Welding Engineering
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Module - 4
Arc Welding Processes
Lecture - 7
GMAW

So, in the fourth module of this series of the lectures on the welding engineering, this fourth module is based on the arc welding processes. Under this, this is the seventh lecture, which will be based on the gas metal arc welding processes. In this, one will be talking about first the basic principle of the gas metal welding processes and then we will see that what are the important parameters related with this process, how do they affect the quality of the weld? We will also see that how the metal is transferred during the welding by this process, and what are the important areas of applications related with this process.

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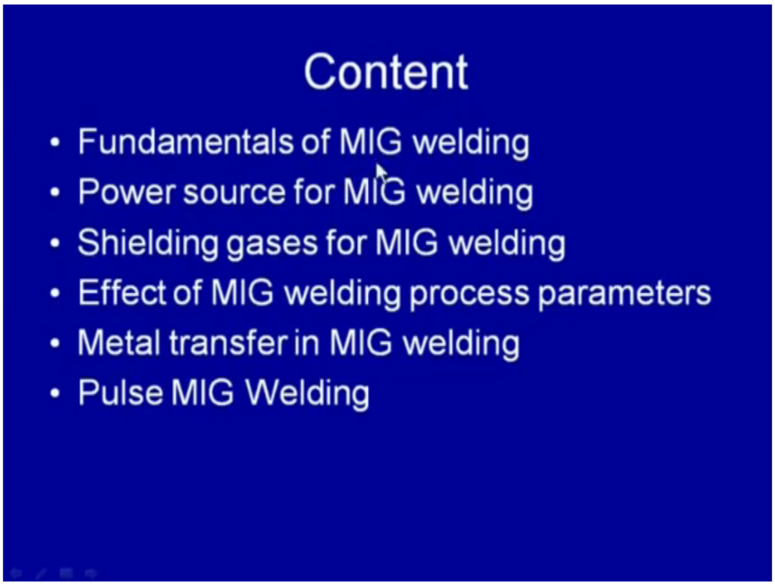

So, staring with the content of the process fundamental of the gas metal arc welding process which is also known as GMAW or the metal inert gas that is MIG or the gas metal arc welding process that is GMAW process. What are the power sources that are used with the process? Normally, we go with either constant current power sources or the constant voltage type of power sources. So, depending upon the electrode diameter, the suitable type of the power sources is selected, then the different gases that are commonly used with metal inert gas welding processes. That is the helium or the argon or the mixture of argon and helium and the mixture of other gases.

Then, what are the important the parameters related with the gas metal arc welding process, how do they affect the quality of the weld joint? Also, try to look into that how the metal is transferred in the gas metal arc welding and what are the conditions that effect the modes of the metal transfer? One variant of the gas metal inert gas welding processes, the pulse metal inert gas welding about that will also try to a say that the basic principle of the pulse GMAW or the pulse MIG welding process.

So, starting with the principle this of the gas metal inert gas welding process, this process basically uses the heat generated between the consumable electrode and the base metal for melting the faying surfaces of the base metal. So, the metallic continuity can be obtained for developing the weld joint and for protecting the weld pool from the atmosphere contamination. In this process, the inert gas or the inactive gases are used, so this is the basic principle where the developing weld is melting.

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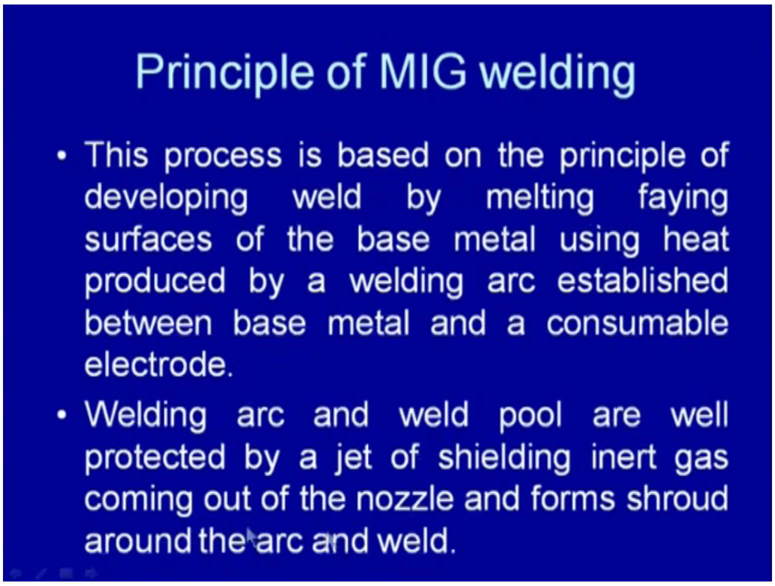

The faying surfaces are obtained using the heat produced by a welding arc, which is established between base metal and a consumable electrode. So, the difference from the GTAW process where the consumable electrode is used in this process, the consumable electrode is used just like submerged arc welding process. But in this the process for protection of the weld pool inert gas or inactive gas gases are used. The welding arc and the weld pool are well protected by a jet of the shielding inert gas or inactive gas, which is coming out from the nozzle and from the complete shroud around the arc zone and the molten weld metal.

So, the atmospheric gas can be kept away from the weld zone and the molten metal can be protected from any adverse effect on the quality of the weld metal. So, the basic thing here is that melting of the faying surfaces of the base material is ensured using the heat of the arc which is developed between the base metal and the consumable electrode. To protect the weld pool from the atmospheric contamination, the shielding gases are used; these shielding gases may be inert gases or the inactive gases for the shield.

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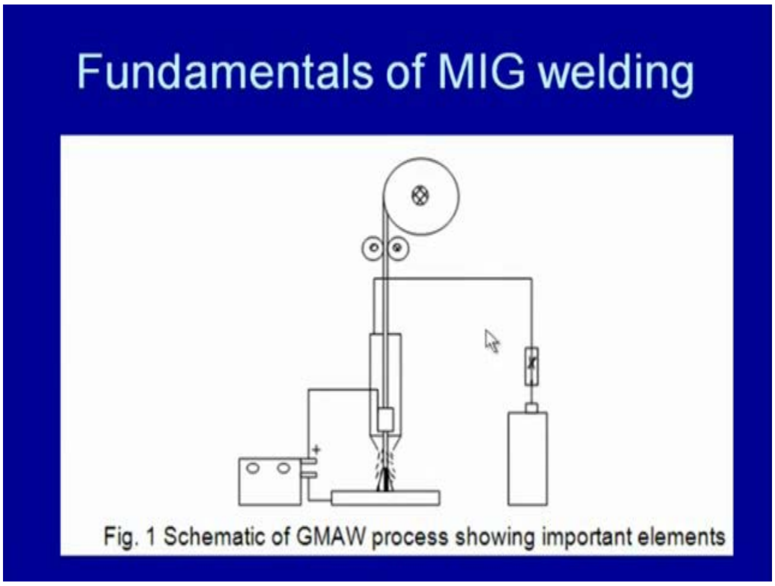

So, this is the diagram schematic diagram showing that in this process, the arc is established between the electrodes which are fed continuously from the spool of the electrode. So, with the help of these fed roller and the power is supplied through the suitable type of the power source, it can be of the constant current or the constant voltage type. Then, the terminals of the power source are connected to the electrode and the base material to complete the welding circuit and inert gas or the inactive gas mixture is supplied from the gas mixture cylinders to the welding torch. Then when it comes out of the nozzle, it forms complete jet the around the weld pool. So, the weld metal can be protected from the atmospheric contamination and any adverse effect on the weld metal can be avoided.

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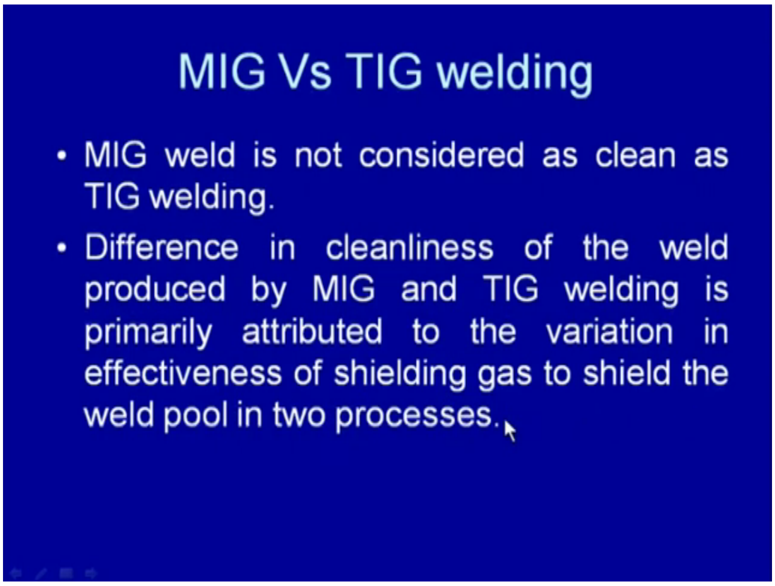

The gas metal is found significantly different from the tungsten inert gas welding process in the sense that it uses the consumable electrode while in case of the gas tungsten arc welding process, non consumable is used. The second thing is the arc gap in case of the gas metal arc welding process is found to be grater then that of the G T A W process. Because of these differences, the significant difference in the quality of the weld which is developed by GMAW process is obtained than that is developed by the G T A W process. So, M I G welding, M I G welds are not considered as clean as the weld produced the by the G T A W or the T I G welding process.

The difference in the cleanliness of the weld is attributed to the various factors and that is mainly due to the variation in effectiveness of the shielding gas is which are used in the two processes. The effectiveness of shielding gas is to protect the weld pool is found to be different in case of the gas metal arc welding process than the gas tungsten arc welding process. This difference is caused by the two factors: one is the stability of the arc and the second is the arc length or the gap between the electrode and the work piece. So, that is what we will see in further, so the cleanliness of the weld by the two processes is significantly governed by the effectiveness of the shielding process which is found different in the two processes.

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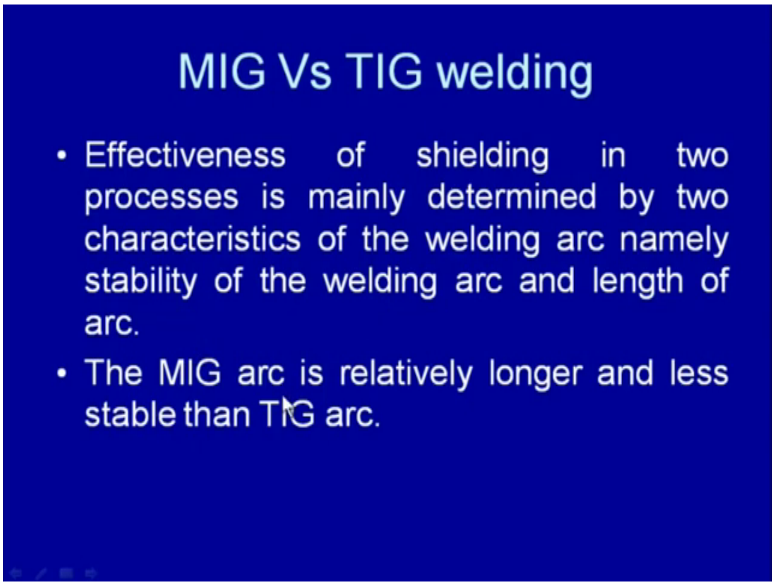

So, if we see effectiveness of the shielding in the two processes is mainly determined by the stability of the arc and the arc length as I just said, so if the arc is stable then how will be getting better shielding effect. If the arc is short, then also will be getting the better shielding effect because the gases will not be able to restore the arc zone and to the weld metal and to have any adverse effect. So in case of the G T A W process, arc stability is found to be much better than the GMAW because of the presence of the consumable tungsten arc which can emit the electrons very easily.

That is why the stability of the arc in G T A W process is very good, which ensures that arc is always covered with shielding gas is effectively and helps prove that in turn helps to protect the weld pool form the atmospheric contamination. Further, in the G T A W process the arc length is found to be much lower than the GMAW and that is why the possibility for the presence of atmospheric gas in the arc zone is further reduced. This in turn helps in producing the better and the cleaner weld by the G T A W process than the G M A W. In case of G M A W, arc is relatively longer and less stable than the G T AW process. So, the difference in the stability of the arc in case of the two processes are mainly attributed to the presence of the consumable electrode.

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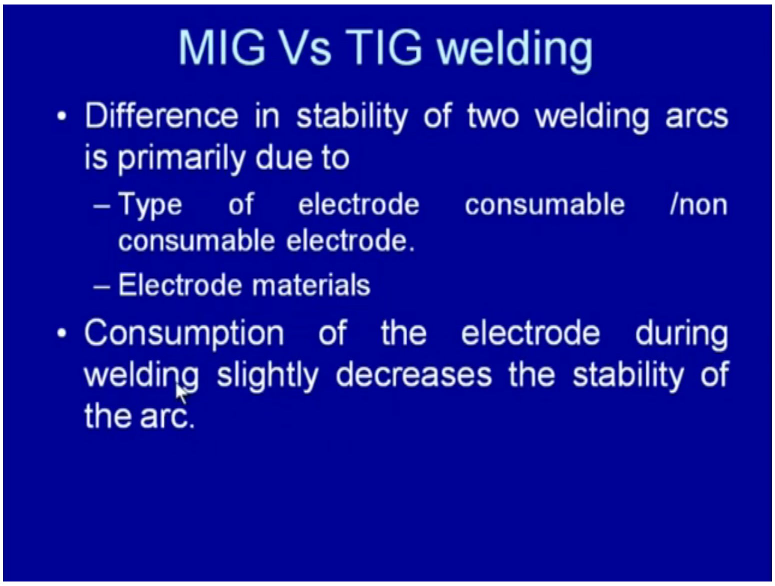

In case of the GMAW process and in case of the G T A W process, non consumable electrode and the electrode material is the another factor because in case of the G T A W process we used tungsten electrode. This helps in developing very good and stable arc weld, the stability of the arc is not that good because GMAW we use the filler material either of aluminum or steel as per the requirement and these materials are not that good electron emitting materials.

That is why stability because of the type of the electrode material is found to be poor with GMAW than the G T A W process. So, the consumption of the electrode in during welding further decreases the stability of arc. We know that in GMAW the electrode is consumed continuously by melting of the electrode tip and because of this consumption welding aim is, stability of the arc is slightly decreased a decreases as compared to that of the non consumable electrode which is used.

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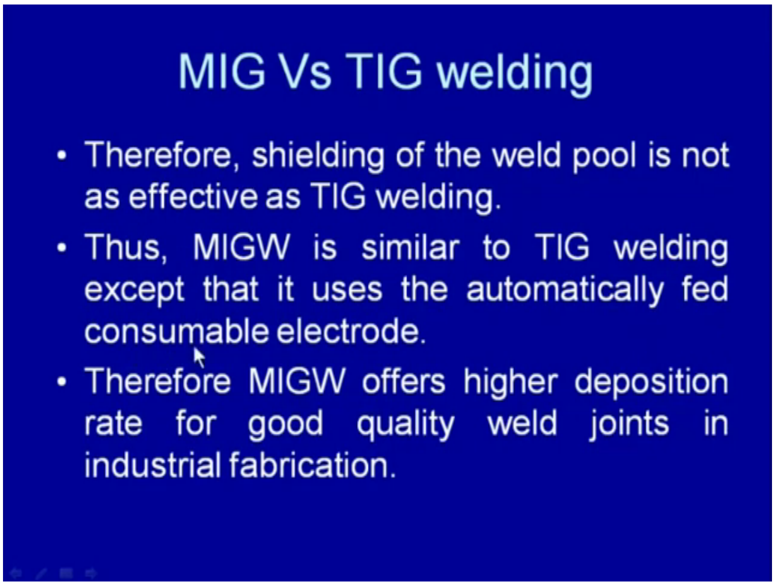

In case of the G T A W process and therefore, shielding of the weld pool is not as effective in case of the GMAW process or M I G process as incase of the T I G process. Thus, the GMAW process is similar to the G T A W except that it uses the automatically fed consumable electrode, but the cleanliness is not that good. Therefore, GMAW of pulse, the because of the use of the consumable electrode which is fed continuously incase of the GMAW or the M I G welding process. It offers the much higher deposition rate and which in turn helps in achieving the higher welding velocities and also the quality of the weld is reasonably good. That is why the GMAW process is extensively used in the steel fabrications where good quality weld joint are required.

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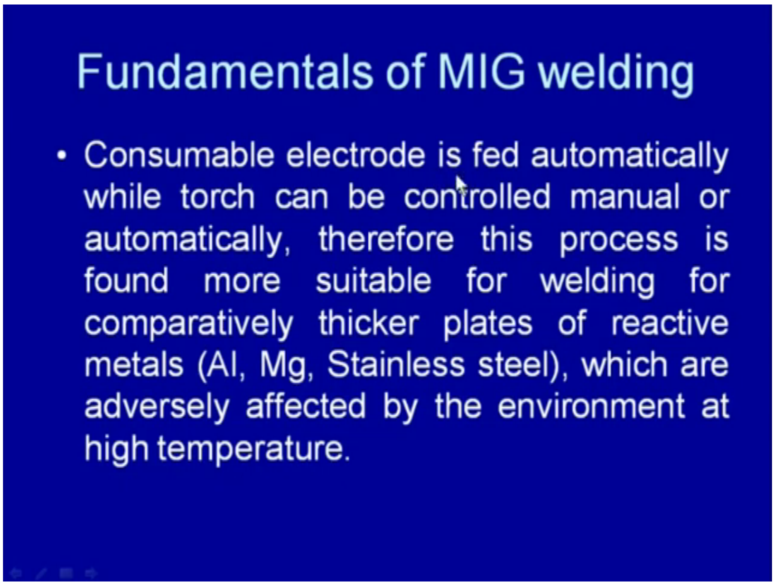

Therefore, consumable electrode in this GMAW process is fed automatically while torch can be controlled manual or automatically, so based on the kind of control which is available by given GMAW process. The process can be used for comparatively thicker plates of the reactive metals which can be adversely affected by the environment at high temperature. So, since the process uses the continuously fed the consumable electrode and that in turn helps in achieving the deposition rate and the higher welding speed. The proper shielding of the weld pool by the inert gas or the inactive gases in the GMAW process helps in successful welding of the reactive metals like the aluminium magnesium stainless steel because of the chromium presence. These can help in because of this cleaner weld these are extensively used in industrial fabrications.

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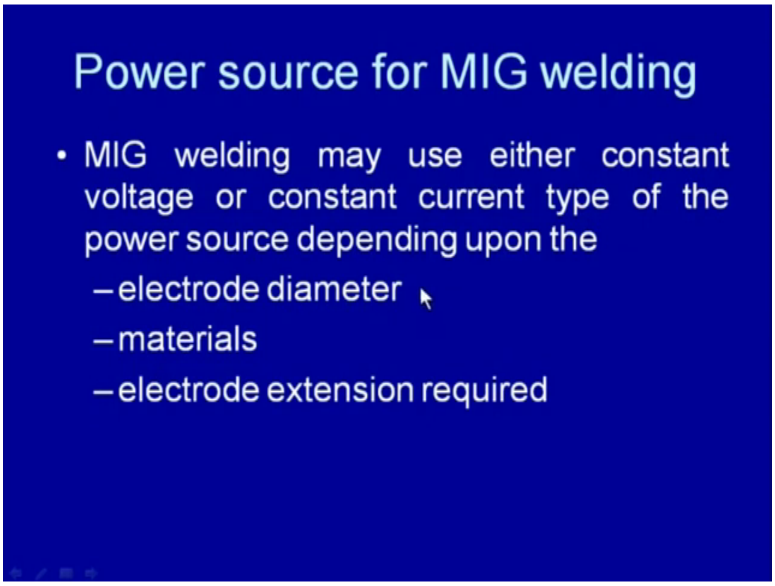

Now, we will see that what the power sources which can be used effectively are. In the GMAW process for developing the sound weld joint, the GMAW process can used either constant voltage or the constant current type of the power source depending upon the electrode diameter. So, these are the factor mainly which effect the kind of power source which can be recommended. Normally, for the large diameter electrodes, the constant current type of the power sources recommended while with the small diameter materials constant voltage type of the power sources are recommended, so that the sulphidating arc can be achieved.

A material like the electrical resistivity of the material of the electrode also effects the selection of the power source for a given diameter. If the material is of the higher electrical resistivity and it will result in the greater resistance. So, it will respond in better way with the constant voltage type of power source for achieving the self regulating arc as compared to the constant current type of the power source. So, the materials like copper and the aluminum of the higher electrical conductivity with the last diameter. It is preferred to use the constant current type of power source rather than the constant voltage type in case the melting rate will not be much effected by the electrical resistive heating occurring due to the flow of the heavy current.

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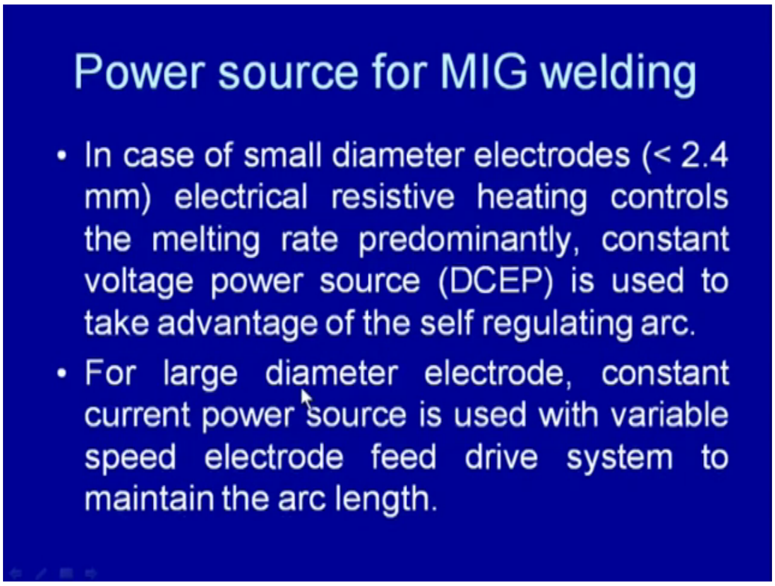

Further the electrode extension also effects the type of the power source which can be used in size on the selection of the power source. In case of the small diameter, electrodes lesser than the 2.4 mm electrode, resistive heating controls the melting rate of the electrode predominantly. Under these conditions, constant voltage type of power sources with the D C E P that is the direct current electrode positive polarity is used to take the advantage of the self regulating arc.

So, the arc length can be maintained using the constant voltage type of the power source. In case of the large diameter electrode, constant current power source is used with the variable speed electrode feed drive system to maintain the arc length because in these conditions, the variation in the current does not effect the melting rate of the large diameter electrodes. This one is also applicable for the metals or the electrodes of the high electrical of the low electrical resistivity or the good electrical conductivity.

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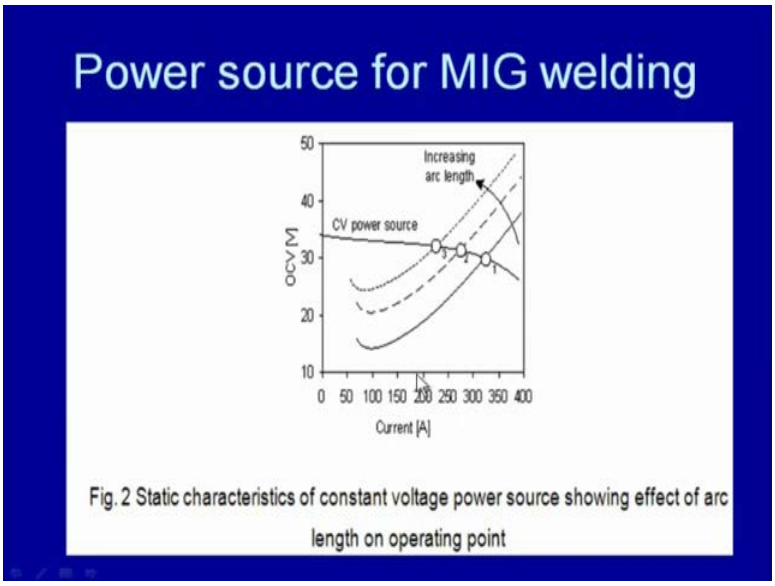

If we see this diagram, this diagram simply shows that what happens when the constant voltage type of the power source is used with the varying arc lines. We can see that when the arc length is increased, then the operating point shift from 1 to 2 and then 2 to 3 and because of these shifts in the operation due to the increasing arc length there will be reduction in the welding current. This reduction in welding current will be effecting to the melting rate, so this helps in this helps in obtaining the self regulating arc.

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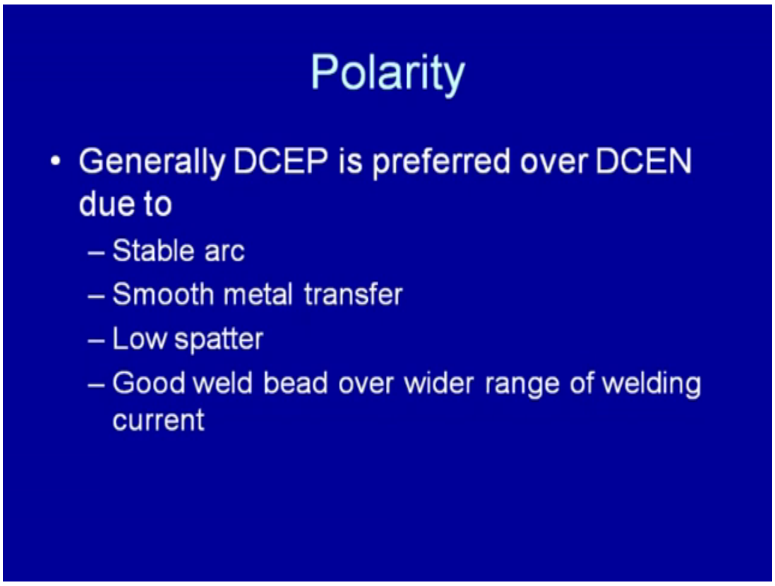

Then we will see the polarity and its effect in the gas metal arc welding process. It is generally the D C E P that is the d c electrode positive polarity is normally used in case of GMAW welding process. D C E N is rarely used because the D C E P offers the advantage of the stable arc smooth metal transfer low spatter. The good weld bed characteristics over the wider range of the welding current. So, because of these advantages D C E P are straight reverse polarity is normally preferred over the D C E N which is the straight polarity.

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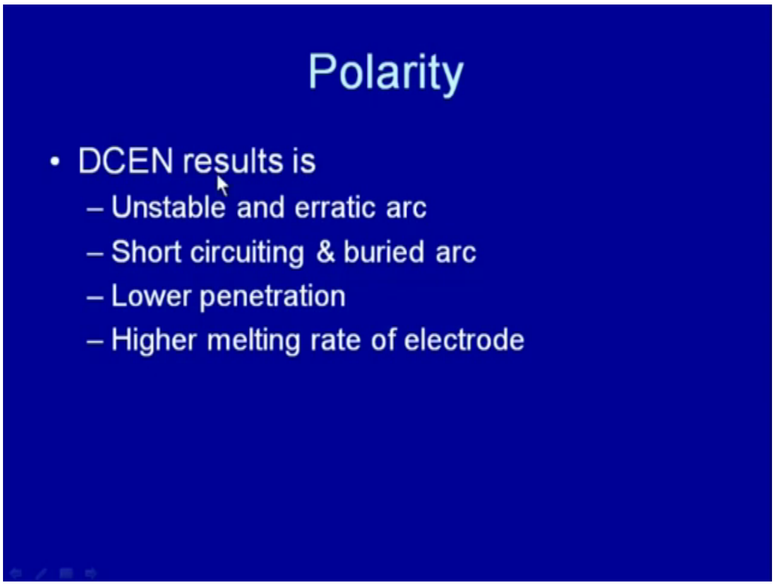

So, D C E N because results in main unfavorable characteristics like the unstable and the erratic arc and the short circuiting and the buried arc also developed under these conditions. Further, it results in the lower penetration rate; however the higher melting can be achieved when the D C E N is used. So, accept the benefit of the having higher melting rate other the features related with the D C E N are unfavorable especially the lower penetration on unstable and erratic arc. Use of the A C in GMAW is not very common due to the two factors.

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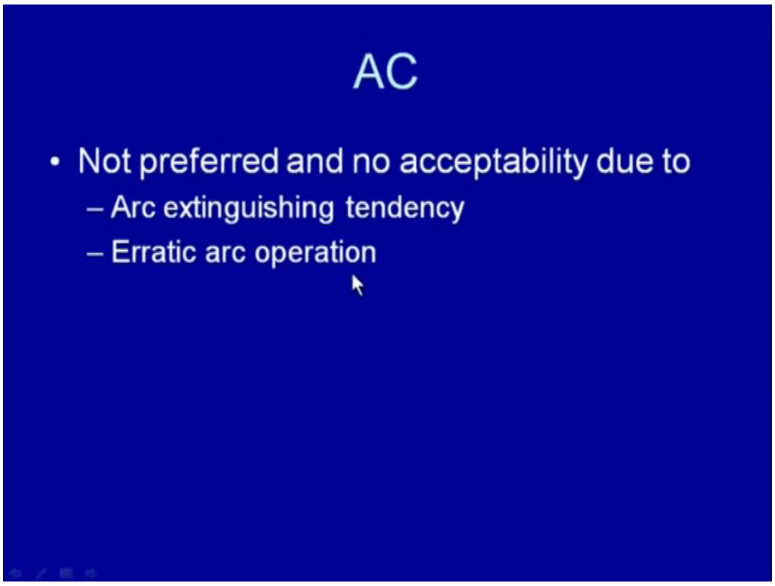

One arc shows the excessive extinguishing tendency means, arc tends to go off, so and the arc is found the erratic. So, because of the two reasons the A C is found very poor accessibility in case of the GMAW process.

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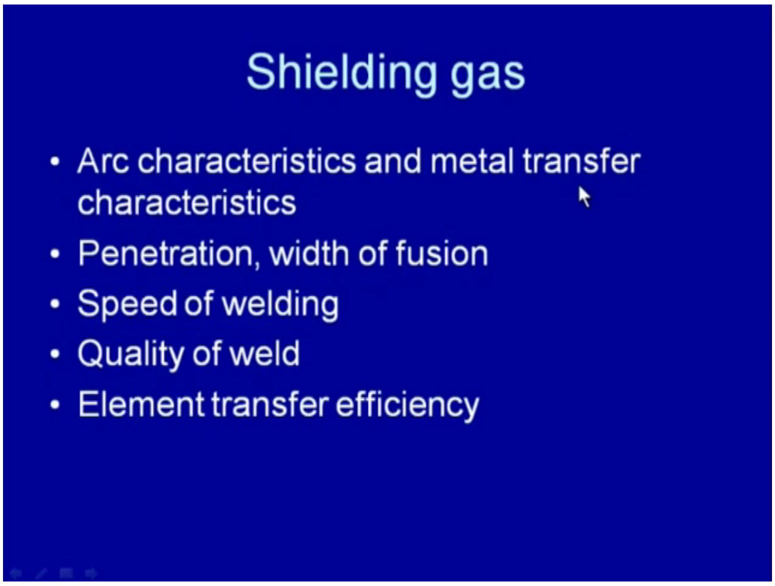

That is why it is not preferred apart from the power sources and the effect of the polarity or the polarity selection. The gas which is used for protecting the weld pool from the atmospheric contamination also affects the many other characteristics of the weld joint. The characteristics related with the welding and the shielding gas affects the arc characteristics and the metal transfer characteristics. We know that the helium and the argon and the modification of the argon by the other gases effects there ionization potential.

So, if the shielding gas is having the higher ionization potential, then it will result in the different arc characteristic. Then, one having the lower ionization potential, so if the arc characteristic is if the ionization potential is more than the peak characteristic will be on the higher side with respect to the voltage and shielding gas also effect the metal transfer characteristic. For example, argon leads to the leads to have the different type of the metal transfers like the globular transfer and the spray transfer, but when we shift to the C O 2, it hardly effects the mode of the metal transfer. It causes the great, the larger amount of the spattering during the welding.

We will see these things further in the coming slides, how the characteristic and the metal transfer affected by the shielding gas depending upon the effect of the shielding gas on the heat generation penetration are affected. For example, the helium causes the higher ionization potential because of the higher ionization potential develops a lot of heat and which in turn helps to increase the depth of the penetration.

The width of the fusion is also effected the welding speed, more heat generation by the helium causes the effective transfer of the heat to the base metal. So, the rapid melting helps to increase the welding speed, but higher flow rate of the helium is required as compare to the argon, so depending upon the way by which the shielding gas is affecting to the heat generation. So, the melting of the base material which affects the welding speeds.

Further, the quality of the weld is also affected by the shielding gas which is being used like the argon and helium offers very good quality welds. When these are modified by the oxygen or the C O 2 is used, it adversely effects the quality of the weld due to the presence of the oxygen in the arc region. Further, the other gases as additives in the shielding gases than these can affect the metal transfer element transfer efficiency.

That is about what percentage of the elements being transferred from the electrode tip to the weld pool. Actually, because some of the elements are lost due to the oxidation or the other gas effect of the adverse effect of the other gases present in the arc zone. So, if the gases are not pure and having the lot of impurities, then these impurities can react with the elements being transferred during the welding from the electrode tip to the weld pool.

Because of this, the reduced percentage of the elements can be there in the weld metal which in turn will be decreasing the elemental transfer efficiency. So, decreased elemental transfer efficiency will leading will be leading the difference in the weld metal composition.

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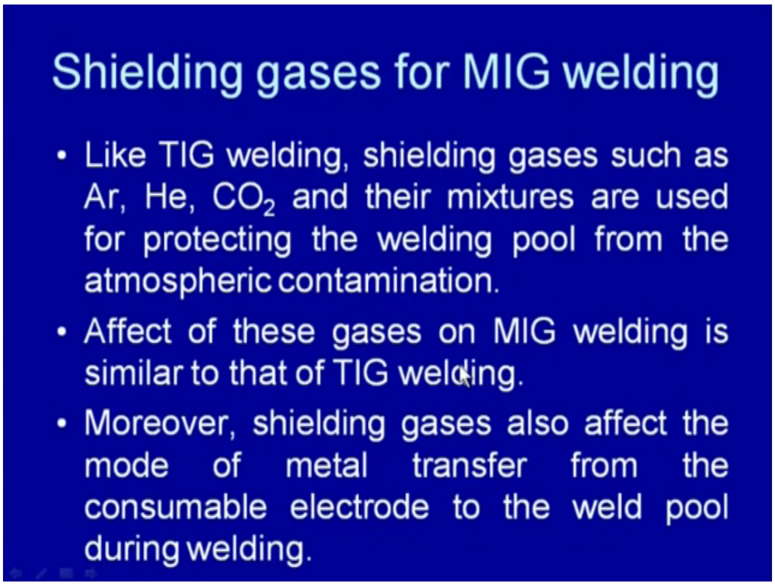

Now, we will see in detail role the shielding gases and their role in GMAW like the G T A W or the T I G welding such as argon helium or C O 2 or their mixtures are used for protecting the weld pool from the atmospheric contamination. The effect of these gases on the M I G welding is similar to that of the T I G welding. Because primarily there is shield to protect the weld pool from the atmospheric contamination at the same time, also affect the kind of heat which is generated during the welding.

So, desired defect of penetration can be achieved moreover the shielding gases also affect the mode of the metal transfer incase of the GMAW process from the consumable electrode to the weld pool, which is not observed in case of the G T A W because G T A W uses the non consumable type of the electrode.

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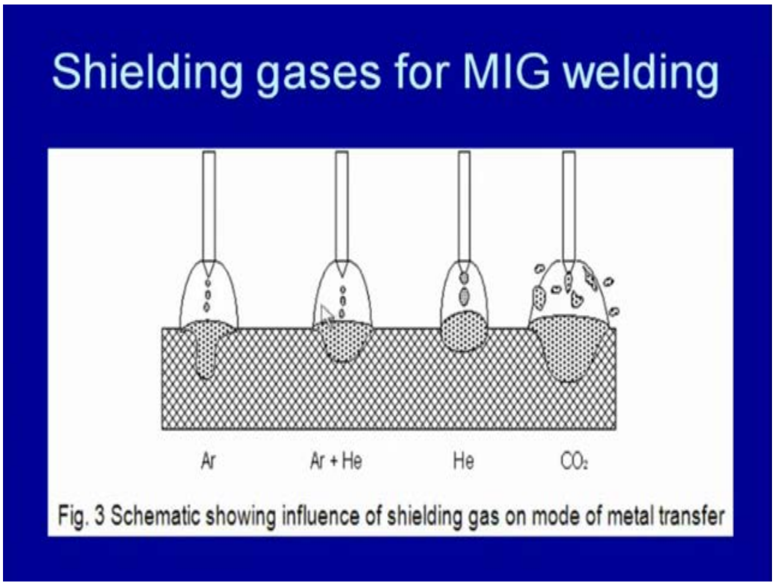

Fig. 3 Schematic showing influence of shielding gas on mode of metal transfer

If we see the incase of the arc welding process if when we use argon very dipper penetration and the narrow weld bead is obtain with the metal transfer ranging from metal transfer ranging from the globular to the spray. The mixture of the argon and the helium results in the optimum penetration and in terms of the penetration and the weld bead helium for the causes the optimum the weld bead cross section while the C O 2 results in lot of the spatter. The large size of the weld pool, so if see incase of the C O 2 metal transfer is not much effected by the increase in current weld. In case of the argon increase in current significantly effects the metal transfer mode from the globular to the spray, so then M I G welding with argon as shielding gas.

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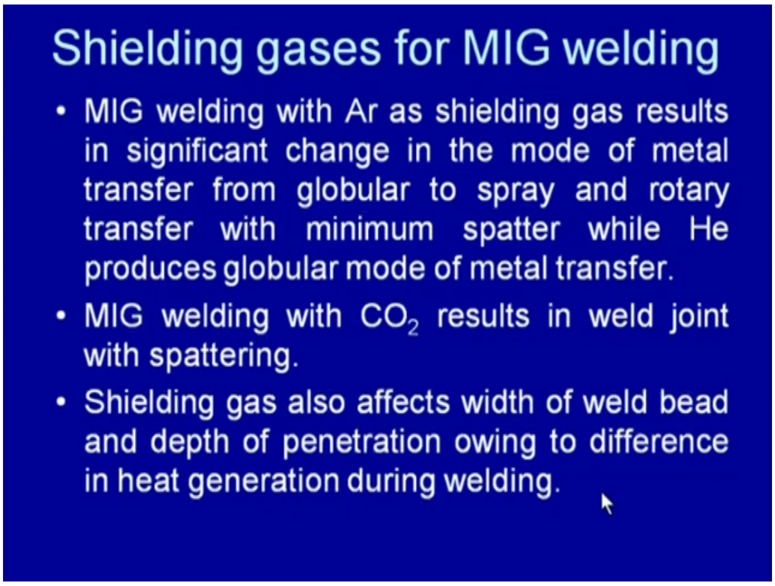

This results in significant change in the mode of the metal transfer from globular to spray and the rotary transfer with the minimum spatter, while the helium produces the globular mode of metal transfer. The M I G welding with C O 2 results in the weld joint with the spattering, so spattering is commonly encountered when the C O 2 is used as a shielding gas. So, shielding gas also affects width of the weld bed and the depth of the penetration due to the difference in the heat generation during the welding. So, the heat generation is effected due to the variation in the shielding gas being used the weld bed cross section can be influenced with the change of shielding gas.

Then that change can be observed in respect of the weld width of the weld bead and depth of the penetration being taking place. Now, we will see, what are the important welding parameters that play significant role in development of the sound weld joint, the deposition rate and the width of the bead reinforcement of the bead and the quality of the weld joint.

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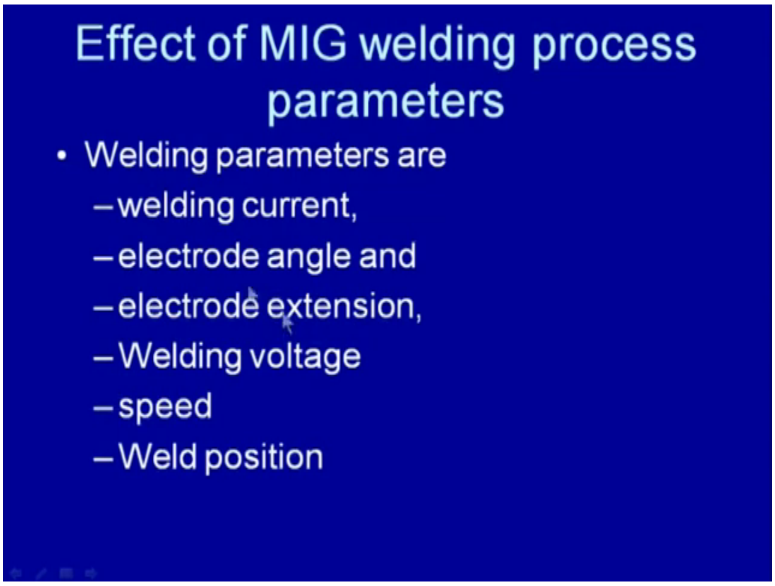

Now, will see the important parameters that effects the various important aspects related with the GMAW or the welding speed, sorry welding current the electrode angle. Electrode extension the welding voltage welding speed and the welding position one by one will be trying to look into the details of each of these current. In general, the increase in welding current increases the depth of the penetration and the melting rate of the electrode. So, the deposition rate higher deposition rate is achieved the electrode angle electrode angle it can be perpendicular to the plate or it can be at certain angle from the normal position.

So, when the electrode is pointed towards the welding direction, we call it as a forward welding or when we points the electrode tip towards the opposite to the welding direction then it termed as a back hand welding. Forward welding results in shallow penetration and the wider weld while the back hand welding results in the deeper penetration and the narrower bed. So, that is how it effects the weld bed cross section, also the electrode extension effects the width of the weld bead and penetration.

At the same time, the deposition rate is also affected because of the electrical resistance heating the welding voltage has the marginal effect on the characteristics of the weld joint. But, marginal increase in range of marginal increase in voltage increases the width of the weld bead. In case of the welding speed, welding speed directly effects the depth of the penetration and the weld bed reinforcement and the weld bed width. So, there with the increase of the weld bed, the reinforcement increases depending upon the kind of the electrode diameter which is being used. But for a particular optimum speed maximum penetration achieved higher and lower welding speed results in the lower penetration and different shapes of the weld bed cross section.

Then the welding position effects the quality of the weld which is being made and that how that can be made. For example, in the normal down hand position or the flat position welding spray transfer can be effectively used for developing the weld joint at high deposition rate. In case of the odd position or vertical positions the pulse welding is found to be more pulse M I G welding is found to be more useful. Now, we will see these effects of the parameters on the quality of the weld joint one by one.

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So, the welding current mainly effects to the weld penetration because and these all these effects are mainly observed because of because of the variation in the heat generated during the welding due to the variation in the welding current. In general, increase in welding current increases the heat being generated during the welding. So, the greater the heat generation, greater will be the penetration during the GMAW process, which in turn will also be increase the deposition rate due to the increased melting rate of the electrode.

Further, it also effects the weld bed geometry, because the higher welding current can lead to the deeper penetration and the weld bed cross section can also increase. Because of the increase in the welding current, the quality of the weld is also effected in terms of the mechanical performs or in terms of the defects say very low welding current will be leading to the very low heat input which can increase the polarity.

Too high use of the too high current can lead to the development of the defects like under cut or significant coarsening of the structure in the heat effected zone and in the weld region itself. So, the selection of the optimum current is important from weld penetration deposition rate the weld bed geometry and the weld quality point of view.

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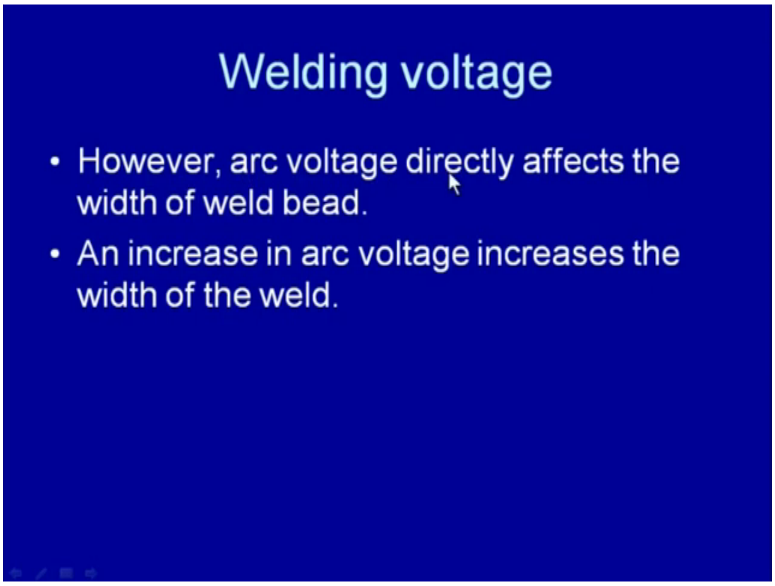

Another important parameter is the welding voltage; we know that the welding voltage has the marginal effect on the quality of the weld and the weld bed. If we increase the welding voltage over a narrow range, then the increase in the arc voltage affects the width of the weld bed. In general an increase in the arc voltage increases the width of the weld bed.

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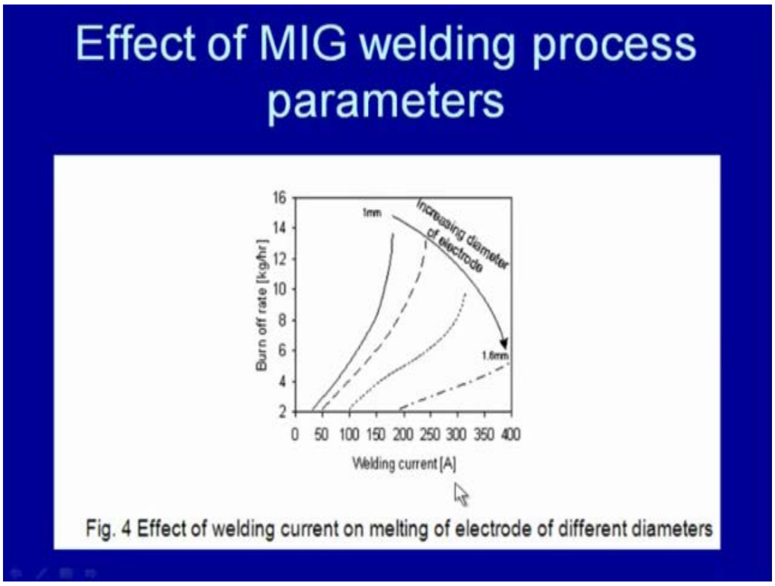

Fig. 4 Effect of welding current on melting of electrode of different diameters

If we see this diagram, this diagram shows the direct relationship between the rate at which the electrode melts means the electrode deposition rate and means the metal deposition rate or the welding current. If we take the large diameter electrode and here say for the small diameter electrode of one m say that how the increase in welding current will be effecting to the electrode burn off rate or so the metal deposition rate by the GMAW process.

In this case, if we see that when the current is increased slowly increased at low level, then the relationship between the burn off rate and the welding current is almost linear. But, when we go on the higher side, then the relationship between the electrode burn off rate and the welding current tends to be the non-linear and this nonlinearity at the upper end of the welding current range. This is encountered milli incase of the small diameter electrodes than the large diameter electrodes and it happens only in the higher end of the welding current range and this happens because of the increased effect of the electrical resistance heating.

When the high current is used with the small diameter electrode while when the current rises small even the current is low even with the small diameter electrodes, linear relation largely linear relationship exist between the welding current and the burn off rate. If we see that even when we are using too high rate of current with the large diameter electrodes, this relationship is still remains of the linear kind. So, this is what we can see the electrode diameter and the welding current significantly affect the deposition rate. For a given diameter of the electrode increase in welding current increases the deposition rate significantly, so welding current is primarily used to regulate the overall size of the weld bed.

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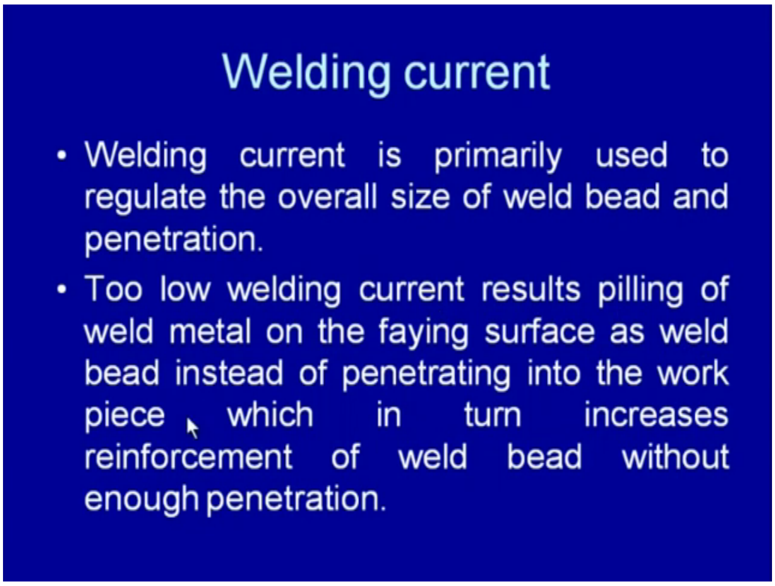

The penetration is higher if the current is more will be the heat generation higher will be linear, the melting rate of the electrode, which in turn will be increase in the weld bed cross section and the depth of the penetration will also be increased. While the too low welding current results in spilling of the weld metal on the faying surfaces as weld bed instead of penetrating into the work piece, which in turn increases reinforcement of weld bed without enough energy. So, there are two adverse effects are related with the too low welding current: one is the unnecessary reinforcement of the weld bed without significantly penetrating into the work piece. So, the poor penetration can lead to the premature failure of the weld joint.

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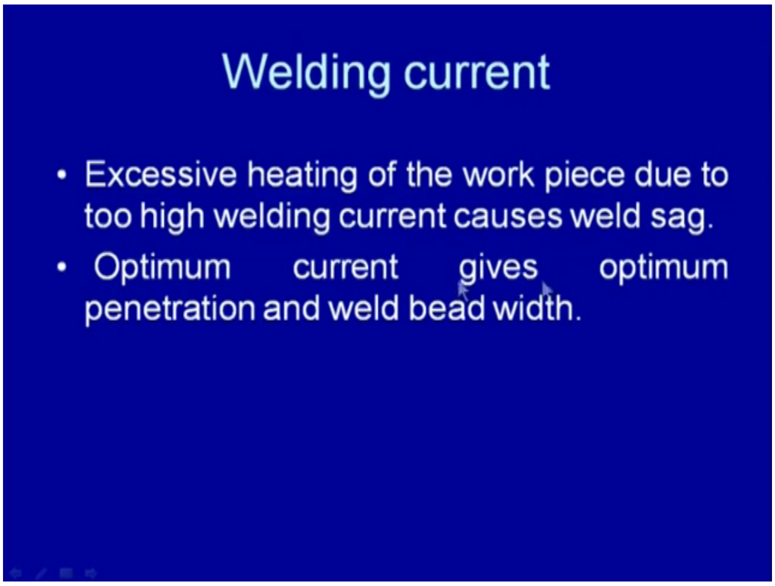

While excessively high current due to the excessive heating of the work piece due to the too high current can lead to the weld sagging and that is why optimum current gives the optimum penetration and weld bed width. Electrode extension is another important parameter that affects the deposition rate and the weld bed cross section the electrode extension.

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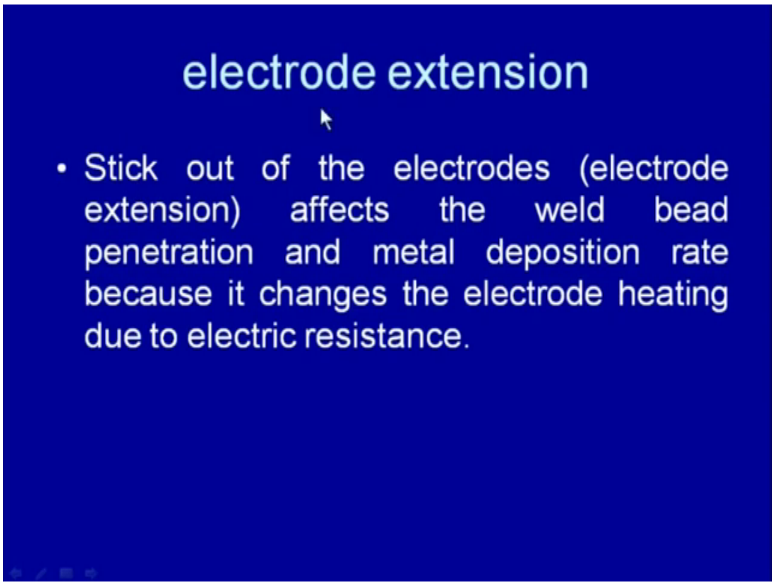

Basically, the line from the electrode which is coming out of the contactive and the electrode tip, so the distance between the last point or the end of the contactive. The electrode tip through which current is flowing during the welding is called electrode extensions stick. The stick out of the electrode means the portion of the electrode, which is projecting from the contactive, and is termed as the electrode extension.

The electrode extension affects the weld bead penetration and the deposition rate because it directly affects the electrical resistance heating. Greater is the electrical resistance heating, greater will be the deposition rate, but it decreases the penetration. It decreases the extent of the penetration it for the short circuit metal transfers normally 6 to 12 ampere electrode extension is normally used. But for the globular and the spray transfers 12 to 25 mm electrode extensions is commonly used.

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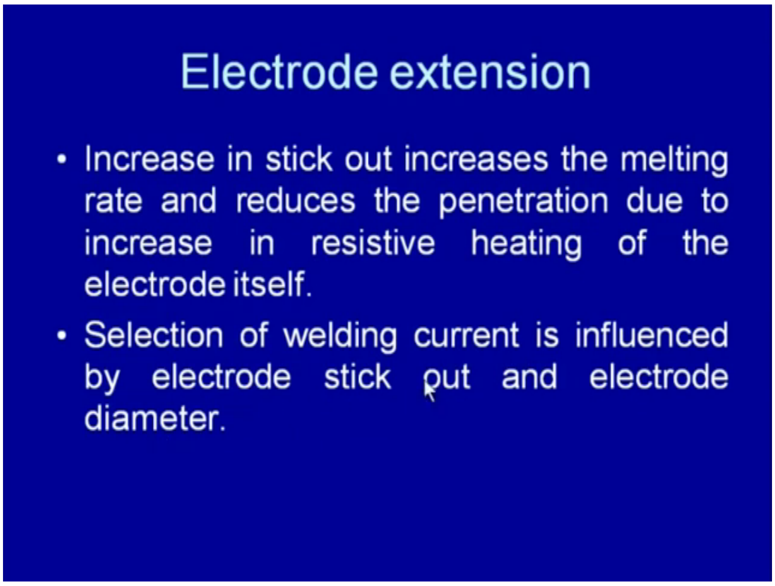

So, if we see the increase in electrode stick out increases the melting rate because of the increase electrical resistance heating of electrode extension part. It also decreases the penetration due to the increased resistive heating of the electrode itself. Too much electrode extension increases all though increases the melting rate, but it makes difficult the placement of the weld metal in the required position and the weld bead.

Morphology is the weld bead shape is also adversely affected. So, that is why the electrode stick out and the electrode diameter these two things significantly affect the selection of the welding current. Inappropriate electrode stick out and for a given electrode diameter can adversely affect the penetration and the weld bead geometry which is developed.

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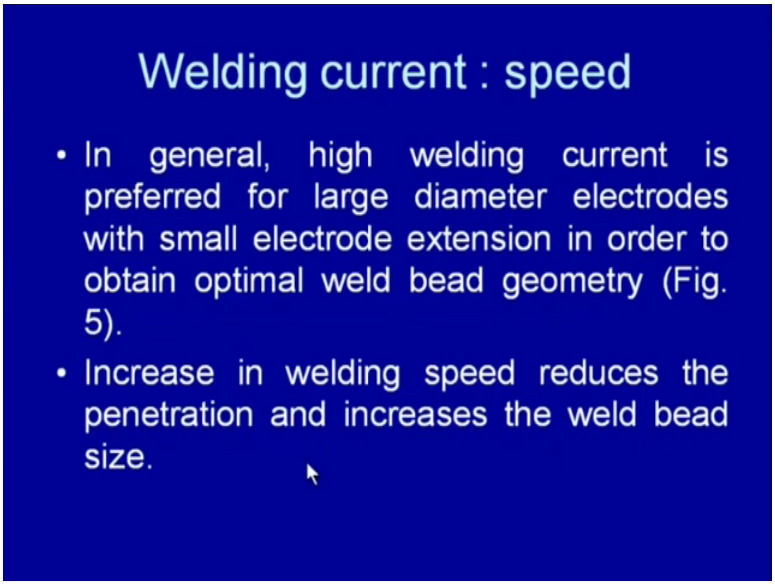

Now, we will see this is what we have said that if really we want to develop too high heat while welding the stick sections the high penetration is mandatory, then it will be necessary to use the high welding current. So, for working with the high welding current it is necessary to go with the large diameter electrodes, so that the required amount of the heat can be generated. With these, we use small electrode extension in order to obtain the optimum weld bead geometry.

In general, increase in the welding speed reduces the penetration and increases the weld bead size. It has been observed, that the for a given welding current and for a given welding voltage, when the welding speed is increased for a particularly speed, the welding the penetration of the weld bead is found to be maximum and the lower and the higher side, the weld bead decreases the penetration and this happens when too high welding speed is used.

It decreases the net amount of the heat being supplied to the base metal for the melting and when too low welding speed is used most of the heat is supplied over the top of the weld pool and metal is not and the heat is not able to penetrate and down into the base metal. So, the lower and the high welding speed both do not have much in achieving the desired depth of the penetration, but optimum speed results in maximum penetration.

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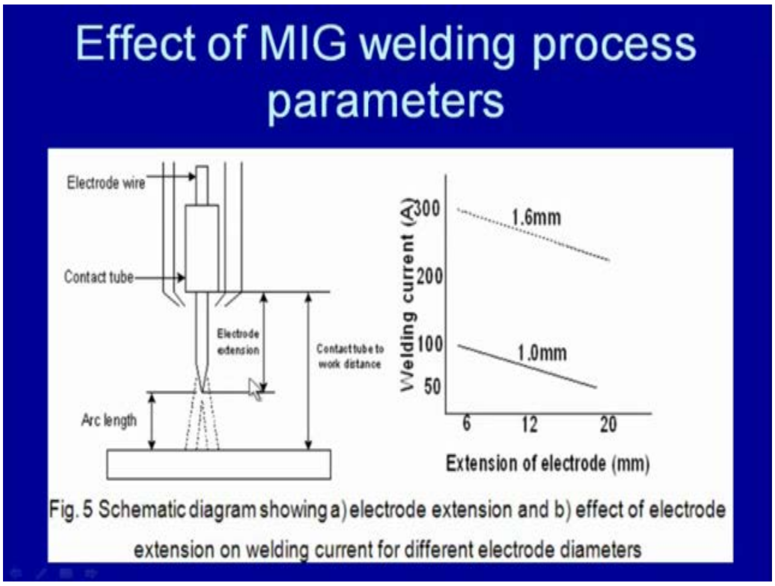

Fig. 5 Schematic diagram showing a) electrode extension and b) effect of electrode extension on welding current for different electrode diameters

If we see this diagram, it will clearly indicate this is the contactive tube through which electrode is coming out. So, the end of the contactive and this end of the contactive are supplying current to the electrode and the tip of the electrode. So, this portion which is this portion of the electrode which is projecting from projecting out from the contactive is called electrode extension. The gap between the electrode tip and the work piece is called arc length.

So, if we see if we increase the electrode extension then for a given welding current of one electrode size. Then, it is desired that electrode extension with the increase of the welding current electrode extension should be decreased. We can work with the larger electrode extension when we are using the small lower current, when high current is used with the one electrode size the smaller electrode extension should be used while we can use the very high current. It is required to walk with the larger diameter electrode, so the electrode extension for this shows the electrode extension can vary from the 6 to say 18 or 20 mm.

But the range of the current will vary according to the diameter of the electrode which is being used. For example, this can walk with the 200 to 300 ampere range while it can walk with say about to fifty to hundred ampere welding current range, so the selection of the electrode extension and the welding current is important for a governed electrode diameter. In an appropriate selection can lead to the in poor weld bead shape and poor penetration, however we may we can get the higher the deposition rate.

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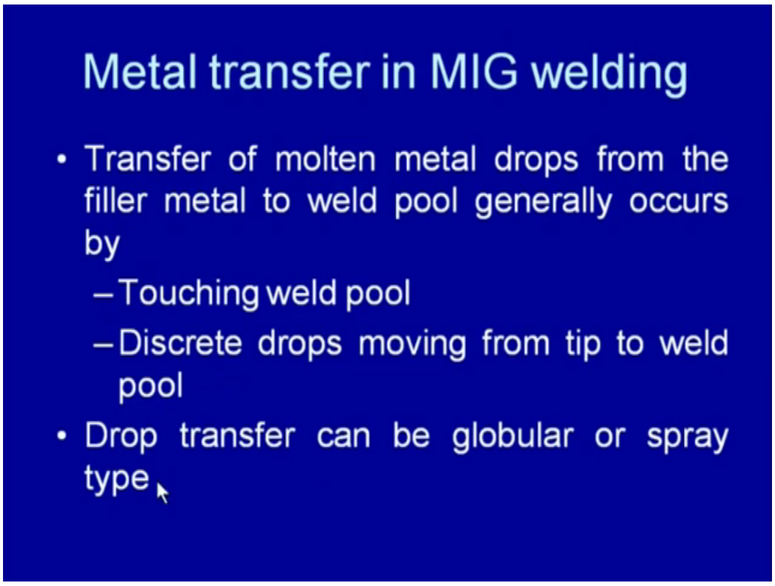

Now, we will see the another important aspect related with gas metal arc welding process is that the metal transfer is the metal transfer is observed in all consumable arc welding process where electrode tip melts and the molten metal is transferred to the weld pool. In case of the gas metal arc welding process, the transfer of the molten metal takes place drop by drop from the filler metal to the weld pool.

Generally, it occurs this transfer of the molten metal drops takes place in the two ways; one is by touching to the weld pool that is the short circuiting mode of the metal transfer or in form of the transfer of the discrete drops moving from the electrode tip to the weld pool. So, this transfer of the molten metal in form of the discrete drops can be being formed the globular or the spray type which can happen under the different conditions.

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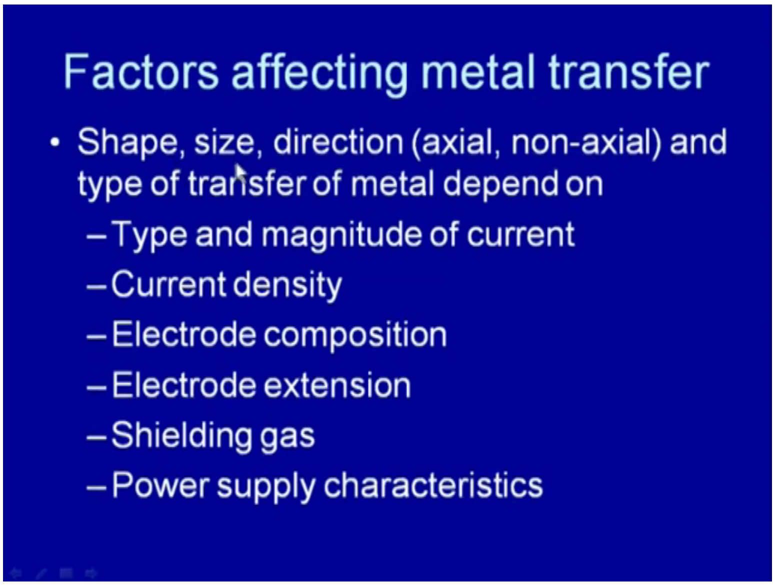

We know that the depending upon the welding conditions being used the various the size of the size of the drop, shape of the drop under direction in which it is moving and the type of the metal transfer, which will be occurring can be effected by the various factors related with the welding. For example, the type of the current and the magnitude in general the like the DC current affects the metal transfer in very systematic way as compare to the AC. Increase in the welding current magnitude shifts the molten metal transfer from the globular to the spray when especially when the gas shielding gas is argon.

So, this happens because mainly because of the in reduction in surface tension force and the increase in the pinch force magnitude and the variation in the melting rate. Current density is the another important factor that effects the size of the droplet and the molten metal transfer too high current density will be causing the faster melting. The higher pinch force will be decreasing the size of the drop being transferred the electrode composition will be effecting to the electrical resistivity.

So, it will be effecting to the way by which molten metal the melting of the electrode of the tip is taking place at the electrode tip is taking place and then it is transferred to the weld pool. Electrode extension will be effecting to the electrical resistivity and accordingly the rate at which molten metal drops will be developing at the tip of the electrode shielding gas. On the other hand, effects the weather there will be rotary type of the transfer.

The spray or the globular transfer or short circuit mode of the metal transfer because it effects the heat generation because, heat generation due to the difference in the ionization potential of the various gases. The metal transfer also is affected by the characteristic of the power source being used weather it is constant current type or the constant voltage type. So, if see the common types of the metal transfers are the short circuiting transfer.

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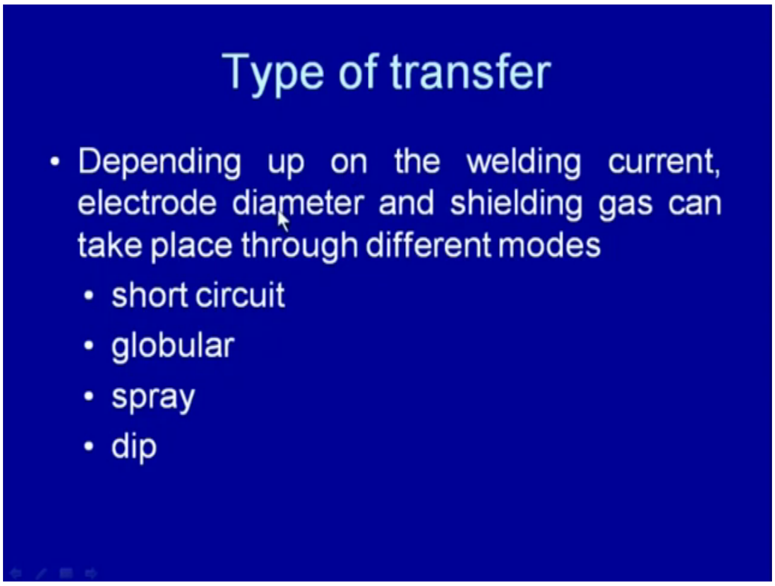

Globular spray or the dip transfer depending upon the welding current and the electrode diameter being used shielding and the shielding gas is which is being used. We can have these common type of the metal transfers in the gas metal arc welding.

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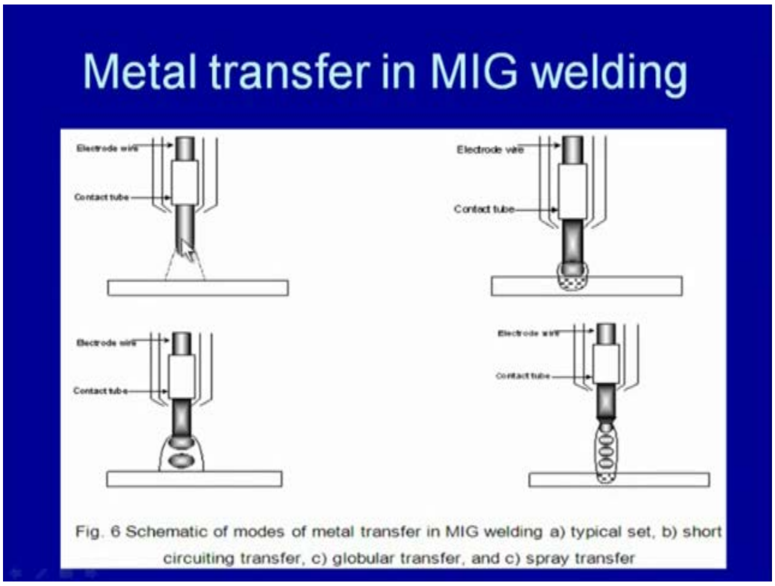

This is a schematic diagram showing the arc between the electrode tip and the work piece and here the electrode tip is touching to the weld pool and then molten metal drop being form at the tip is getting transferred. So, this will be leading to have the short circuit metal transfer and here slow melting of the electrode tip will be leading to the development of the electrode molten metal drop to the larger size. Then it is getting transferred under the gravitational force. When the current is too high, then the rapid melting and the high pinch force will be causing the detachment of the droplets when there are of the very fine size, thus leading to the spray kind of that transfer.

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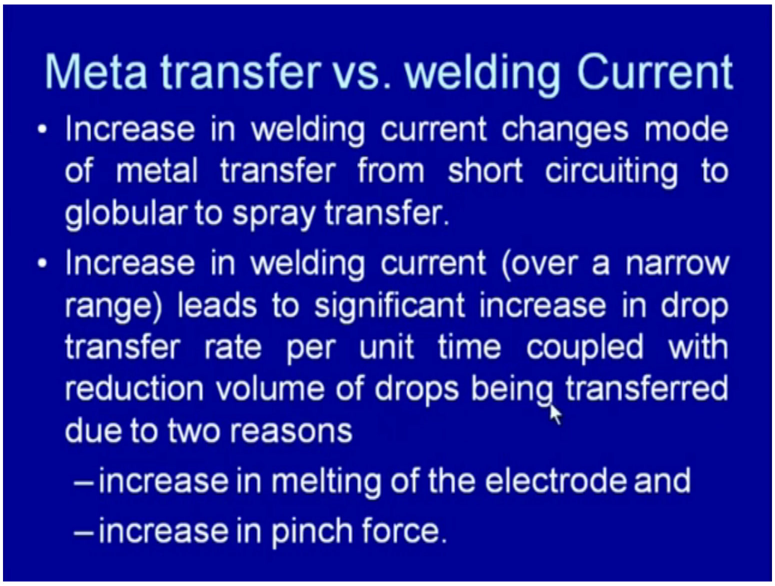

So, increase in the welding current changes the mode of metal transfer from short from shot circuiting to the globular and then globular to the spray increase in welding current. Over a narrow range leads to the significant increase in the drop transfer rate per unit time coupled with the reduction in the volume or the size of the drops being transferred and this happens mainly because of the two reasons. Means increase in welding current increases the drop transferred rate and decreases the size of the drops being transferred and this happens, because of the increase in melting of the electrode and increase magnitude of the pinch force.

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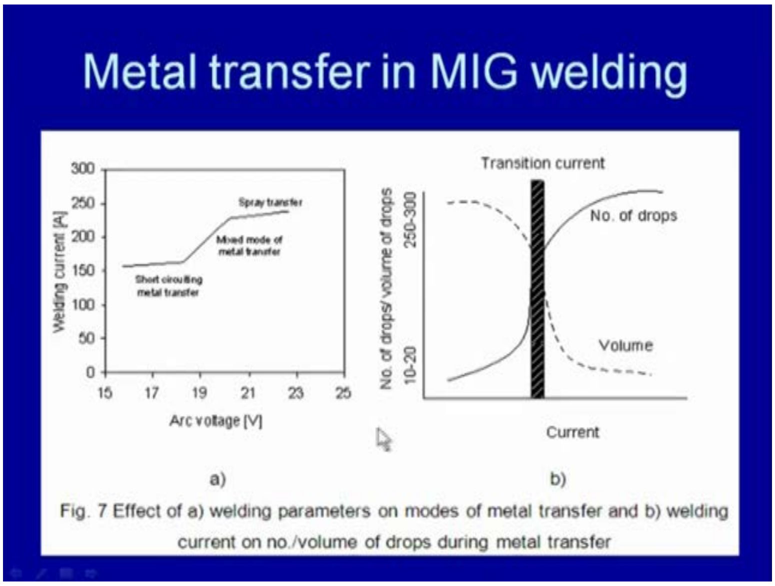

If we see here in case of the gas metal arc welding process, this schematic diagram showing this diagram showing the relationship between the arc voltage and the welding current. If we see here, when the welding current is increased for a certain range, the mode of metal transfer remains the globular kind and the drop and when we increase the welding current. In certain range, we find the spray kind of transfer and in between the mixed mode is observed.

Further, if we see the current magnitude is increased then the number of transfers then the number of drops being transferred per unit volume or per unit time or the volume of the drops that the relationship between the welding current. These two characteristics that is volume of the drops and the number of the drops being transferred, so if we see here schematic diagram showing that if we increase in the welding current. The volume drops rapidly and the number of the drops increases, the increases significantly.

There is range of the current over which this variation in the volume drops and the number of drops takes place very abruptly. So, this value of the current or narrow band of the current is called transition current cross which the change in the mode of metal transfer from the globular to the spray takes place. We can say then the number of drops being transferred in the globular are very less may be 10 to 20 drops per second while these can be in the range of the 250 to 300. In case of the spray mode of transfer that transition current is to be crossed to have the spray mode of the metal transfer.

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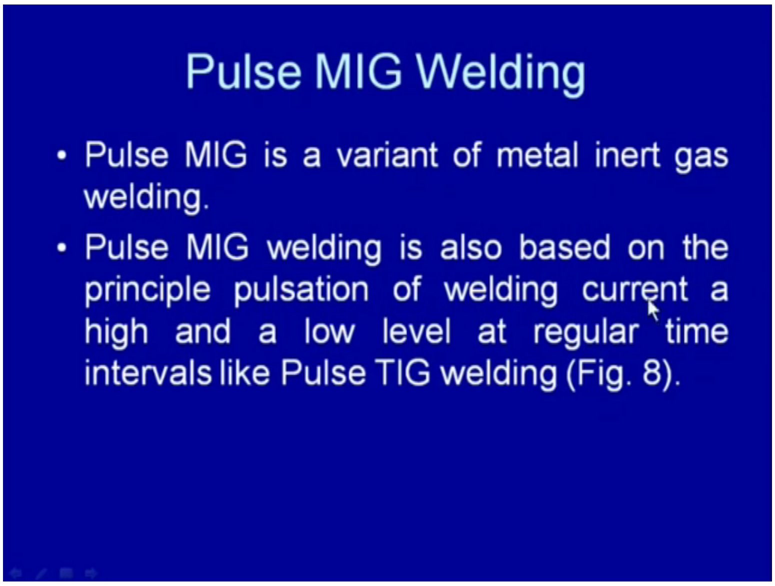

The pulse MIG is the one variant of metal inert gas metal arc welding process, which is commonly used especially when the low heat input is required for developing the sound weld joint. In this case current is varied between the background current and the peak current levels pulse current base. It is based on the pulsation of the welding current between high and the low levels at the regular interval of the time like in the TIG welding process.

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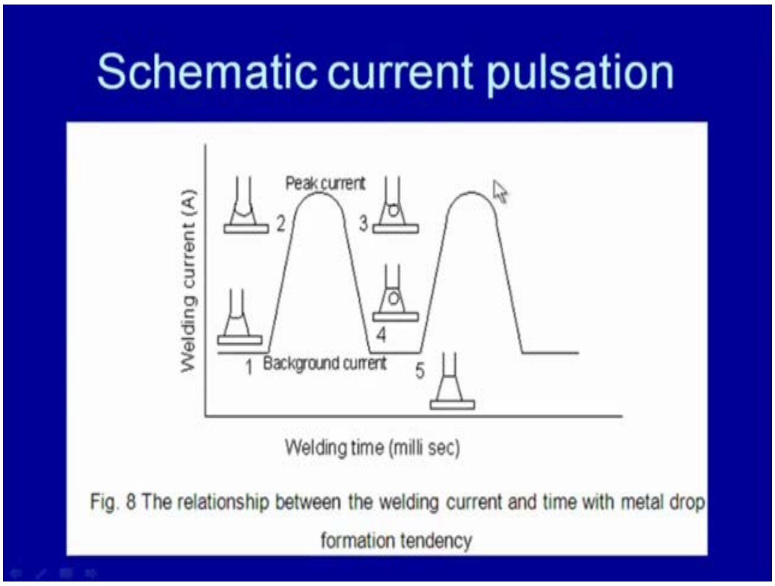

So, here current is varied between the background current and the peak current levels which in turn peak current helps to melt the electrode tip and the transfer of the droplet during the background current portion, the solidification is facilitated.

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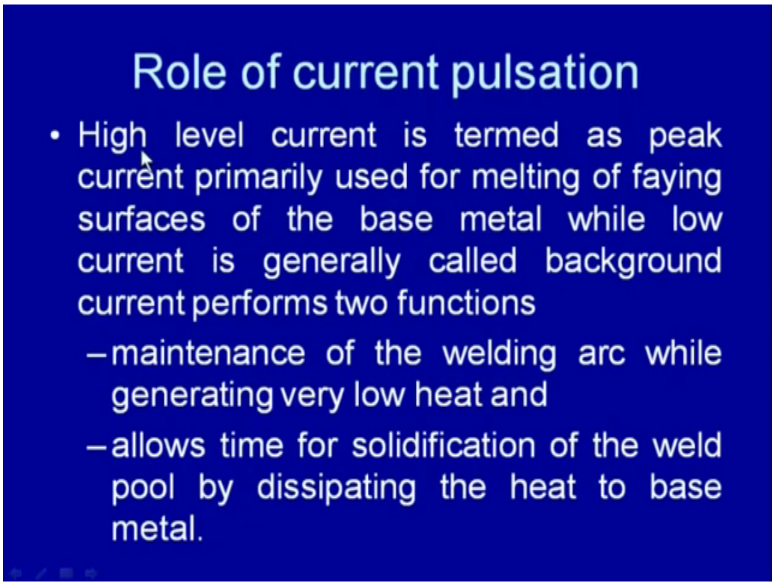

So, if we see the high level current is termed as peak current primarily used for melting of faying surfaces of the base material and the electrode tip. While the low current is generally called background current, performs the two function, it helps to maintain the welding current while generating the low heat input. Further it allows time for solidify by dissipating the heat to the base material.

So now we conclude this presentation. In this presentation, we have seen the basic principle of the gas material arc welding process and the important parameters, which are playing the significant role in the development of the sound weld joint. We have also seen that the power sources which can be used with the gas metal arc welding process and the effect of the polarity on the quality of the weld. The weld bead which is made by the gas metal arc welding process, further we have also seen that one variant of the gas metal arc welding process that is the pulse gas metal arc welding process.

This one is mainly used, when the low heat input is important for developing the sound weld joint. Like the metals, which are very assist to the heat or low heat input is required for developing the weld joint like in the odd position, like the vertical or the overhead welding conditions. Now, thanks for your attention and in subsequent lectures. We will be presenting the some other welding processes.

Thanks for attention.