Welding Engineering
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Module - 2
Physics of Welding Arc
Lecture - 4
Arc Forces

So, in this presentation mainly, we will be talking about the forces acting in the arc zone, effect of the polarity on the welding and the arc blow which is normally encountered during the DC welding, the mechanism of the arc flow and the methods for overcoming the arc blow phenomena and its effects on the welding process. So, well in the previous lectures, we have seen that how the arc is initiated, how arc is maintained and what is the need of igniting the arc successfully using the various approaches, so that sound the weld joint can be produced. So, starting with the content of this presentation will be covering these three main topics forces in the arc zone.

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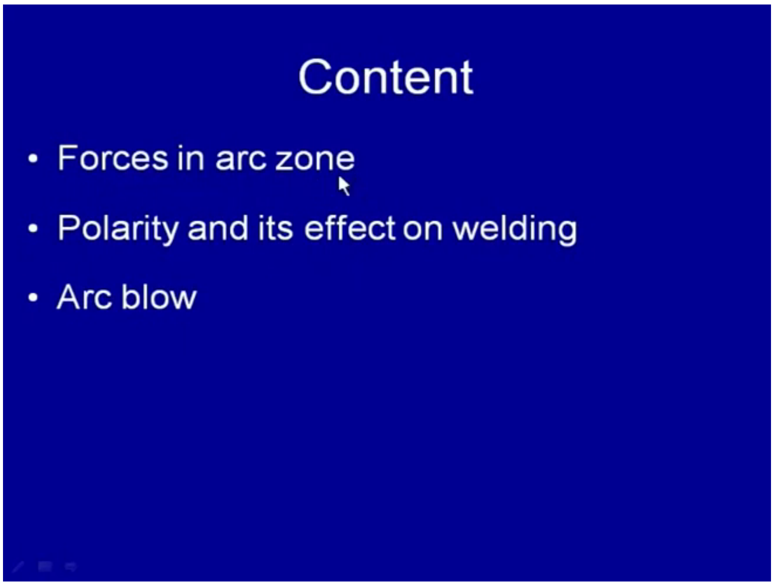

So, need to studied the forces acting in the arc zone, various types of the forces acting in the arc zone and how do they affect the development of the sound weld joint that also will be discussed in detail. The polarity, what kind of polarity is being used during the welding, what are the various types of polarities, and in which way they effect the development of the weld joint in successful manner. Similarly, in an undesirable phenomena, which is normally encountered, while using the DC welding.

So, the mechanism of the arc blow and the effect of the arc blow and the methods, which are used to take care of the arc flow will also be covered in the presentation. So, if we see the arc forces, the various types of the arc forces in the arc region and these arc forces mainly affect the transfer of the molten metal drop from the electrode side to the weld pool side.

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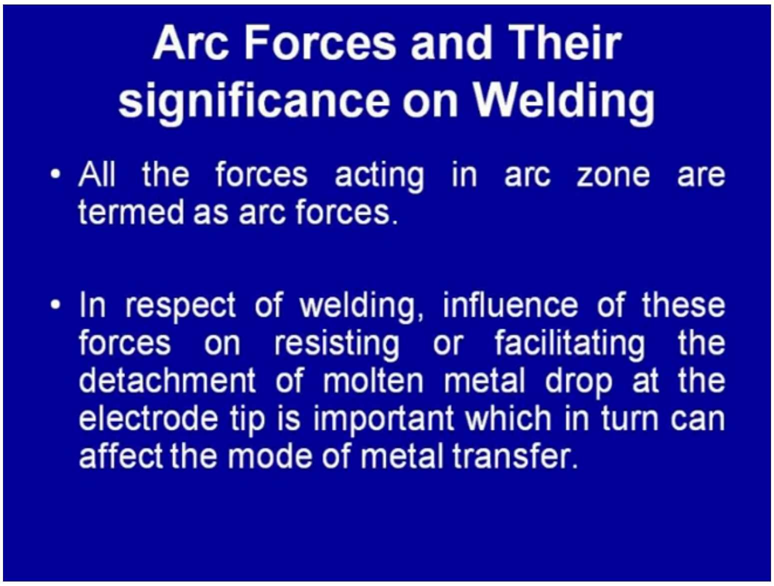

This transfer, mode of the transfer of this the way by which the molten metal is transfer from the electrode tip to the weld pool affects the quality of the molten metal and so the effects of the effects the quality of the weld joint. So, we will see that the forces acting in the arc zone are termed as the arc forces. What these do the in respect of the welding influence of these arc forces affects mainly the resisting or facilitating the detachment of the molten metal drop hanging at the tip of the electrode. This in turn affects the way by which molten metal is transferred from the electrode side to the weld pool side. This mode of the metal transfer governs the way by which the quality of the kind of quality which is obtained after development of the weld joint.

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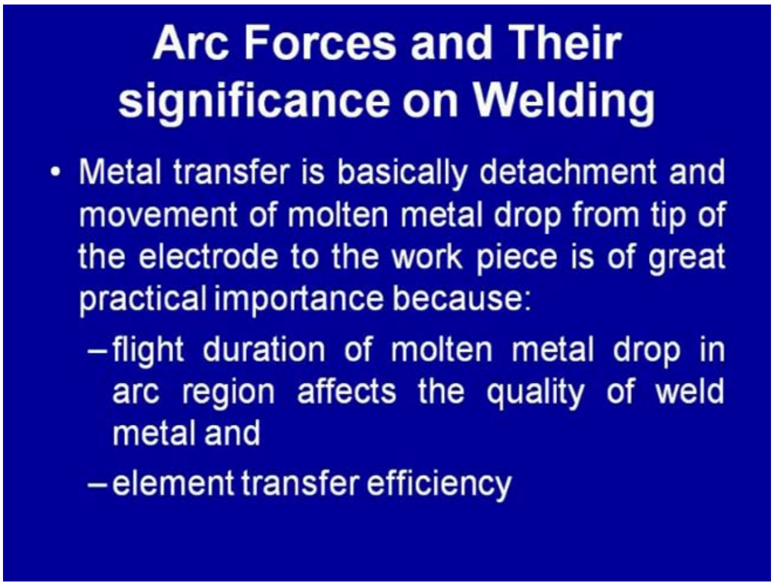

So, the transfer the way by which molten metal is transferred from the electrode side to the weld pool side is called the metal transfer. It is basically the detachment and movement of the molten metal drop from the tip of the electrode to the work piece. It is important to understand, the way by which molten metal drop transfer is taking place because it effects the duration in which the molten metal drop is transferred to the weld pool.

Say for example, longer is the flight duration of the molten metal drop in the arc region, greater will be the affect adverse affect of the gases present in the arc zone on the quality of the molten metal drop, so the quality of the weld joint. Similarly, the element transfer efficiency is also affected by the molten metal transfer mode. Now, we will see schematically the importance of understanding the various types of the forces acting in arc zone and the way by which they affect the mode of metal transfer.

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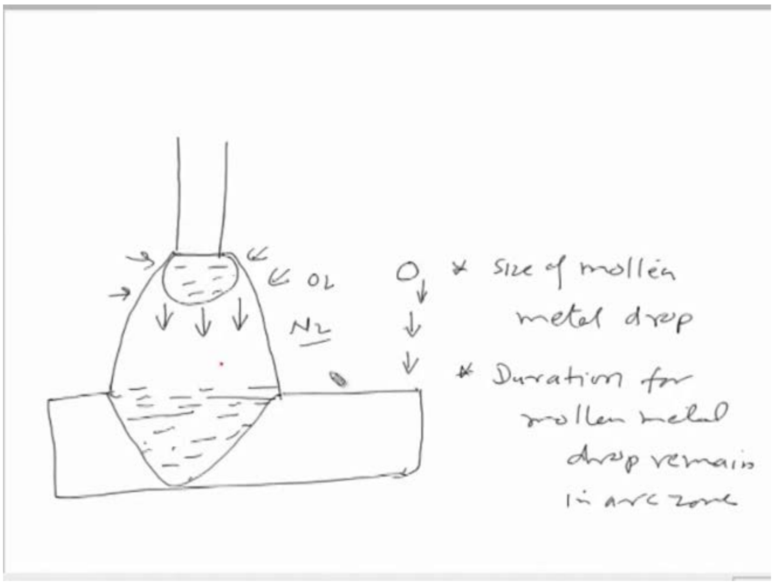

To see this, we need to see that if the tip of the consumable electrode, molten metal drop is being formed then under the influence of the various forces, it is transferred to the weld pool. The way by which it is transferred to the weld pool affects the quality of the molten metal drop. So, this is the molten metal drop and this is the weld pool present in the arc region. So, here the whether the drop in a tense very large size before it is getting transferred to the weld pool or when it is of the smaller size itself and then when it is of very small size even then it is transferred to the weld pool.

So, the size of the molten metal drop this is one aspect, which is influenced by the forces acting in the arc zone. The second is the time in during which it remains in the arc zone before it is transferred to the weld pool. Longer is the time during which molten metal drop remains in the arc zone, greater will be the adverse effect of the gases present in the arc environment in form of the oxygen nitrogen and the other gases. So, greater will be adverse effect of the atmospheric gases and the other gases present in the arc region.

So, the second thing is the duration for which molten metal drop remains in the arc zone. So, greater is the duration for which molten metal drop hangs at the tip of electrode and the greater is the time during which remains in the arc zone, greater will be the affect of the gases present in the arc environment on the molten metal drop. So, accordingly it will be affecting the quality of the molten metal drop molten metal drop.

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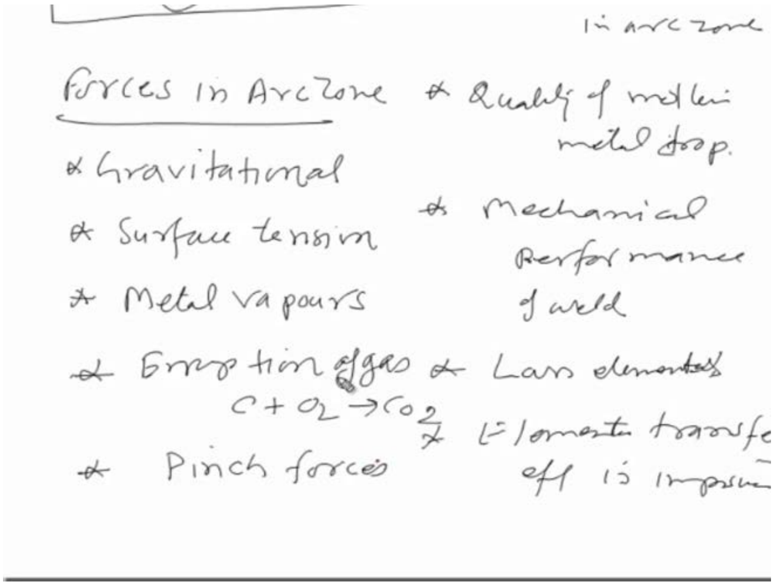

So, if the greater is the effect of the gases present in the arc zone on the quality of the molten metal drop, greater will be the affect of these things on the quality of the weld joint. So, if the molten metal drop is stays in the arc region for longer time, the quality of the weld metal is deteriorated and which in turn adversely affects the mechanical performance of weld joint. So, to avoid these kind of adverse affect, it is necessary that the forces are generated in the arc region is such a way that the duration the tip of the electrode of the molten metal drop is for minimum period and it as soon as it is formed it is transferred to the weld pool.

The second thing is that the alloying elements present with the molten metal also react with the gases present. When these elements react with the gases present in the arc environment these are lost inform of the impurities inform of oxides and nitrides. So, the loss of elements results in the change in composition of the weld pool metal and we do not get the elements which should be there in the weld joint in the desired quantity. The, reduction in the percentage of the elements desired in the weld metal in turn decreases the mechanical performance and the quality of the weld joint.

So, all these things are basically associated with the duration for which molten metal drop remains at the tip of the electrode. So, if the molten metal drop remains for shorter duration, then adverse effect of the gases present in the arc zone, on the molten metal drop will be minimum and the second thing loss of the alloying elements will be reduced, so the element transfer efficiency is improved. So, keeping these things in mind the forces in the arc zone are generated in such a way that the adverse affect due to the longer stay of the molten metal drop at the tip of the electrode and the arc zone can be reduced, so that the better quality of the weld joint can be produced.

If we see the very common forces which are generated in the arc zone or very simple one is the gravitational force. The gravitational force is one due to the gravity effect on the molten metal drop hanging at the tip of the electrode. Another is surface tension force, surface tension force it is due to the viscosity and surface tension forces acting on the liquid molten metal hanging at the tip of the electrode. This force mostly tends to raises the detachment of the molten metal drop hanging at the tip of the electrode. Other is forces due to the metal vapours, forces due to the metal vapours coming from the weld pool side, further resist the detachment of the molten metal drop from the tip of the electrode.

The forth one is the forces due to the eruption of the gases; these gases are generally formed due to reaction of the gases present in the molten metal with the other elements. For example, the oxygen present with the molten metal reacting with the carbon and forming the carbon dioxide to produce the bubbles in the molten metal drop hanging at the tip of the electrode.

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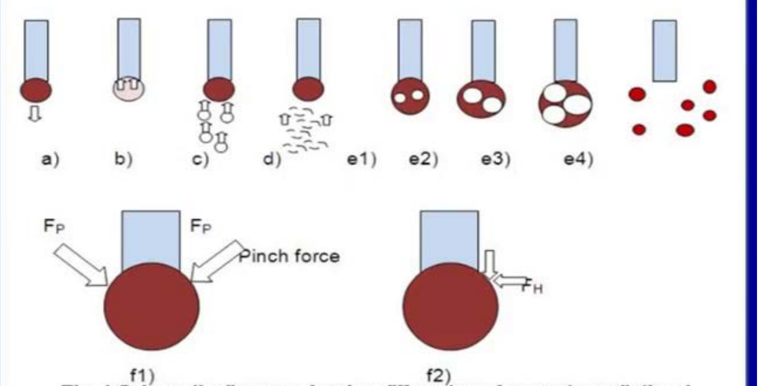

Fig. 1 Schematic diagram showing different arc forces a) gravitational force, b) surface tension force, c) force due to impact of charge particles, d) force due to metal vapours, e1 to e5) stages in force generation due to gas eruption and f1 & f2) electromagnetic pinch force

When these bubbles grow to the large extent then suddenly busting of the molten metal drop takes place, which in turn leads to the significant spattering. Similarly, electromagnetic forces cause the presence of the pinch force at the tip of the electrode, where molten metal drop is hanging. So, now we will see the effect of these various forces acting in the arc zone and how they affect the transfer of the molten metal from the electrode tip.

So, here you see the various types of the forces which are acting. The first diagram which is a showing the diagram a showing that the molten metal drop hanging at the tip of the electrode, this force gravitational force will be acting in downward direction due to the weight of the molten metal drop hanging at the tip of the electrode. Second one is the surface tension force, the surface tension force trends to hold the molten metal drop hanging at the tip of the electrode and thereby it resist the detachment of the molten metal drop from the electrode tip.

Third is the molten these vapours and the charge particles coming in the arc region, so here if we see the various types of the charge particles which are produced in the arc zone. These charged particles according their charged these move either towards the electrode or towards the work piece side. So, the electrons will be moving towards the cathode and the positively charged ions will be moving towards the cathode and negatively charged particles will be moving towards the anode. So, when the high velocity particles like negatively charged particles like electrons moving towards the anode hitting at high velocity and there by resisting the resisting the detachment of the molten metal drop hanging at the tip of the electrode.

Similarly, so this is the case when the charge particles hitting the molten metal drop hanging of the tip of the electrode from the bottom side and there by resisting there detachment from the electrode tip. The next case is say here molten metal vapours coming from the weld pool moving in upward direction and thus the forces acting from the bottom side towards the upward direction in a upward direction. So, the resisting heat attachments of the molten metal drop from the electrode tip. The third and this case means figure e 1 to e 4 shows that how the bubbles grow, if the elements present in the molten metal drop react with the gases present in the molten metal drop itself.

So, like the carbon present in case of steel, if the large amount of the oxygen is present with the molten metal then carbon reacts with the oxygen to form C O 2. Gradually, these bubbles grow and when the bubbles grow to the large extent, eventually the molten metal drop was in form of the fine particles. So, these fine molten metal particles will be moving; will be falling here and there in form of the spatter. So, these kind of forces acting basically due to the generation of the gases and then suddenly busting of the molten metal drop resulting in the falling of the molten metal particles here and there. So, producing lot of spattering, reducing the deposition, if we since see of the weld metal.

The next force is the electromagnetic force which, basically acts due to the interaction between the electromagnetic forces generated in the arc zone and the electromagnetic forces due generated due to the charged particles. So, these forces a basically tend to pinch the molten metal drop hanging at the tip of the electrode at particular angle. So, this efforts will be acting at particular angle, it disc angle can be because of this force acting at particular angle.

This can be dissolved into the two components one is vertical and another is horizontal. So, the horizontal force tends to reduce the cross section of the molten metal drop hanging at the tip of the electrode while the vertical component of the force tends to detach the molten metal drop hanging at the tip of the electrode. Thus when the pinch force is acting on the molten metal drop it tends to detach the drop from the tip of the electrode even when the size of the drop is very small and this force becomes dominant and very significant when the welding current is high.

So, we work with the high welding current pinch force magnitudes becomes high and which in turns results in the detachment of the drops from the electrode tip When it is of very small in size. This type of the transfer, results in the spray transfer when the drops are formed very rapidly. And these are detached at faster rate even when they are of very small in size and gives the feeling of like development of a the spray or the spray of the molten metal from the electrode side towards the work piece side on the weld pool. Now, we will see one by one these forces what are the factors that affect these forces and how these affect the metal transfer related aspects, the gravitational force this force is mainly due to the gravitational.

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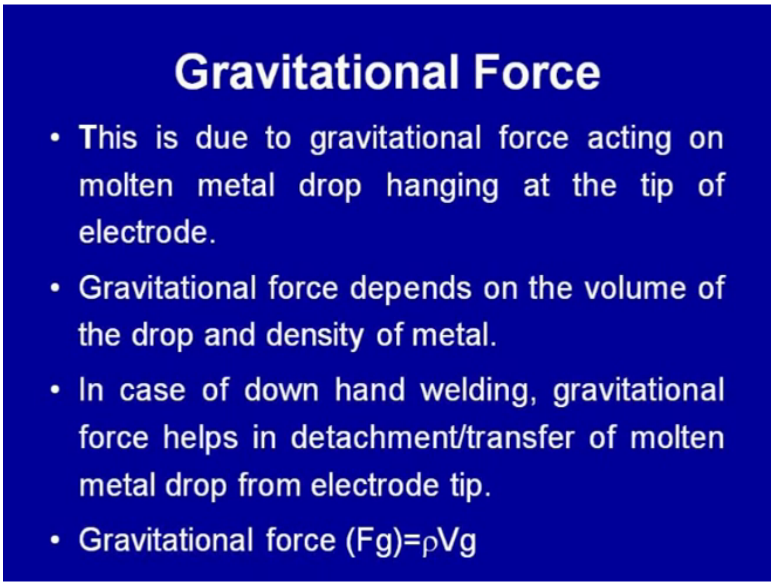

Gravitational force acting on the molten metal drop hanging at the tip of the electrode, this force depends on the size of the drop that is determining the volume of the drop and the density of the metal. So, larger is the size of the drop, larger will be the volume of the molten metal with the drop and if the density is high then the gravitational forces acting on the molten metal drop will be more. So, in case of the down hand welding the gravitational force acting in downward direction tends to the help in detaching or transferring the molten metal drop from the electrode tip.

If we see this equation here, the gravitational force acting at the tip of the acting on the molten metal drop is govern by the row v g. Where row is the density of the metal in question and the v is a volume of the drop, which is determine directly by the size of the drop hanging at the tip of the electrode and g is the gravitational coefficient. So, larger is the size greater will be the gravitational force. Specially, in case of the down hand welding the gravitational force tends to detach the drop from the electrode tip and thus facilitates in the metal transfer.

So, if higher is the density and larger is the size, then the more will be the gravitational force. So, for large high density materials the detachment will be occurring at the higher rate and much earlier without tending the large size of the molten metal drop at the electrode tip. Next is the surface tension force this forces experience by the drop of the liquid material hanging at the tip of the electrode due to the surface tension effect. So, if you see here in the next diagram.

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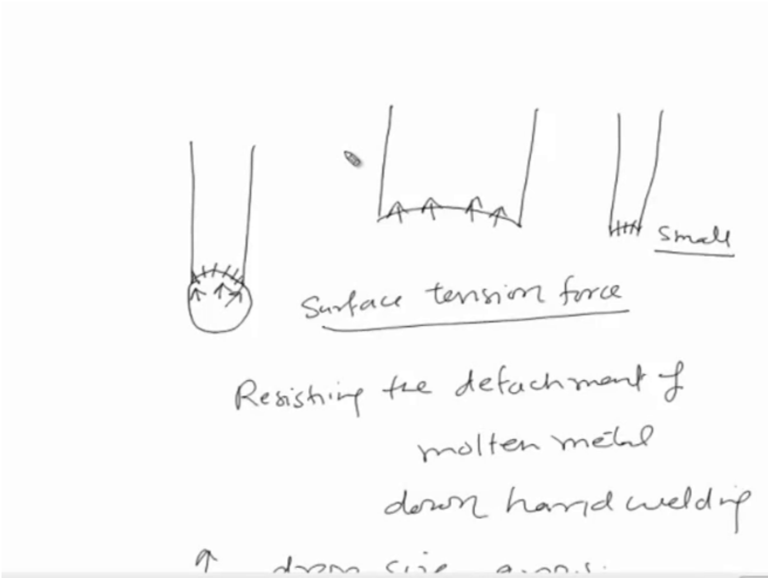

So, this is the electrode which is being used in this is the molten metal drop hanging at the tip of the electrode. So, this is the area through which molten metal drop is in contact with the electrode surface and because of the surface tension forces, this forces will be tending to hold the molten material drop with the electrode tip itself. Thereby resisting the detachment of the molten metal and this resistance is mainly experienced in case of the down hand welding position. So, if this force is resisting the detachment of the molten metal drop then means indirectly, it will be helping the drop size to grow.

So, the increased in the size of the drop is mainly facilitated by the surface tension force. If high surface tension forces acting then obliviously, it will be it will be making sure that the drop grows to the large size before it is detached from the electrode tip. So, higher is the magnitude of the surface tension force, greater will be the size of the molten metal drop which it will attain before its detachment. This surface tension force is affected by the viscosity and the viscosity is one and the other thing is the size of electrode tip.

If the larger is the size of the electrode, greater will be the area, which will be offering the surface tension force acting at the tip of the electrode as compare to the case when the electrode size is small. If the electrode size is very small then the surface tension force magnitude will be less and it will not be able to resist much to the detachment of the molten metal drop hanging at the tip of the electrode. So, the size of the electrode is one of the parameters the same way the temperature generated in the arc zone under the welding conditions.

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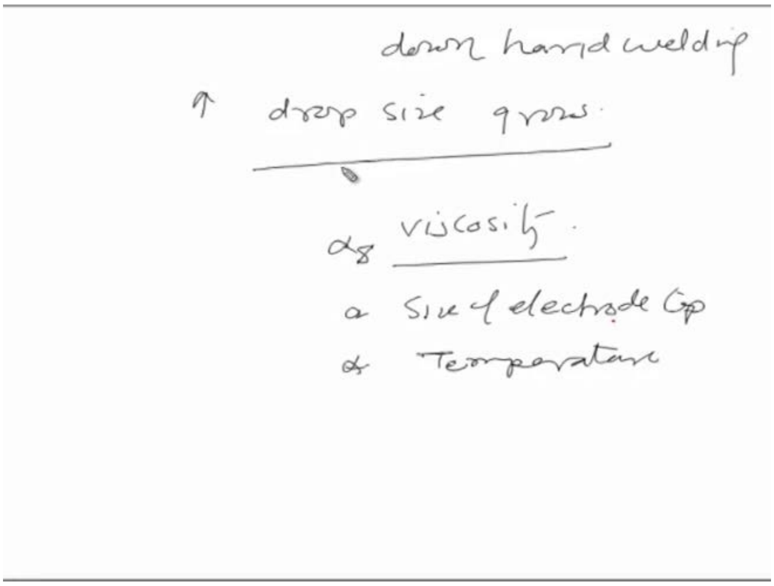

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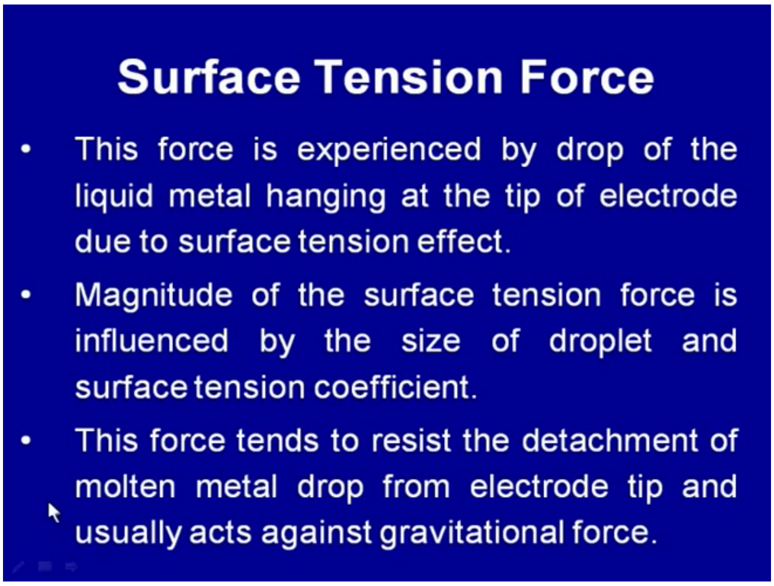

If higher is the temperature generated in the arc zone then the higher will be temperature of the molten metal in a high temperature of the molten metal will be reducing surface tension and the viscosity and which intern will be reducing surface tension force. A reduction in the surface tension force will be leading to the early detachment of the molten metal drop hanging at the tip of the electrode before it attends the larger size.

Now, this is how we will see that how does it affects the molten metal transfer hanging at the tip of the electrode. So, the magnitude of the surface tension force is influenced by the size of the droplet surface tension coefficient. Apart from these two parameters as I said, the size of the electrode tip which will be dictating to the size of the droplet and the viscosity related aspects. So, this force tends to resist the detachment of the molten metal drop from the electrode tip.

Therefore, it usually acts against the gravitational force in the down hand welding position, the gravitational force acts in downward direction while the surface tension surface force acts in the upward direction. So, it will be counter acting or it will be acting against the gravitational force acting on the molten metal drop surface. Well, in case of the vertical and over head welding positions, surface tension force helps to place the molten metal at the required position more effectively and thereby reducing the tendency to fall down.

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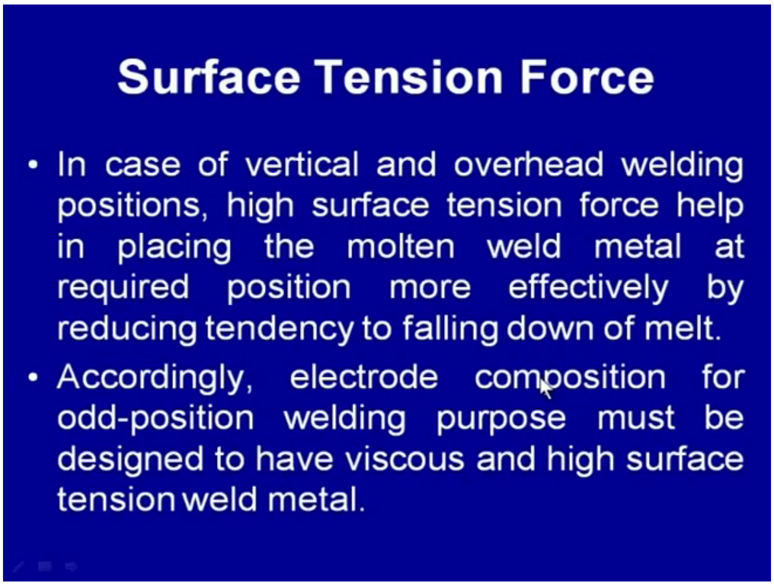

So, the main thing is here that is the surface tension force decreases the falling tendency and increases the resistance to the detachment of the drop then it is used effectively for placing the molten metal specially, in the odd position. If we are working in the over head and in the vertical positions and it is always desired that molten metal has the good viscosity and the surface tension, so that molten metal does not flow down and it does not fall down rapidly from the area where it has been placed. So, for this purpose sometimes the electrode coating and the fluxes are design in such a way the surface tension, for high surface tension force molten metal is generated. So, that it does not fall down rapidly specially when working with the vertical and over head welding positions.

So, if we see here the electrode composition for odd position, welding purpose is there for must be designed, so that molten metal is having enough high viscosity and surface tension force, so that this kind of falling tendency can be reduced. We see to calculate the surface tension force here, twice of the sigma pi R e square divided by 4 R, where the sigma is surface tension coefficient, pi is a coefficient and the R e is a size of the radius of the electrode tip, which is governed by size of the electrode.

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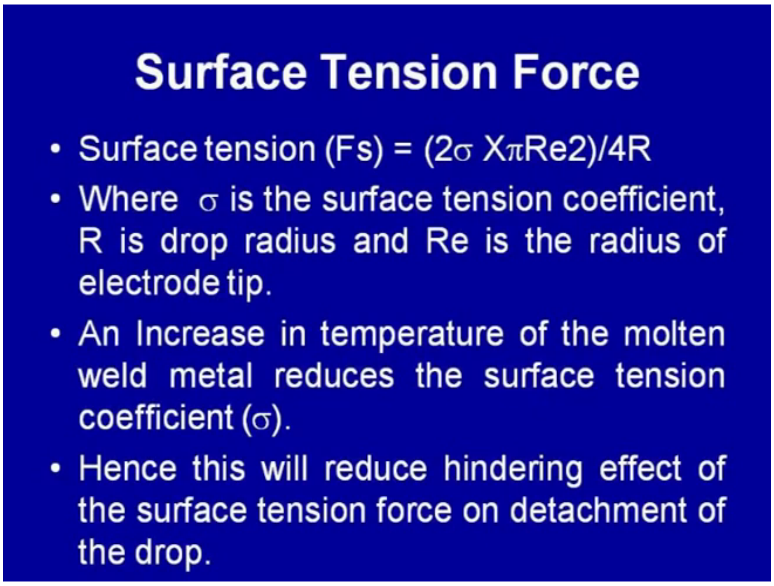

So, half of the electrode diameter will be corresponding to the radius of the electrode tip and the capital R is the radius of the molten metal drop hanging at the tip of the electrode. So, if you see these equations, greater is the size of the electrode then higher will be the surface tension force. Similarly, higher is the surface tension coefficient of the molten metal higher will be surface tension force, but if the drop rate size is big then surface tension force will be a small. So, the large size the drop will be adversely effecting magnitudinal surface tension force, which will be acting at the tip of the electrode which is trying to hold the molten metal drop at the tip of the electrode.

Further, increasing temperature of the molten metal since reduces the surface tension coefficient and viscosity and therefore, any factor like welding current, welding voltage, arc length which is increasing the temperature of arc region. The temperature of the molten metal will be reducing the surface tension force magnitude and thereby facilitating the transfer of the molten metal droplets of the electrode tip towards a weld pool even when they are of the small in size. Hence, this reduces the hindering effect of the surface tension force on the detachment of the droplets.

Now, we will see the third type of a force which acts in the arc region it is the process due to the impact of the charge carrier. We know that in the arc zone the gap between the electrode tip at the work piece is full of the charge particles, to facilitate the flow of current from the electrode side to the work piece side.

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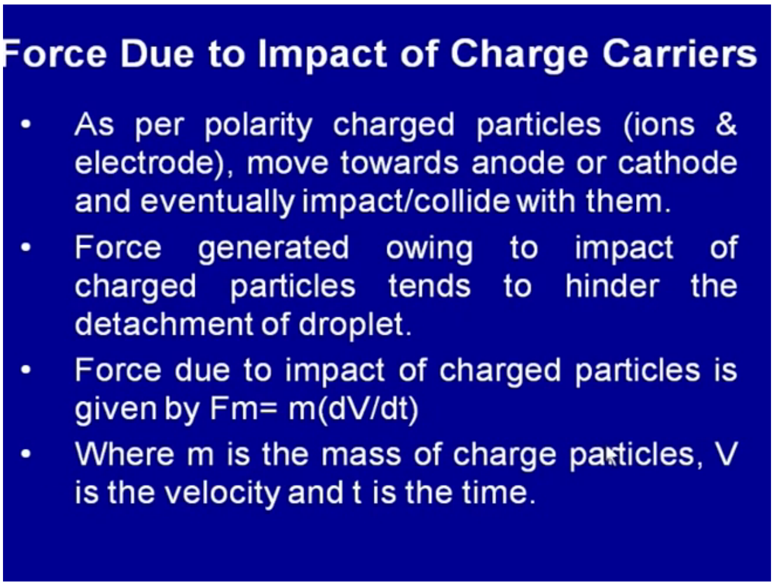

So, that arc can be maintain and the heat can be generated uniformly, these charge particles move continuously from the one side to another. So, the ions will be moving towards the cathode and the negatively charged particles like electrons will move towards the anode. When these move and impact with the either cathode or with the anode, they result in generation of the some force.

So, force generated due to the impact charged particles tends to hinder the detachment of the molten metal drop. The force due to the impact of the charged particles is given by the mass of the charged particles m multiplied by the rate at which the velocity is being changed that is the acceleration. So, the m is a mass of charged particles and v is the velocity of the particle at which it is moving and the t is the time rate at which the velocity is changing.

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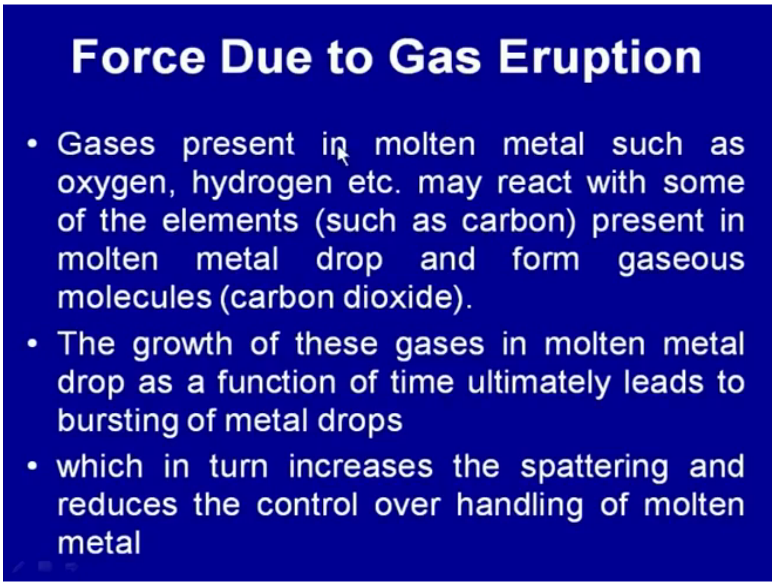

The third force is the force due to the gas eruption, as I said these gas eruption forces due to the gas eruption mainly develop when the elements present in the molten metal drop reacts with the gases present in the drop itself. So, this reaction results in development of the gases drops and forms the large bubbles inside the molten metal drop. When these grow to the large extent busting of the molten metal drop takes place, resulting in spattering of the molten metal or falling of the molten metal particles here and there.

So, the gases present in the molten metal such as oxygen and hydrogen may react with the some of the elements, such as carbon present in the molten metal drop and form the gaseous molecules like carbon dioxide. When, these gases grow in the molten metal drop as a function of time ultimately these leads to the bursting of the molten metal drops which in turn increases the spattering and reduces the control over the handling of the molten metal.

So, if this is taking place as the larger extent then the deposition efficiency is reduced and the molten metal particles will be depositing here and there. This will be increasing the stress concentration and adversely affecting the mechanical performance of the weld joint, so it is always desire to reduce the spattering. To avoid this kind of force, so that the desired molten metal can be placed in the positions where it is required to develop the sound weld joint which can take the mechanical loads and perform the desired function. The next force is a force which is generated due to the electromagnetic field.

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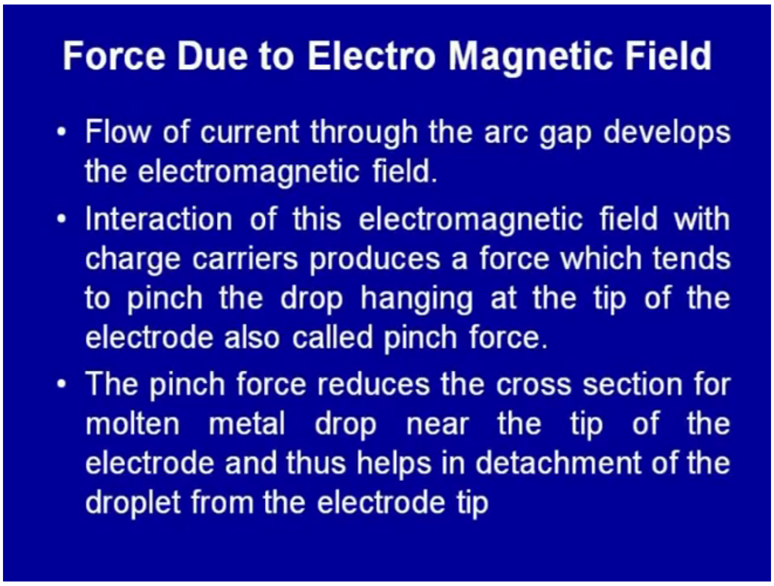

This kind of force is mainly generated due to the flow of current through the arc zone and here, there is a flow of current through the arc gap. It develops its own electromagnetic field and when this electromagnetic field interacts with the electromagnetic field generated by the charge particles themselves a force is generated. This tends to pinch of the hanging drop the molten metal drop hanging in the tip of the electrode. So, here these pinch forces raise a significant role in determining the mode of the metal transfer or the size at which it is detached from the electrode tip.

The pinch force reduces the cross section of the molten metal drop hanging near the tip of the electrode and that is helps in detachment of the droplet from the electrode tip. So, we see that since the pinch force acts at a particular angle on the surface of the molten material drop hanging at the tip of the electrode.

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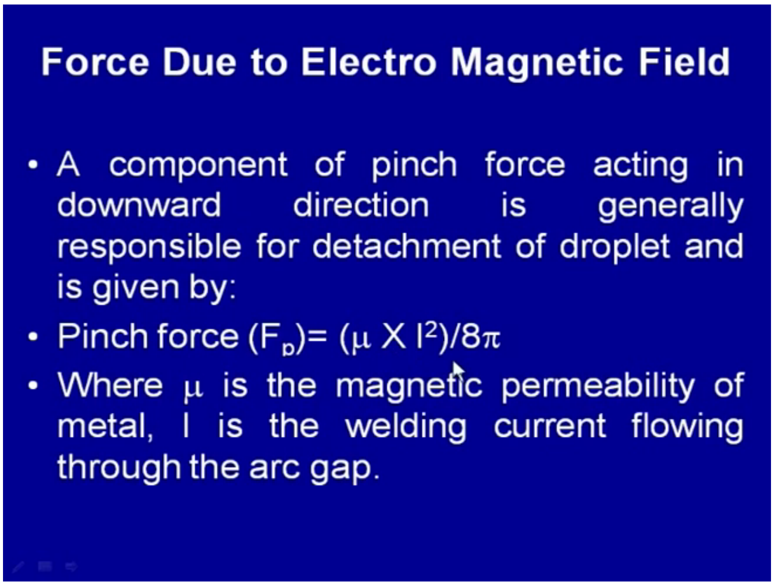

Therefore, it is one component of the pinch force acting in downward direction is generally held responsible for detachment of the molten material drop and this force is given by the mu multiplied by I square divided by 8 pi. So, here if we see mainly the pinch force is governed by the welding current, higher is the welding current and the higher is the pinch force which is generated.

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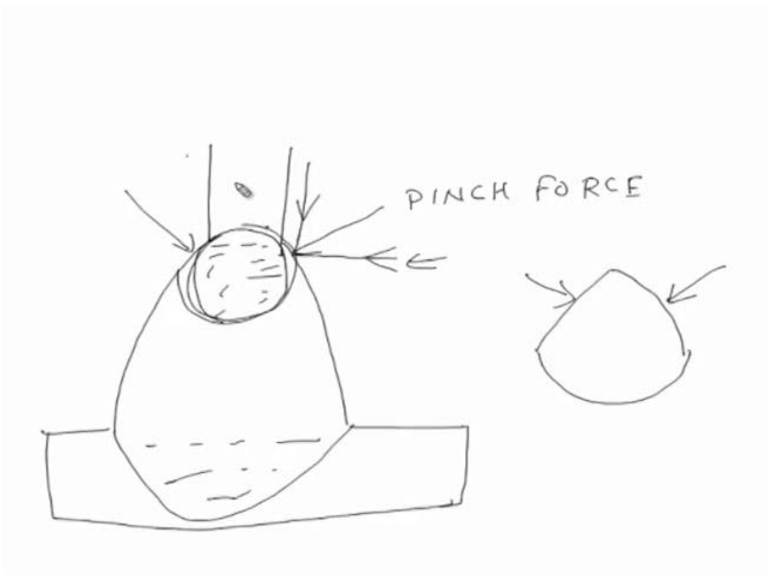

If we see here to understand this clearly, if we can look in to the way by which pinch force acts during the welding, this is the arc, this is the weld pool, this is a base metal and say molten metal drop is hanging at the tip of the electrode like this. So, the pinch force always acts at particular angle like this, we can say as pinch force, this pinch force acts at an angle on the molten metal drop hanging at the tip of the electrode like this. So, acting a particular angle, so this force working at a particular angle can be resolved in to the two components, this is the horizontal component and this is vertical component.

So, horizontal component tends to press the electrode tip, electrode molten metal drop hanging at the tip of the electrode and this pressing by the horizontal force tends to reduce the cross section of the molten metal drop size.

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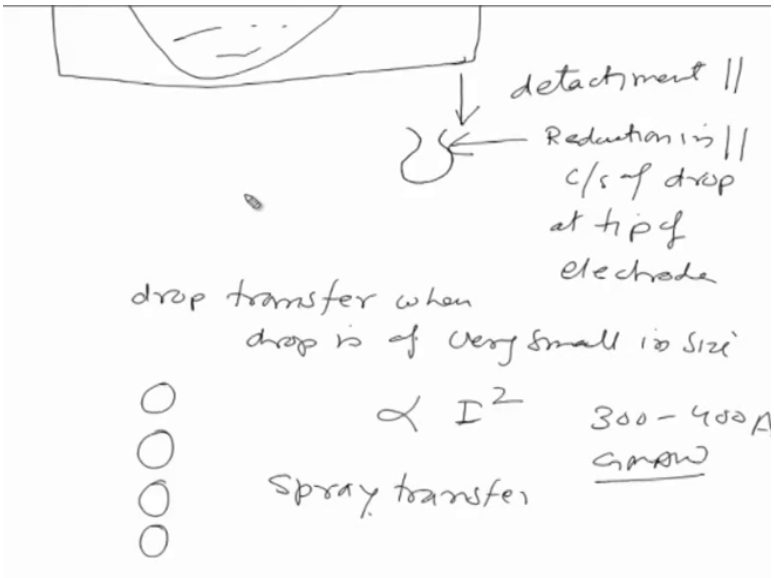

So, this reduction in the cross section of the drop at tip of electrode, this is one affect which is because of the electromagnetic force acting in form of the pinch force and this reduction apart from this reduction in cross section of the molten metal drop hanging at the tip of the electrode. The force component acting in downward direction helps to detach, so detachment is basically facilitated by the vertical component acting in downward direction, while the force acting horizontally tends to reduce the cross section of the molten metal drop.

So, this reduction in cross section as well as force is acting in downward direction facilitates the drop transfer, when the drop is of very small in size and magnitude of this force is a directly proportional to the I square. So, at low level of current this magnitude of this force may not be very high and this magnitude of this force may not be very high. But as current magnitude is increase say 300 or 400 amperes in case of the G M A W welding process. Magnitude at high level of the current, high pinch forces generated and the pinch force becomes so high that the molten metal drop is detached very rapidly by this pinch force effect.

It is transferred continuously even when it is of very small size giving a feeling like the spray of the molten metal from the electrode tip to the weld pool. So, accordingly this kind of transfer is called spray transfer and it is this kind of transfer takes place mainly because of the electromagnetic force causing the pinch force. So, pinch force basically causes the spray transfer specially when working with the high level of the welding current.

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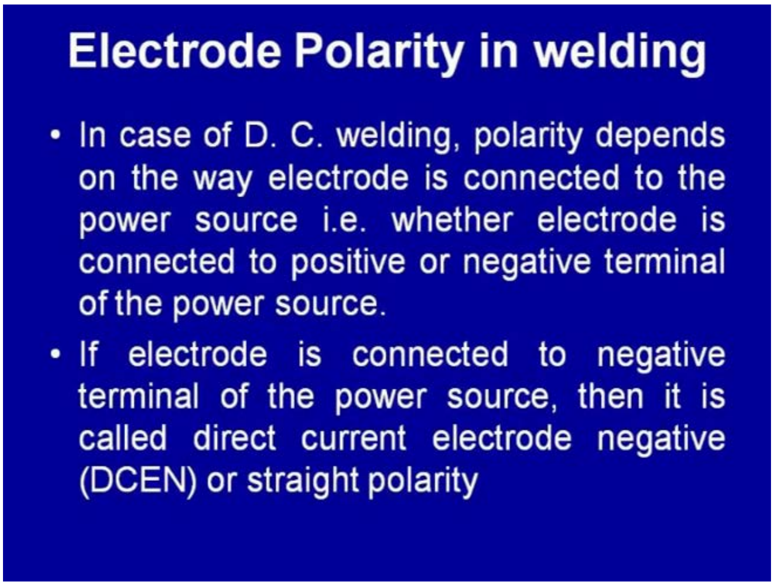

So, as we can see that pinch forces given by the mu, that is magnetic permeability or it is a welding current used and divided by 8 pi, so others are the coefficient. So, I is a welding current flowing through the arc gap, it is direct this equation is suggesting that I use of the high welding current results in the higher pinch force. Now, we will see that welding can be performed using the two types of the currents one is AC and another is

DC. So, when AC current is used the polarity continuously changes after each half cycle, while in case of the DC the polarity remains constant and the direction as the direction of the current and its magnitude largely remains constant.

So, the polarity continuously changes in case of the AC, while in case of the DC welding polarity remains fixed and it depends up on the way by which electrode and the work piece have been connected to the power supply. So, the connection type of connection determines the nature of the polarity being used during the welding. So, if the electrode is connected to the, if electrode is connected to the positive terminal of power supply, we say that the electrode positive polarity or if electrode is connected to the negative terminal of the power supply we say that electrode DCEN or DC electrode negative polarity.

So, in case of the D C polarity depends up on the way by which electrode is connected to the power source, there electrode is connected to the positive or negative terminal of the power source. If the electrode is connected to the negative terminal of the power source then it is called the direct current electrode negative that is called DCEN and it is also termed as the straight polarity. So, when electrode is connected to the negative terminal of the power supply, this termed is straight polarity or the DC electrode negative.

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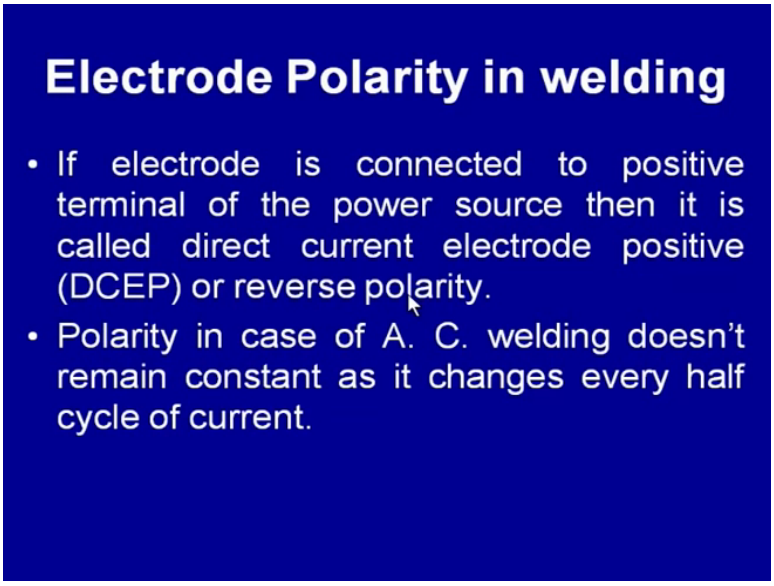

Similarly, when the electrode is connected to the positive terminal of the power source then it is called direct current electrode positive that is DCEP and this type of polarity is also called reverse polarity. So, depending upon the way by which that connection have been made we can have the positive DCEP or DCEN, that is straight polarity or reverse polarity. So, polarity in case of the AC welding does not remain constant as it changes continuously after each half cycle after each half cycle there will be continues change in magnitude of the current and the direction of the current.

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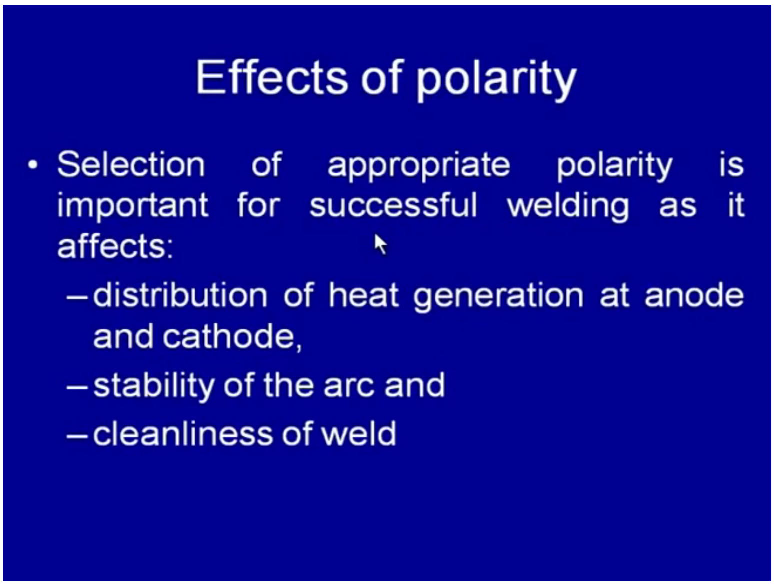

So, that is about the kind of polarities which are there in case of specially, in case of DC welding, to look into that how what is the importance of the polarity and how it can be used effectively, so that the successful and sound weld joint can be made. Selection of the polarity is important because it affects the various aspects related to the welding significantly. These are like distribution of the heat being generated at the anode and cathode is directly governed by the kind of polarity which is being used.

Apart from the heat generation at the anode or cathode side, the stability of the arc and the cleanliness of the weld is also dictated by the polarity being used, while the relative effect of the polarity may not be same, welding the verity of the metals. So, depending up on the kind of metal systems the effect of the polarity on the development of the sound weld joints can vary significantly, this is what we will see in detail in the coming slides.

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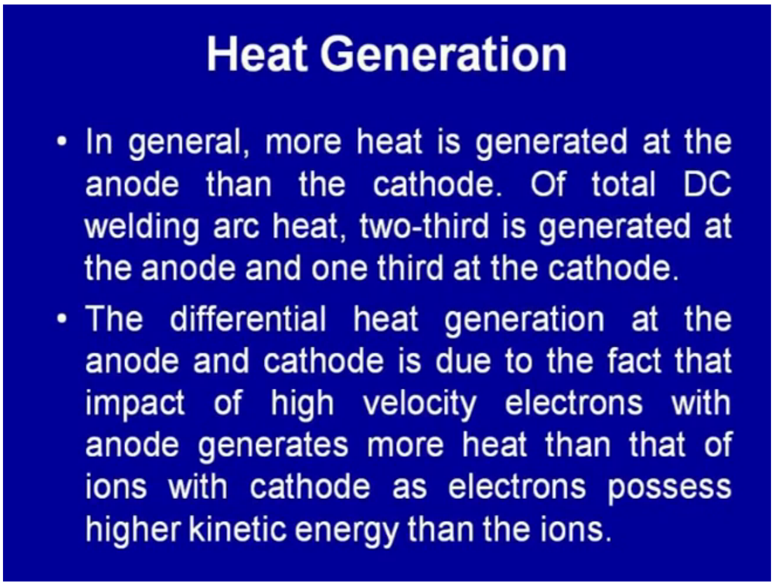

So, as far as heat generation is concerned the heat generation, we know that when the current flows during the welding the power of arc is given by the v i. So, to this v i determine basically, the amount of heat being generated during the welding, but the amount of heat is not equal specially, when we are using the DC. So, the more heat is generated in case of the anode side than the cathode side of the total DC arc welding heat generated about two-third is generated at the anode side and one-third is generated at the cathode side. So, this skew distribution of the heat generation is used in effective way as per the needs for developing the sound weld joint.

If this is taking care of properly otherwise it can adversely affect the production rate, welding speed and the electrode life. So, this differential heat generation at the anode and cathode is primarily attributed to the impact of the high velocity electrons with the anode and which in turn generates more heat than the ions which collide with the cathode side. These ions move very slowly and therefore, the energy generated by them on the impact is less and therefore, some metal less heat is generated on the cathode side with the impact of the ions. So, the more heat is generated on the anode side due to the high velocity impact of the electrons moving in the arc zone while somewhat lesser heat is generated on the cathode side due to the impact of the ions which move at the low speed.

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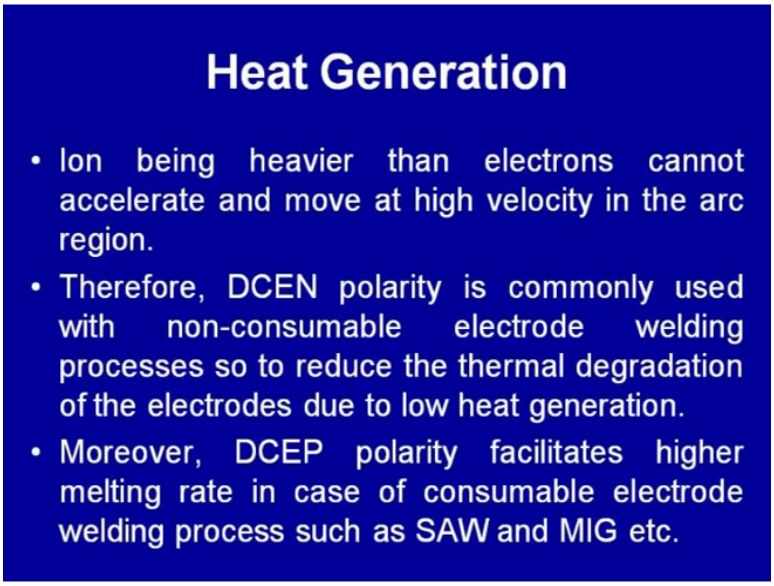

So, ions being high, being heavier than the electrons cannot move and accelerated at faster rate and therefore, they move slowly in the arc region and do not impact the cathode at a high velocity. Therefore, these in term results in the generation of the lesser heat in the cathode side than the anode side. Therefore, DCEN polarity is commonly used with the non consumable electrode welding process in order to reduce the thermal degradation of the electrodes due to the heat generation. We know that the electrodes which are commonly non consumable welding processes use the electrodes like tungsten and carbon and these are the reflective materials, which melts at a high temperature.

So, if the less heat is generated on the electrode side then adverse effect of the heat generation in the arc zone is reduced. Therefore, intentionally in the non consumable arc welding processes, where either tungsten or the carbon is being used as a electrode, it is required or it is desirable that the lesser heat is generated on the electrode side. So, that adverse effect of the heat generation in the arc zone can be reduced. Therefore, for non consumable arc welding processes it is common to work with the DCEN, there is the electrode negative polarity, so that the lesser heat is generated on the electrode side.

While in case of the DC electrode positive polarity, higher generation of the, high amount of heat in the electrode side results in the higher melting rate of the electrode. Specially, in case of the consumable electrodes, in consumable electrode welding process, it is desired that the tip of the molten tip of the electrode melt at faster rate. So, that the molten metal can be transferred at higher rate in the weld joint weld group, so that the weld can be produce at the higher rate.

So, the welding processes like submerged arc welding and metal inert gas welding, where melting of the consumable electrode is important for higher welding speed. It is desired that the melting takes place at the faster rate, so the generation of the more heat on the electrode side by use of the DC electrode positive polarity, facilitate the high melting rate and so the higher welding speed. So, it is common for welding of the thick sheets using metal inert gas welding process as a submerged arc welding process to use the DC electrode positive polarity, another aspect that is affected by the polarity is the stability of the arc.

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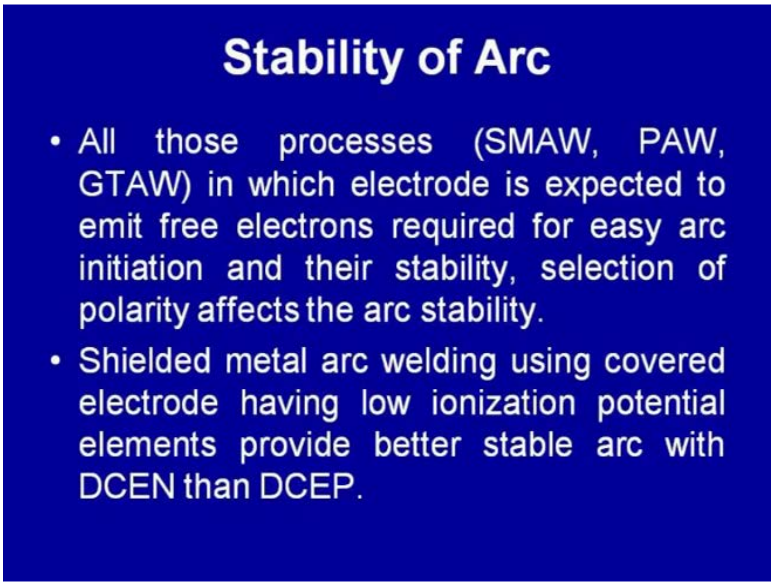

All those process where electrodes are expected to produce the free electrons, the polarity affects the stability. Those metal systems which are good electron emitting elements or good metals like metals like the tungsten, which are tungsten electrode, which are is expected to release the electrons, so that the good arc stability can be obtain and the arc can be initiated easily. It is desired that those metal systems and the electrodes are connected to the electrode negative polarity. So that they can be made cathode, so that electrons can be emitted easily and arc can be initiated.

So, those welding process like in the shielding metal arc welding, plasma arc and the gas tungsten arc welding process in which either low ionization potential elements like calcium and potassium are added with flux. In case of submerged arc welding process or tungsten electrode is used in the plasma and the gas tungsten arc welding process in the both the cases. It is expected at these elements and these metals will emit the electrons to have the easy initiation and stabilization of the welding arc.

So, in these cases it is invariably desired that the electrodes are connected to the negative terminal of the power supply. So, that the electrons can be released easily and the arc can be initiated and stabilized easily. So, instead of the DCEP, DCEN is normally used under those situations, where electrode is expected to emit the free electrons required for easy arc initiation and their stability. So, well in case of the DC, in case of the shielding metal arc welding process with the DCEP gives a smoother arc.

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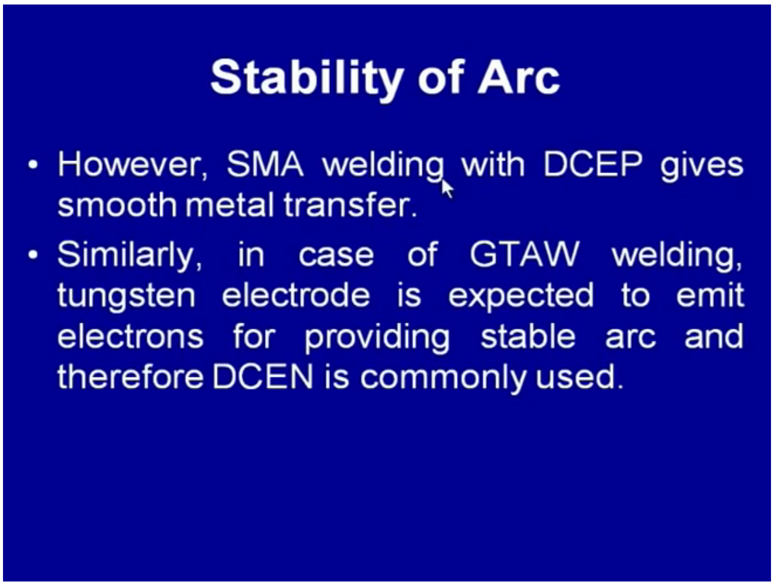

But the arc stability becomes the poor, but the metal transfer becomes the smoother. Similarly, in case of the GTA welding process, the tungsten electrode is expected to emit the electrons for providing the stable arc and therefore, DCEN is commonly used. So, this is how, now we will conclude this presentation regarding the effect of the polarity and the arc forces. In this presentation, mainly we have talked about the importance of studying the arc forces, the way by which arc forces effect the molten metal transfer and the detachment of the molten metal from the electrode tip towards the weld pool.

And what are the various types of the polarities, and how do they effect the development of the sound weld joint. In coming lectures, we will see that what are the adverse effects related with the arc blow? What is a mechanism of arc blow, and how to take care of the adverse effect related to the arc blow.

So, thank you for your attention.