Manufacturing Process – I

Prof. Dr. D. K. Dwivedi
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture - 9
Gas Metal Arc Welding

Welcome students. We will continue the lecture on Gas Metal Arc Welding Process. In the previous lecture, I have covered the welding power sources which are used in this process, the electrode materials, and electro diameter aspects wire feed unit, and had just started the shielding gas aspects. In detail we will see the different shielding gases for the different materials, and how the shielding gases affect the performance of the weld mends.

In addition to the shielding gases, I will also see one by one the effect of the welding parameters like welding current, welding voltage, travel speed on the performance of the weld mend, and the one variant of the gas metal arc welding process, that is the pulse metal in inert gas welding. We will see its principle and its effect on the performance and the soundness of the weld joint which is given by the pulse gas metal arc welding process. Then, we will see some of the advantages, disadvantages related with this process along with the applications. So, in gas metal arc welding process, shielding gases plays a significant role because protection to the weld pool from the atmospheric contamination is provided mainly by the shielding gases.

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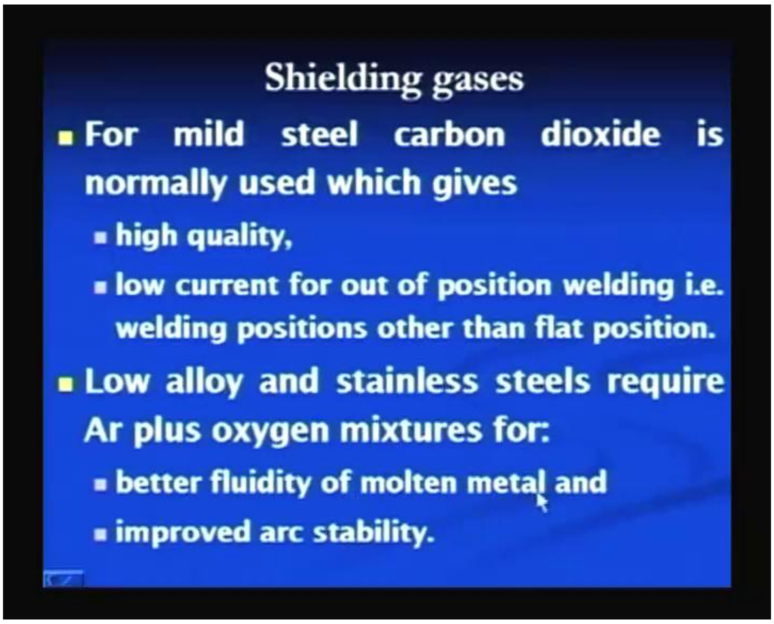

Shielding gases which are commonly used in the gas metal arc welding process, or either argon or helium or helium-argon mixture or active gases like CO2 N2 and hydrogen oxygen or their mixture with the carbon dioxide. For mild steel, mainly carbon dioxide is used as a shielding gas because it is capable to produce high quality weld joints that too economically, and the low currents are possible for welding with the CO2 as the shielding gas and that allows to weld in odd positions also because the low welding current makes sure that fluidity of the material is not that high, and in that way, it prevents the falling down of the molten metal from the weld pool.

When welding is carried out in odd positions, particularly for the low alloy steel and stainless steel metal welding argon and oxygen mixtures are used particularly because these offers the advantage of the better fluidity of the molten metal and the improved arc stability. So, in the ferrous metals like mild steel or the low alloy steel and stainless steel, argon and oxygen mixture or the carbon dioxide are used as shielding gases.

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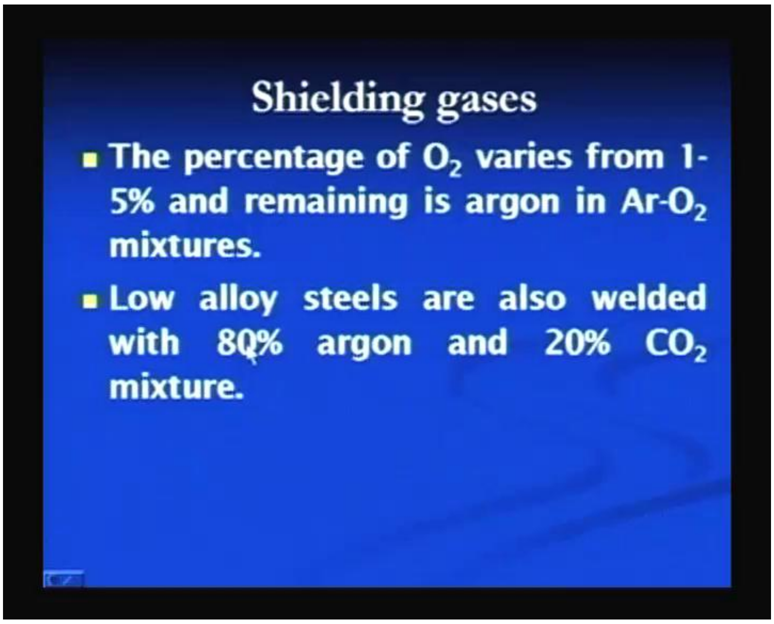

The percentage of the oxygen which is added with the argon normally varies from 1 to 5 percent and the remaining it can be, means the percentage of oxygen can be in range of 1 to 5 percent and remaining is the argon in argon-oxygen mixture, and low alloy steels are also welded with 80 percent argon and 20 percent CO2 mixture.

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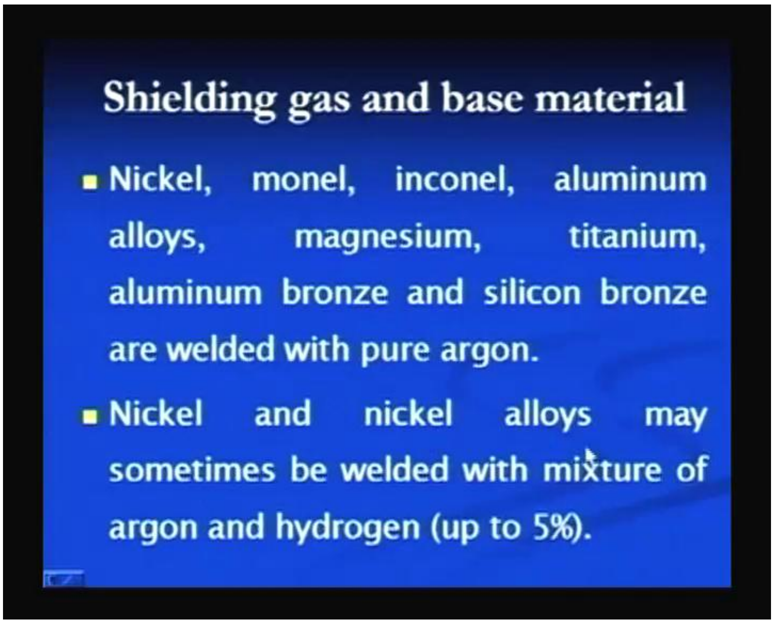

For the different specific metals, some shielding gases are normally used like for nickel, monel, inconel, aluminum alloys, magnesium alloys, titanium, aluminum bronze and silicon bronze. These metals are effectively welded by using pure argon because these are sensitive to the atmospheric oxygen particularly. So, proper protection from the atmospheric oxygen is required, and that is provided by the inert shielding gas when it is in pure form instead of active gases. Nickel and nickel alloys may sometimes be welded with the mixture of the argon and hydrogen because addition of the hydrogen helps the welding arc to burn hotter and increase the welding speed and the penetration aspects. So, argon and hydrogen mixtures are also used in to get the benefit of the higher welding speed and deeper penetration in the welding of nickel and nickel alloys.

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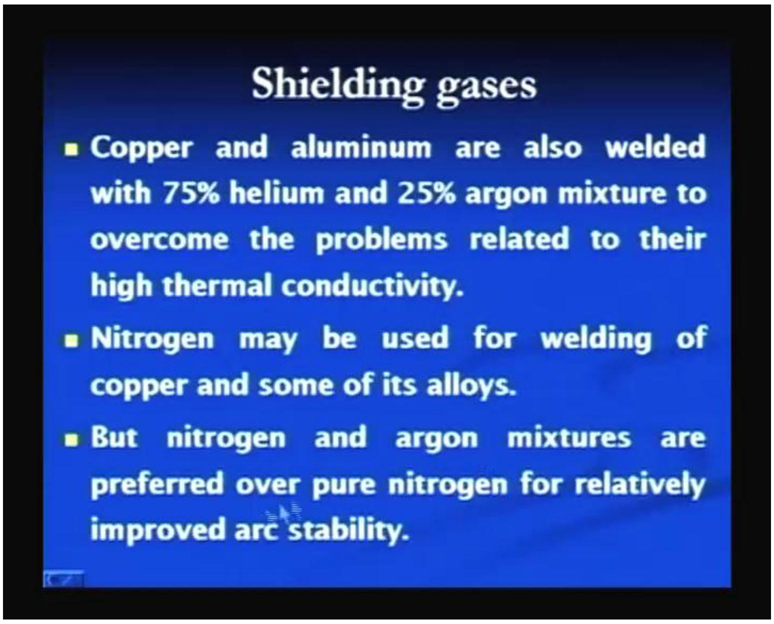

The copper and aluminum alloys are also welded with 75 percent helium and 25 percent of argon mixtures to overcome the problems related with their thermal conductivity. Here, helium helps to burn the arc hotter and the conductivity of the helium is much higher than that of argon, but the argon helps to provide the better arc stability and in order to take the advantage of both inert gases like a presence of argon makes the arc more stable and smooth, while the presence of helium helps to burn the arc hotter and provides the more effective heat transfer from the arc and the base material.

So, the presence of both like 75 percent of helium and 25 percent of argon mixture helps to overcome the problems related with the high thermal conductivity of aluminum and copper because if the thermal conductivity of the base metal is very high, heat will be immediately transferred away, and the weld area to the base metal and melting of the base metal or the faying surfaces may become difficult. So, if the mixture of helium or argon is used, helium will effectively be able to transfer the heat generated from the arc to the base metal, and will help to melt the base metal effectively even if it is there in form of copper or aluminum which are having high thermal conductivity.

Nitrogen may be used for the welding of the copper and some of its alloys, but the nitrogen and argon mixtures are preferred over the pure nitrogen for relatively improved arc stability. It is better to use mixture of argon and nitrogen rather than pure nitrogen as a shielding gas for better arc stability reasons.

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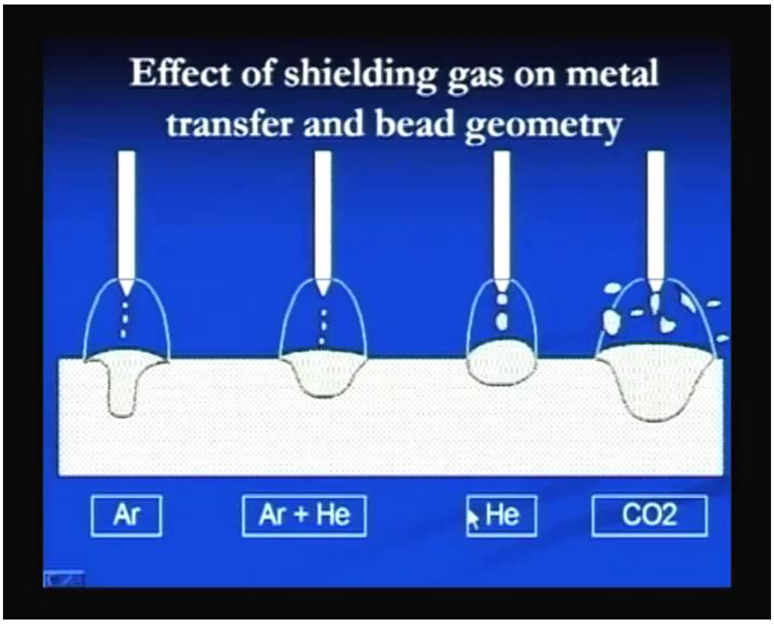

Shielding gas we have seen. There are different types of shielding gases which are used in gas metal arc welding process. These are say argon, argon helium, helium or CO2. When these shielding gases are used, we get the different kind of bead geometries and different types of the metal transfers. We will see here argon offers the deeper penetration and somewhat lesser width of the weld bead. Here the penetration is reduced and the width somewhat increases with the argon and helium mixture, and here helium optimum penetration and width is obtained when helium is used, that is shielding gas. Somewhat wider large cross-sectional area of the weld bead is produced with presence of some spatter and during the transfer of the metals is observed when CO2 is used as a shielding gas.

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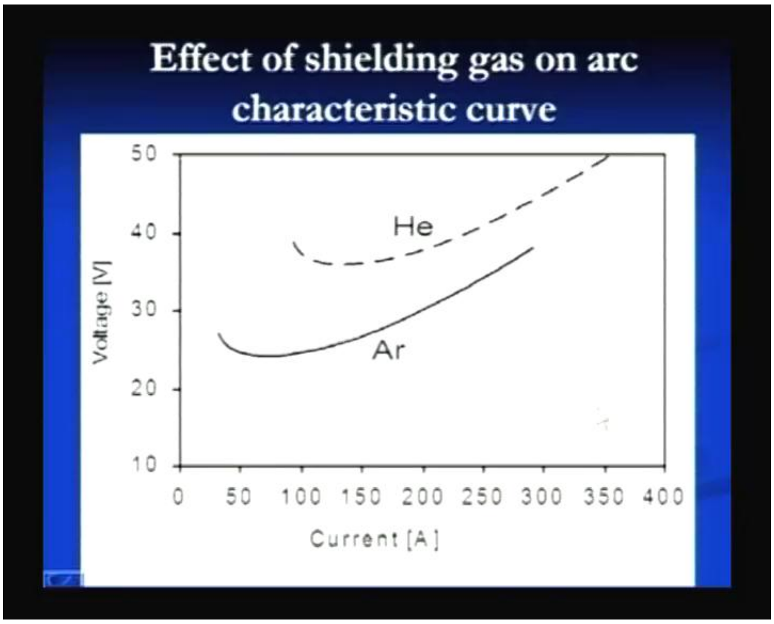

These shielding gases are also known to affect the arc characteristics or VI characteristic of the arc. The relationship between the voltage and current is affected in gas metal arc welding with the presence of the shielding gas. When argon is used as a shielding gas, the arc voltage is somewhat lower for a given current setting compared to the case when helium is used. For 150 ampere current, here arc voltage in case of argon would be somewhere 28. While in case of helium, it would be somewhere 38.

So, higher arc voltage is generally observed with the helium as with the helium as a shielding gas compared to the argon and this high arc voltage helps to burn the arc hotter, and high thermal conductivity of the helium helps to melt the faying surfaces effectively, and this high arc voltage with the helium as the shielding gas is attributed to the high ionization potential of the helium compared to that of argon here. The difference in the characteristics of like ionization potential of the argon and the helium, thermal conductivity of an argon and helium are attributed to the difference in performance of the helium and argon as the shielding gases, and the kind of the weld bead which are formed and the soundness of the weld mend.

Argon is heavier than the helium. That is why helium immediately after coming out from the nozzle tends to move up, tends to rise in upward direction. That is why it needs higher flow rate compared to that of iron. Argon becomes heavier than the atmospheric air and that is why it tends to settle down after coming out from the nozzle, and it forms from blanket around the weld pool and the arc region. That is why argon needs somewhat lower flow rates compared to that of helium because helium tends to move up immediately after coming out from the nozzle compared to that of argon. So, the density of helium and argon also plays significant role in effective shielding of the weld pool and the arc region.

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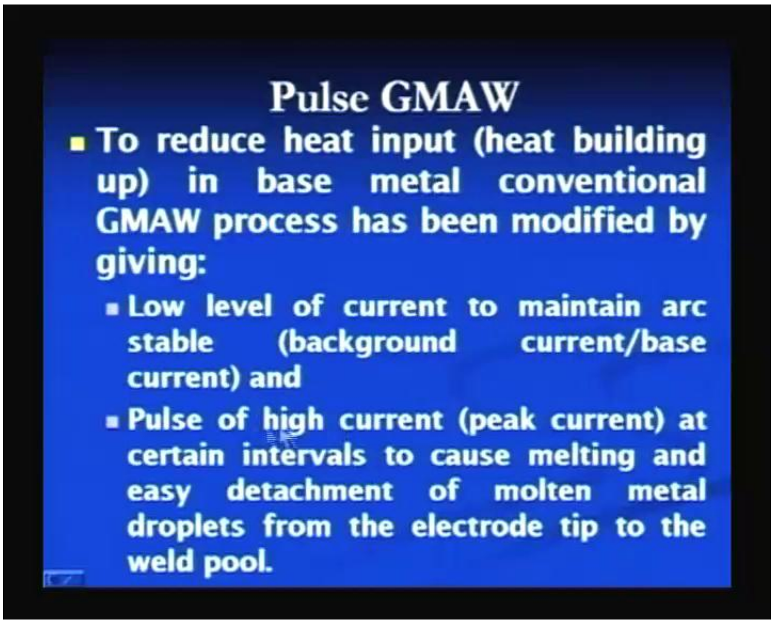

The one variant of the gas metal are welding process is the pulse gas metal arc welding process. In conventional gas metal arc welding process, the welding current at a given level is supplied continuously to get a continuous heat in the arc region and continuous and uniform melting of the base metal, but this continuous supply of heat to the base metal tends to build up the heat which tends to cause a number of undesirable effects in the base metal like wider heat effected zone and development of the residual stresses and distortion of the welded components.

In order to reduce the building up of the heat or reduce the heat input to the base metal in some modification in the conventional gas metal arc welding process has been made, and that one variant of such process is the pulse gas metal arc welding process. In this process, the two levels of the currents are supplied during the welding. One level of current is known as the background current or the base current. This is a very low level of current and it is set in such a way that arc is just maintained and it is stable. On the other hand, the high pulses of the high current are supplied which helps to melt the base metal, and it helps to detach also the molten metal droplets from the tip of the electrode.

So, here in this variant of the gas metal arc welding process, that is pulse gas metal arc welding process, the welding current is pulsed between one low level that is background current and the high level that is peak current or high current, and this pulsing helps to melt the metal during a certain period and then, allows to molten metal to solidify in the remaining period. So, the solidification of the molten weld pool is suppose to take place when there is only background current, and that solid and the melting of the base metal takes place when there is pulse current or the peak current. So, this peak current is supplied at regular intervals, so that it continuous melts and that melting at regular intervals of the base metal takes place. At the same time, the solidification same molten metal will continue to solidify when there is base current.

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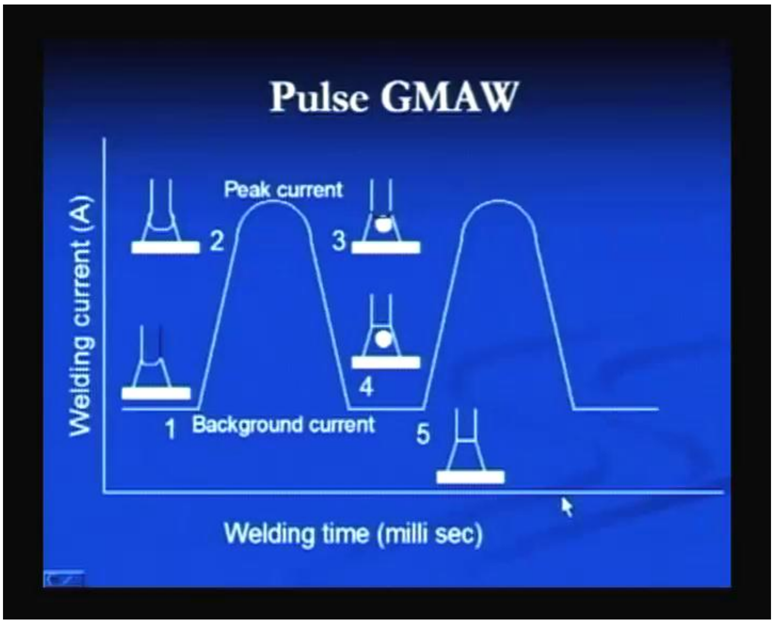

Schematically we can see that how the current varies in the pulse gas metal arc welding process. Here this is the lower level of current which is known as background current, and here the maximum current or the higher level of current which is known as peak current. Here the current is pulsed means the pulses of peak current are given at regular intervals. So, this welding current is pulsed between the background current and the peak current at regular intervals.

During this background current portion, solidification of the base metals are solidification of the weld pool takes place, and during the peak current portion time during which the peak current is there or the pulse current is given, the melting and the detachment of the droplet takes place. In sequence we can see here schematically say this is the back ground region, and here solidification of the weld pool is taking place. As soon as pulse of the high current is given and the current starts to increase up, and it reaches to the region to here from one to two second zone, the continuous melting will be taking place and here, there is no molten metal at the tip.

Here the molten metal droplet starts to form and it grows continuously to form 2 to 3 also and here, as soon as it reaches to the peak value, it starts to get detached by the peak force, and then it is detached further and then, it is transferred to the weld pool. Then, temperature comes this current and decreases gracefully up to 0.4, and here when the pulse current comes down to the background current level or the pulse current is over, then the solidification of the transferred molten metal starts and in 0.4 to 5 in this, the solidification of the molten weld pool will be taking place. This cycle goes on repeating itself like in it goes in 4 steps. Here, 0.1, 0.2, 0.3, 0.4. Here melting takes place and pinching of, then detachment of the droplets and the solidification of the weld pool forms 0.4 to 0.5.

So, this is how the pulse current helps to melt and transfer the molten metal droplet from tip of electrode to the weld pool, and then during certain period, only solidification of the weld pool takes place. No melting across during that portion and that is the portion when background current is only background current. So, that time during which background current is maintained is known as base current duration, and the time during which peak current is maintained is known as peak current duration or pulse duration or base current duration like that peak current or peak current or background current or base current.

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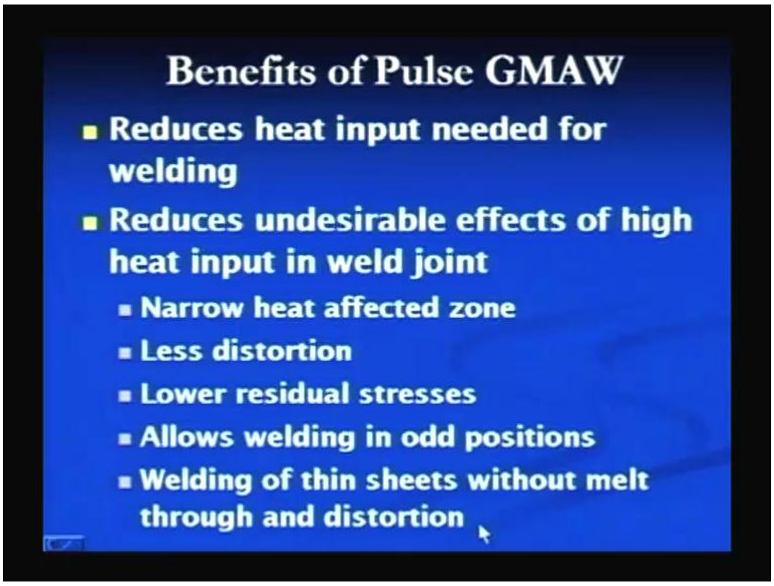

This pulsing of the current between the background or the peak level or high-low level and high level helps to reduce the heat input into the base metal which in turn offers the number of benefits like reduce heat input helps to reduce the undesirable effects related to the heat input in the weld joint, like reduced heat affected zone greater is the heat input to the base metal wider will be the heat affected zone, and heat affected zone is a portion where depending upon the kind of metal which is being welded, either softening or hardening of the metal can take place. That is the undesirable change in the metal cum metal properties and metallurgical properties of the base metal which is being welded. It is not desired to have the heat affected zone and width of this heat affected zone is reduced with the reduction in the heat input.

Another important point is greater is the heat input, greater will be the chances for the development residual stresses and so the distortion. So, if the heat input is reduced, distortion related distortion will also be reduced. The reduced residual stresses because the less volume of material will be heated, less will be the non-uniformed volumetric change in the material during the welding which in turn helps to reduce the residual stresses also, allows the welding in odd positions because heat input is reduced significantly that in turn helps to improve the better control that increases the control over the molten weld pool because fluidity of the molten metal is reduced with the reduction in heat input, and that helps to put the molten metal in the positions where it is required without falling down even in the odd positions, and welding of the thin sheet, it is also possible without melting through and distortion because thin sheet welding needs less heat input and thus, that better control over the less heat input is possible with the pulse and gas welding arc metal process because current is continuously pulsed between the low and high level. These durations of the pulse current and the base current can be adjusted as per needs of the heat input for a given welding conditions.

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Metal transfer aspects in the gas metal arc welding process is very important because success of the weld joint by the gas metal arc welding process to a great extent depends on that how effectively it is being transferred because kind of the micro structure or the soundness of the weld joint which is obtained, depends upon how the metal transfer, how metal is being transferred from the electrode tip to the weld pool.

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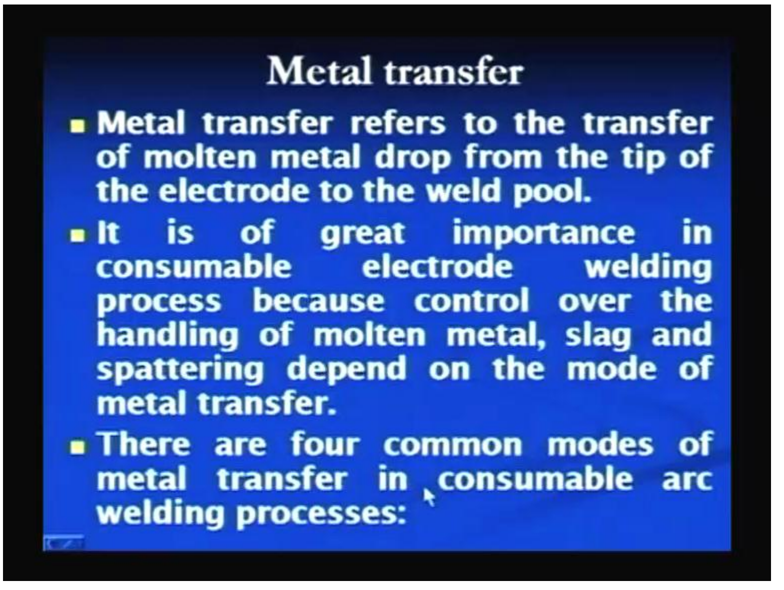

Here metal transfer as I have explained earlier also, it refers to the transfer of the molten metal from the tip of the electrode to the weld pool, and it is of great importance in consumable electrode welding process particularly because control over the handling of the molten metal, slag, spattering depends upon the mode of the metal transfer. How the metal transfer is taking place, that significantly affects control over the molten metal, slag and the spattering aspects. Here, there in gas metal arc welding process, there are four common modes of the metal transfers in consumable arc welding process or in this gas metal arc welding process.

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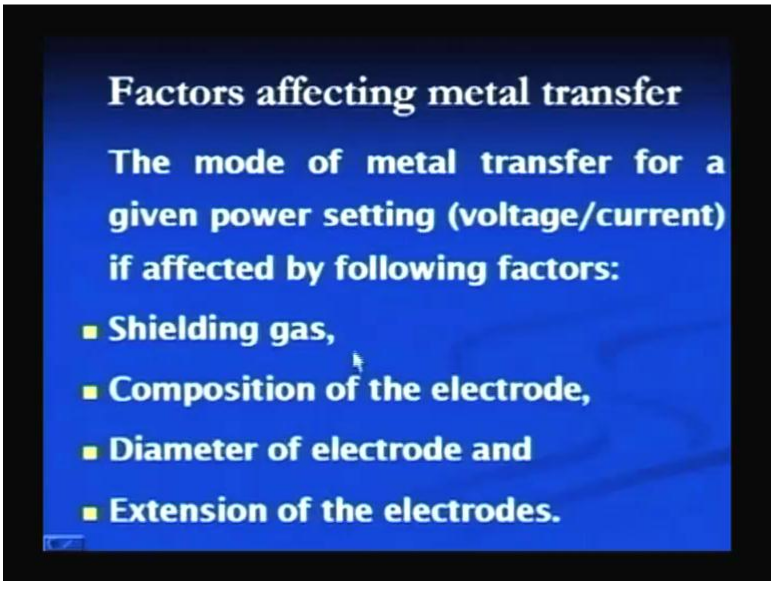

These are like these are the short circuit metal transfer, globular metal transfer, spray transfer, dip transfer, radial transfer, etcetera and these metal transfers are significantly affected by the welding conditions like welding voltage and the welding current particularly in addition to the diameter of the electrode, and its material or the electrical resistivity aspects. So, the mode of metal transfer for a given power setting, that is voltage and current is affected by the factors like the shielding gas, like the composition of the electrode, diameter of the electrode and the extension of the electrode here because all these factors composition of the shielding gas affects the heat. The kind of heat which is generated in the arc region is affected by the shielding gas like helium generates more heat compared to that of argon.

Composition of the electrode electrical resistance heating in electrode extension portion is governed by the composition of the electrode, like electrical resistance heating will be more in case of aluminum compared to that of, sorry electrical resistance heating will be more in case of steel compared to that of aluminum because electrical resistivity of a steel is higher than that of the aluminum, and the diameter of the electrode. Also, large diameter electrodes will be subjected to the greater, lesser electrical resistance heating compared to the small diameter electrodes. The electrode extension greater will be the electrical resistance heating and the amount of heat which is being generated in the arc region or in the electrode or in the region close to the electrode tip that affects the mode of the metal transfer that we see detail in coming slides.

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A short circuit metal transfer takes place under certain welding conditions. In short circuiting metal transfer, the molten metal droplet touches to the weld pool before it gets to the weld pool and this happens when welding current is low and the arc gap is also a small. Under these conditions, the droplet grows gracefully at the tip of the electrode and as soon as it grows enough in size, it touches to the weld pool. So, short circuiting takes place, and as soon as short circuiting takes place, high heat is generated because of increase in the current which in turn reduces the surface tension and reduce the surface tension helps to detach the droplet from the electrode tip to the weld pool. So, therefore, welding current during the short circuiting increases significantly which in turn causes the heating of the molten metal at a lower surface tension appreciably.

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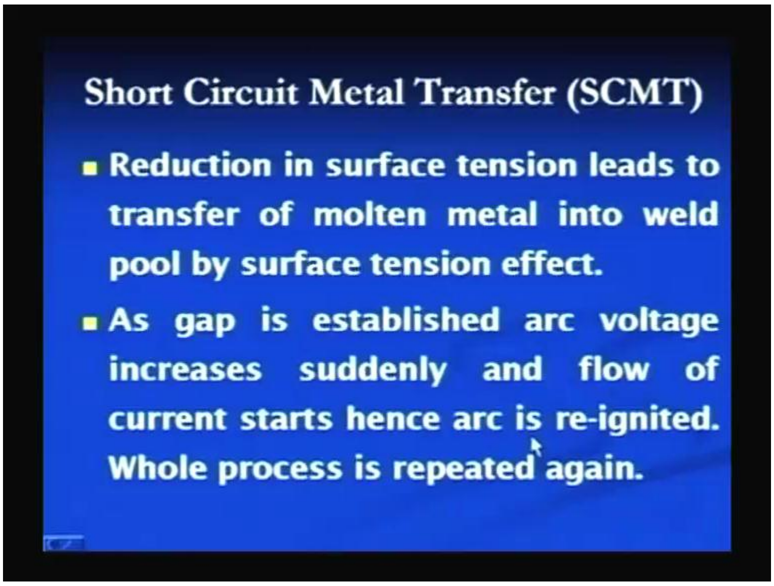

Reduced surface tension leads to the transfer of the molten metal into the weld pool by surface tension effect. So, here during the short circuiting, the droplet which has grown at the tip of electrode touches to the weld pool, and by surface tension affect, it is transferred to the weld pool from the electrode tip. As the gap is established, once the droplet is transferred, again gap is established between the electrode tip and the weld pool. So, arc is established gap. So, as gap is established, arc voltage increases suddenly and flow of current starts. So, that arc is re-ignited and this whole process in. So, shield in short circuiting metal transfer continuous or it is repeated again and again.

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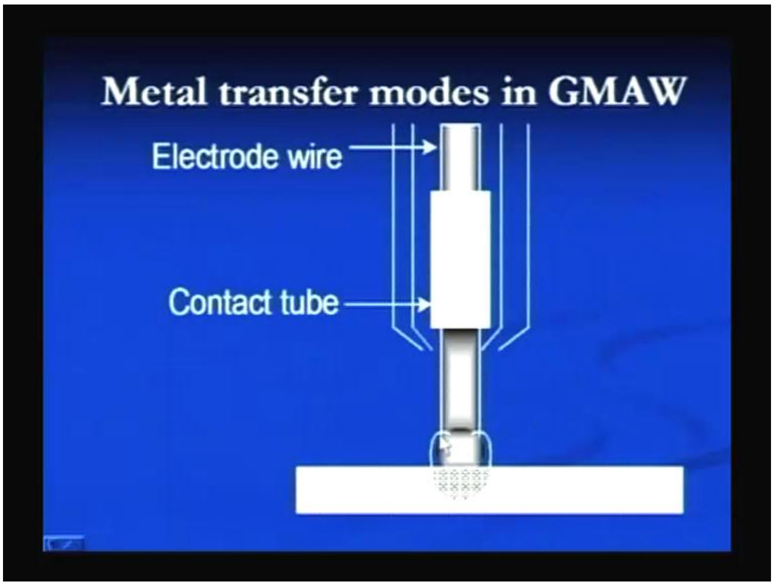

This we can see the short circuiting metal transfer here at the tip of the electrode. This ball grows gracefully one by one and as soon as it grows in the large enough size, it touches to the weld pool and as soon as it touches to the weld pool, short circuiting takes place which increases the welding current, significantly develops lot of heat and surface tension of this molten droplet is reduced and by the surface tension force of the weld pool also, it is transferred or it gets detached from the tip of the electrode.

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Another transfer mode is a metal transfer mode is the globular metal transfer, and the welding conditions for the globular metal transfer to take place is that welding current should be low, but the current for this transfer is somewhat higher than that of the short circuiting metal transfer, and the arc gap is also large here because welding current is low. So, the molten metal droplet will be growing gracefully and as this is gap is also large, so the molten metal droplet will be able to grow to the large extent before it gets transferred due to the gravitational force.

So, under the conditions of the low welding current and the large arc gap, as the droplets grows slowly at the tip of the electrode to the large extent and as soon as drop attends large size enough under the gravitational force and other forces like surface tension force drop detaches from the electrode tip. Mainly here gravitational force pulling down the droplet when it becomes large enough is held responsible for the transfer of the drop from the electrode tip to weld pool.

Here this transfer normally occurs when the droplet size is larger than the electrode, and in this case, no short circuiting takes place because the gap between the electrode tip and the weld pool is large and that is why, this globular metal transfer is normally preferred because it is a spatter free and a smooth transfer of the molten metal takes place.

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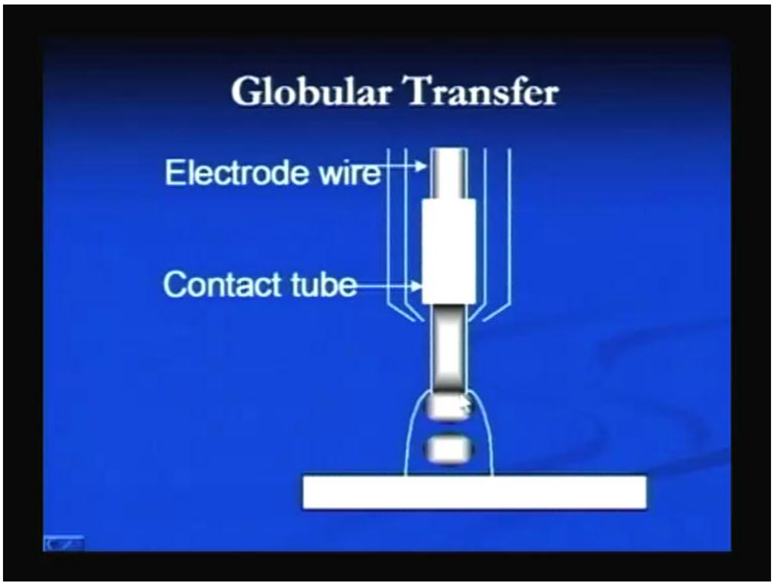

Schematically, we can see here the globular metal transfer. Here at the tip of the electrode, the molten metal droplet will be growing gracefully and as and when it attends the size, large size enough under the gravitational force, it is detached from the tip of the electrode and transferred to the weld pool. The size of the droplet normally becomes larger than the diameter of the electrode in this case.

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Spray metal transfer is another important metal transfer mode which takes place in the gas metal arc welding process, and it is noticed when welding current is higher than that is required for the globular metal transfer, and the high welding current here makes it possible to have the high melting rate because melting rate is governed by this equation is aI plus b L I square, where I represents to the current value, L is the electrode extension and a and b are the coefficients. Here, a and I represents to the heat generated, melting due to the heat generated in anode or cathode side, and b L I square represents the melting rate being governed by due to the electrical resistance heating in the electrode extension portion.

So, higher the current value, higher the value of melting rate. Since the current is high in case of spray metal transfer, melting takes place very rapidly and the pinch forces which are acting on the molten metal droplet hanging at the tip of electrode are also high because pinch force is proportional to the square of the current. So, high current leads to the high melting rate. Droplets are formed rapidly and those droplets are detached rapidly under the effect of pinch force, and that is why they are not able to attain very large size.

So, the continuous formation, and rapid formation of the droplet at the electrode tip and they are immediate detachment under the effect of pinch force leads to the continuous transfer of the fine droplet from electrode tip to the weld pool. Therefore, droplets are formed rapidly under these are pinched off from the tip of the electrode even when they are of a very small size, and this is attributed mainly to the high welding current which results in high melting rate and the high pinch force at the tip of electrode. Another possible reason for this is that when temperature is high due to the high current surface, tension force is also reduced significantly due to the high temperature in arc region which also helps which also reduces the resistance to the detachment of the molten metal droplet at the tip of the electrode. So, here the high pinch force reduced the surface tension forces and high melting rate makes the spray metal transfer possible.

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Schematically, we can see this spray metal transfer in the coming slides, and that will make things more clear. When this transfer takes place, we get appearance such that it is just like spray of some liquid in the line of the axis of the electrode. So, continuous detachment of the droplets from the electrode tip in line of the electrode axis gives a spray kind of appearance. That is why it is called when this spray transfer is achieved, it helps to direct the molten metal droplet directly in line of the electrode axis. That makes it possible to deposit the metal in the area, where it is required particularly in odd position welding. So, this spray kind of feature helps to direct the molten metal in proper place where it is required.

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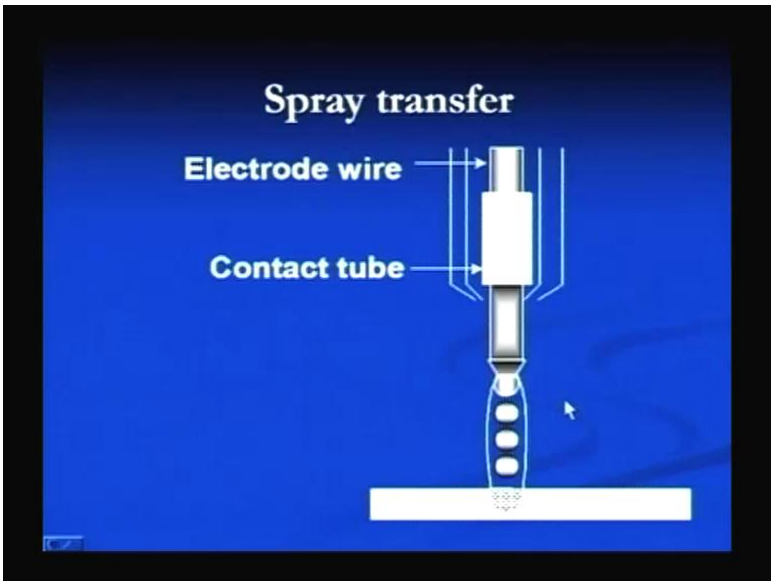

Here, schematically we can see here this is the electrode tip under the high current. The electrode, the tip of electrode, the droplets will be formed rapidly and under the affect of pinch force, it will be pinched off rapidly under the droplets will be detached even when they are of a quite small size. That gives the droplets are being sprayed from the electrode side to the weld pool, and that gives spray kind of appearance. That is why it is called spray metal transfer.

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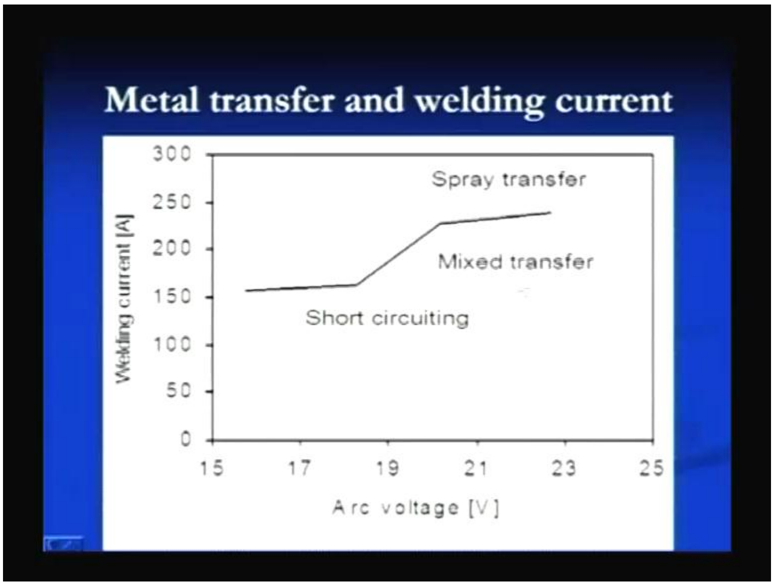

Here, spray metal transfer and welding conditions are closely related and we can see that when the current is low, we get the short circuiting metal transfer in a certain medium range, and it is mixed transfer and in the higher current side, it is the spray transfer.

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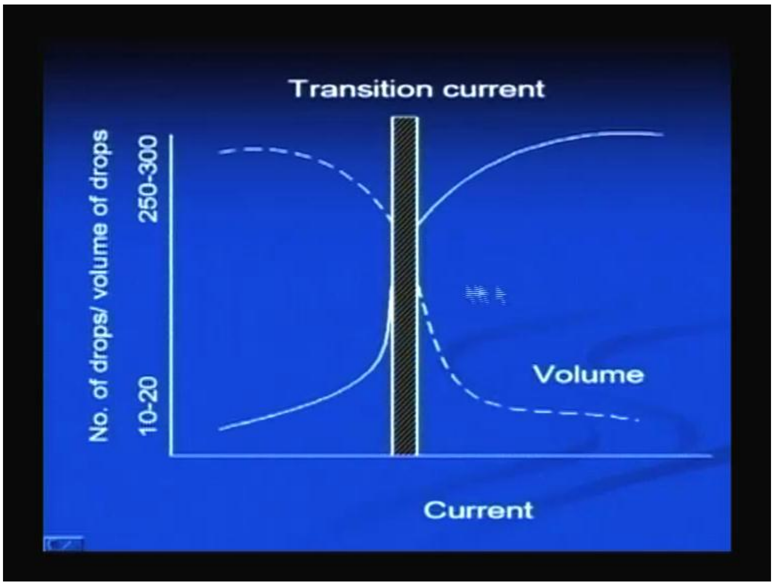

Here, the transition from the globular transfer to the spray transfer occurs over a range of current, so that the arbitrary value of the current above which the spray mode of the transfer is observed is known as transition current. Here we will see how the change in the number of droplets being transferred or the volume of the droplets being transferred is effected with the change of current. As we increase a number, as we increase the welding current, we can see here there is increase in the volume, there is increase in number of the droplets being transferred and these numbers of droplets initially at low level of current which may be 10 to 20. When current is increased to have the spray transfer, these numbers of droplet transferred may increase right up to 250 to 300 degrees and 300 in numbers.

So, the rate at which droplets are being transferred increases significantly with an increase in the current, and accordingly the droplets which were large enough in volume at the low level of current and that volume of the droplet decreases significantly. So, when current is high, droplets of very small volume and very large in number are formed. So, this is the arbitrary value or the value of the current above which this increased numbers of the droplets of very small size are formed is termed as transition current. So, here this is the range of current in which the globular transfer takes place, and this is the range of current in which a spray mode of transfer takes place.

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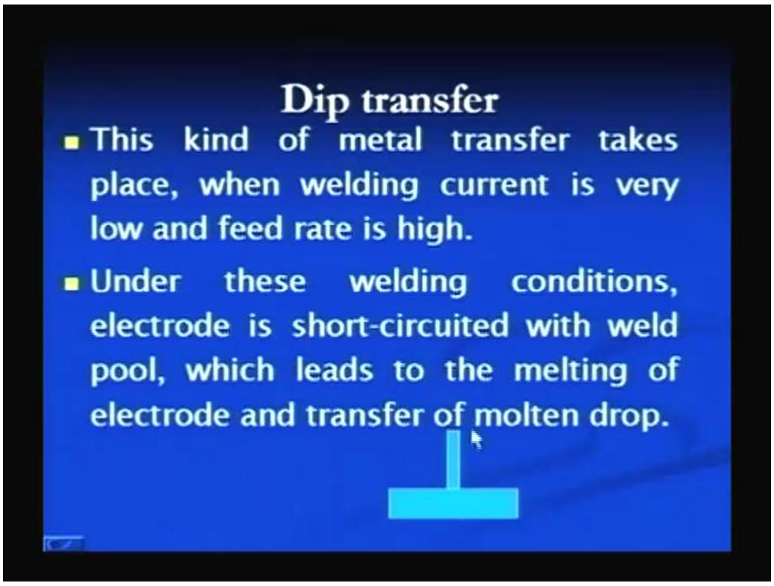

Dip transfer is another mode of metal transfer which occurs when welding current is very low and the feed rates are high. Here the melting will be taking place gracefully compared to that of feed rate. So, when feed rate is high, the electrode wire itself dips in to the weld pool, short circuiting takes place and thereby use generation of the heat helps to deposit, helps to transfer the molten metal to the weld pool. So, under these conditions when welding current is low and feed rate is high, the electrode, the short circuit with the weld pool which leads to the melting of the electrode and the transfer of the molten metal drop to the weld pool. Here we can see electrode dips to the weld pool when its feed rate is high and welding current is low.

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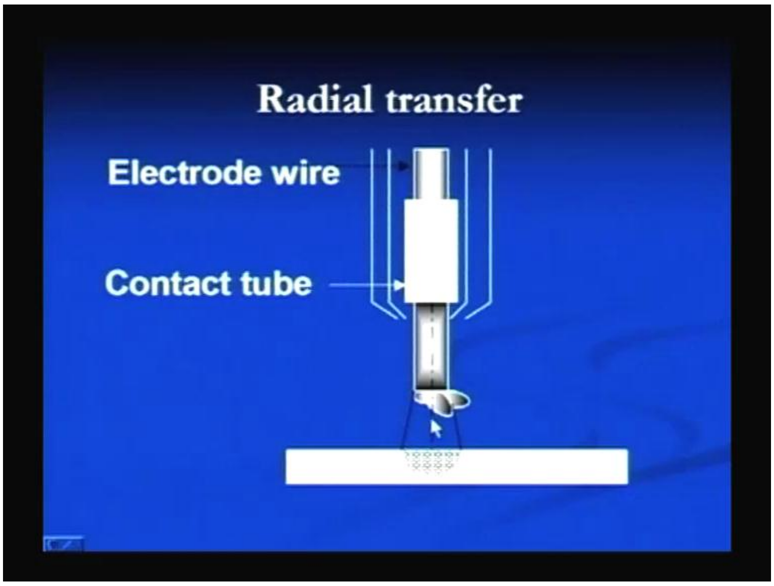

Radial transfer is another transfer due to the gases which are coming out from the weld pool side, and the various out forces leads to the movement of droplets being formed tip of the electrode in the radial directions. This leads to lot of spray or sorry, this leads to the spatter during the welding. However, it also takes place under some of the conditions.

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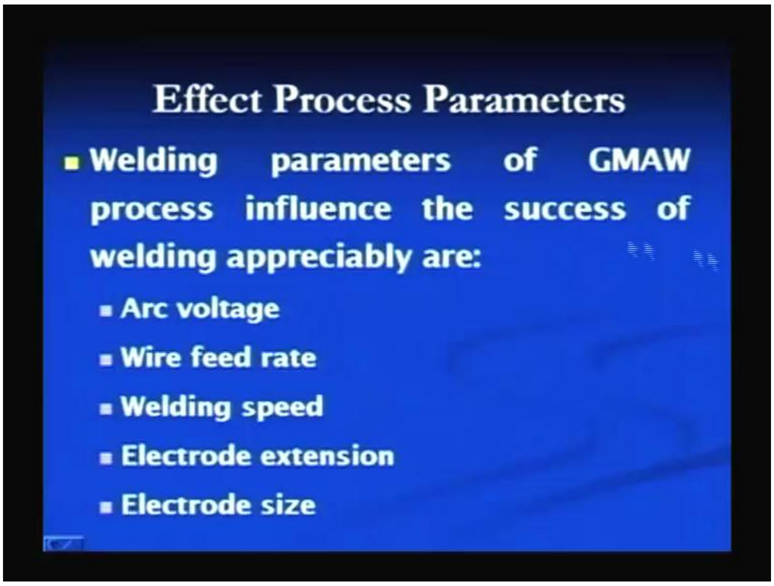

Effect of the welding parameters we will see on the soundness of the weld joints, and the performance of the gas metal arc welding process. There are various parameters which significantly affect the success of the welding, and these welding parameters are arc voltage, wire feed, rate welding, speed electrode extension and the electrode size.

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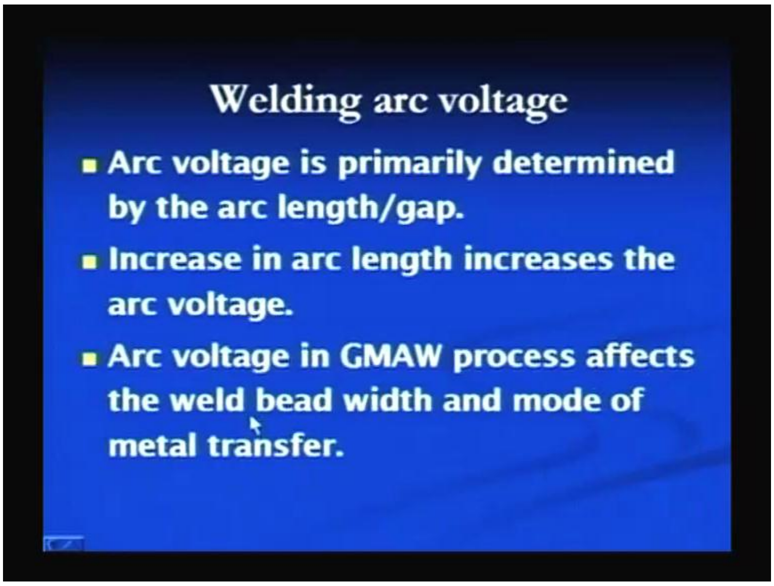

Here we will be start with the welding arc voltage. Welding arc voltage primarily determines the arc length or arc gap. Increase in arc length increases the arc voltage, and arc voltage in gas metal welding process particularly affects the weld bead width and mode of metal transfer. Here increase in arc voltage increases the weld bead width particularly.

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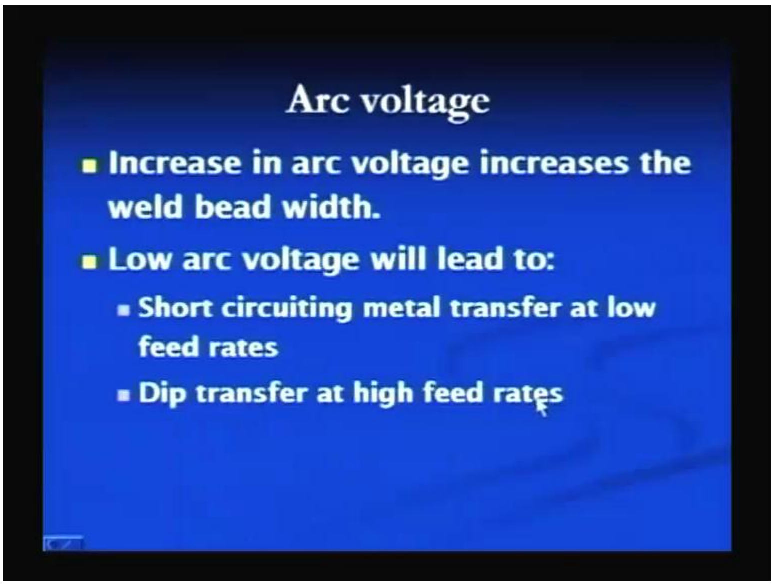

Here that is what we can see increase in arc voltage, increases the weld bead width. Low arc voltage will lead to the number of undesirable aspects like short circuiting metal transfer at low feed rates, dip transfer at high feed rates.

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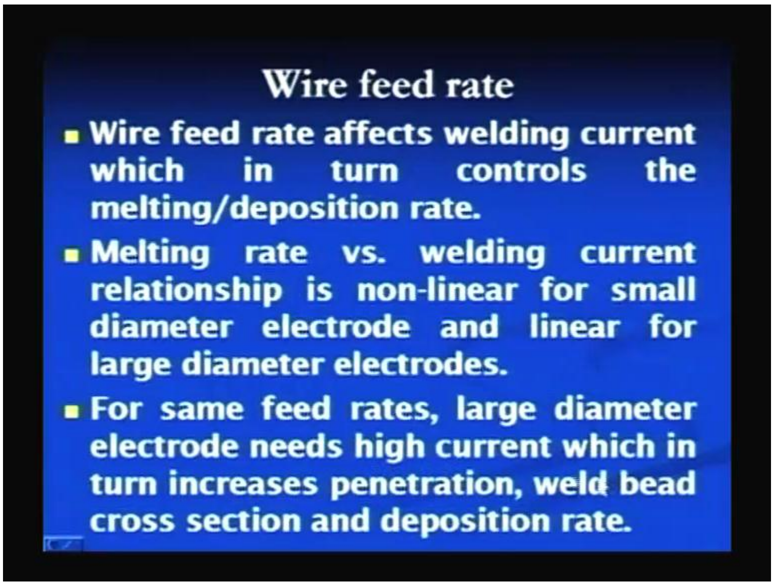

Then, the wire feed rate is another aspect that affects the success of the gas metal arc welding process. Feed rate affects the welding current which in turn controls the melting rate because increase in feed rates affects increase in the welding current which in turn also increases the deposition rate. Here melting rate versus the welding current relationship is non-linear for small electrode diameters, and it is linear for large electrode diameters because the excessive electrical resistance heating takes place in case of the electrical, in case of the small diameter electrodes and that leads to the significant rise in the melting rate with the increase in welding current, the relationship between the melting rate and the welding current. That is why becomes non-linear for the small diameter electrode compared to the large diameter electrode.

For same feed rate, large diameter electrode needs the high current which in turn increases the penetration weld bead cross-section and deposition rate. So, if the feed rate is kept or fixed, then increase in diameter will allow using higher welding current which in turn will permit to get the higher penetration, higher deposition rate and the wide weld bead cross-section.

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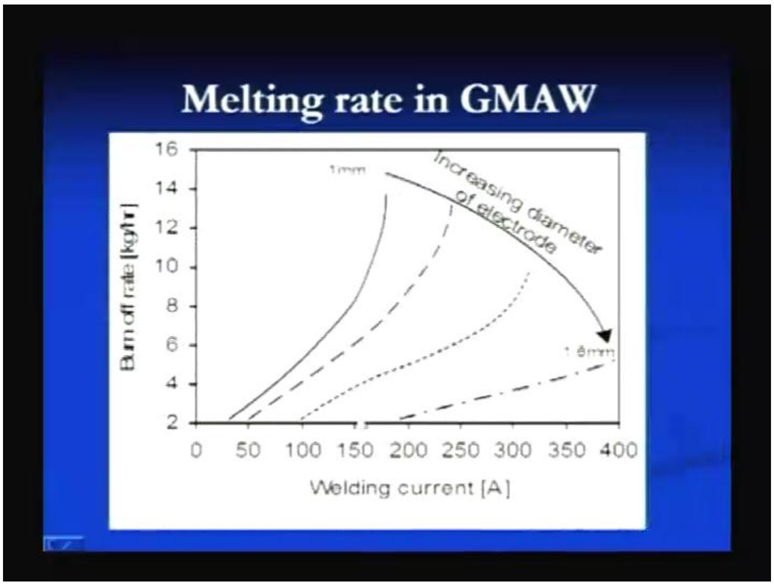

Melting rate relationship with the welding current or the burn-off rate relationship with the welding current in gas metal arc welding can be seen for the different electrode diameters. When the electrode diameters is large like say 1.6 mm increase in welding current increases the burn of it, or melting rate linearly and with the reduction in the electrode diameter, this increase in burn of rate with the increase of welding current becomes non-linear because of increased electrical resistance heating of the small diameter electrodes.

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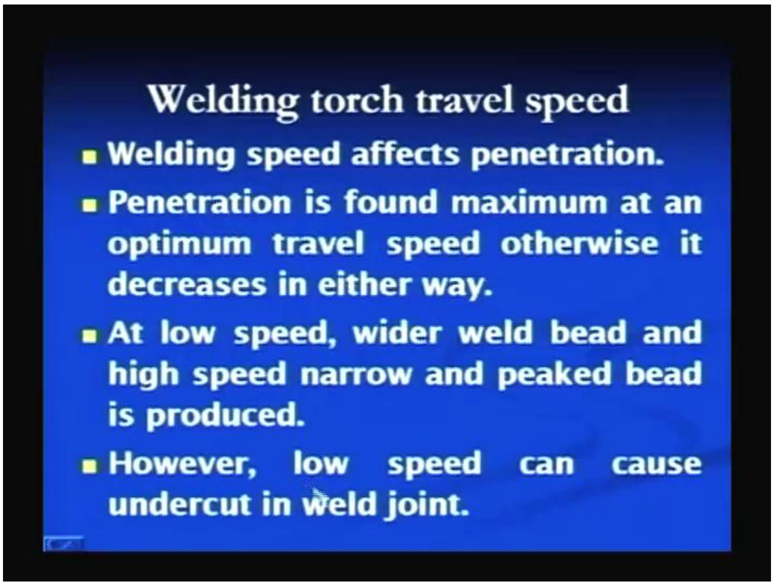

The welding torch is speed travel. Speed is another important aspect that affects the weld bead cross section and the weld bead geometry. Here weld bead affects the penetration particularly. Penetration is formed to be maximum at optimum level, otherwise it decreases in both the cases. The travel speed higher in the optimum level or lower than the optimum level leads to the reduced penetration, and at a low speed wider weld bead cross-section wider weld bead and at high speed narrow and peaked bead is produced.

So, here the weld bead affects particularly weld bead width and the penetration, and the penetration both here at lowest speed we get the wider weld bead at high speed. The peaked or the narrow weld bead width at lowest speed can cause the undercut in the weld joints. So, this is another undesirable aspects related to the lowest speed welding in gas metal arc welding process.

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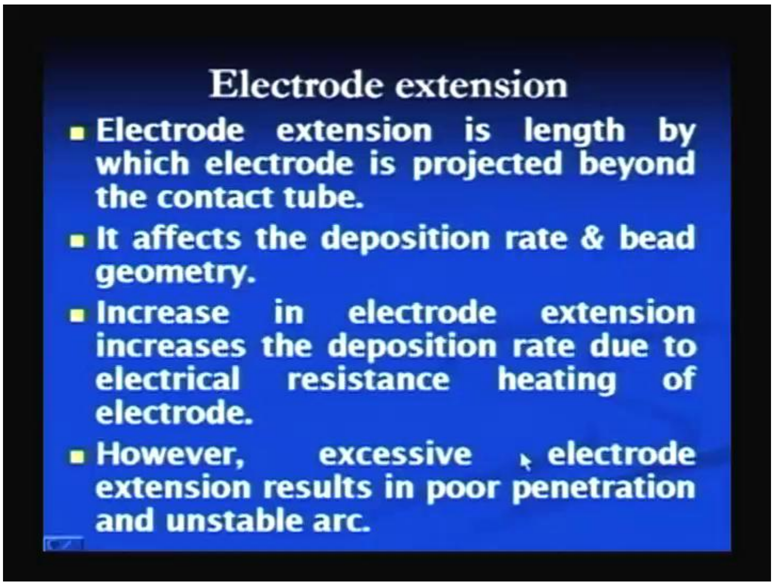

Electrode extension is the length by which electrode is projected beyond the contact tube that decides the electrode portion, electrode extension length. So, if the electrode extension is more, it will lead to more electrical resistance heating of the electrode and thereby, it will affect to the melting rate. So, electrode extension is the length by which electrode is projected beyond the contact tube, and it affects the deposition rate and the bead geometry. Increase in electrode extension increases the deposition rate due to the electrical resistance heating of the electrode.

However, excessive electrode extension results in poor penetration and unstable arc. There will be an optimum value or a range, there is an optimum range for electrode extension which will offer the better results. Otherwise, too close, too less electrode extension or too much electrode extension, both will result undesirable effects.

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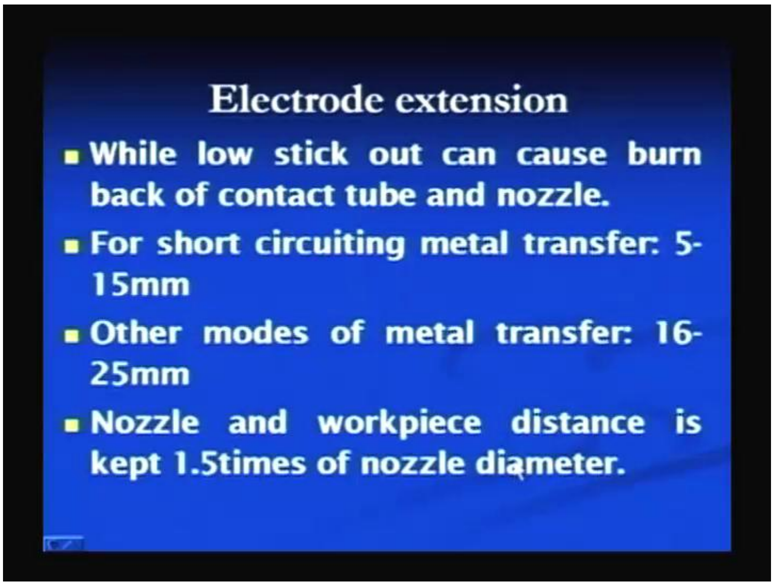

Low electrode extension can cause burn back of the contact tube and the nozzle due to the heat of the arc because a nozzle and the contact tube both will be closer to the arc zone. That can cause back burn or the burning back of the contact tube and nozzle, and for short circuit metal transfer normally electrode extension is in range of 5 to 15 mm. Therefore, other modes of the metal transfer, it can be in the range of 16 to 25 mm and normally for safe working nozzle and work piece distance should be 1.5 times of the internal diameter of the nozzle for the safe working. Otherwise, too close distance between the nozzle and the work piece reduces the life of the nozzle particularly.

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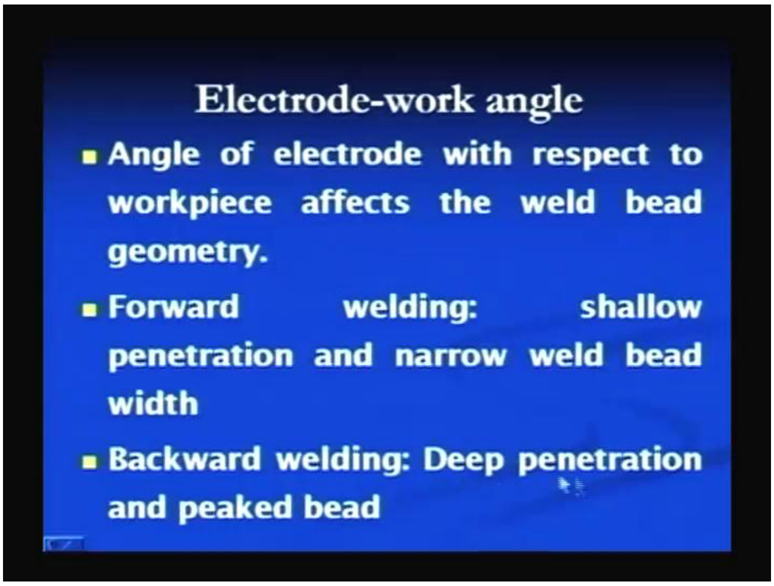

Electrode and work piece angle also affect the weld bead cross-section and the penetration, and in the forward welding when electrode is pointed towards the direction of the welding, we get the shallow penetration and a narrow weld bead width. On the other hand, when in the backward welding when electrode is pointed towards the region which has been already welded results in deep penetration and peaked bead. Here reinforcement will be high and weld bead width will be smaller one.

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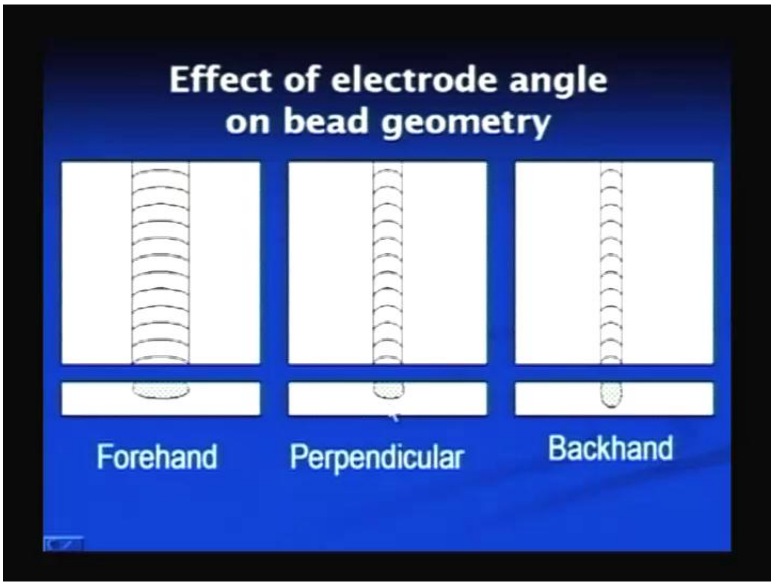

Here systematically we can see the forehand welding or forward welding. You can see here width is more and here penetration is more, and here in case of perpendicular when electrode is perpendicular to the work piece, it is an optimum one. Here this perpendicular electrode position is particularly used in automatic welding conditions, otherwise backhand or forehand welding can be used as per the needs.

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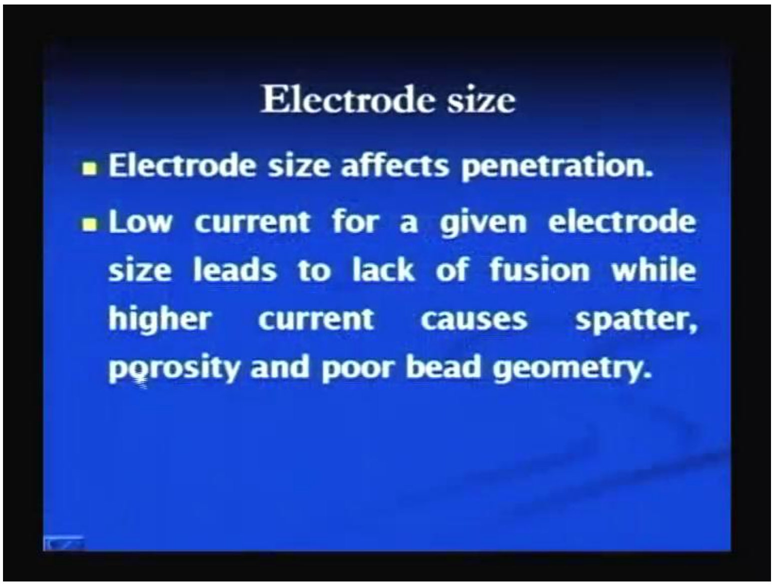

The electrode size is another important aspect that affects the penetration of the weld bead or penetration of the weld bead which is formed and during the welding, low current for a given electrode leads to the lack of fusion and while higher current causes the spatter and porosity. So, proper current setting for a given electrode diameter is important. Otherwise, it can create the number of problems like lower current side can lead to the lack of fusion, improper bonding between the plates being welded and the weld bead. On the other hand, higher current can lead to the loss of material, spatter and the defects like the porosity and the poor bead geometry.

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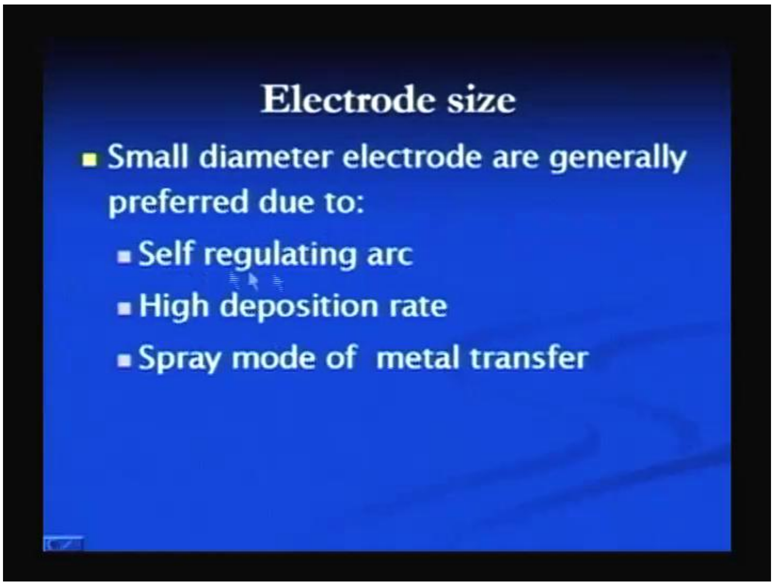

A small diameter electrode is generally preferred in gas metal arc welding process because it offers number of advantages like self-regulating arc is obtained. It offers the high deposition rate and it is easy to get somewhat easy to get a spray kind of metal transfer.

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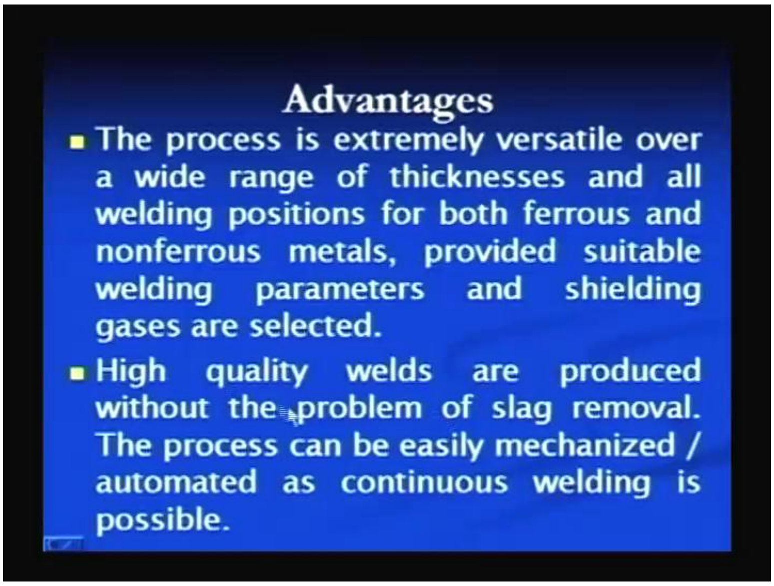

So, here we have seen that the welding parameter significantly affects the performance of the gas metal arc welding process, and the soundness of the weld joint particularly the penetration weld width cross-section of the weld bead. So, those are to be selected properly for successful welding.

Now, we will see some of the very plus points related to the gas metal arc welding because of which it is extensively used in industry. This process is very versatile and it can be used for wide range of the thicknesses, and for welding in all positions of both ferrous and non-ferrous metals provided, we select the suitable combination of the parameters and the shielding gases. So, versatility of this process is a key factor behind its success and commercial exploitation in the industry. High quality welds are produced without problems of the slag removal because shielding gases is used. So, slag shielding gas is used. So, no flux is used to remove the impurities from the weld region and therefore, no slag formation is there which needs to be removed. So, the high quality welds are formed and that to without any problem related to the slag removal, and a process can be easily mechanized and automated for the continuous welding conditions as per needs.

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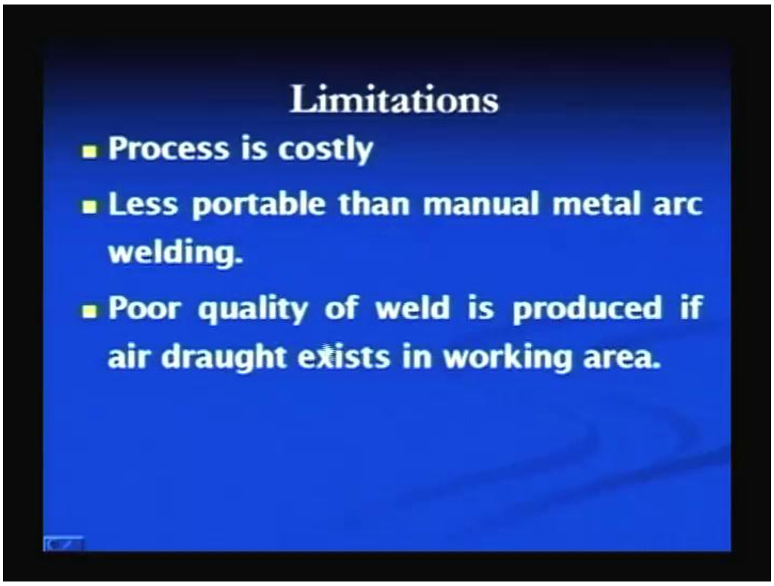

Some limitations related to this process are like investment is huge to establish this process and to use it successfully. So, the process is costly and the system is less portable compared to the manual metal arc welding. So, if we have to go at site for the welding, then it will be difficult to go with this process compared to the manual metal arc welding process, and the poor quality of the weld bead is produced if the flow rate of the air is also significantly high because that will adversely affect the shielding which is required for successful or in some weld joint production.

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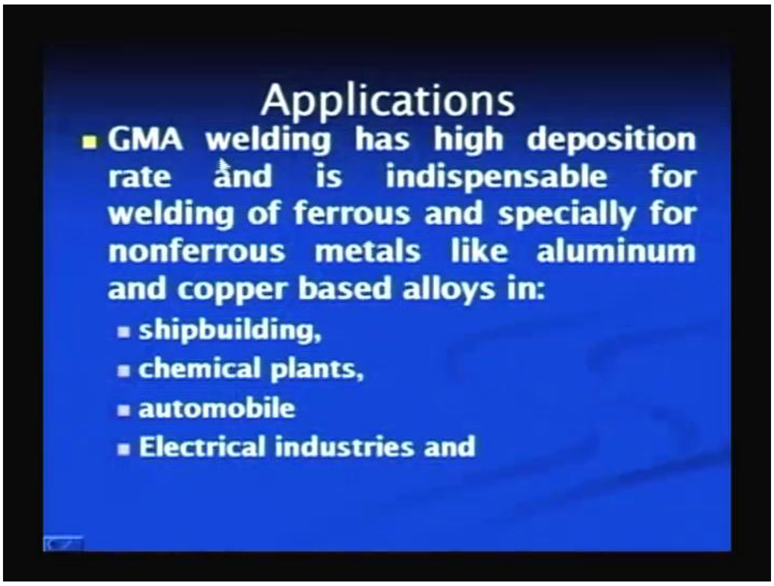

This welding process is particularly used in number of the areas of the industries like a ship building, chemical plants, automobile and electrical industry because it offers the advantage of the high deposition rate and indispensable for the welding of the ferrous and the non-ferrous metals like aluminum, copper, titanium, alloys etcetera. That is why since this process is very capable in terms of the deposition rates, the penetration rates which can be obtained and the capability to produce the weld joints of the reactive metals like stainless steels, aluminum, magnesium alloys, and that is why it is extremely used in the industrial applications or industrial fabrications.

Here, now we will summarize this lecture on the gas metal arc welding process. We have seen that in this lecture, the gas metal arc welding process is a combination of number of components like power source filler metal, wire feed unit and the shielding gas, and these things are to be used in very controlled way and in very selective manner to exploit this process for producing the sound weld joint successfully.

Thank you for your attention.