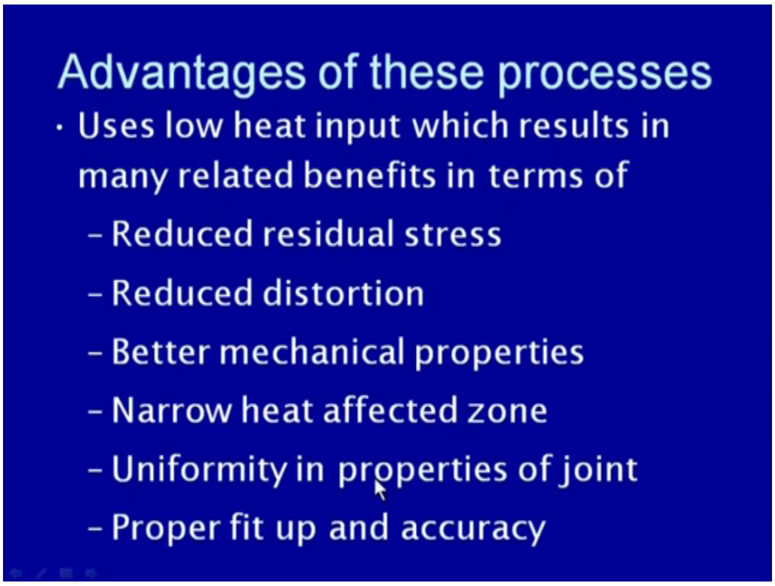

It that, it uses a very less heat input just for heating the edges of the plates to be welded, but not to melt the faying surfaces of the base material and because of this low heat input use of low heat input with this process results in the number of benefits such as the reduced residual stresses. We know that the differential heating and cooling in case of the conventional welding process is a main reason behind the development of the thermal stresses. These thermal stresses lead to the development of the compressive and the tensile residual stresses in the weld metal in the weld joint and in the in the heat affected zone.

These residual stresses many times decrease the mechanical performance and the corrosion performance and during the service conditions. So, if we reduce the heat input to the base material, then the extent of differential heating and cooling of the base material is also reduced, which in turn helps in reducing the extent of residual stresses, which will be developed during the braze welding process, the reduced distortion. We know that no residual stresses means no distortion. But once the residual stresses are developed, under the...

So, the metal systems which are of the poor rigidity are which are held loosely on the fixtures, they will tend to go out of the shape during the welding. But in this case when the heat input is reduced, so the magnitude of the residual stresses are being developed because of the heat application in braze welding is also reduced and reduced residual stresses further helps in reducing the distortion. Means the extent up to which the plates due to the application of the heat and on subsequent cooling can lead to the distortion of the component. So, this distortion is also reduced because of the reduction in heat input reduced heat input, which is used with the braze welding process.

Further the mechanical properties are found better especially in case of the conventional arc welding processes. The heat input commonly leads to the change in the metallurgical properties of the heat affected zone and this mainly happens in form of the coarsening of the grain structure or in form of the hardening and softening. Softening of the base material, so this hardening and softening of the base material many times leads to as hardening of the base material leads to the cracking tendency. While the softening deteriorates the mechanical performance; that is the ability to take up the external load and that happens mainly because of the excessive application of the heat during the fusion welding processes.

It leads to the significant change in the micro structure and mechanical properties of the heat affected zone. So, the extent of the variation in mechanical properties of the heat effected zone, which is formed in the case of fusion welding processes that is reduced and because of that the deterioration in mechanical properties in braze welding of the base material is reduced. This in turn results in the better mechanical properties of the, of the base material including in the heat affected zone. As I have said since the heat affected zone is developed because of the excessive application of the heat for fusion of the base material.

So, if we can reduce the amount of the heat being applied to the base material, then this in turn will help in decreasing the width the distance up to which the base material is effected from the fusion boundary, which means the width of the heat affected zone is reduced because of the reduction in the heat input. The low heat input results in the narrow a narrow heat affected zone and the next is uniformity in properties. So, narrow is the heat affected zone and the better mechanical properties in the base material results in greater uniformity in the properties of the joint, which are formed.

But the strength of these joint is further limited by the properties of the filler material which are there in this case the proper fit up and accuracy is also found better, because of the less heat input the things less heat input. No major dimensional change in the base material during this process take place and this in turn helps in having the better accuracy and the better fit up kind of conditions. During the braze welding there're some other important benefits, which are associated with the braze welding process.

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Is that the no melting of the base material take place in this braze welding process and because of the absence of the melting many undesirable effects related with the melting of the base material can be avoided. There is no issue of no issues related to the metallurgical compatibility, because the filler material only the filler material is brought to the molten state and it fills the gap between the plates to be joined, but the melting of the filler base material does not take place in this process. Therefore, the compatibility between the filler material and the base material does not play much role except under the corrosion conditions.

This can adversely affect the corrosion performance, otherwise as far as the bonding is concerned the metallurgical compatibility between the filler material and base material is not a major issue. In case of the braze welding, but the other joint can be dissembled. If dissembled, if required because the filler material is normally weaker and of the lower strength. So, it can be separated and the components which have been joined by the braze welding can be dissembled easily as compared to the conditions when the two have been welded using the fusion welding processes.

The strength of the joint is also fair, but it is not comparable or it is not as high as that of the typical weld joint. So, under the conditions where mechanical performance too high mechanical performance is not expected from the component the braze welding can be very successfully used for development of the joint for development of the braze weld. Then the, but they have they have certain limitation also associated with the braze welding these are mainly.

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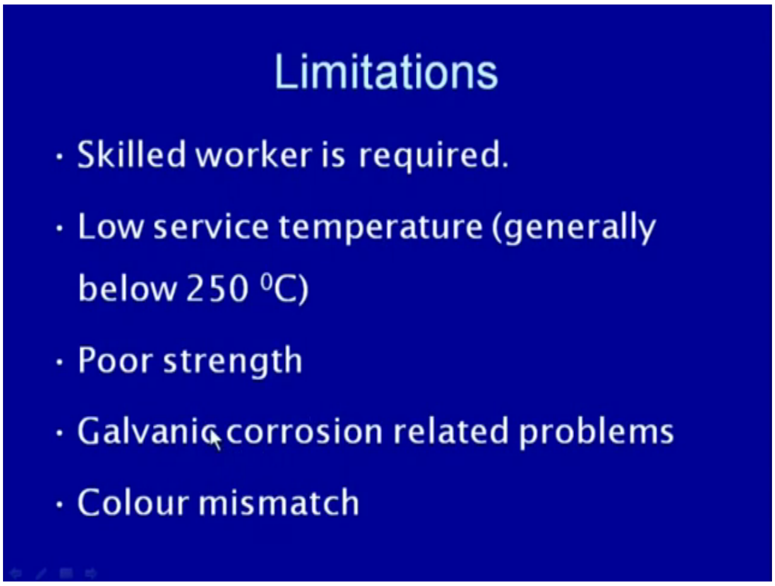

Related with the, that the skilled worker is required for development of the braze weld joint and further the low service temperature conditions are good enough, but it cannot perform at high temperature and the service conditions in which the braze welds can be used is generally limited below 250 degree centigrade. Because if we go on the temperature on the higher side, then the softening of the braze material or the joint braze weld joint will start deterioration and the joint will fail in very premature manner.

Another important is limitation is the poor strength of the braze weld, because these cannot take very severe mechanical load and they will fail under those conditions of the high load and the high temperature conditions. That is why these are not preferred for severe mechanical loading conditions due to the dissimilarity in the metal systems means the dissimilarity in the base material and the filler material. There will be tendency of the galvanic corrosion in the in the corrosive atmosphere. So, the corrosion tendency with the braze weld joints will be more as compared to the normal weld joint. This will this can be mainly because of the dissimilarity in the metallurgical properties of the base material and the braze weld joint means.

That the brazing material which is being used for developing the braze weld joint and the colour mismatch can be the another limitation related with the braze welding, because in the braze filler material offers the sometimes different colour from the conventional base materials like steels. Therefore, there can be a mismatch which can adversely affect the esteem value of the product which is being joined by the braze welding.

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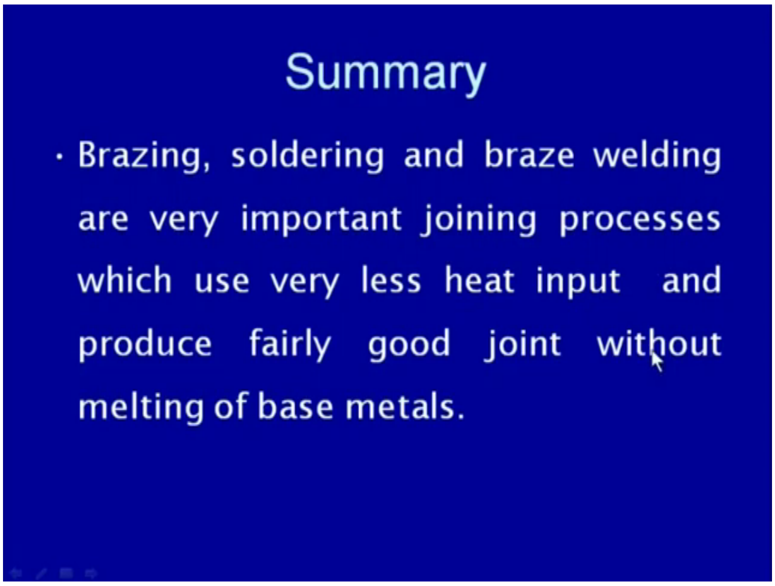

So, if you try to summarize this portion of the which we had talked is brazing soldering and the braze welding. We can say that these two these three processes are very important in the sense that these are the solid liquid processes where only the filler material is brought to the molten state, but the braze base material still remains in the solid state. No material, no melting of the base material takes place and another key feature of these three processes is at very low less heat input is used for development of the weld joint.

The joint has fairly good strength, but not for the conditions, which are high in temperature and the low means the load very severe kind of the load can act on the joints. But under the conditions where the load is very fair and not on the higher side can be easily taken up these joints very effectively. In these three processes the base material is not brought to the molten state for development of the weld joint. Now, we will see another important process which is extensively used in the heavy engineering industry for development of the weld joints where especially very heavy thicknesses are used.

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The name of this process is the electroslag welding. It has found very difficult to classify this special the electroslag welding process, because it is neither the arc welding process nor it is the resistance welding process, but here it is a combination of the both where the heat is generated first by establishing the arc between the electrode and the base material. Once the heat generated is sufficient for melting of the flux a pool of the flux is formed molten flux is formed. Then the flow of current from the electrode to the base material through the molten flux leads to the development of the heat by electrical resistance heating.

So, this process uses the combination of the heat generation by both the arcing and the electrical resistance heating however the arcing is mainly used in the initial stage for bringing the flux in the molten state. Once the flux a pool is generated, the heat is generated by the electrical resistance heating. We will go one by one, in this the need of this process, the process capabilities and the principle of this process and the various advantages and disadvantages related with this process. This process is typically characterized by the uphill welding process, because during the welding the weld joint made is made in the vertically upward direction. So, edges of the plates to be welded are brought in aligned state vertically

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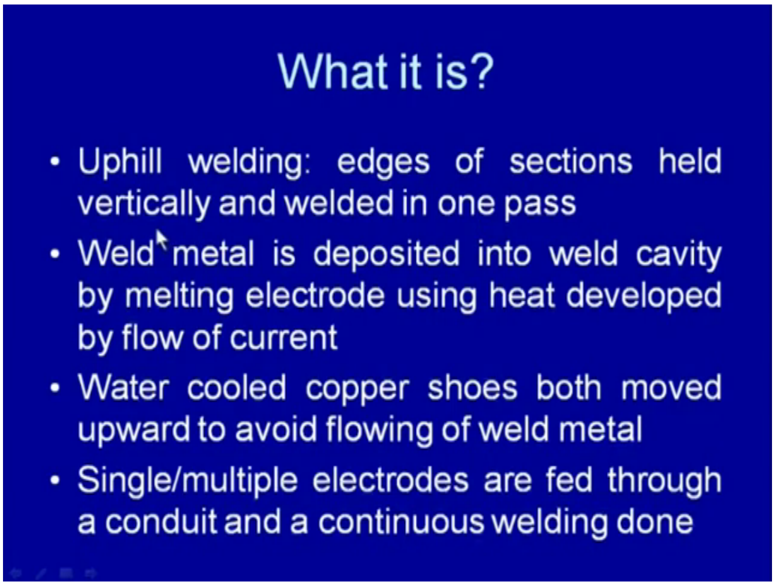

Then joint is made in one pass so and this one pass is made in vertical upward direction and because of this uphill this is typically known as uphill welding process. Means the typical nature of this process is uphill welding in and it is made between the plates which are held vertically and the weld joint is completed in one pass. The weld metal is deposited into the weld cavity by melting the electrode, which uses the heat being developed by the flow of current. So, heat development and the melting of the base material related aspects will be further covering in the remaining portion.

Means in the subsequent slides further in this process, the water cooled copper shoes are used in both the sides of the weld region, which is being made to avoid the flowing out of the weld metal. This process can be the single or multi electrode process through which current is passed and the heat is generated continuously for developing very thick, for developing the weld joint between a very thick plates. If we have to understand the process of the basic principle of this process, then we will we will try to see this schematic diagram.

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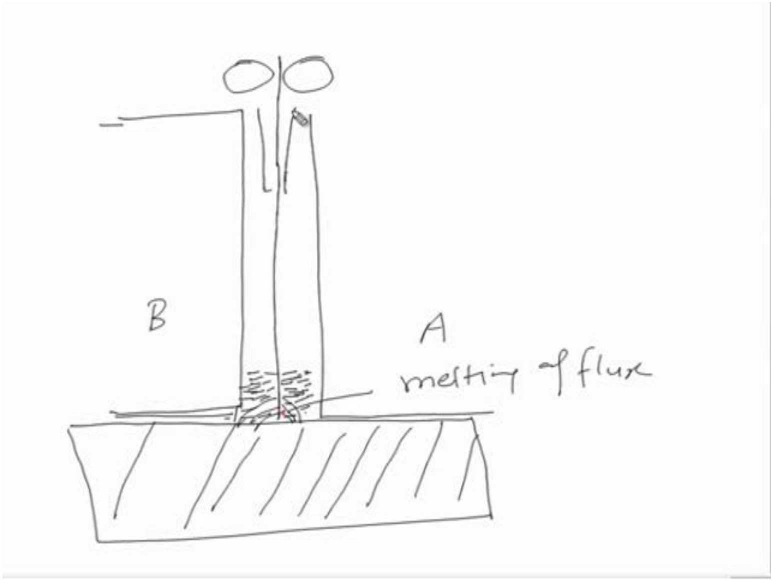

Here say the plates to be welded are placed vertically. This is the front view this is one edge of the plate and say this is another edge of the plate and both are placed over some plate form like this. So, this is plate A and this is plate B and the electrode is fed through the rollers. Then it is fed with the help of some tube that is the conduit pipe to direct it, so that it can strike the arc and this region is initially made full of the granular flux.

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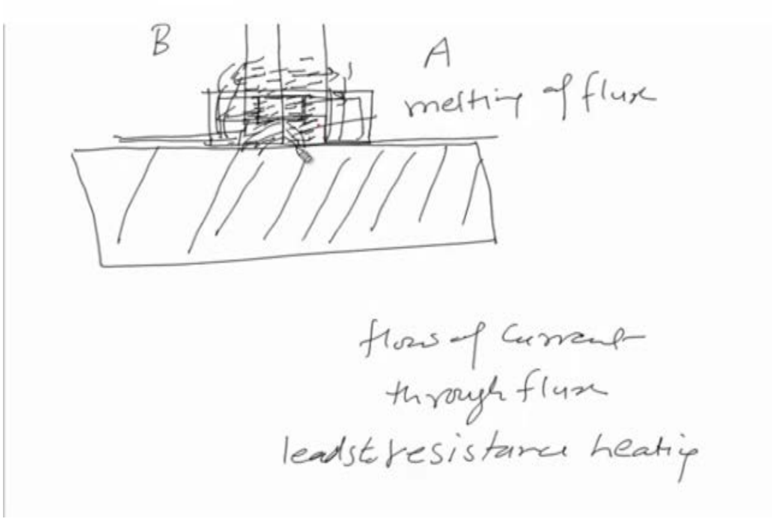

So, initially the flow of current through the electrode and between this the base plate leads to the striking of arc this striking of arc in the initial stage is leads to the melting of the flux in the beginning. Once the melting of the flux takes place to such an extent; that entire means this electrode wire with the arc and the flux molten flux is completely filled in. The molten flux is completely covering to the wire, so and in this situation the flow of current starts through the molten flux.

So, the flow of current through flux molten flux leads to the resistance this leads to resistance heating this electrical resistance heating causes the heat generation in this weld molten flux zone. So, heat being generated is used heat being generated by the molten flux heat being generated by the molten flux, because of the electrical resistance heating transfers the heat to the base material as well as causes the melting of the electrode. Also, heat being generated by the flow of current through the molten flux is transferred to the base material. This leads to the little melting of the base material, also the continuous melting of the, as soon as the melting of the base material starts.

The, this one is completely covered by the copper shoes from the sides, so there are two plates, there are two plates and which are kept vertically the wire is fed arc is striked. So, striking of the arc leads to the melting of the flux and by electrical resistance heating heat is generated, which is transferred to the base material. So, the heat being transferred to the base materials causes the melting of the edges of the plates to be welded. Once this starts the solidification of weld metal is generated and it starts to settling down in the bottom portion.

So, once the base metal starts settling down in the bottom portion, the sides will be well covered both the sides open sides of the base material are well covered by the copper shoes. These copper shoes are in contact of the molten metal and the molten flux. So, to maintain them these copper shoes from both the sides are water cooled continuously. So, that they can be maintained within the temperature within the safe temperature limit, once the sufficient size of the pool of the molten metal.

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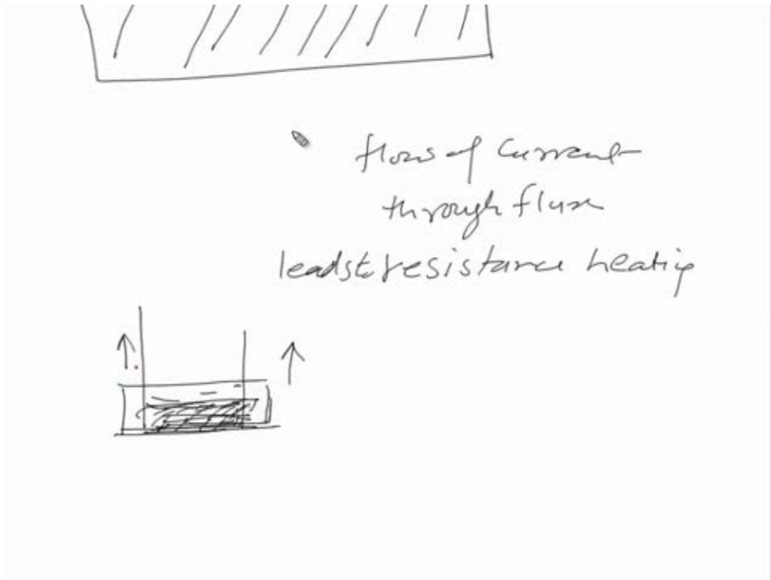

Like say this fresh diagram, this is the molten metal pool has been formed and this is well covered from both the these sides by the copper shoes. Once if it is formed in the bottom side, its solidification will start. So, we if this is the portion which has been solid solidified in the bottom the joint completed. Then this is the portion which has solidified joint completed, this is how one by one sequentially the joint is developed. Once the sufficient size joint is made you keep copper shoe will keep on moving up along with the electrode and electrode is fed downwards continuously.

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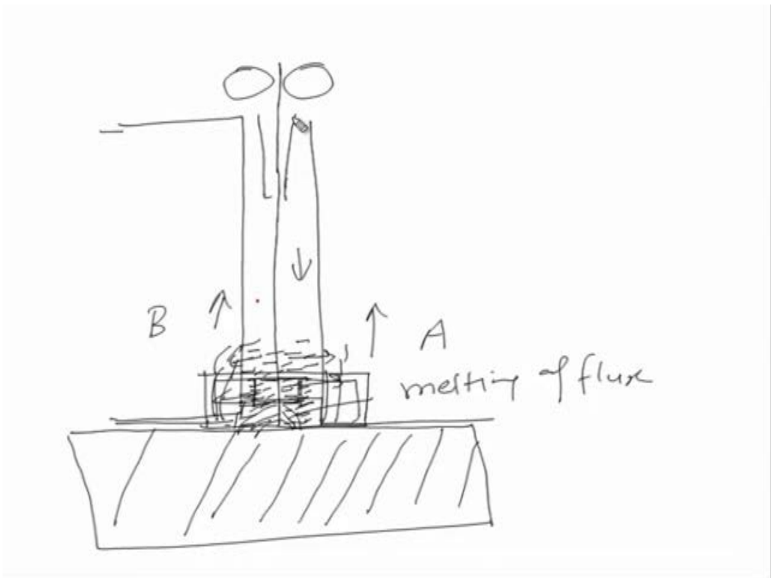

But these copper shoes start moving up and so this continuous upward movement will be done until the weld joint is made between the two plates to be joined in one go. So, it starts from the bottom development of weld joint starts from the bottom. Then it will continue until the complete length of the plates have been joined. This is what we will try to see in the in the slides, it is a uphill welding process the edges are edges of the plates to be welded are held vertically and welded in one pass.

So, once the welding started the complete weld joint is made in one pass and the weld metal is deposited into the weld cavity that is a bit, the gap between the two plates to be welded by melting of the electrode using the heat developed by flow of current. So, this heat being generated by the electrical resistance heating is mainly used for melting of the filler material and the to the and the melting of the base material. The water copper shoe water cooled copper shoes are used to prevent the flowing of flowing out of the molten metal from the weld area. The single and multiple can be used depending upon the thickness of the plates to be welded.

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If we see the capability wise the electroslag welding is used mainly in heavy engineering industry for joining very thick sheets ranging from 12 to 75 mm or even thicker sections can be welded easily in one pass using the electroslag welding process. This process has been widely used for joining large castings forgings to produce very large composite structures of steels. Titanium and aluminium alloys applications are of the construction of thick walled large diameter pipes pressure vessels storage tanks and the ships these are areas where it can be used.

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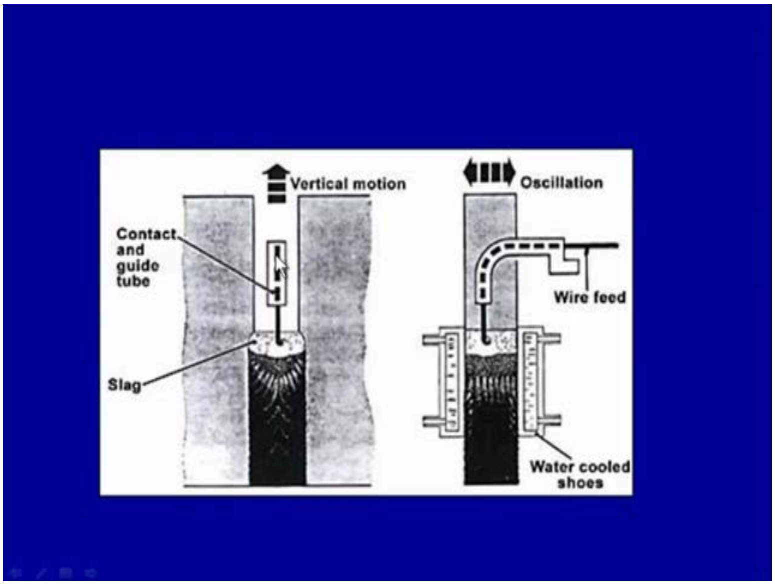

If we see schematic diagram of this process shows that these are the two plates to be welded and here. This is the pipe or the contact tube through which the electrode is fed continuously. Initially there will be only the flux granular flux and the heat generated by the arc in the initial stages is used for developing a pool of the flux molten pool of the flux. Once the pool is formed of the sufficient size the flow of current through the molten pool starts to develop heat by electrical resistance heating. They as in this process the little melting of the edges of the plates of the base material will be taking place at the same time melting of the electrode will also be taking place.

This in turn will result in the molten metal molten weld metal between the plates to be welded. As soon as solidification starts of the weld metal, these copper shoes are moved in upward direction. So, here we can say these are the two copper shoes to prevent the flowing out of the flowing of the molten metal away from the weld area. So, as soon as the weld is completed in one location these copper shoes are moved in upward direction and once the upward movement is complete. This upward movement will be completed only when the entire length of the plates to be welded is weld joint is completed in the entire length of the weld.

The top of, we know that just like any other welding process, what are the impurities are present between the in the weld metal? These will be reacting with the flux and forming the slag, so slag because of being light of its low density it will be floating over the surface of the molten flux. So, it will be, it will be present on the top of the molten flux layer further. If the gap between the plates to be welded is normally kept of the 30 mm and to have the uniform distribution of the heat between the plates to being welded, sometimes the arc this electrode is oscillated between the plates being welded.

So, that uniform distribution of heat both the sides of the edges of the plates being welded can be ensured. We can see here these are the water cooled copper shoes and these are cooled continuously by circulation of the water, so that the temperature of the copper shoes can be maintained within the safe limits. So, if you see the electrode is fed in the in the cavity between the plates to be welded.

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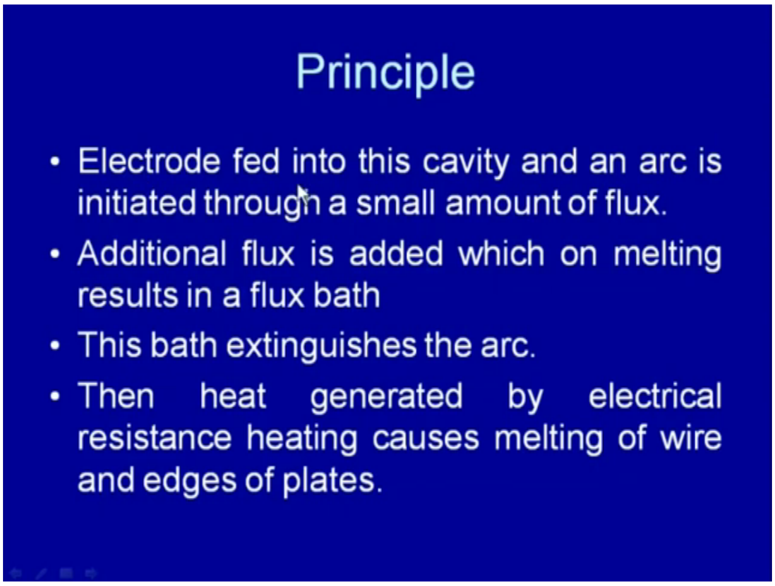

Arc is initiated through the small amount of the flux and additional flux is added which is consumed in process of the electroslag welding, which on melting results in the flux bath. Its molten flux bath is obtained this bath is this, bath extinguishes the arc arc which was developed in the in the beginning or in the initial stages, that will extinguished. Then heat generated by the electrical resistance heating causes the melting of the wire and edges of the plates being welded.

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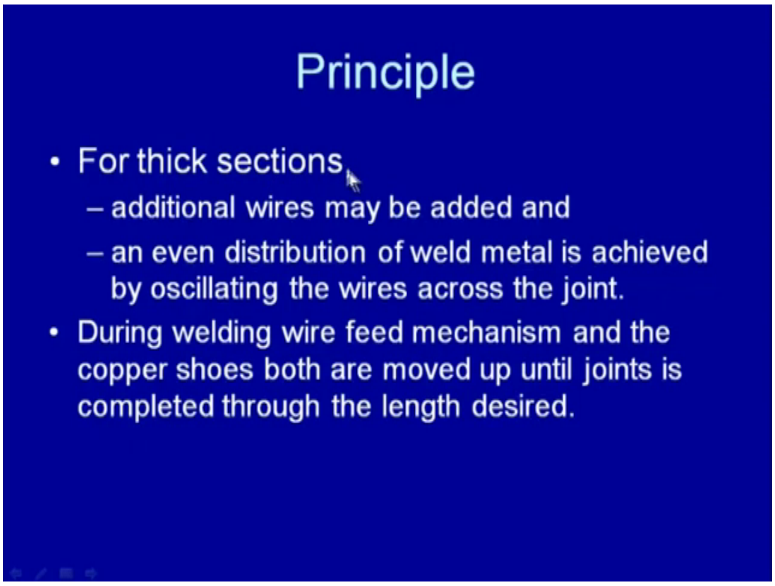

So, for thick plates additional wires may be added there may be two or three wires in one electroslag welding to fill the weld groove as early as possible. Because it can this process can work with very heavy very thick sections as up to 75 or 80 mm thickness. So, even and for even distribution of the weld metal oscillation of the arc is done during the welding, so that it the heat and the weld metal can be distributed uniformly between the plates being joined. During the welding a wire feed mechanism and the copper shoes both are moved up in upward direction until the joint is completed through the length.

So, this the continuous movement of the copper shoes will be done until the joint is completed throughout its length and the these copper shoes play in an important role in the sense. That when the molten weld pool is formed of the flux and of the weld metal these copper shoes prevent the flowing out of flowing of the molten flux and the molten weld metal away from the weld area. If we see the advantages of this electroslag welding process, the typically nature of this process is that, it applies the heat to the base material by developing the heat through electrical resistance heating.

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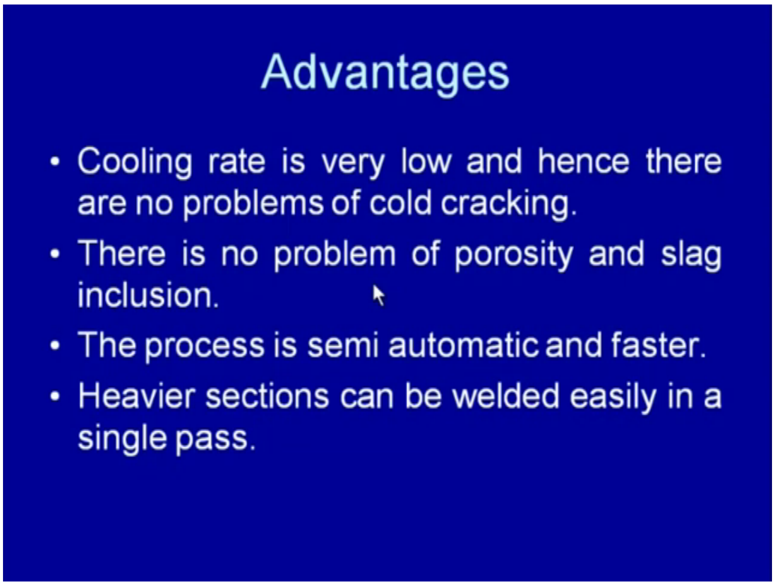

Heat being generated is passed to the base material by flow of heat from the molten flux to the base material to make sure that melting of the base material takes place. So, this process is of very low heat rate of heat generation is low as compared to the arc welding processes. Because of this lot of heat is supplied to the base material for melting the edges of the plates because of typical nature of this process. So, the high heat input associated with this process results in the low cooling rate.

The low cooling rate reduces the tendency of the cold cracking, which can be encountered during the conventional arc welding process because of the high cooling rate. So, the tendency of the hard and brittle martensitic transformation possibility and the high residual stress development, so the low heat input a low means high heat input causes the low cooling rate, which in turn decreases the cold cracking tendency. The low cooling rate increases the solidification time, so whatever gases are present with the weld metal they will be having enough time to come out of the weld metal. If the inclusions are present they will be able to come out of the weld metal and solidify and will result in very clean weld.

So, there is no problem, because of the slow cooling rate very low cooling rate encountered by the weld metal and the heat affected zone. There is no problem of the porosity and the slag inclusions in the electro in the joint made by the electroslag welding process. Further this process is semi-automatic in nature and the faster also very thick sheets can be welded in single pass, so the process is faster in that way. The heavier sections can be easily welded in one pass, so because of these advantages many benefits are achieved like high productivity because of the joining of the heavy sections in one pass.

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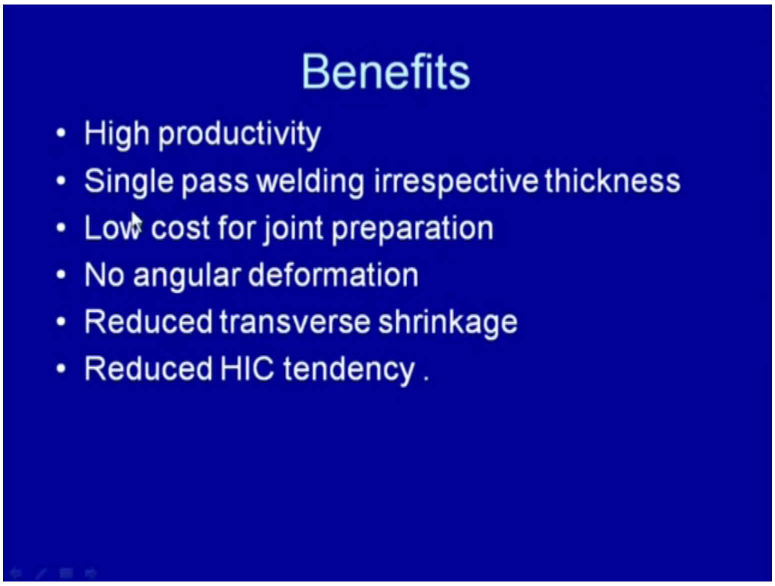

The single pass welding irrespective of thickness is achieved and the these in turn results in the low cost of the joint preparation this process mainly uses the square edges of the component or the plates to be joined so... Because of the absence of any specialized preparation like v groove u groove or the j groove or the bevel groove simple squaring of the edges is done to have the straight and the square edges. So, the edge preparation required for the electroslag welding is of very low cost, so low cost for joint preparation is required no angular deformation, because the plates are kept in simple vertical position.

The no edge preparation and the weld metal is deposited through the thickness of the plates in one go. The thickness of the weld metal along the length is also uniform and because of this no angular this deformation takes place in the case of electroslag welding further. This reduces the transverse shrinkage also and as I have just described, because of the low cooling rate a reduced tendency of the martensitic transformation and increased tendency of escaping of the gases being gases present in the weld zone. The hydrogen induced cracking tendency in case of the electroslag welding is reduced significantly.

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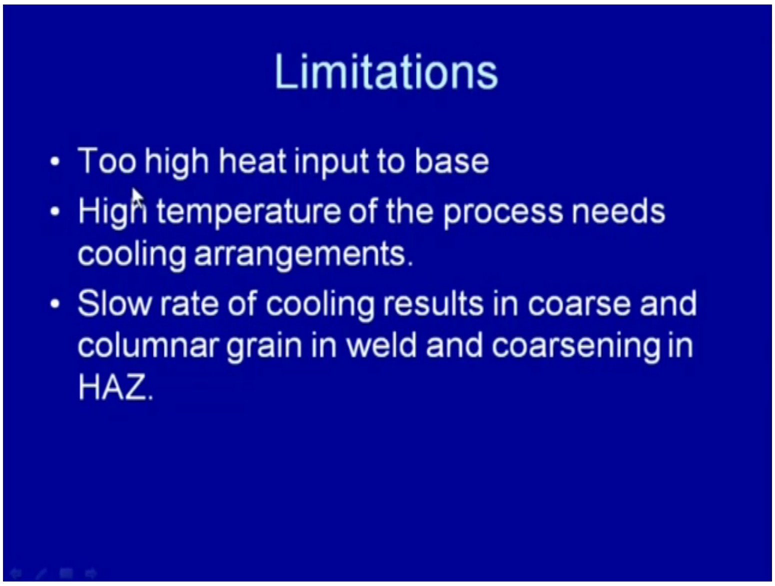

At the same time, this process will also be having certain limitations like too high heat input to the base material. Since, the heat is generated by the electrical resistance heating due to the flow of current through the molten flux and the heat generated by the flux due to the flow of current is transferred to the base material. Because of this slow process of the heat being supplied to the base material lot of heat is required to melt the base material. In this process, huge heat huge amount of the heat is supplied to the base material.

So, high heat input offers the other undesirable effect in the base material like coarsening of the grains in the heat affected zone and significantly reduced the toughness of the material due to the excessive grain coarsening in the heat affected zone. That is why frequently the joints made using the electroslag welding process are subjected to the normalizing operation. So, that the grain refinement in the heat affected zone can be done, so that the properties of the weld material. The heat affected zone can be improved for the other high temperature process needs the cooling arrangement, proper cooling of the copper shoes is done.

So, that any melting of the copper shoes can be avoided because of the high temperature experienced by them further the slow cooling rate being experienced by the heat affected zone, results in the coarser or grain structure coarser and columned grain structure in the weld region. So, the coarser and columnar grain structure in the weld region deteriorates the mechanical properties. At the same time coarsening of the grains in the heat affected zone due to the slow cooling. The high heat input significantly decreases the toughness and the mechanical properties of the weld joint made by the electroslag welding process.

So, because of these regions the weld joint made by the electroslag welding process is frequently subjected. It must be subjected to the normalizing operation heat treatment normalizing operation, so that the properties of the weld joint can be improved. Now, here we will conclude this presentation in this presentation, we have seen mainly the heat being that the brazed welding the basic principle of the braze welding under the conditions under which braze welding can be successfully used.

Further we have also seen that the basic principle of the electroslag welding under the conditions under which electroslag welding can be effectively used. What are the advantages and limitations of the electroslag welding important point is that, the electro slag weld joints are found to be the inferior in terms of the mechanical properties. That is why these joints must be subjected to the normalizing operations. So, that the grain structure can be refined and the mechanical properties can be improved. So, this is how I conclude the presentation.

Thank you for your attention.