Welding Engineering
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Module - 2
Physics of Welding Arc
Lecture - 3
Arc Maintenance and Arc Characteristics

We know that for using the heat of the arc welding process, it is necessary that arc is ignited first and then it is maintained, so that uniform heat can be supplied to the faying surfaces of the base material. So, that they can be brought to the molten state and uniform and the sound weld can be made, but in process of a developing the heat uniformly for a, uniform melting of the base material it is necessary that the smooth and stable arc is maintained.

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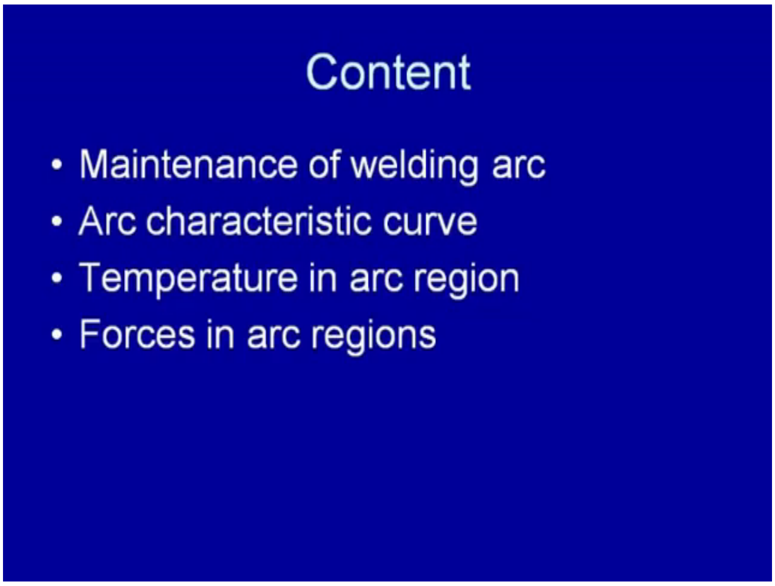

So, after the initiation of the welding arc, the first thing is to maintain the arc. So, we will be looking into the details of that, what are the conditions required for maintenance of the arc and how it can be maintained effectively, when the different types of the welding currents are used.

Thereafter, we will also see that what is the relationship between the arc voltage and the welding current, when the different arc lengths are used and how does it affect the heat generation and the welding related aspects. Further we will also see the temperature generated in the different zones of the arc and how does it affect, the melting another that the things related with the development of the sound weld joint. In addition to the temperature, we will also be looking into the forces, which are generated in the arc region and their effect on the metal transfer, which in turn affects the quality of the weld joint.

So, in this presentation mainly we will be highlighting the maintenance of the arc, arc characteristics the temperature and the forces related aspects in the arc region. So, we know that once the arc is ignited, either with the help of a touch start method or the field start method, it is necessary to maintain. So, that heat can be uniformly generated and can be applied in the areas for melting of the faying surfaces, so that a weld joint can be developed. So, in this connection maintenance of the arc becomes important.

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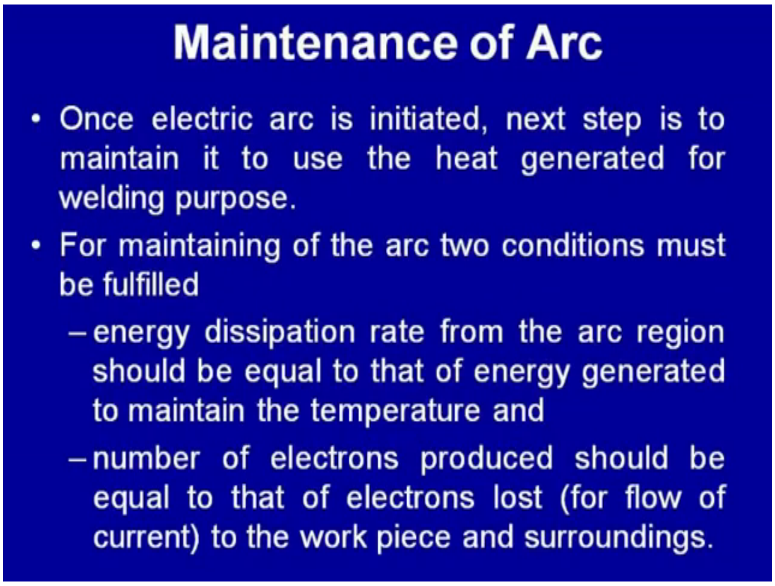

To maintain the arc there are certain conditions which must be fulfilled, that is these 2 conditions are basically, whatever heat is being generated will be dissipated in course of the welding. So, heat being dissipated during the welding must be compensated by the heat generation. So, the one condition which is important to be fulfilled for maintenance of the arc is the energy dissipation rate from the arc region should be equal to the energy generated to maintain the arc.

So, that temperature within the arc can be maintained and the required thermal ionization and other things can continue to happen for development of the charge particles in the arc region and the arc can be maintained. Similarly, during the welding the number of charged particles present in the arc gap will be lost gradually either to the surroundings or to the base material or they may reunite.

So, the loss of these particles charged particles during the spark or during the arc once it is initiated that must be maintained. So, the loss of these charge particles in form of electrons and the ions must be compensated by generating, the more number of the electrons. So, that the sufficient number of charged particles in the arc gap can be maintained and the flow of current can continue. So, once the arc is initiated to maintain, it these 2 conditions must be fulfilled in that is the energy generation must be equal to the energy loss to the base material and to the surrounding.

And the second is number of the charged particles produced, must be equal to the number of charged particles lost to the surroundings and or to the base material to. Then now, we will see that how these charged particles lost to the surrounding or to the base material, as we know that and what that role is.

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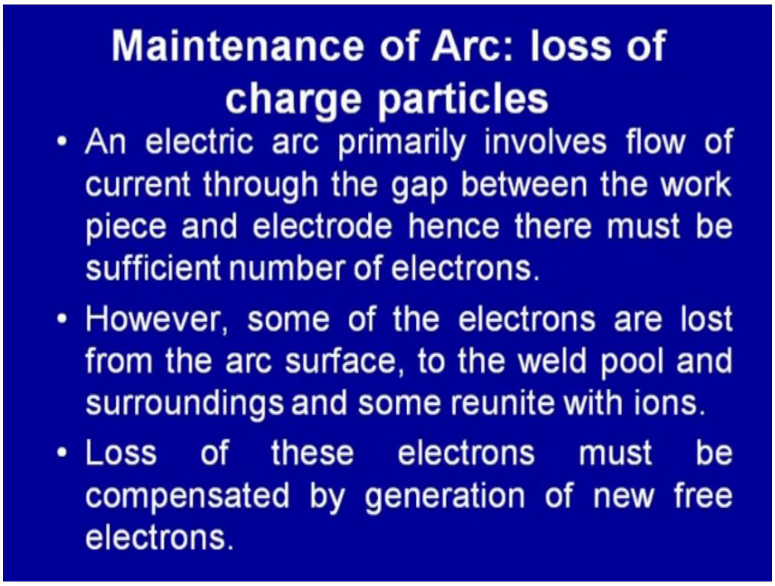

Now, we know that as an electric current, electric arc primarily involves the flow of current through, the gap between the work piece and the electrode. Hence there must be sufficient number of the charge particles. However, some of these electrons and the ions are lost to the arc surface and to the pool and some of them to the surrounding or some of them also lost by reuniting with the ions.

So, loss of these electrons and the charge particles, in turn decreases their density in the arc gap and which may make the current flow difficult. If the density of the charge particles in the arc gap decreases significantly and this therefore, this loss of the charge particles must be compensated by generation of a new free electron, if we see here in this diagram.

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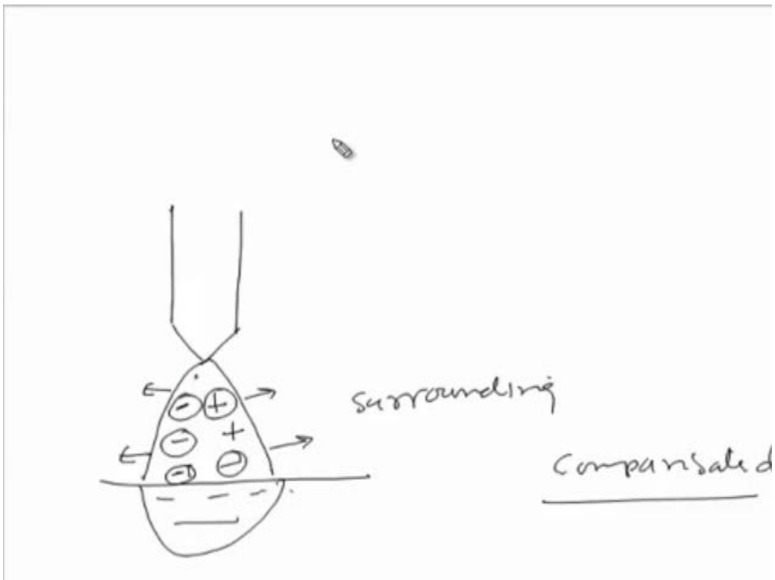

We can see that these charged particles, say here is an welding arc between the electrode and the work piece. Welding arc will be involving the flow of current through the charged particles, these charged particles during the once the arc is ignited by the flow of current will start. But in process of the welding these charged particles are lost to the surroundings and some of these charged particles are lost to the base material.

So, these losses to the charged particles must be compensated. Otherwise these will decrease, the number of the charged particles in the arc gap and which will make the flow of current difficult. Another important aspect is that, the heat will be lost from the arc zone.

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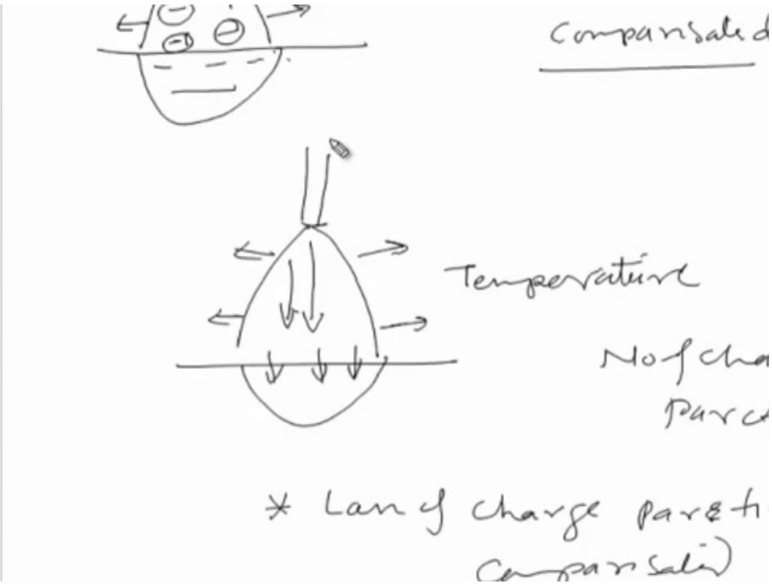

To the base material and to the surrounding, this heat loss will be this heat being transferred to the surrounding and to the base material will be decreasing the temperature. So, the reduction in temperature will decrease the thermal emission and other aspects, which will further decrease the presence of the charge particles in the arc gap.

So, the loss of heat to the surrounding and to the base material this also should be compensated in order to have the sufficient number of charged particles in the arc gap. So, that sufficient electrical conductivity between the gaps can be maintained and the flow of current can continue to maintain the arc.

So, these are the 2 important conditions that the loss of charged particles is compensated and the loss of heat is also compensated. Otherwise this will lead to the reduced number of the charge particles in the arc gap and the flow of current will stop and the arc will extinguish. So, these are the 2 conditions which must be satisfied for maintaining the flow of current through the arc gap.

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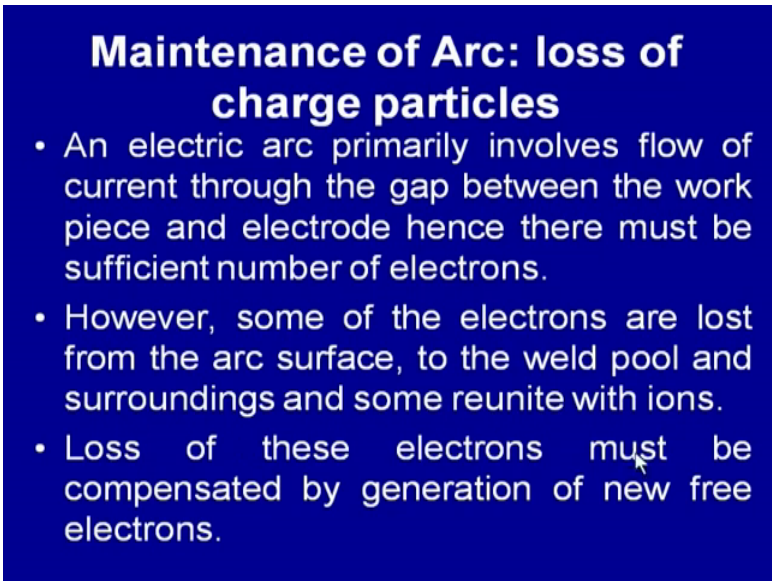

So, now we will see further that this what we have seen that is the loss of these charge particles must be compensated by generation of the new free electrons. So, that the sufficient electrical conductivity in the arc gap can be maintained, to have the smooth flow of current, so that arc can be maintained.

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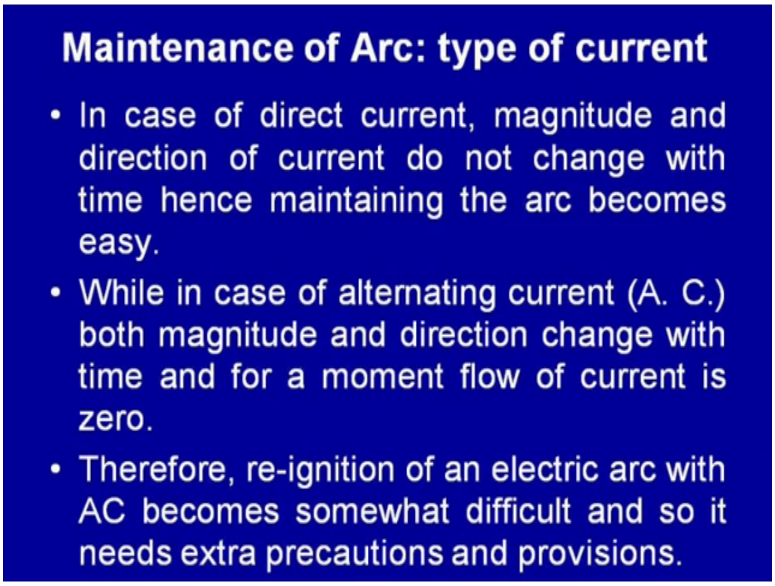

Now this maintenance of the arc is significantly affected by the type of current being used. There are 2 types of currents which are normally used, that these are the direct current and the alternating current.

In case of the direct current magnitude of the current and the direction does not change, but in case of the alternating current, the direction and magnitude of the current changes continuously. So, this variation in magnitude and direction of the current in alternating current makes the flow of current difficult. And so the maintenance of the arc is also made difficult in case of the alternating current.

So, if we compare the D C and the A C in terms of the maintenance of arc then it becomes easier to maintain the arc in case of the direct current, because, the magnitude and the direction of the current do not change with the time. And hence, the current continue to flow smoothly from the electrode to work piece or electrode work piece towards the electrode depending upon the polarity. Well in case of the alternating current both magnitude and directions change with the time and even for a movement the current becomes 0 under those conditions. It becomes difficult to maintain the flow of current and arc shows the tendency to get extinguish. Therefore re-ignition of the electric arc with the A C sum becomes, some what difficult and it needs extra precautions and the provisions. And for this purpose special methods are used and these 2 methods are basically.

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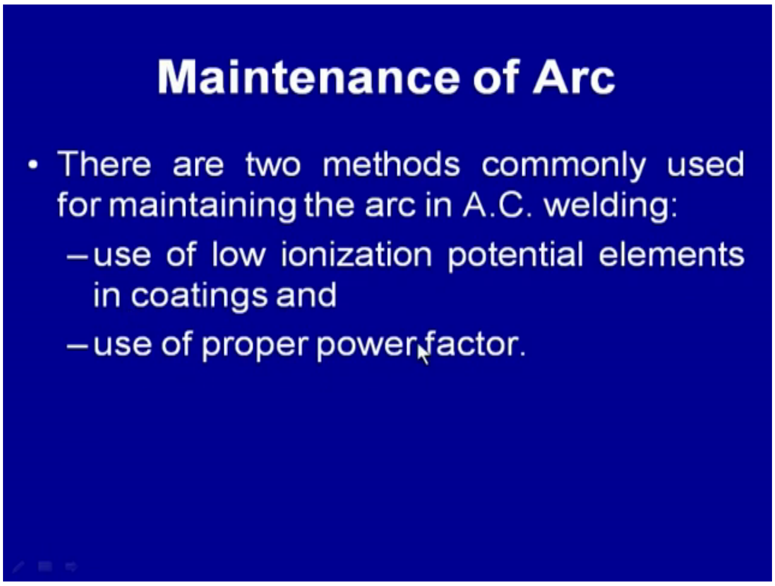

The use of the low ionization potential elements with the coating and use of the power factors, in both these approaches, basically, the efforts are made to facilitate the easy presence of the large number of charged particles in the arc gap. Even under the conditions, when either opens circuit voltage is very low or when the current is very low. So, under those conditions, presence of large number of charge particles help to reignite the arc easily. So, we look into the details of that, how these 2 methods help in maintaining the arc, especially, when alternating current is used for the welding purpose.

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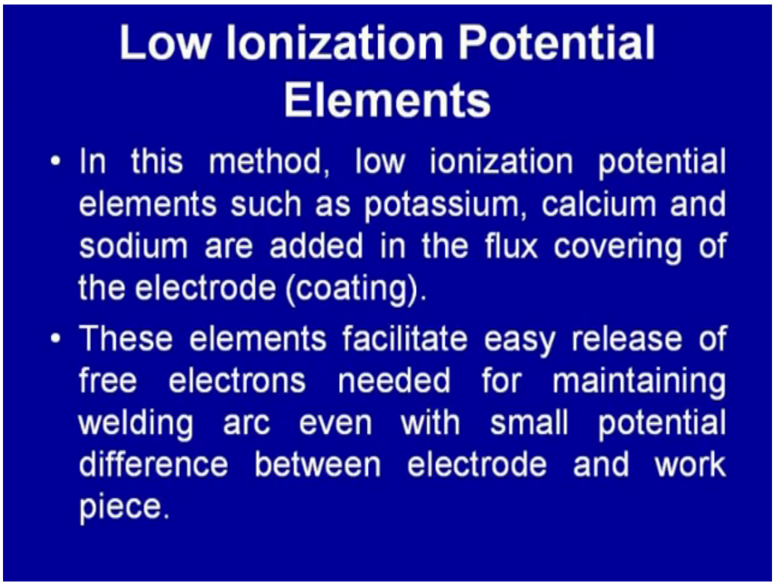

If we see, the first method in case of, low ionization potential element method, in this method low ionization potential element materials like. The calcium and the potassium these are added with the flux or with the coating of the electrode. And these materials easily, provide the release of the electrons in the arc gap and which helps to maintain the flow of the current, even under the conditions when the current is changing rapidly as a function of time in terms of the magnitude and the direction. So, these elements facilitate easy release of the free electrons required for maintaining the arc, even with the small potential difference, when exist between the electrode and the work piece.

So, this is an important aspect that is used, so when using the A C current for welding purpose. So, the electrode or electrode coating must have the low ionization potential elements that will help in providing, the easy release of the free electrons required for maintaining the welding arc. So, that the smooth arc can be maintained and uniform heat can be generated for melting the faying surfaces of the base material uniformly for developing the sound weld.

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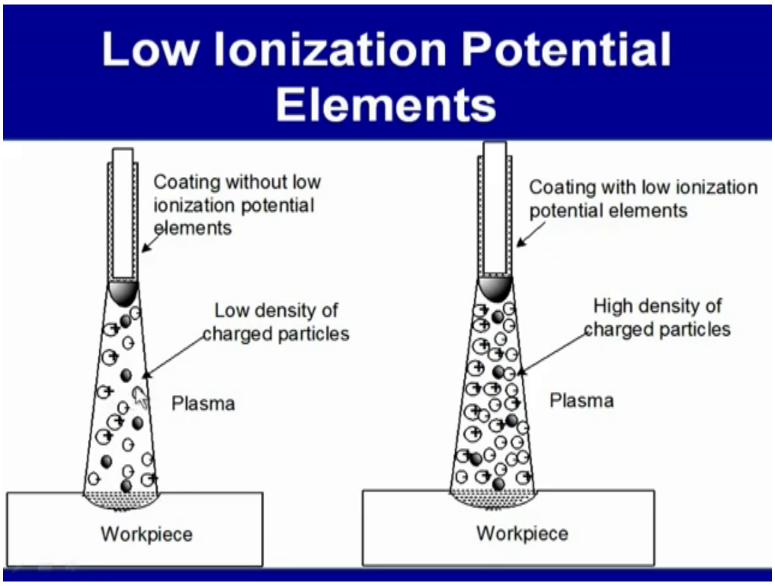

Here we can see this schematically the difference in the 2 cases, when the low ionization potential elements are present with the coating or when there is no presence of the low ionization potential elements. So, either when, we are using the bare electrode and the electro and arc is established between the weir electrode at the base material, we will see that is the number of charged particles in the arc gap are low. And the particle density is low this makes the flow of current between the electrode and work piece difficult and that is why the stability of arc especially becomes poor, when the bare electrodes are used.

Especially, when using the A C current while in even with the bare electrodes use of D C current helps to maintain the reasonably good arc. Therefore, in case of bare electrodes when no coating material is used or when no low ionization potential elements are used with the electrodes. The stability of arc with the A C becomes poor and this in turn results in non uniform heat and unstable heat generation, leads to the development of the poor, weld joint while in case of when the low ionization potential elements are used with the coating materials.

These low ionization potential elements provide, easy release of the free electrons and the charge particles in the arc gap and in the increased particle density of the charged particles in the arc gap. Facilitates the easy flow of the current through the gap and there by helps to maintain the arc easily, even when the A C current is used.

So, this is how we can see that, when the low ionization potential elements are used, these facilitate the presence of the large number of charged particles in the arc gap and there by they ensure. The easy flow of the current for maintenance of the arc, the poor the proper power factor is the another approach where.

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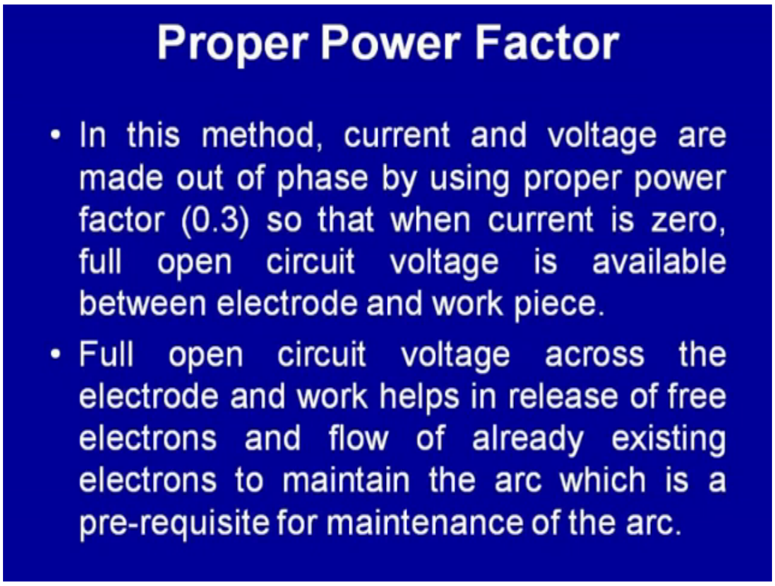

The current and the voltage are made out of the phase by using proper power factor. So, that when the current is 0, the full open circuit voltage is available between the electrode and work piece. So, in this method especially the welding current and the voltage are made out of the phase. So, that when the current is 0, the open circuit voltage is maximum and is higher open circuit voltage facilitates the re-ignition of the arc easily even when current value is very low. So, this is the basic principle of this using the proper power factor approach.

So, the full circuit full open circuit voltage across the electrode and the work piece helps in release of the electrons, easy release of the electrons and the flow of current or of the already existing electrons to maintain the arc. So, this flow of current is mandatory to have the arc and to maintain the arc between the electrode and the work piece.

So, when the current value is very low, in case of the A C current the higher open circuit voltage facilitates. The easy flow of the current as well as easy release of the free electrons in the arc gap, which in turn makes maintenance of the arc in between the electrode and work piece easier and that is how the maintenance of the arc is facilitated by the use of proper power factor, we can see here.

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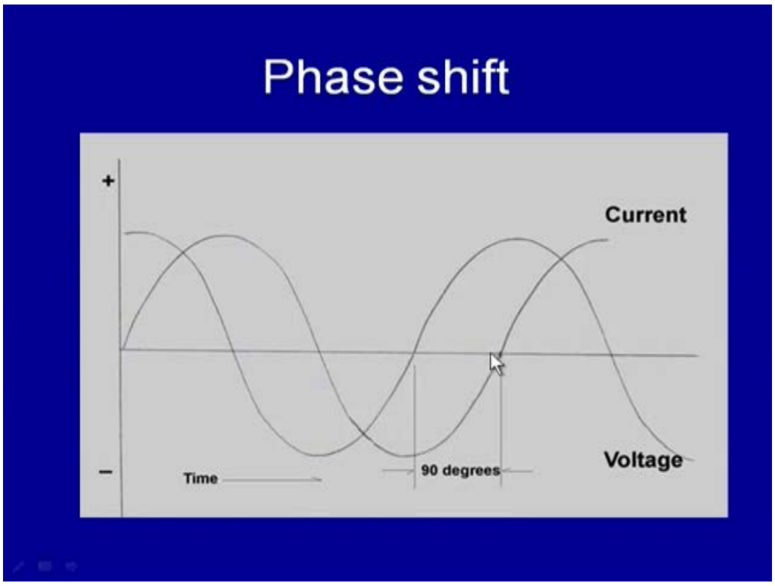

That when the current say this current side variation, in the current as a function of time and the variation voltage as a function of time, and there is a phase shift of say some 90 degree between the voltage and the current.

So, when current is this current say, the current is 0, the voltage is maximum. So, this kind of the phase shift efforts are made to have, a phase shift where the when the current is 0. The voltage is maximum and this kind of the shift is applied by using proper factor for welding using A C. So, that arc can be maintained, this we can see a more clearly.

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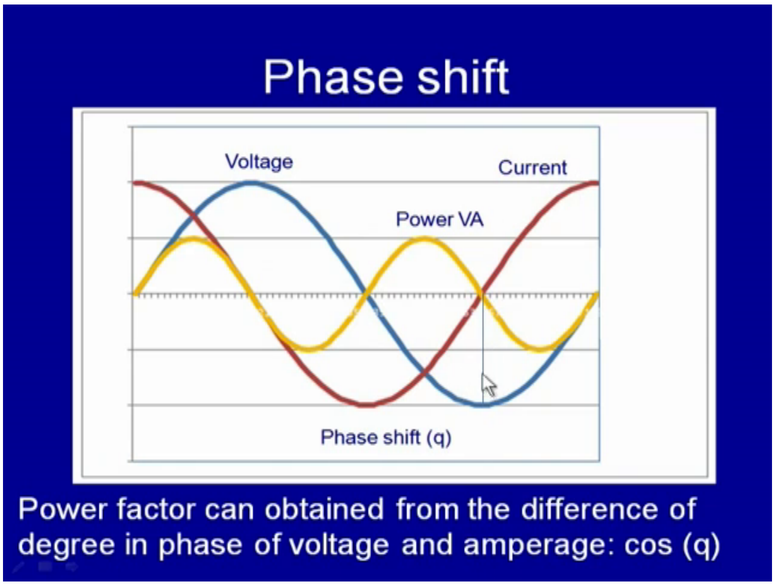

That the use of proper power factor has to maintain the proper phase shift between the voltage and between the current, so that when the current is 0, the full open circuit voltage is available, which will facilitate the release of the electrons as well as the flow of the electrons required for maintenance of the arc. So, these are the 2 methods which are normally used for proper maintenance of the arc in A C is used. Now, we will see that how the arc voltage varies, when the welding current is changed under the different welding conditions to look into this. We need to see that how arc is generated and how the temperature is affected in the arc region, we will see here.

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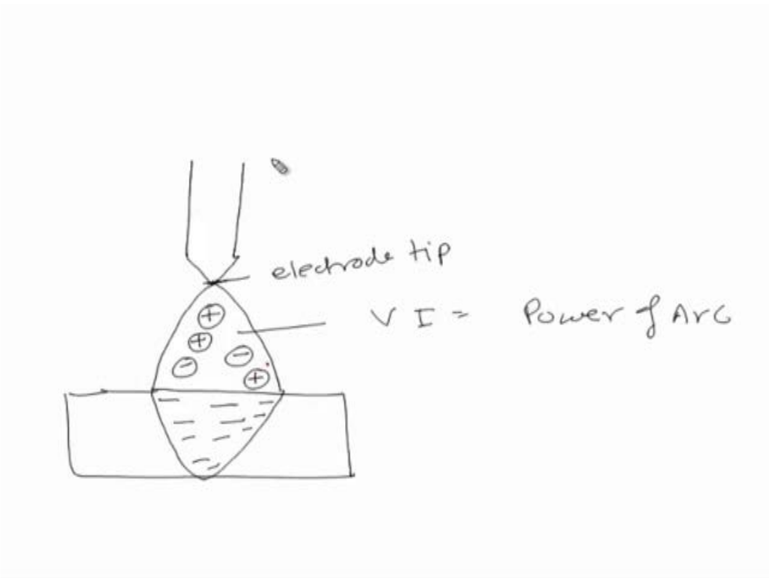

This is the molten weld pool and this is the arc zone having the charged particles in the arc zone. This is the electrode tip and the heat is generated given by the V I, it is the power of arc. So, this heat generated in the arc region actually, varies with the location from the electrode tip to the base metal axially and the radially also that is the away from the access on the arc. So, in the arc characteristics what we need to see.

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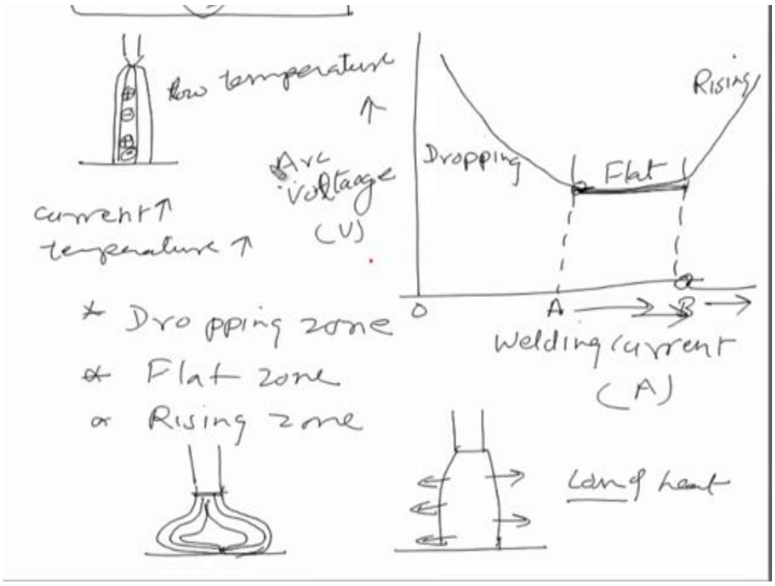

That the variation in the arc voltage V, in the y axis and the welding current in ampere in x axis. So, when the welding current is increased, how the arc voltage varies. So, if you see here this trend is typically of this kind where, the increase in welding current first decreases the arc voltage up to a certain limit that is this zone. And then it becomes almost constant in this for a certain range of the increase in welding current and further increase in welding current increases the arc voltage again.

And accordingly, we have these 3 different types of the variations, the first 1 is called the dropping 1, where decrease in the arc voltage with the increase of the welding current takes place. Second is called the flat 1, flat region where, the arc voltage largely remains constant as with the increase of the welding current. And the third 1 where, there is increase in arc voltage with the increase of the welding current. So, these are the 3 zones in the arc characteristic arrow, which is showing the relationship between the arc voltage and the welding current, these are the 3 dropping characteristic zone, the flat zone and the rising one.

Now, we will see that what is the reason behind the development of these 3 zones and if, we see here, when the current value is very small, the arc is established between the electrode and the work piece. So, when the arc is established between the electrode and the work piece using very small current, arc is very thin in small diameter and current is low. So, so use of the low current results in the very low temperature, low temperature means the very presence of view few charged particles in the arc gap.

So, when the current is increased initially, let arc is very thin temperature is low, increase of current results in increase in temperature, so as current is increased temperature increases. So, this increase in temperature increases the number of charged particles present in arc gap and increase in number of charged particles in the arc gap, with the increase of current results, in the reduction in electrical increase in electrical conductivity.

Because, of the increase in number of the charge particles or particle density. So, increase in electrical conductivity, decreases the arc voltage and this trend continue up to certain limit, when the increase in current continues to increase the temperature and increase the particle density in the arc gap.

So, it will keep on increasing the arc voltage, but with further or significant increase in the welding current, increases the size of the arc also. So, with the increase in size of arc up to a certain limit, the increase in temperature takes place, but thereafter significant increase in size of the arc, leads to the increased losses of heat to the surrounding. And increase in losses of the heat to the surrounding with the increase of current due to the increase in size of the arc, leads to the no major increase in the arc temperature.

And no major change in arc temperature leads to no change in the particle density, charge particle density and no change in the particle density results in no change in arc voltage that is why. So, up to certain extent, increase in welding current, increases the temperature, increases the particle density in the arc gap which in turn, decreases the arc voltage. But beyond a certain limit when the increase in current, starts increasing the size of the arc, which in turn increases the losses of heat from the arc zone. May end in turn leads to which in turn leads to the temperature constancy and no significant change in the temperature results, in no change in the particle density and therefore, your arc voltage largely remains constant.

So, this is a region where increase in welding current, does not change arc voltage appreciably and this is called the flat zone. And if, we talk about the 3 region, where increase in welding current, beyond a certain limit starts to distort the shape of the arc in this manner. So, this leads to the increased arc length, increased arc length means increased distances to be covered by the current flowing from the electrode side to the work piece.

So, this bulging or distortion in the shape of the arc, in turn increases the arc length and increased arc length leads to or the length of through, which or path through which electrons will have to flow, through the gap in turn increases the arc voltage. So, this basically changes in shape of the arc, undesirable shape of the arc leads to the increase in arc voltage beyond a certain limit of the welding current.

So, this we can say from 0 to A level of the welding current, there is a dropping characteristic zone a to b level, there is a flat characteristic zone and above the b level. There is a rising characteristic zone in which, basically the bulging or distortion in the shape of the arc leads to the increase in the arc voltage. So, this is what we typically call the arc characteristic having the different zones.

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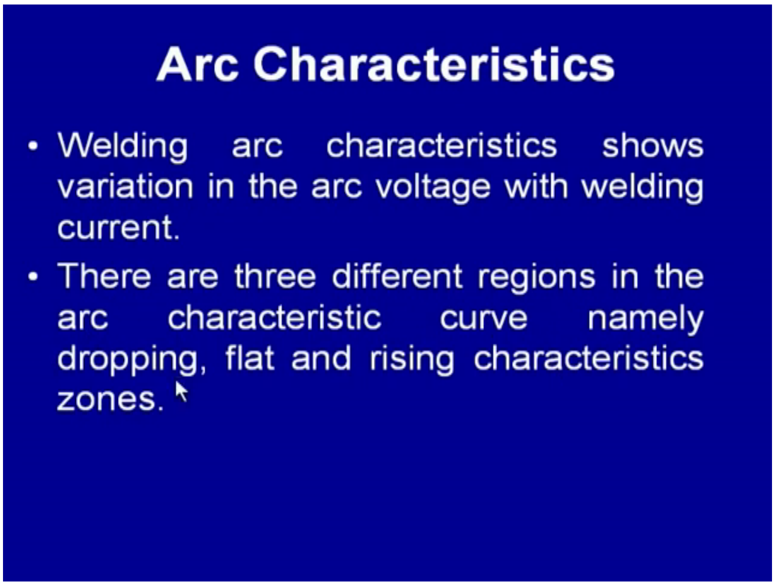

There are 3 different regions in the arc characteristic curve, namely dropping characteristic flat.

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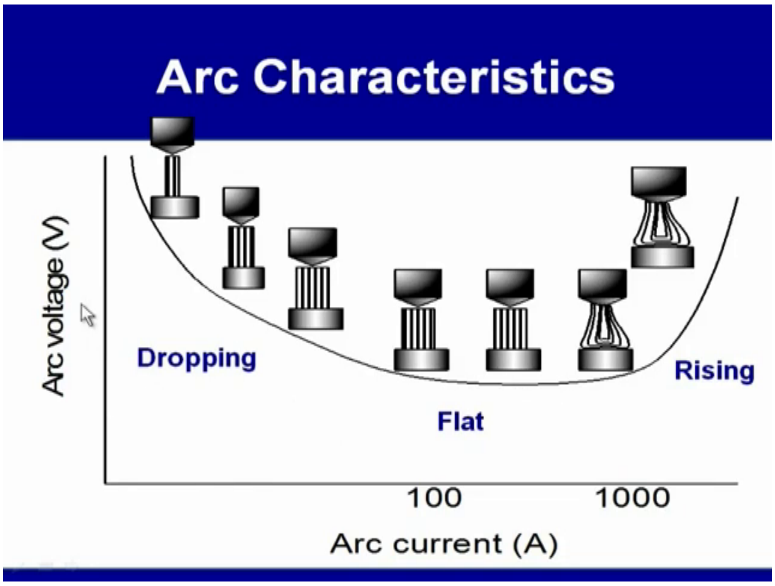

And the rising characteristic zone, these we can see a arc voltage versus arc current relationship, that when the current is very low when initially it is increased for a range of say up to 10 degree. There is a continuous increase in the size of the arc as well as the temperature of the arc. So, increase in temperature, increases the charged particle density which in turn decreases the arc voltage and this continues till up to say 100 degree. A 100 ampere welding current and thereafter, there is no significant change in the arc voltage, that is the flat zone and beyond of certain limit of the current say 1000 ampere or so. The distortion of the bulging in the arc takes place, which in and at this stage the arc voltage starts to increase with the increase of welding current.

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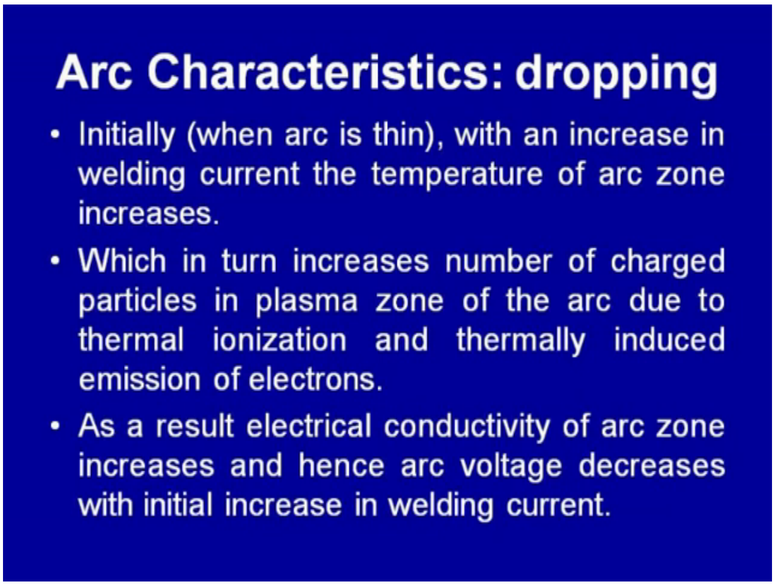

So, initially when the arc is sent in the dropping characteristic zone, when the arc is within the increase of the welding current temperature of the arc zone increases, which in turn increases the number of charge particles, in the plasma zone of the arc, due to the thermal ionization and thermally induced, emission of the electrons, and as a result of the increased number of the charge particles and the electrons in the arc gap. The thermal conductivity of the arc zone increases and hence the arc voltage decreases with initial increase in the welding current and this trend continues up to.

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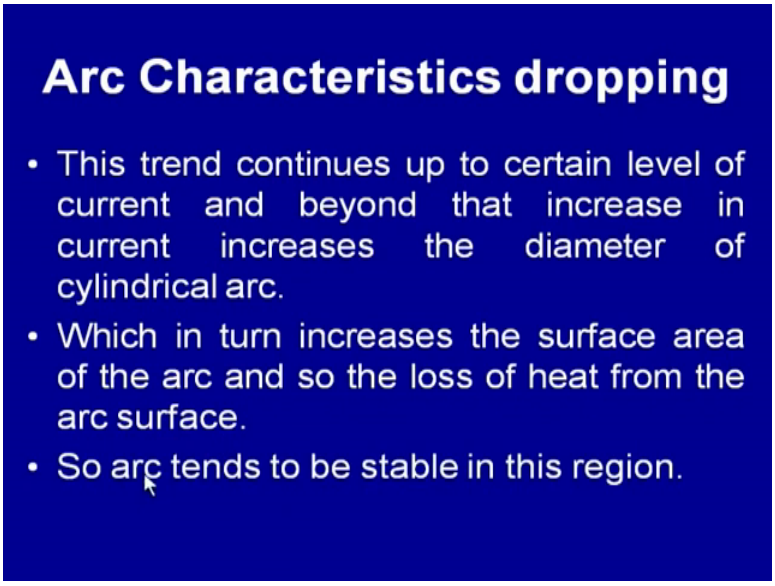

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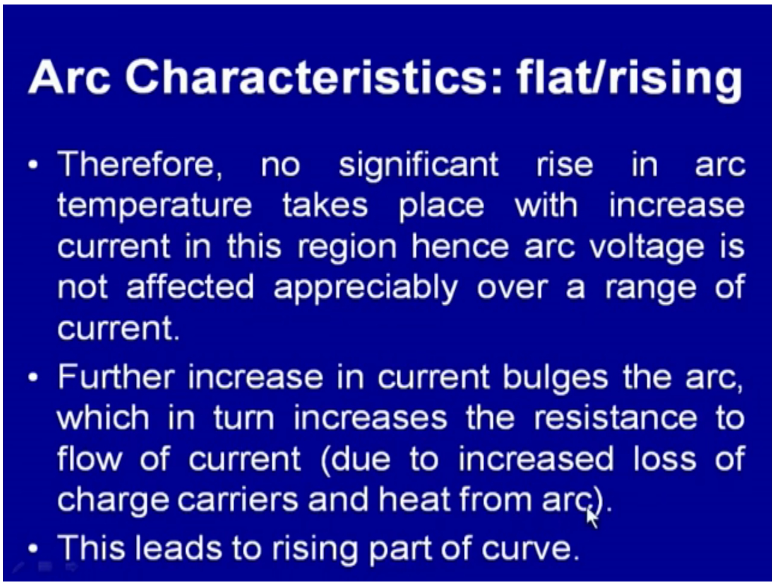

A certain level of the voltage up to certain level of the current and beyond that increase in current increases the diameter of the cylindrical arc, which in turn increases the surface area of the arc and. So, the losses of heat from the arc surface take place and when this happens the arc voltage tends to stabilize in this zone.

And therefore, no significant rise in the arc temperature takes place in this, with the increase of current in this region and hence the arc voltage is not affected appreciably over a range of the current. Further increase in the current bulges the arc, which in turn increases the resistance to the flow of current due to the increased losses of the charged carrier and heat from the arc surface. Because, effective length of the length through which the current will have to flow, after bulging of the arc increases and this increase in the arc.

This increase in the path through, which current will have to flow in turn leads to the increased losses of the charge particles and the heat from the arc, which in turn decreases. The particle density in the arc zone and starts and this reduced particle density in the arc zone decrease the electrical conductivity, which in turn increases the arc voltage and this leads to the rising part of the curve. Now, we will see that how the variation in the arc length affects the arc characteristic.

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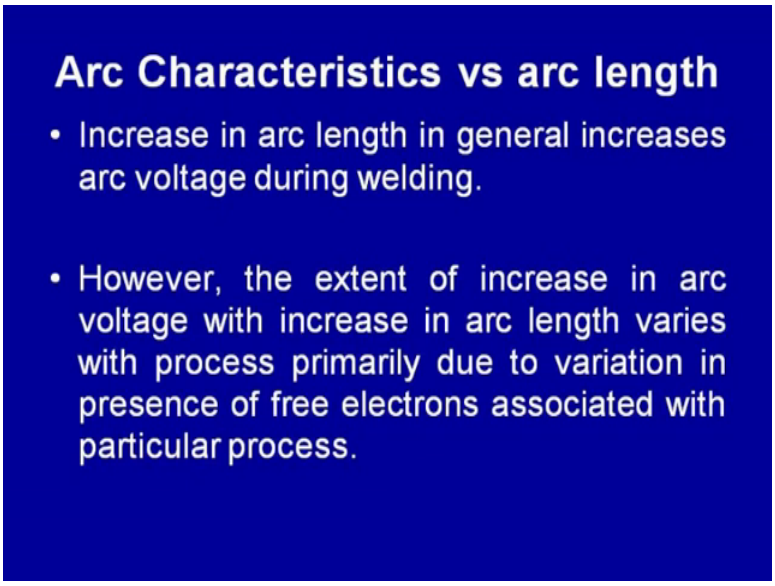

We know that increase in arc length in general increases the arc voltage during the welding and this primarily happens due to the increased resistance to the flow of the current with the increase of the arc length and this. But this increase in the arc length does not lead to the similar increase in the arc voltage, in case of the different welding processes. However, the extent of increase in arc voltage with the increase of arc length therefore, varies with the welding process in question and this primarily happens due to the variation in presence of the charged particles, associated with the particular process.

In some cases increase in arc length significantly, increases the arc voltage as compared to the other process. Is what we can see in this the diagram, where increase in arc length, increases the arc voltage more significantly in case of the submerged arc welding, then in case of metal inert gas and in case of the tig welding. And this difference is primarily due to the ability to release the electrons and free electrons. And the to provide the charged particles in the arc gap, in these 3 processes in case of the tungsten inert gas welding process.

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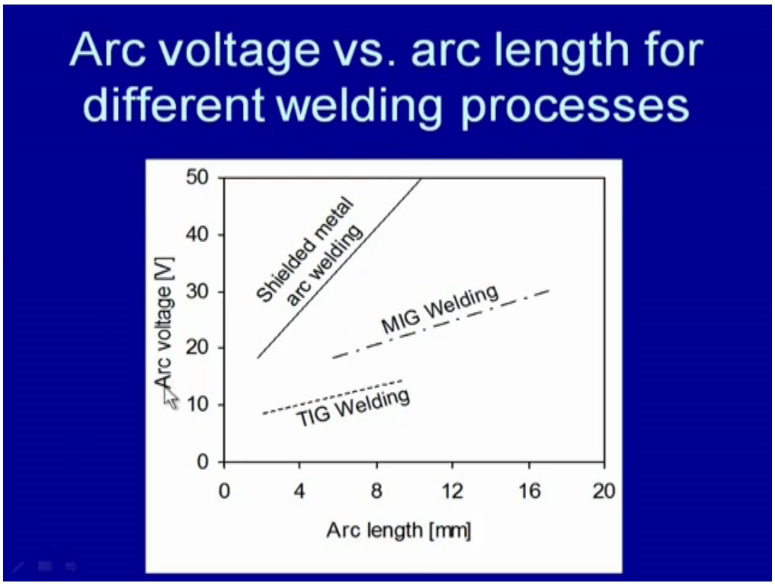

The easy release of the free electrons in tungsten inert gas welding process makes a easy release of the electrons facilitates. The minor increase in the arc voltage with the increase of arc length, while in case of the submerged shielding metal arc welding process. The these kind of release of the free electrons and charged particles in the arc gap is not easily facilitated.

Therefore, with increase of the arc length in case of the shielded metal arc welding process leads to the deficiency of the charge particles in the arc gap and which in turn leads to the significant increases in arc voltage with the increases in arc length. While in case of the tig welding due to the easy availability of the charged particles, in the arc gap the increase in arc length does not affect the arc voltage appreciably. So, this is what we have seen that the arc characteristic is affected by the arc length.

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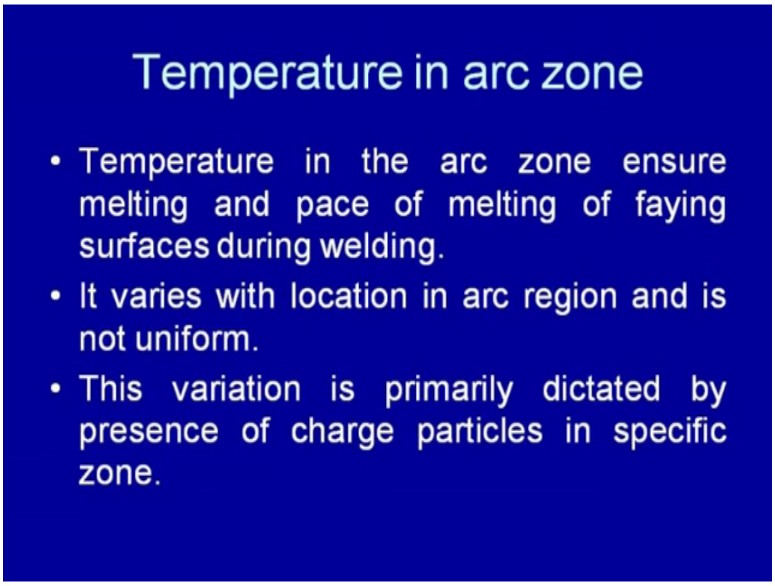

But these changes in the arc characteristic also affect the kind of heat, which is generated in the arc zone and the difference in the heat generation leads to the variation in temperature of the arc. And the temperature of the different zones in the arc we know that the temperature of the arc is important, because it ensures the melting of the faying surfaces.

The difference in temperature of the base material and the arc is not much then it will make the melting of the material difficult. Especially, refractive materials therefore, the temperature of the arc zone is important as it facilitates, as it ensures the melting as well as the speed at which the faying surfaces can brought to the molten state during the welding.

So, further this temperature in the arc zone also varies with the location and is not found uniform, it varies axially and the radially both. The variation is primarily dictated by the presence of the charge particles in the specific zone, if we see the next diagram, here this is the electrode tip say cathode spot is here and arc is established.

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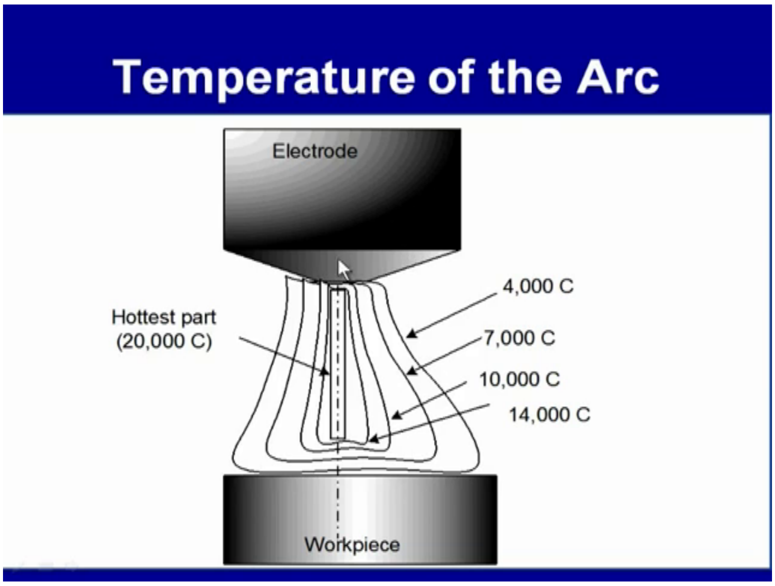

So, here the if you see, there are the 2 is to look into the temperature variation in the arc zone, 1 is along the axis of the arc and another is radially with respect to the axis of the arc. That is the moving away from the axis of the arc. So, if we see here these different lines are the isothermal lines, indicating that the peak temperature is generated along the axis of the arc and as we go away from the axis of arc temperature keeps on decreasing. Say outer surface is around say 5 4000 under the along the axis of the arc it is 14000.

So, maximum temperature is generated along the axis of arc and you can see the hottest region is of around 20000 degree centigrade, in the heart of the along just along the centre line of the arc. So, the peak temperature is 20000 degree centigrade along the axis of arc as we move away from the axis of arc temperature is reduced, say it up to 14000 and then 10000 7000.

So, the temperature varies this, these things indicate the temperature varies as we move radially away from the axis of arc. Similarly, the temperature is also low at the tip of the electrode and near the work piece surface. These temperatures are these low temperatures at both the ends at the tip of electrode, near the tip of the electrode. And the work piece is basically, due to the cooling effect being offered by the electrode and the work piece, which leads to the sometimes melting of the electrode in case of the consumable arc welding process and melting of the base material.

So, the cooling effects of offered by the electrode and the work piece, leads to the lower temperatures at their surfaces, while the peak temperature is observed. In the core of the arc, which can range from say 20000 to 30000 degree centigrade depending upon the current being used.

But this diagram basically indicates the temperature varies radially away from the axis of the arc and also temperature varies with the distance from the electrode and the work piece. And it is a the maximum in the plasma zone and in other areas it is lower. So, we will see that what are the factors that affect the temperature in the arc zone, these temperatures are the you know.

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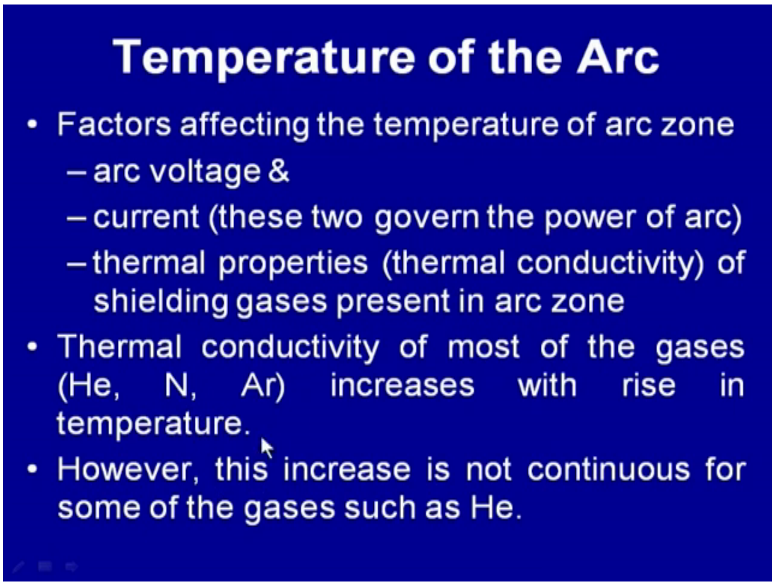

That the temperature in the arc zone is primarily dictated by the heat being generated and the heat generation is governed by primarily, the arc voltage which is being used and the welding current. And the product of these 2 gives you the power of the arc higher is higher current in combination with the higher voltage results in the high heat generation.

So, the temperature of the arc zone is primarily governed by the arc voltage and the welding current being used. Because, these 2 factors govern the power of arc apart from the these 2 welding conditions, the thermal properties of the gases also gases and the work piece in the based material, effect the temperature in the arc zone. We will see here the thermal properties like thermal conductivity of the shielding gas also affects the temperature in the arc zone.

Because it facilitates the rate at which heat will be transferred from the arc zone, to the surrounding into the base material. Thermal conductivity of the shielding gas like helium is much better than argon, this effectively transfers the heat from the arc zone to the base material and to the surrounding. Thermal conductivity of the shielding gases also effects the temperature gradient from the axis of the arc to the surface of the arc and also from the electrode tip to the core of the arc.

So, thermal conductivity and further we know that thermal conductivity of the gases increase with increase of a temperature. So, this increase in temperature in turn effects the temperature gradient. So, if we are working with the low welding current, resulting in the low temperature of the arc low and so the lower thermal conductivity of these gases and the higher will be the temperature gradient.

This is one way how we can say this affect of the shielding gases on the temperature gradient and the variation in temperature in the arc zone. However, this increase in the thermal conductivity is not found uniform for the gases like the helium or argon. It varies it increases, but increase rate of variation or rate of increase with the increase of temperature is not found uniform.

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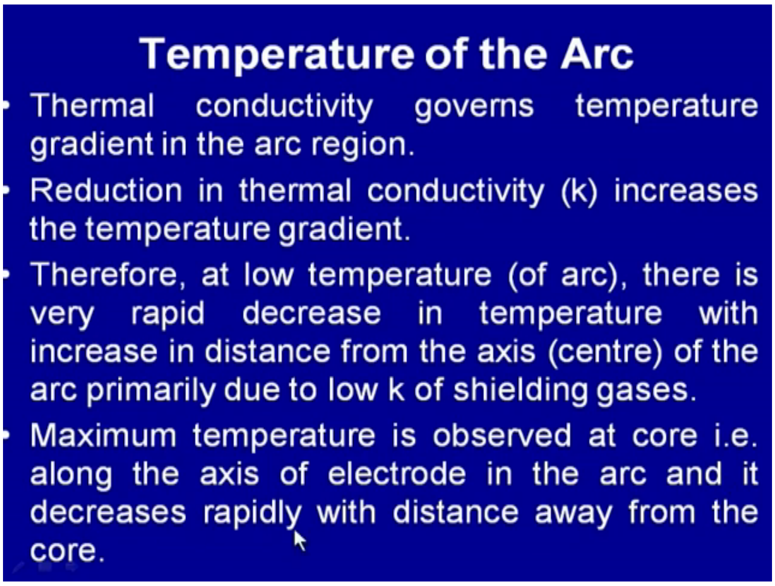

Thermal conductivity we know that governs the temperature gradient in the arc region. Greater is the thermal conductivity means greater is the thermal conductivity, lower will be the temperature gradient or reduction in thermal conductivity leads to the increase in the temperature gradient.

So, sharp temperature gradients are observed mainly in case of the low thermal conductivity shielding gases, like argon as compared to that of the helium gas. Therefore, at the low temperatures, there is a very rapid decrease in temperature with the increase of distance from the axis. So, this suggest that, if we are working with the low temperature due to the low current then this will lead to the greater or higher temperature gradiance.

Because, of the poor thermal conductivity of the shielding gases. So, if we increase welding current, increase in welding current will increase the temperature of the arc zone, which in turn will increase the thermal conductivity of the shielding gases. And will which in turn will decrease the temperature gradient, a varying from the axis of the arc to the surface of the arc.

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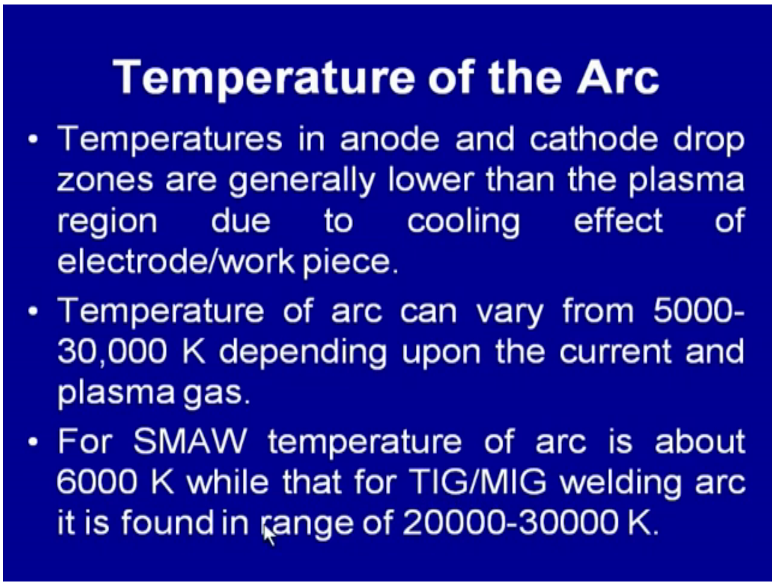

And the maximum temperature, as we have seen that is observed at the core of the arc, that is along the axis of the electrode in the arc region and it decreases very rapidly with the increase in distance away from the core. So, this rate of decrease with the increase in distance away from the core is basically, the temperature gradient and is found as a function of the shielding gas. So, the temperature further if it is the temperatures in the anode and the cathode drop zones, which are closer to the electrode and the work piece.

As generally lower than the plasma zone, which is the core portion of the arc and this lower temperatures of anode and cathode drop zones are primarily attributed to the cooling effects offered by the electrode and the work piece. The temperature in general can vary in the arc region from 5000 to 30000 degree centigrade depending upon the type of welding process being used, welding current is being used and the plasma gases of the plasma gas being used. For example, application of the helium gas results in the higher arc temperature as compared to the case, when the argon is used and this is because, of the high ionization potential of the helium gas.

So, the shielding gas the kind of current, which is being used also affect the temperature or the maximum temperature, which can be generated and the temperature gradient, which is generated within the arc. Just for example, like the maximum temperature generated in the arc in case of the shielded metal arc welding is around 6000 k, while in case of the tungsten inert gas and the metal inert gas welding process it is found in the range of 20000 to 30000 k. Depending upon the kind of the current the shielding gases and the electrode materials being used.

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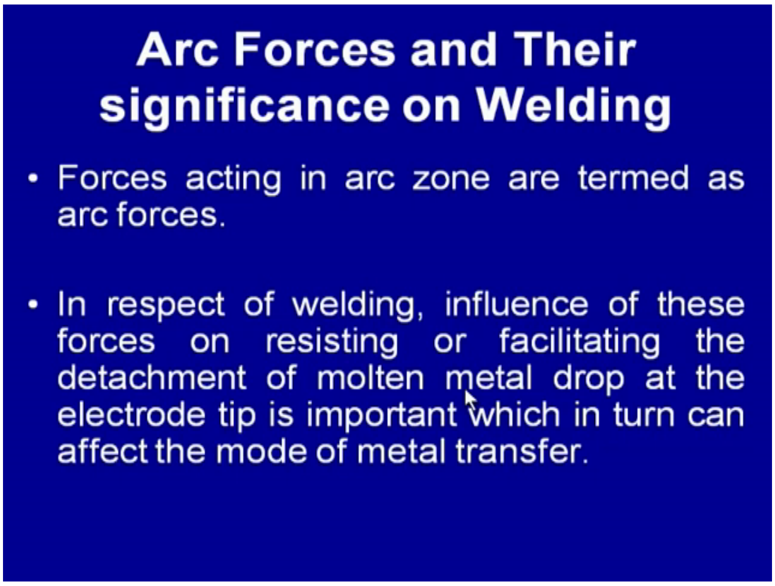

Now, we will see the arc forces is the another important aspect associated with the physics of the welding arc. Because, it affects the way by which metal will be transferred from the electrode tip to the weld pool and this is mainly important in case of the consumable arc welding process. Because it directly dictates the mode of the metal transfer, that is the how metal molten metal drop is transferred from the electrode tip towards the work piece.

So, if the arcs forces are present, if the arc forces are present and depending upon the type of the arc forces and their magnitudes, the metal transfer is affected. So, for example, in case of the force, which is due to the electromagnetic, forces the mode of metal transfer is affected. Because of the easy detachment, well in case of the surface tension force helps to keep the molten metal drop, attached with the tip of the electrode.

So, resists the metal transfer. So, depending upon the type of the arc forces present in and their magnitudes. The metal transfer is mainly affected by the arc forces in the arc zone. And sometimes, there apart from the metal transfer the spattering is also affected by the arc forces, which are generated in the arc region. In this lecture we will see that, what are the different arc forces present in the arc zone and how do they affect the metal transfer and the spattering aspects in process of development of the sound weld joint.

So, in this presentation we have mainly seen that, as far as the physics of the arc welding is concerned the important aspects related to the physics of arc welding, like the temperature in the arc zone. The maintenance of the arc and the arc characteristic curve, effect of the arc length, we have seen and also. We have observed that how the temperature of arc affects the welding aspects and what is the importance of the arc maintenance of arc, for developing the sound weld joint.

In the coming presentations, in next presentation we will see that, what are the different arc forces, what are the and how do they affect the modes of the metal transfer. What is and how to get the magnitude of the different types of the arc forces, which are present, what are the factors affect, those arc forces.

And then we will also see that under what conditions arc can deflect from it is path and how to control the deflection of arc from it is path, that is called arc blow. So, the fundamentals associated with the welding arc blow and the methods of controlling the arc blow, will also be look in into the details.

Thank you for your attention.