Welding Engineering
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Module - 2
Physics of Welding Arc
Lecture - 6
Melting Rate in Different Welding Processes

In this presentation related with the physics of the welding arc, we will be looking into the details of the modes of the metal transfer, the need to study about the modes of the metal transfer, various modes of the metal transfers and the factors affecting the melting rate. As far as content is concerned for the presentation, we will see the need to study the metal transfer, you know that when the electrode in consumable arc welding processes when the electrode melts the molten metal hanging at the tip of the electrode is transferred one by one from the electrode side to the weld pool side.

So, this transfer of the molten metal from the electrode side to the weld pool side is termed as metal transfer. And what is the need to look into the way by which the metal transfer takes place during the welding that we will see first, thereafter what are the different ways through which metal transfer takes place.

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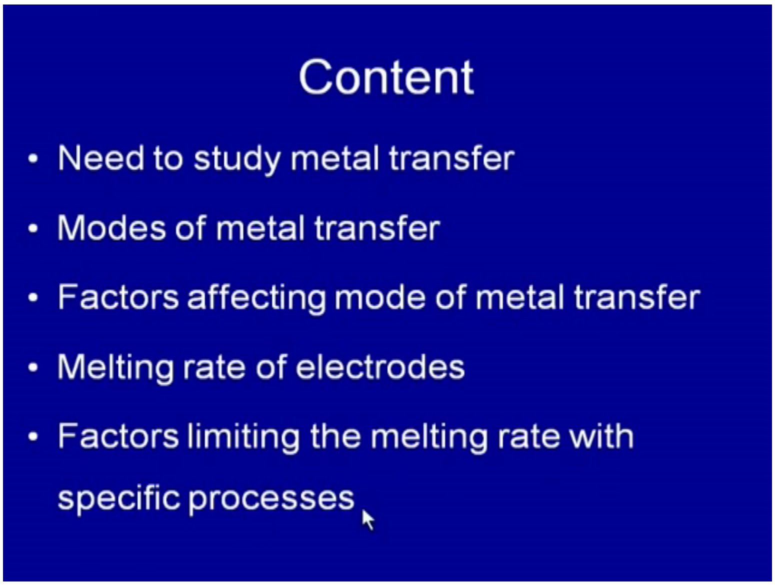

Especially in the form in which the metal transfer takes place from the electrode tip to the weld pool, thereafter we will also see what are the important factors that affect the modes of the metal transfers. And then this presentation will also include the melting rate of the electrode in case of the consumable arc welding processes and the various factors that affect the melting rate. And the things that limit the melting rate associated with the specific welding processes. So, this is the thing that we will be taking up at the end of, means in the last part of the presentation.

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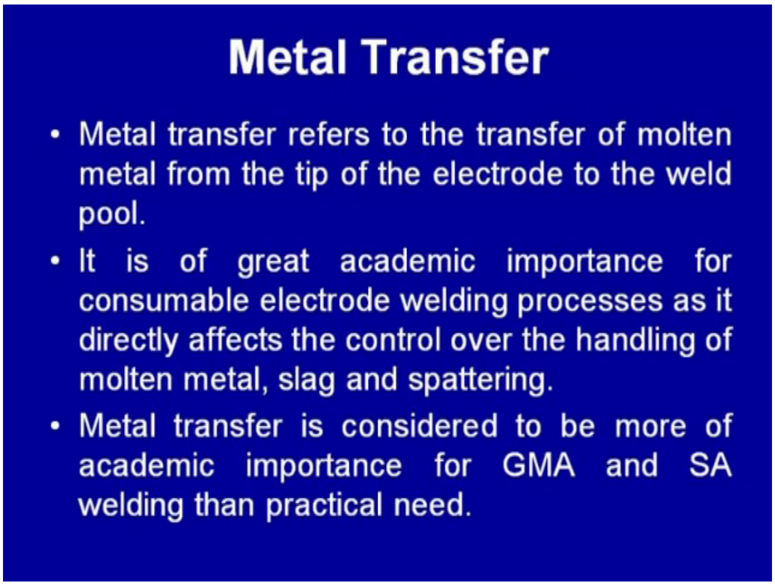

So, as far as the metal transfer is concerned as I have just said that in the consumable arc welding processes, with the application of heat of the welding arc, the electrode tip melts. This molten metal from the electrode tip is gradually transferred from the electrode tip to the weld pool and that is how gradually the weld joint is developed. So, this metal transfer basically refers to the transfer of the molten metal from the tip of the electrode to the weld pool.

So, it is, it is important to study because it effects that cleanliness of the weld and it also effects that how much amount of the molten metal being transferred from the electrode tip is actually transferred to the weld pool. And how much portion falls here and there in form of this spatters. That is why it is of the great academic importance for the consumable arc welding processes, because it effects the handling of the molten metal, means the way by which it is placed in the position where it is desired.

And it also affects the slag formation tendency and the kind of impurities which are developed during their flight from the electrode tip to the weld pool. And how much amount of the molten metal is actually placed with the weld pool, how much amount of the molten metal falls here and there in form of spatters due to inappropriate metal transfer which happens under the certain unfavorable welding conditions. Therefore, the further if we see as a casual welder then the metal transfer is of the more academic importance and the less of the practical importance.

Because it is mainly about the situations which are experienced, the things which are experienced by the molten metal hanging at the tip of the electrode and during its flight from the during its journey from the electrode tip to the weld pool. Therefore, it is mainly considered as a, the, of more academic importance especially in consumable arc welding processes like GMAW and the submerged arc welding process and the less of the practical need. But of course, if the proper mode of the metal transfer is applied during the welding then we can get the more cleaner weld with the higher and the higher the deposition deficiency during the welding process can be achieved.

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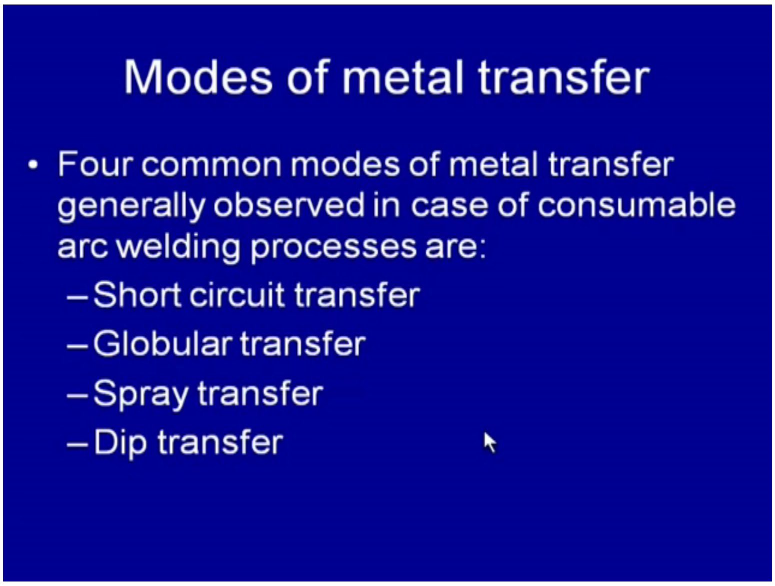

To look into the different ways through which the metal is transferred from the electrode tip to the weld pool. There are four common types of the modes through which metal is transferred, which are generally and these modes are observed in case of the consumable arc welding processes. These include the short circuit metal transfer, the globular transfer, the spray transfer and the dip transfer. And the, which type of the metal transfer will be active at a particular stage that will depend upon the kind of welding conditions like the voltage welding current and the arc gap in, is being used and apart from this the shielding gases also effect the mode of the metal transfer or the way by which metal transfer is taking place.

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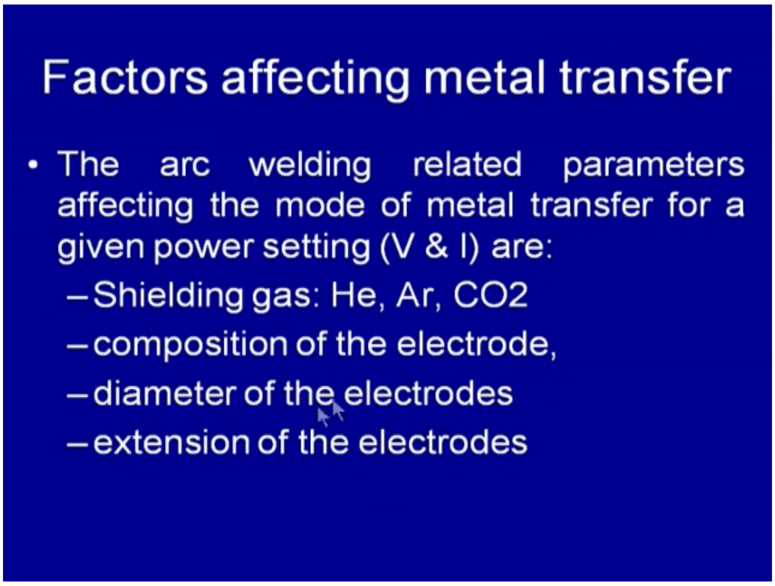

So, to look into the different factors that affect the metal transfer, it these factors are basically associated with the factors that affect the heat generation, the surface tension of the molten metal, heat generation during the welding and surface tension of the molten metal hanging at the tip of the electrode or the when it is moving in the arc zone. So, the shielding gas is one of them since the shielding gas, the type of the shielding gas being used effects the heat generation.

Therefore, it effects the melting rate because of the difference in the ionization potential of the different shielding gases. The extent of the heat generation under the identical conditions of the welding current and the arc voltage heat generation is effected and the heat generation directly effects the rate of melting, which in turn effects the rate at which the molten metal will be transferred from the electrode tip to the weld pool.

Further, the composition of the electrode also effects because the composition of the electrode can affect the metal transfer in two ways. One is that, one is that it the presence of the alloying elements in the metal effects the surface tension. With the presence of the certain elements it can be of high surface tension, there will be the presence of other elements it can be of significantly low surface tension. Since surface tension effects the detachability of the molten metal drop hanging at tip of the electrode and therefore, it effects the metal transfer.

Similarly, the composition of the electrode will also be effecting the electrical conductivity. Which in turn will be effecting the heat generation due to the electrical resistance heating because, in consumable arc welding processes mainly current flows from the electrode current, flows through the electrode then through the arc zone and then through the base metal. So, if the electrical resistivity of the electrode material is high, then the flow of current through the electrode especially in electrode extension portion, extensive heat is generated.

This heat generation effects the melting rate and which in turn can effect the rate at which molten metal will be transferred from the electrode tip to the work piece. So, the electrode composition can effect the metal transfer by influencing the electrical resistivity, the electrical resistance heating and the rate of the melting. The another way by which electrical composition can affect the electrode composition is that, it affects the surface tension of the molten metal and the diameter of the electrode.

Similarly, the last diameter of the electrode reduces the electrical resistance heating and therefore, it will affect the, it will affect the rate of the melting of the electrode tip and the extension of the electrode. So like the composition, the electrode diameter and electrode extension both affects the resistance to the flow of current through the electrode extension portion. Therefore, it affects the heat generation and heat generation in turn affects the rate at which it will be transferred from tip of the electrode to the weld pool. So, these are the, these were the important factors that can affect the mode of metal transfer under the identical welding current and the arc voltage conditions.

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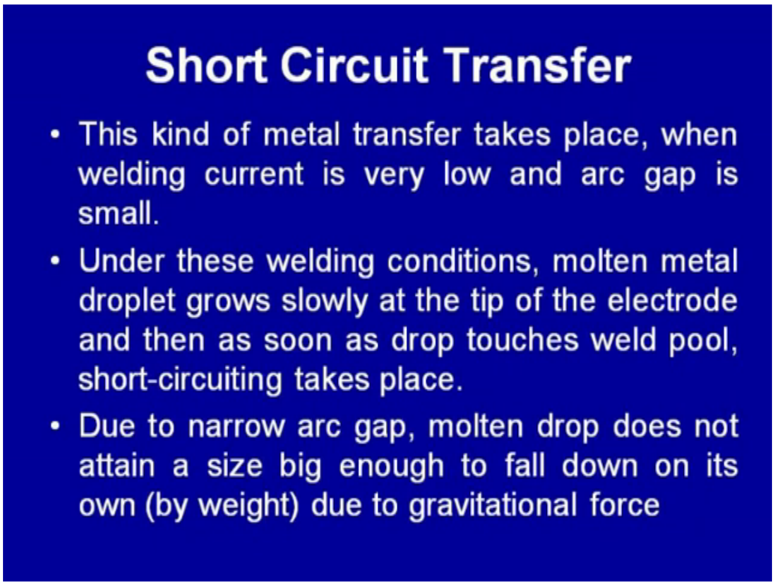

Out of the four common types of the modes of the metal transfers, if we look into the details of the first type that is the short circuit transfer, this kind of transfer basically takes place when the arc gap is very small and the welding current is low. So, this is the necessary condition for the metal transfer, short circuit metal transfer to takes place. Under these conditions of the low welding current and the small arc gap, molten metal droplet growing at slowly at the tip of the electrode and then it touches to the weld pool and as soon as it touches, the short circuiting takes place.

So, the main thing is here is the welding current is low so melting will be taking place slowly. The molten drop, molten metal drop hanging at the tip of the electrode will be growing slowly and as soon as it touches to the weld pool short circuiting takes place. As the short circuiting takes place there will be heavy flow of the current, which in turn generates lot of heat and the things down the molten metal means the surface tension is reduced, ((Refer Time: 10:40)) is reduced. Then by the surface tension force the molten metal drop is detached from the electrode tip to the weld pool zone, so to understand this if we look into the way by which this kind of transfer takes place considering that here.

If we have one electrode and the welding current is flowing magnitude of the welding current is very limited considering this that the base metal is very close to the electrode tip. So, as soon as this melting takes place gradually, so this drop grows gradually one by one and because of the closeness of the weld pool with the electrode tip this as soon as this arc, this molten metal drop touches to the weld pool the short circuiting stage is achieved.

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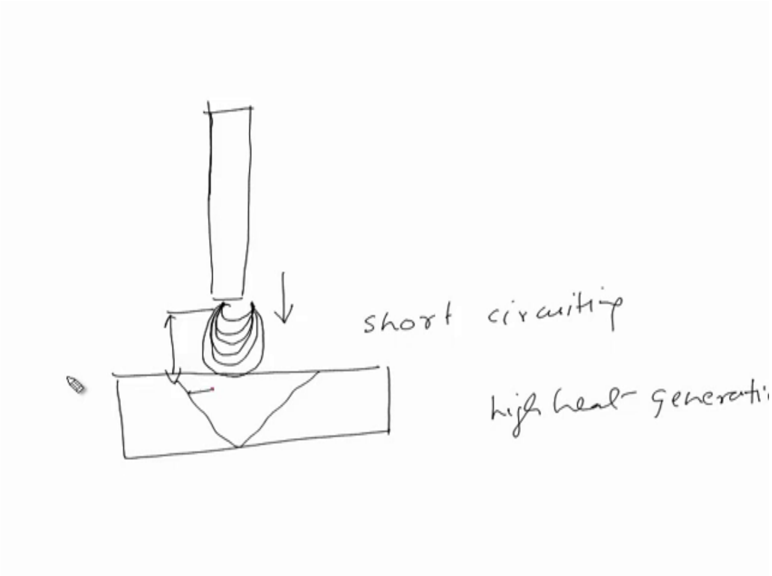

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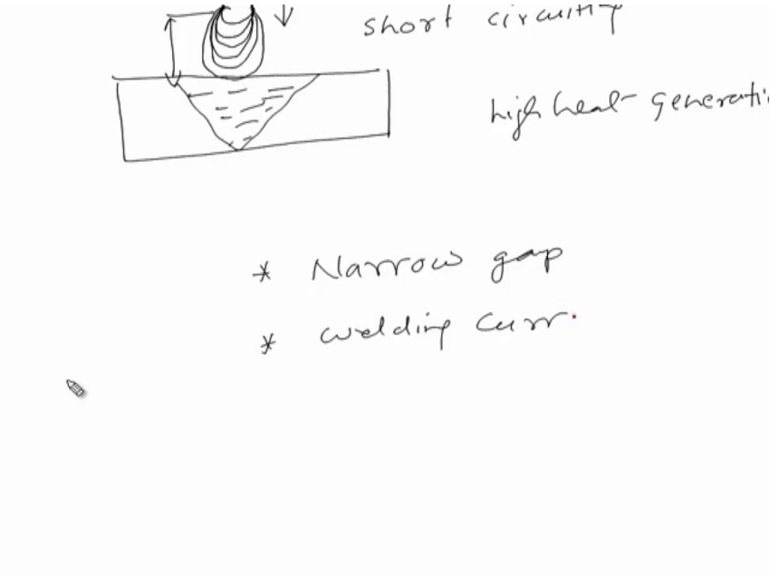

So, under this condition of the short circuiting heavy flow of the current starts from the molten metal itself, and the heavy flow of current, because of short circuiting leads to the high heat generation. High heat generation causes the thinning of the molten metal and as soon as the thinning takes place by the surface tension affect from the weld metal, this drop is detached and as the drop is detached the gap is created once again and this the arc is reignited.

So, in the short circuiting the necessary condition is that the narrow gap is there between the electrode tip and the work piece and the welding current is low. So, when these two conditions exist the short circuiting mode of the metal transfer is observed in the consumable arc welding processes.

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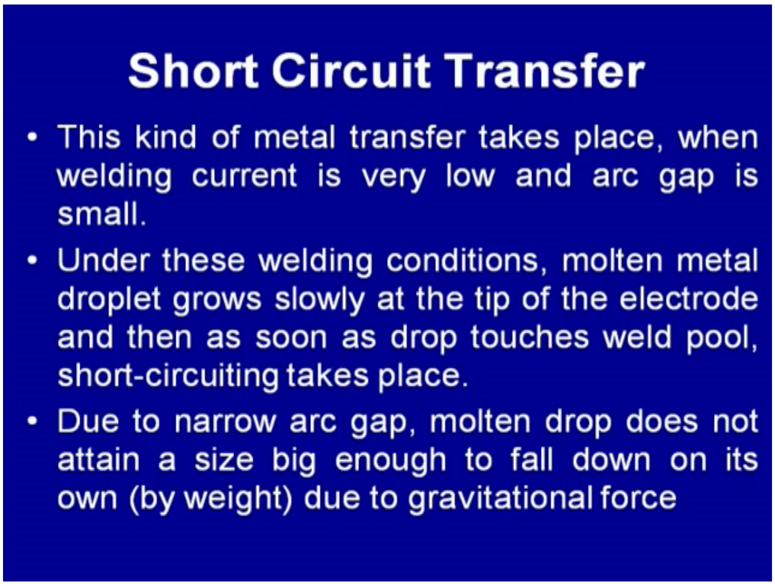

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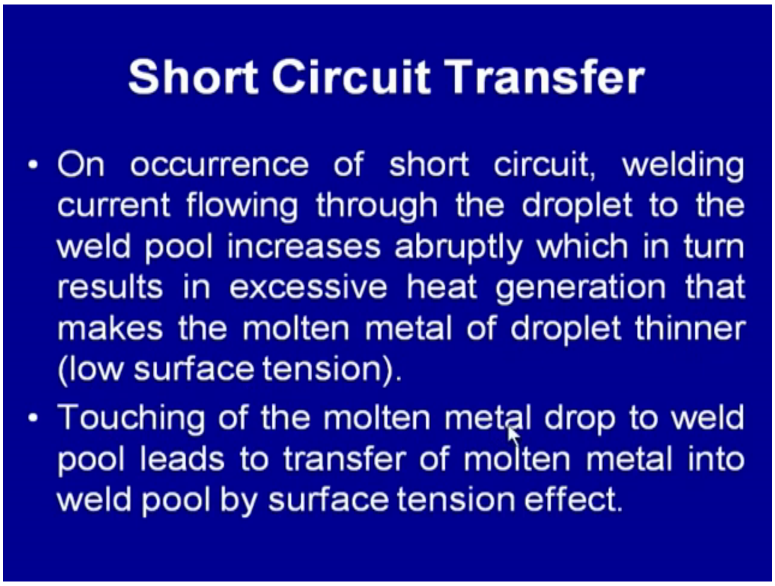

So, the due to the narrow arc gap molten metal drop does not attain a big size enough to fall down on to, on its own by weight due to the gravitational force. But on occurrence of the short circuit as soon as the drop molten metal drop touches the weld pool, welding current flowing through the droplet to the weld pool increases abruptly. Which in turn results in the excessive heat generation, that makes the molten metal droplet thinner that is the, of low surface tension. And the touching of the molten metal drop to the weld pool leads to the transfer of the molten metal drop into the weld pool by the surface tension effect.

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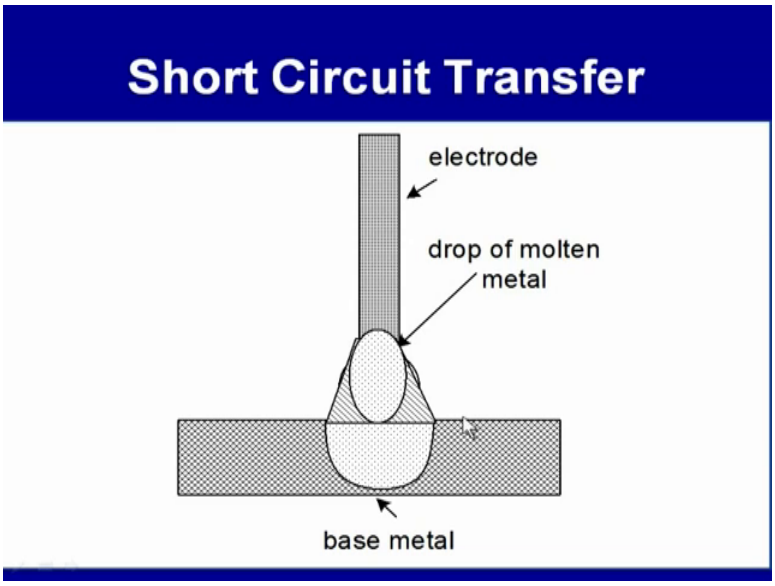

If we see this is schematically, this is the electrode which is melting with the influence of the arc heat. So, as the molten metal drop touches the weld pool by the surface tension effect, by the surface tension effect it is transferred to the weld pool, but this happens only when the welding current is low and the gap between the electrode and the work piece is also small.

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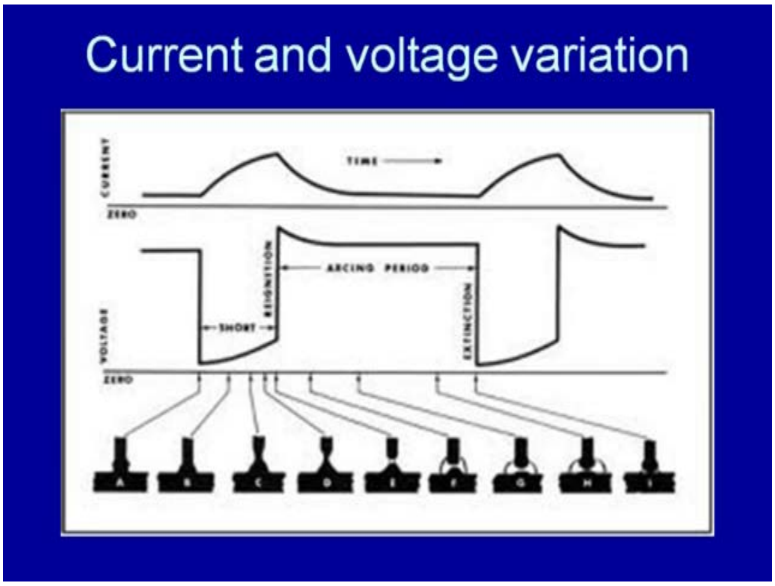

If we see how the variation in the welding current and the voltage takes place when the short circuit mode of the metal transfer occurs. Say this is the first situation when the molten metal drop just touches to the weld pool. So there is a sharp drop in the voltage and short circuiting takes place as soon as the, and this results in the increase in flow of current. And the flow of current as it increases rapidly in this band after this short circuiting. Then heavy thinning will be taking place, heat will be generated under the influence of the welding current and then it will be, so this, in this stage say thinning is taking place and then it is just about to detach the molten metal drop, is about to detach.

As soon as the this detachment takes place and the arc voltage abruptly increases suddenly, increases from this level to this level. So this minor increase in the voltage is occurring because of the thinning which is taking place and the ((Refer Time: 15:17)) of the molten metal drop is taking place in the process of detachment. So, once the gap is created the full open circuit voltage is established and then on striking of the arc again this voltage is stabilized in this portion of the, in this portion of the time during the welding.

The current magnitude also reduces as soon as that molten metal drop is detached, the current, the short circuiting is off short circuiting is stopped at this stage and welding current starts to decrease. In this portion again the molten metal drop starts to grow gradually and then short circuiting again takes place. So, here these are the stages through which say, from this stage the molten metal drop at the tip of the electrode starts to grow and this growth will be continuing.

And as soon as in the, these three four stages the growth, the molten metal drop grows to such an extent that short circuiting takes place again. There will be certain drop in the voltage, arc voltage and this, there will be the gradually increase in the welding current. This kind of cycle keeps on repeating in this mode of the metal transfer. So, there is abrupt decrease in the voltage and thereafter welding current starts to increase. In this process of the increase and decrease of the welding current when there is a short circuiting, there will be increase in welding current and decrease in arc voltage.

So, this kind of cycle keeps on repeating when the short circuiting, when the short circuit mode of the metal transfer occurs. So, once the molten metal is transferred to the weld pool in arc gap is established which in turn increases the arc voltage abruptly and this increase in arc voltage due to the setting up of ((Refer Time: 17:14)) the gap reignites the arc and the flow of the current it starts. And this whole process is repeated during the welding.

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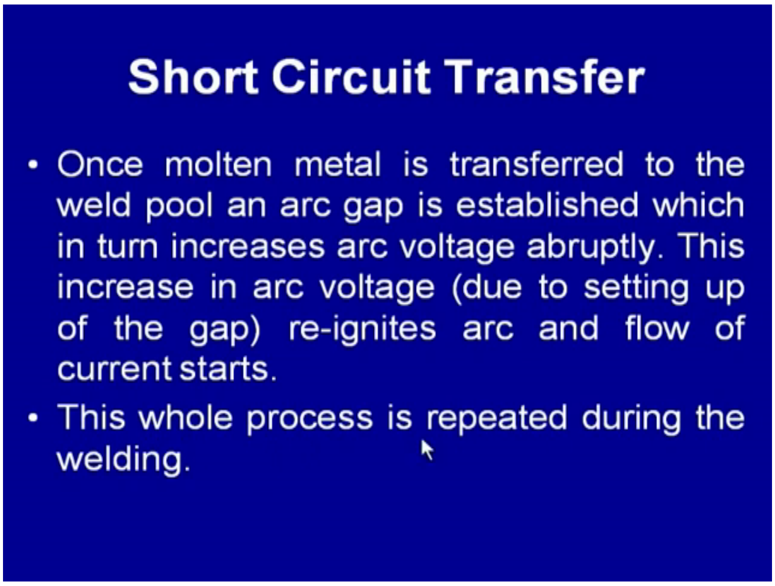

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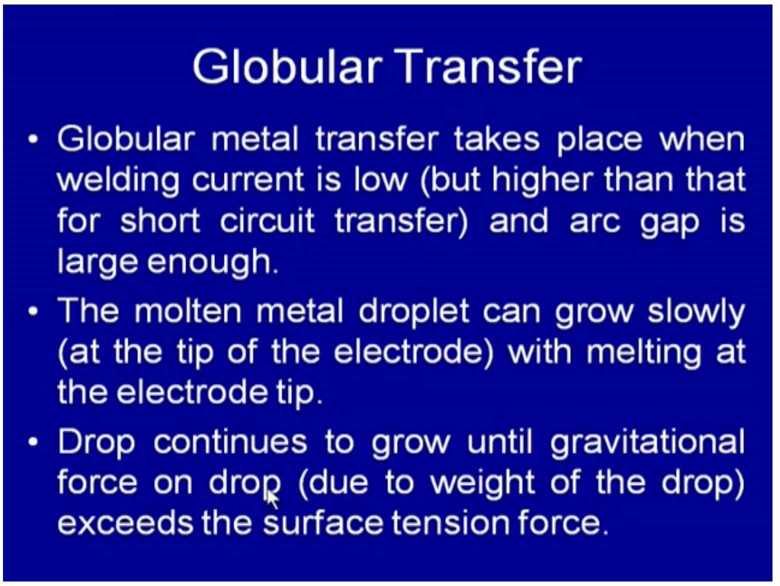

The globular mode of the metal transfer is the another one which is commonly experienced in case of the shielded metal arc welding process, in case of the gas metal arc welding process and a submerged arc welding processes. So, here the globular mode of the metal transfer takes place when the welding current is low, but the arc gap is significantly high. So, this is an interesting one and the difference from the short circuiting mode of metal transfer at the welding current is still low, but the gap is high so that the molten metal drop and developing or growing at the tip of the electrode can grow to the larger extent.

And when it happens the molten metal drop can grow in this case to the larger extent and as the drop continue to grow until the gravitational force acting on the drop due to its weight exceeds the surface tension force. So, once the gravitational force due to the size of the drop exceeds the surface tension force, detachment of the droplet from the electrode tip takes place.

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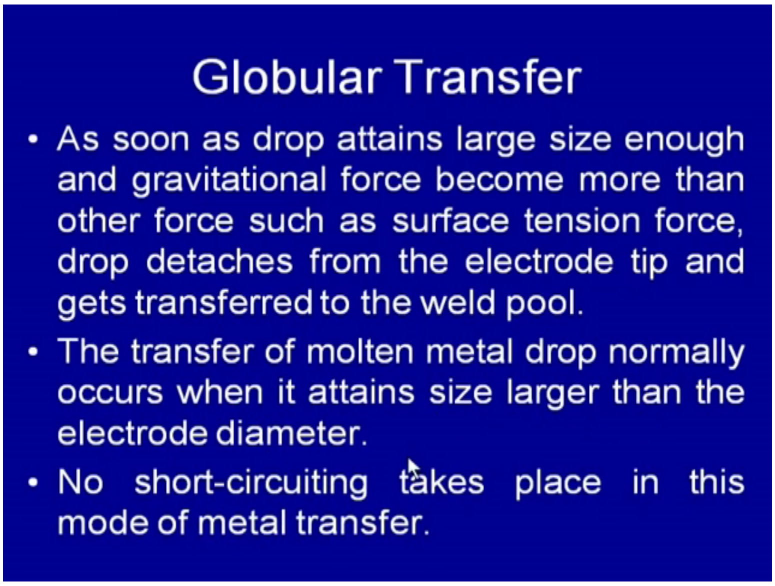

So, here if we see as soon as the drop attains the large size enough, gravitational force become more than the other forces such as the surface tension force which mainly resist the detachment of the drop from the electrode tip. So, if the gravitational force exceeds the other forces that are resisting the detachment of the drop from the electrode tip, this molten metal drop gets transferred to the weld pool. And the transfer of the molten metal drop normally occurs when, it attains the size which is larger than the electrode diameter itself. In this case no short circuiting takes place in this mode of the metal transfer.

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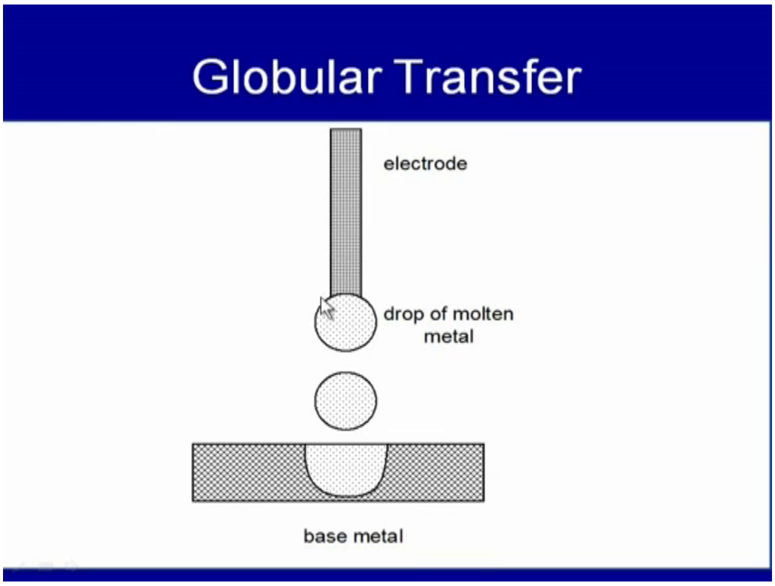

To understand this if we see this schematic diagram, the generation of the heat due to the arc between the electrode and the work piece when the welding current is low. But the gap between the electrode and the work piece is large. The drop at the tip of the electrode grows gradually and as and it will continue to grow until its weight becomes high enough so that, the gravitational force can pull it down and detach from the electrode tip and move. And results in the transfer from the electrode tip to the weld pool. So this is the type of the transfer where the molten metal drop is able to grow to the larger extent so that it can detach on its own from the electrode tip. In this case the drop can grow to a great extent and that is way this is termed as the globular transfer.

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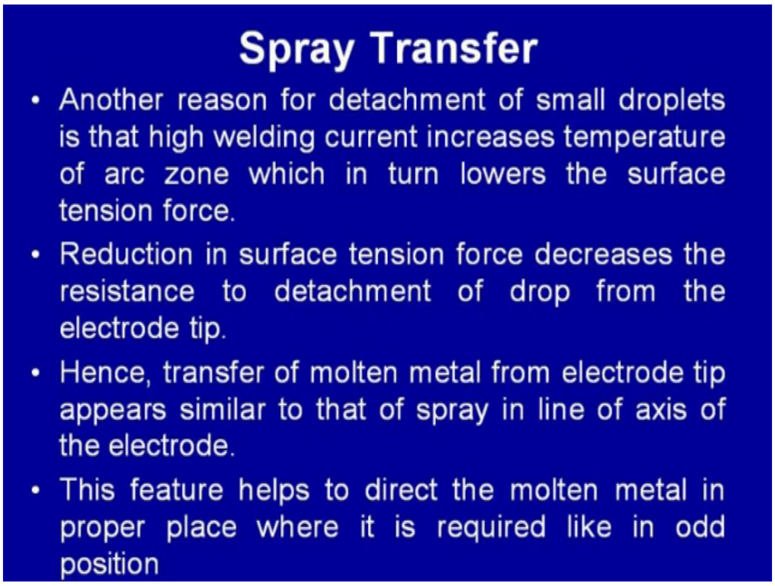

The spray transfer is another one where, this kind of transfer takes place when the welding current is higher than that is required for the globular transfer. In this case the high welding current results in the high melting rate and which also causes high pinch force. So both high melting rate and the high pinch force since both these are directly related with the welding current and are found proportional to the square of welding current. So, with the use of the high welding current, melting rate increases significantly and the pinch force also increases.

Because of these two, because of these two the droplets are formed rapidly and they are pinched off quickly from the tip of the electrode even when they are of very small size. And when this happens it is felt that the there is continuous movement of the drops from the electrode tip towards the weld pool. And gives the feeling of the spray kind of the thing which is happening during the welding and that is way it is termed as the spray transfer. Another reason for the detachment of small droplets is that the welding current increases the temperature in the arc zone which in turn lowers the surface tension.

So, another important factor that affects the spray transfer is the surface tension, which is reduced significantly during this mode of the metal transfer because of high current. Since, the high current application of the high current increases the temperature of the arc zone. And because of the increase in temperature of the arc zone, the molten metal is thin down very to great extent and because of which the surface tension force is reduced. The reduction in surface tension force decreases the resistance to the detachment of the droplet from the electrode tip.

This reduction, this is what it is been mentioned that reduction in surface tension decreases the resistance to the detachment of the drop from the electrode tip. And because of this the molten metal is transferred from the electrode tip, similar to that of the spray in line of axis of the electrode. And this feature helps to direct the molten metal in proper place where it is required especially in the welding where the position is odd.

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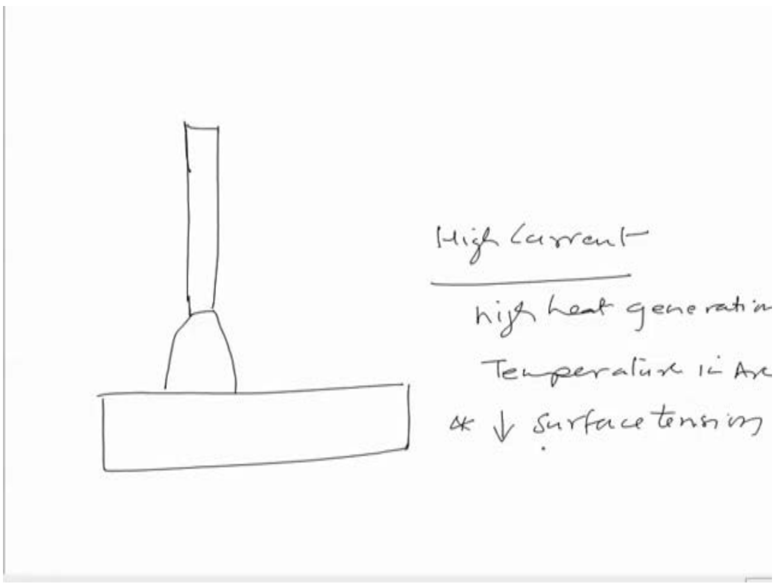

So, schematically if you want to see we can understand this spray mode of the metal transfer in clear way, where when we use the high welding current and the electrode size is small under these conditions. The arc is established between the base metal and the work piece. This case the prerequisite is high current, so high current results in the high heat generation and this high heat generation increases the temperature in arc zone. This increase in temperature of arc zone decreases the surface tension.

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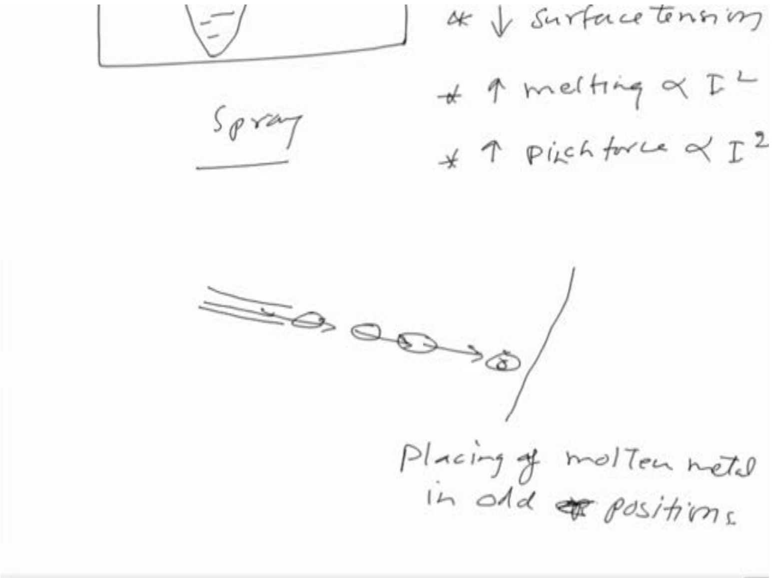

This is one effect which is observed the second, is it increases the melting rate as a proportional to the square of the welding current and the third it increases the pinch force. Pinch force, that is the electromagnetic force that also increases proportional to the square of the current being used. Because of these three effects the melting takes place very rapidly, the drop is formed very quickly at the tip of the electrode and it is detached immediately as soon as it is developed, even when it is of a small size by the heavy pinch force which is acting.

Further this detachment is also facilitated by the low surface tension because of the decrease in surface tension, the resistance to the detachment of the drop at the electrode tip is reduced significantly. Therefore, the drops start getting detached even when they are of very small size and they will continue to get detached they will melt rapidly and get detached.

And when this happens it is felt that there is continuous transfer of the molten metal drop from the electrode tip towards the weld pool. And when this happens it gives us a feeling of the spray kind of thing which is happening and because of this it is termed as the spray mode of the metal transfer. Further this movement of the electrode molten metal drop from the electrode tip takes place in line of the axis of the electrode.

So, this the transfer of the molten metal drops from the electrode tip towards the weld pool in particular line helps to direct the molten metal drops even in the odd positions. Because of this spray kind of the feeling the continuous drop, continuous movement of the drops from the electrode tip towards the weld pool along in the line of the electrode axis, helps us to direct the molten metal from the electrode tip towards the place where it is desired. That is why this model also helps in placing the molten metal, placing of molten metal in the odd positions. And that is why the spray transfer mode is some time used for, placing the molten metal in odd positions or welding in odd positions like overhead conditions.

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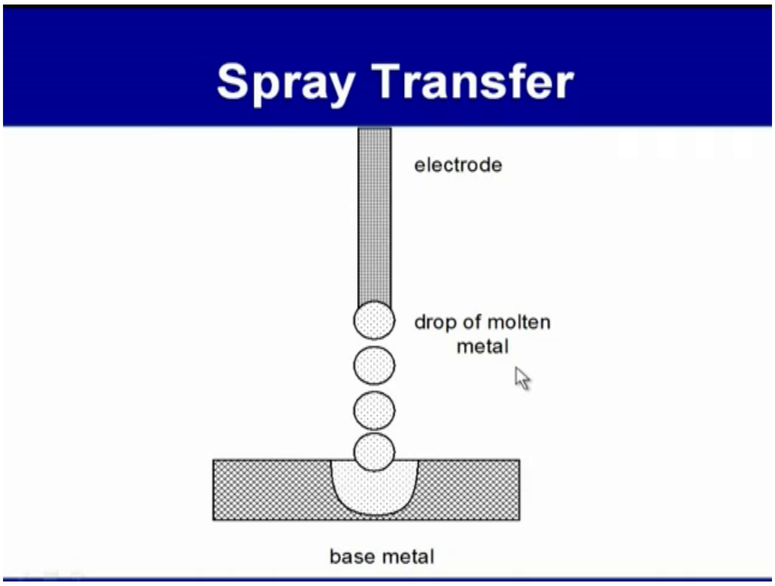

So, this is the kind of the transfer which is observed during the spray mode, the continuous melting of the electrode tip and its detachment from the electrode tip even when they are of the small size resulting in continuous movement of these droplet towards the weld pool gives the feeling of the spray. And that is why it is called a spray transfer.

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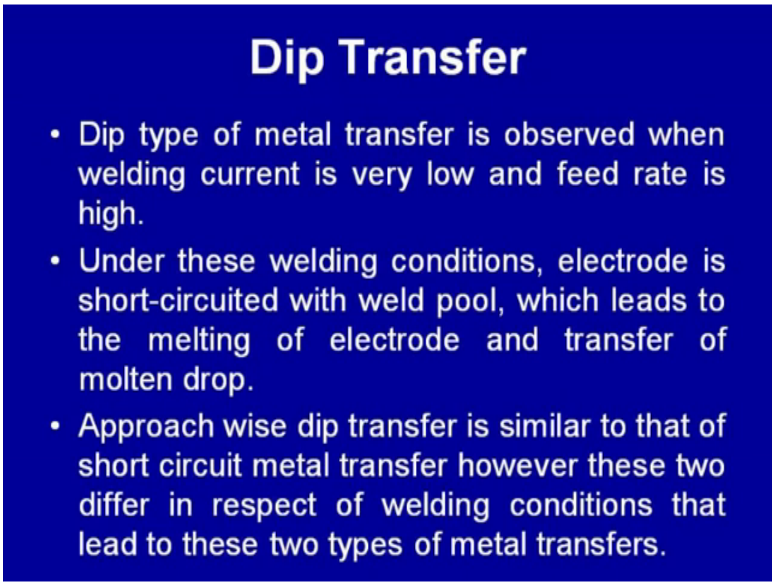

The dip transfer is the another one which is observed under the specific set of welding conditions these are the very low welding current and the high feed rate high feed rate. The dip type of transfer is observed under these conditions, the low melting rate causes the low welding current results in the melting of the electrode tip at very low rate. And if there is no compatibility between the feed rate and the melting rate then the dip transfer takes place. Under these conditions of the low welding current and the high feed rate electrode is short circuited with the weld pool which leads to the melting of the electrode and the transfer of the molten metal drop to the weld pool.

Approach wise this transfer is similar to that of the short circuit. However these differ in respect of the welding conditions that lead to the two types of the transfers. Here basically the high feed rate of the electrode is the main reason behind the dip transfer, although welding current is low in this case and the spray, the short circuit mode of metal transfer also needs the low welding current.

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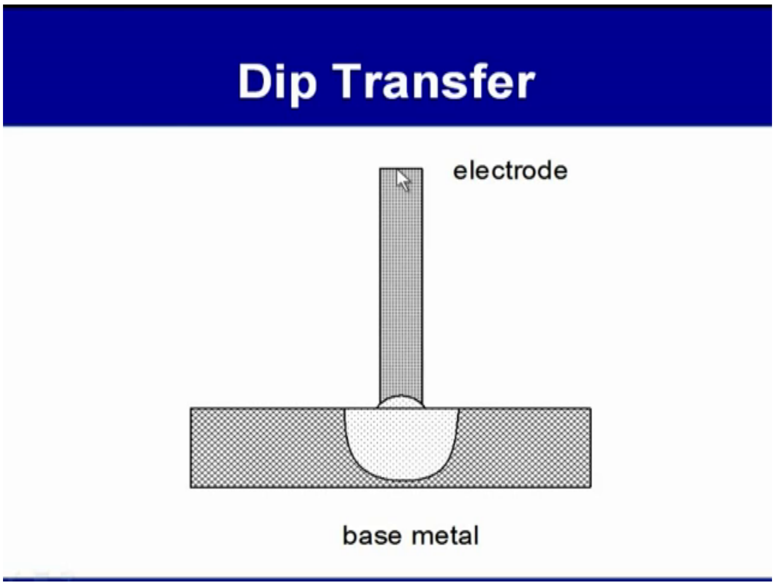

To see this schematically the feed rate of the electrode, if the feed rate of the electrode is higher than the rate at which it is melting at the tip of the electrode, then this electrode tip dips into the pool causes the short circuiting. Flow of the heavy current through this during the short circuiting results in the transfer of the molten metal being formed at the tip of the electrode to the weld pool and thus transfer takes place. So, basically low welding current and the higher feed rate of the electrode contributes to the dip mode of the metal transfer.

One more metal transfer mode is experienced especially under the higher level of the welding current. When the welding current goes above the range of the spray mode of the metal transfer, the rotational transfer is observed. And when the rotational transfer takes place lot of a spray, lot of spattering occurs and which causes the reduction in deposition deficiency and falling of the molten metal here and there. So, to and it is always required that such rotational mode of the metal transfers do not take place during the welding. And there is one more interesting thing as far as the metal transfers takes place, these transfers especially in case of the gas metal welding processes is, significantly affected by the welding current.

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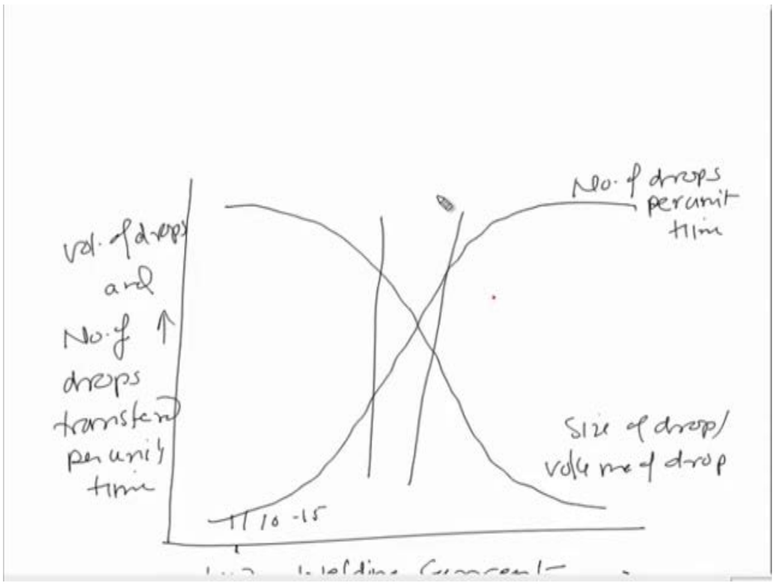

To see that if we, if we plot the relationship between the welding current being used in case of the gas metal arc welding process and the number of drops transferred per unit time. If we see this in one side then with the low welding current the drop size is very high and it keeps on decreasing with the increase of welding current. So, if we see here when the welding current is very low the number of the number of drops, as well as here, we can see the one characteristics goes like this where this we can say the volume of the drop that is the size of the , that is governed by the size of the drop.

And another characteristic goes like this where, we have the number of drops detaching, number of drops transferred per unit time. So these two are opposite in as far as trend is concerned as a function of the welding current, so here the volume of drops this is one and the number of drops being transferred per unit time another. If these two characteristics of the molten metal drops being transferred during the welding as a function of the welding current, then looking into at the low current level the number of drops are very limited, may be ten to fifteen numbers per unit time, may be per unit second.

But these numbers may be the too high with the, for the, with the increase of the welding current there is continuous increase in the number of drops being formed. And there is a band of the current where if we see, there is a sudden increase in the number of drops being formed.

So, this is the situation when welding current is low we say that the globular mode of transfer is active. This is the band when the number of the drops being transferred during the welding are very low. When these number of drops being transferred per unit time increase significantly may be 250 to 300 we say, that the spray mode of transfer is active. And the current value about which this band of the current about which this the transition from the globular mode to the spray mode takes place is called the transition current. And this transition current is found to be the function of the metal being transferred because of the electrical resistivity effect and the diameter of the electrode and the electrode extension.

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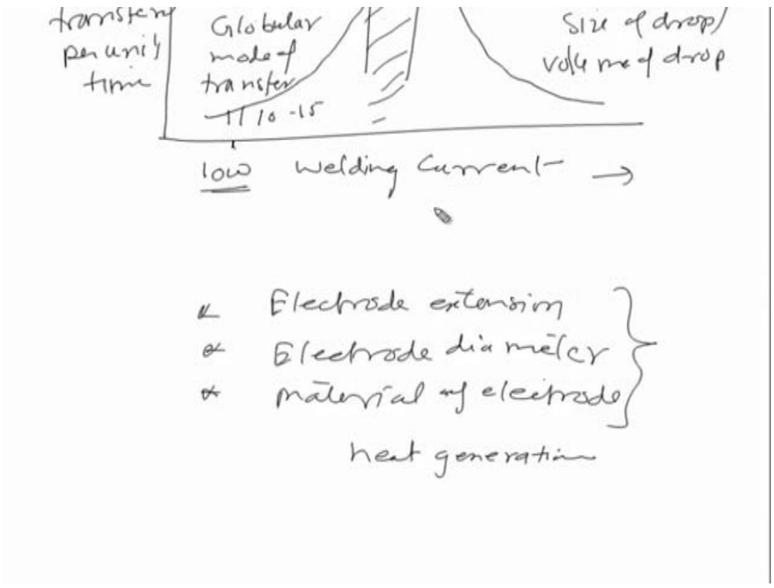

So, electrode extension is one factor, electrode diameter is another and the material of electrode. These factors in totality effect the heat generation under the, for given set of the welding current increase in electrode extension, decrease in electrode diameter and increase in electrical resistivity of the electrode material. All these decrease the current required for this transition to take place from the globular mode of the metal transfer to the spray mode.

Now, we will see the melting rate related aspects in the consumable arc welding process. We know that the speed at which the weld joints can be made in consumable arc welding process is largely governed by the rate at which the molten metal is deposited in the group zone by the melting of the electrode tip. So, the rate at which electrode melts during the welding effects the speed of welding. So, we always make efforts to have the higher melting, so that the weld joint can be made as fast as possible.

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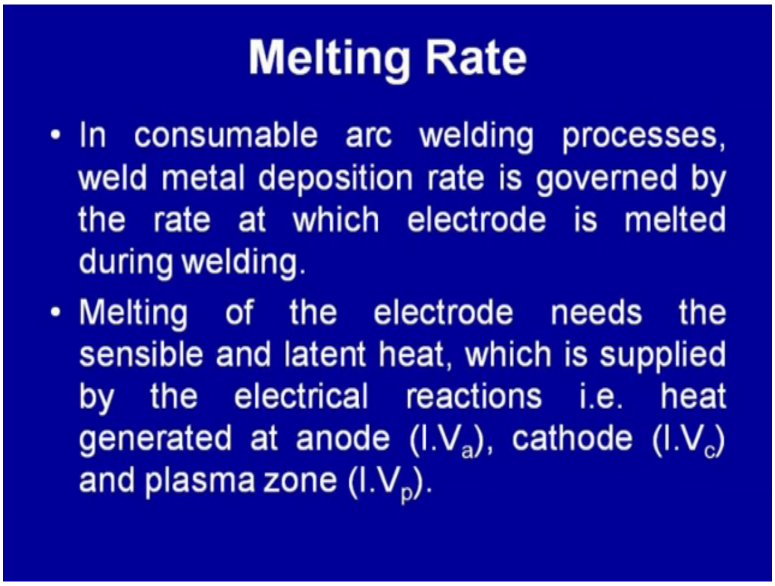

But there are certain factors which limit the rate of the melting associated with the different welding process. To understand that factors that affect the melting rate during the arc welding process, in case of the consumable arc welding we will see the things related with this. In case of the consumable arc welding process weld metal deposition rate is governed by the rate at which electrode is melted during the welding. And the welding of the electrode needs and for melting of the electrode what we need, we need to supply the heat required to increase heat required, heat is required in form of the sensible heat and the latent heat.

So, the sensible heat supply increases the temperature of the electrode tip from the room temperature to the melting point. And the latent heat subsequently changes the phase from the solid to the liquid. So, these two heats are required to be supplied for melting of the electrode tip and these are supplied in form the electrical reactions which will be taking place in the anode drop zone in the cathode drop zone and also in the plasma region.

Apart from these electrical reactions the heat is also generated because of the electrical resistance heating of the electrode in the electrode extension portion. So, in case of the DCEN polarity heat generated and the anode drop zone and the plasma region do not influence the melting of the electrode tip appreciably as the cathode. That is the electrode in case of a straight polarity gets very negligible heat from the other regions which are anode drop zone and the plasma regions.

Especially, when if the, in consumable arc welding process if the DCEN polarity is being used then the heat generated in the cathode drop zone only, plays a significant role in melting of the electrode tip. While the heat generated in the anode drop zone and the plasma regions do not affect the rate of the melting. Therefore, in case of this straight polarity that is the DCEN melting rate of the electrode, primarily depends upon the heat generated at the cathode region that is the cathode reaction, cathode reaction which is taking place because of the current flow near the cathode.

And the electrical resistance heating which is taking place in the electrode extension portion. So, these heats this heat coming from these two factors that is the electrical reactions taking place in the cathode region and the electrical resistance heating in the electrode extension portion primarily governs, the rate at which electrode will be melting during the welding.

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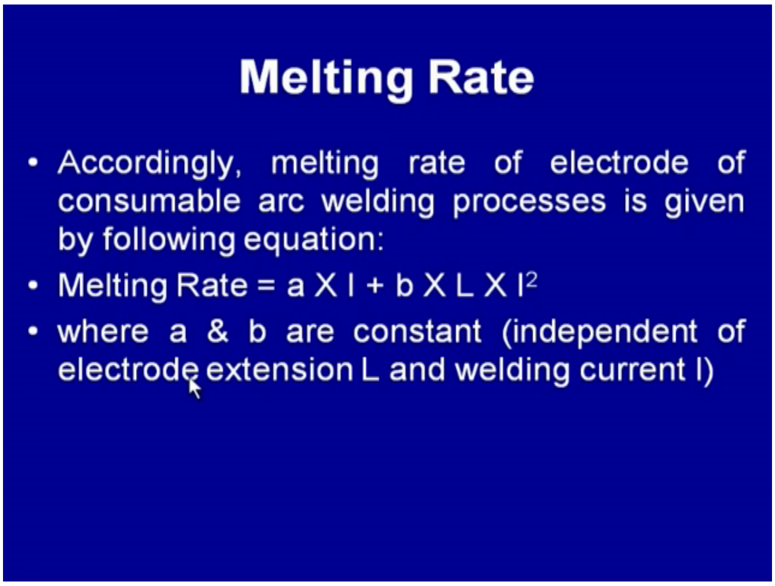

And therefore, the melting rate of the electrode in consumable arc welding process is governed by the following equation where melting rate is given by a into I, a is the coefficient and i is the welding current, plus b into L into I square, where b is again coefficient L is the electrode extension and I is the welding current. So here a and b are the coefficients which take care of the different aspects related with the electrode material ionization potential and the electrical resistance heating aspects. Here in this equation L stands for the electrode extensions and I for the welding current.

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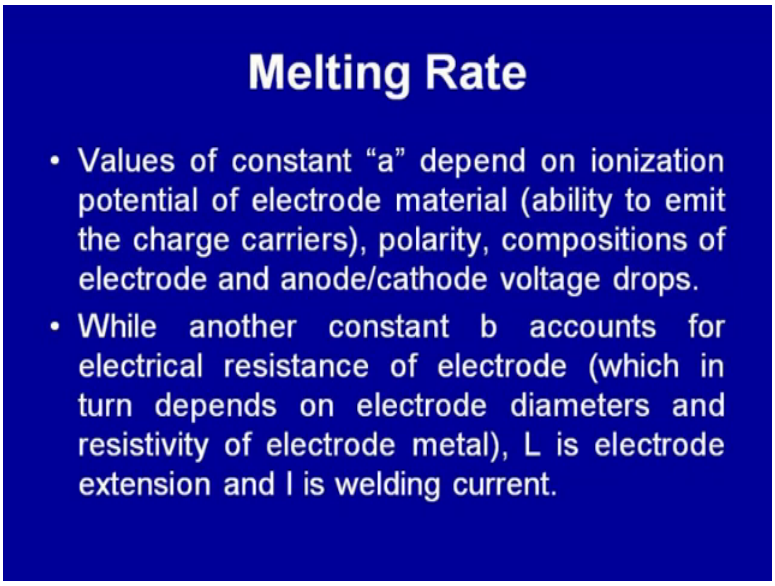

So values of the a and the b are taking care of these two parameters, means values of these two coefficients a and b take care of the different aspects like a depends upon the ionization potential of the material and that is the ability of the material to emit or to produce the charge carriers, and the polarity being used composition of the electrode. And the cathode and the anode voltage drop, drops which are taking place.

So, to take care of the ionization potential of the material polarity, composition of the electrode and the anode and cathode voltage drops, the coefficient a is used and it is multiplied by the welding current. So, the when this coefficient multiplied by the welding current it gives us the heat generated by the anode electrical reactions in the anode zone or in the cathode zone. While the another coefficient that is b that accounts for the electrical resistance of the electrode and which in turn depends upon the electrode diameter and electrical resistivity and L is the electrode extensions and I is the welding current.

So, depending upon the kind of electrode diameter we used and the electrical resistivity of the electrode material, the coefficient value b is effected. So, the different b values and different a values are used for calculating the melting rate of the different electrode materials during the welding while using the different welding current.

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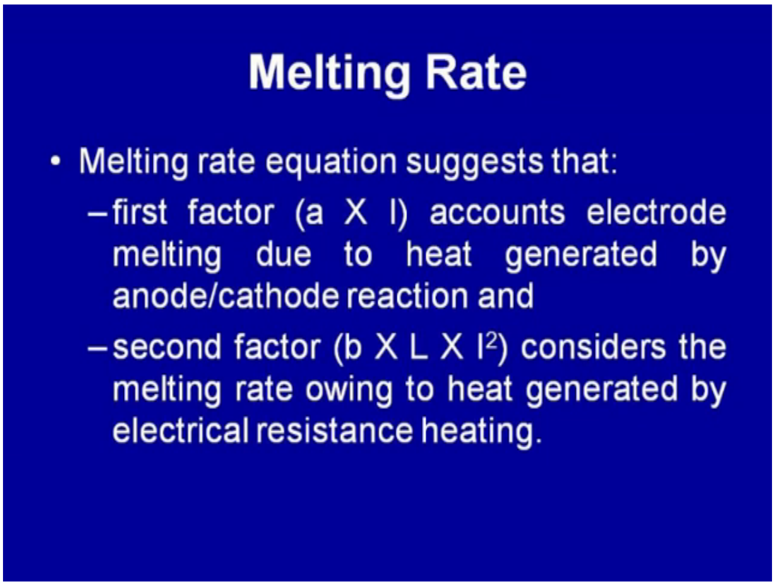

So, melting current equation suggests that the first factor that is the a into I that is, a coefficient into the welding current accounts for the electrode melting which is taking place due to the heat generated by the anode or the cathode reaction. So, this is the first factor that affects the melting rate due to the anodic or cathodic reactions due to, which are effecting to the heat generation. And the second factor b L I square this effects, this considers the effect of melting due to the heat generated by the electrical resistance heating.

And the importance of both these factors is found to vary depending upon the electrode diameter and the electrode material. For the welding processes which are using a small diameter and high current the second factor significantly governs the melting rate. While the welding processes which are using the large dielectrodes and the low conductivity ((Refer Time: 41:16)) means high conductivity electrode materials the first factor significantly affect the melting rate. So, based on the kind of electrode material, the electrode size, electrode extension and the welding currents being used the different, out of the two they are relative influence very significantly.

The melting rate is mainly governed by the first factor when welding current is low that is, means a I factor will be governing the melting rate mainly when the welding current is low and the electrode diameter is large, electrode extension is small. Because electrical resistance heating under these conditions will be very limited whereas, the second factor significantly determines the melting rate of the electrode when welding current is high, electrode diameter is small, extension is large and electrical resistivity of the electrode metal is high.

So, when these factors are there like high welding current, small dielectrode, extension is high and the electrical resistivity is low then the electrical resistance heating significantly dictates the melting rate of the electrode tip and accordingly the melting rate of the electrode is affected.

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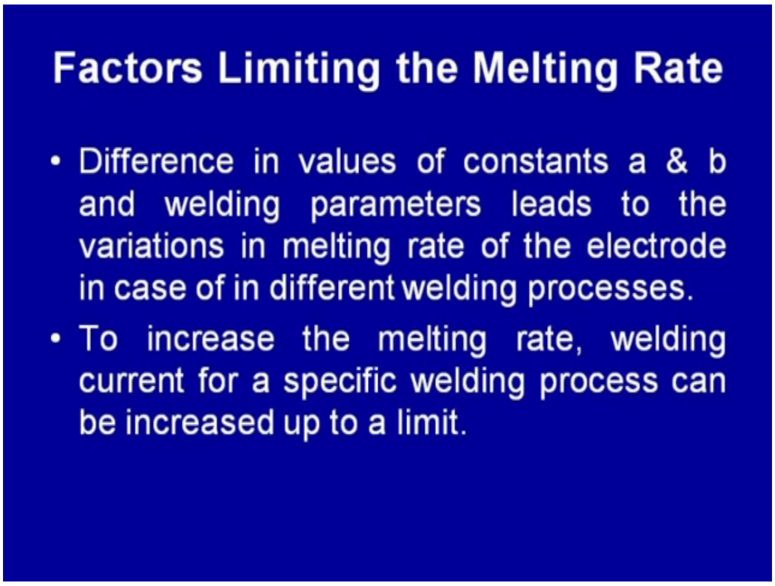

Now, if we see this melting rate equation here we have that the melting rate is given by a I plus b L I square. If we see whether it is of the low whether, low welding current is used or the small dielectrode is being used or the large dielectrode is being used, in both the cases the melting rate is the only factor that significantly affect the melting rate. So, why cannot we increase the welding current to increase the melting rate to as per our requirement. But there are certain factors that limit the use of either low current or the high current and these factors limit the rate of the melting of the electrode, which can be used during the welding for a given electrode size or for given welding process.

The difference in values of the a and b and the welding parameters lead to the variation in the melting of the electrode in case of the different welding processes. If we see the different welding process they will be using different electrode materials, in the different sizes, with the different electrode extension and the level of the welding current.

Accordingly, the values of the coefficients a and b will be different and because of the difference in the current, as well as the coefficients and the electrode extensions the different melting rates are achieved by the different welding processes. To increase the melting rate welding current for a specific welding process can be increased but, this is possible only up to a limit, because thereafter some adverse effects are observed.

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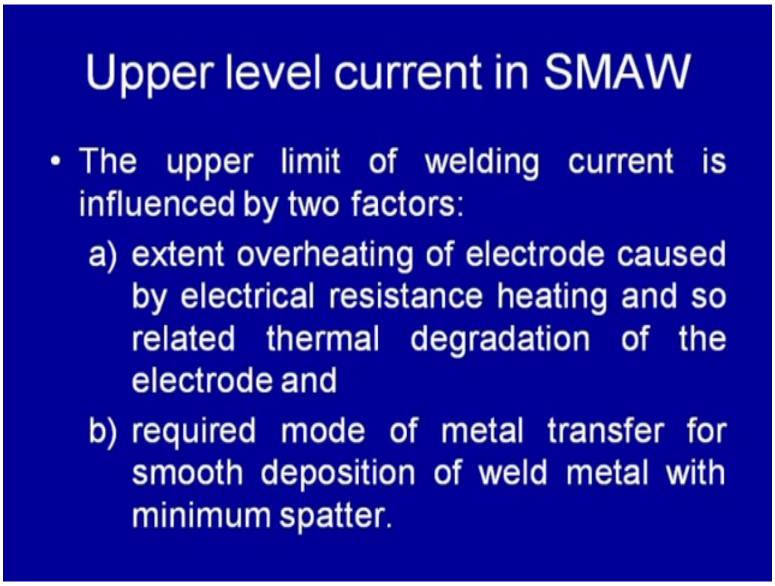

Now, we look into what are the factors that limit the lower or higher level of the currents associated with the particular welding process. If we take up first the shielded metal arc welding process, in this process the upper level of the welding current is influenced by the mainly two factors. One is the extent of over heating of the electrode, that can lead to the thermal degradation of the electrode coating and the second factor is the mode of metal transfer, that is required for smooth deposition of the molten metal with the minimum spatter.

So, if we use very high welding current then the increased electrical resistance heating of the core wire can, thermally damage the flux of the electrode. And can lead to the, a poor shielding of the weld pool because of the prior decomposition of the electrode coating. So, this limits the level of the maximum current which can be used during the welding of the shielded metal arc welding process.

And the second factor is the mode of metal transfer. We want that the metal is transferred as smoothly as possible with the minimum spatter so that, either short circuiting is avoided or the rotational mode of the metal transfer is avoided. So, the current is selected in such a way that these and the metal is deposited smoothly with the minimum a spatter and at the same time electrode flux is not decomposed thermally, because of the excessive core wire heating.

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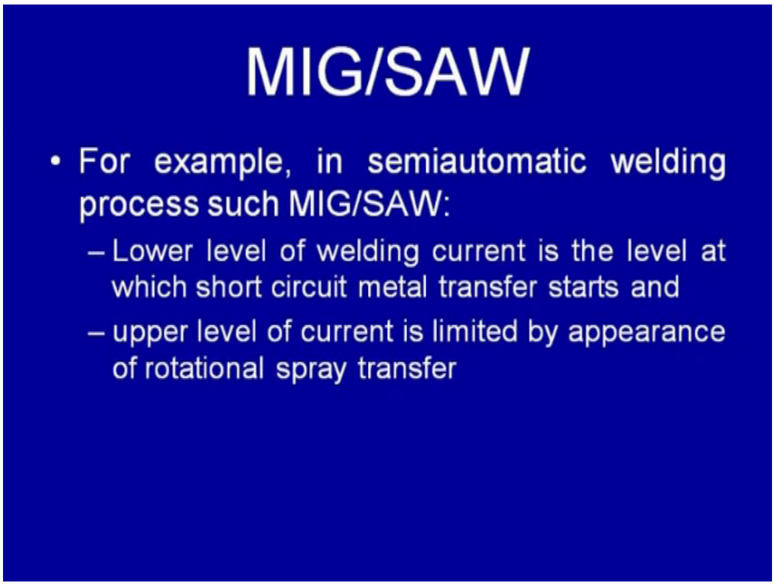

In case of this MIG welding process or in the submerged arc welding process the upper and the lower level of the welding currents are affected by, are determined by the different factors like the lower level of the welding current is the level at which the short circuiting metal transfer starts, while the upper level of the welding current is limited by the appearance of the rotational spread transfer.

So, we want to have the welding current in such a way that the conditions at which the short circuiting metal transfer starts that is used as a the lower level of the welding current, while the upper level of the welding current is set in such a way that the rotational transfer does not takes place.

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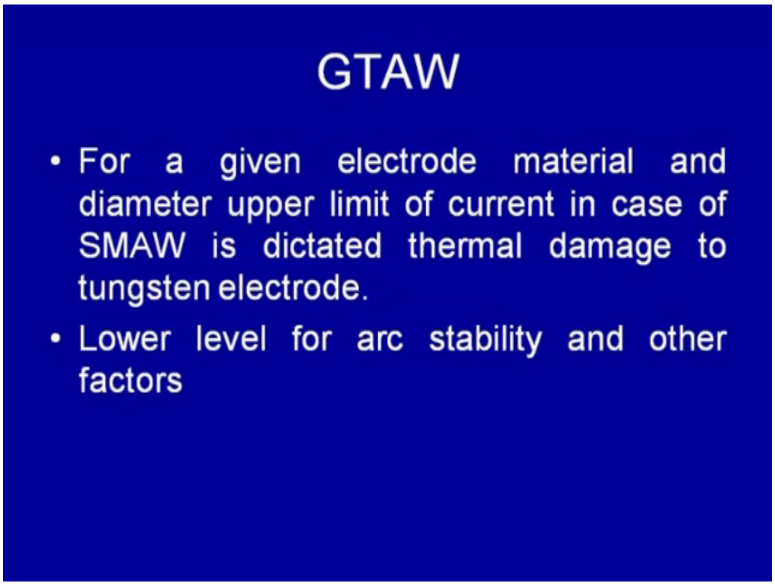

In case of the GT arc welding, the low level of the welding current is dictated by the arc stability while, the higher level of the welding current is set is dictated by the thermal damage which can take place during the welding. Use of the excessively high welding current in case of the ((Refer Time: 46:57)) welding process leads to the very rapid thermal degradation of the electrode and which decreases the life of the electrode very badly. Therefore, too high current is also avoided in case of the ((Refer Time: 47:10)) welding process for a given electrode diameter.

Therefore, electrode material and the electrode diameter must be kept in mind while setting the upper level of the current and the lower level of, for setting the lower level of current. We need to see that arc is stable at the same time we need to see that we are able to develop sufficient heat so that required the welding conditions can be achieved.

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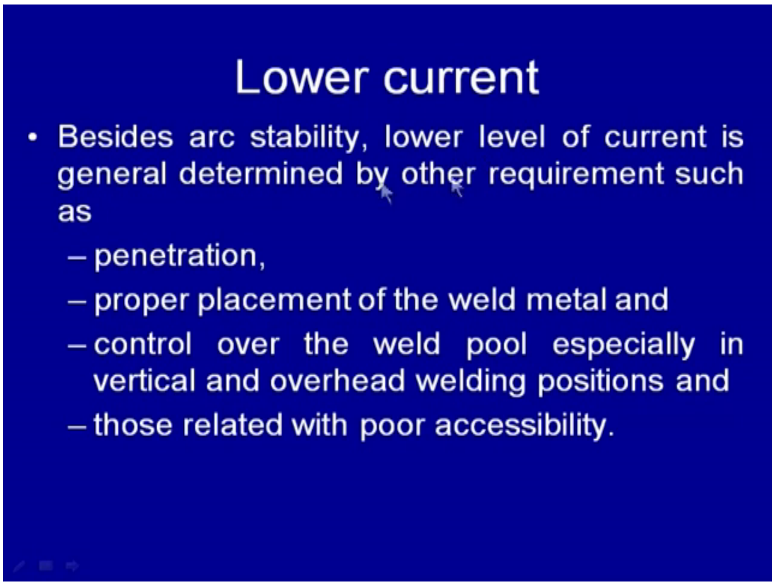

So, those welding conditions will include apart from the arc stability we can see, the lower level of welding current is generated, is in general determined by the requirement such as that we are able to have that required penetration, so that the good weld joint is made. And the molten metal placed properly, because if the heat is insufficient then the fluidity of the molten metal will be proper and we will not be able to place some weld metal in the proper where it is desired. Further the control over the weld pool is also important. If we are not able to control the weld pool due to the poor heat, especially in vertical and overhead welding positions.

Then, we need to see the welding current in such a way that it is low enough so that the fluidity is limited and the molten metal does not fall while welding in odd positions like vertical and overhead welding conditions. And further the factors those related with the poor accessibility dictates the selection of the use of the lower welding current.

So now, this now, I will summarize this presentation. In this presentation, we have seen that, the factors that affect the metal transfer mode, and the what are the various type of the mode of metal transfers, and the need to study about the modes of the metal transfer.

Apart from the metal transfer related aspects, we have also seen that the what are the things that dictate the melting rate of the electrode tip, what are the factors that affect the melting rate of the electrode and what are the factors that affect the selection of the upper and lower level of the welding current associated with the particular welding process.

So, thank you for your attention.