Manufacturing Process - I
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Module - 3
Lecture - 10
Gas Metal Arc Welding

Welcome students, this is the seventh lecture on the gas metal arc welding process. And we will see the different principles related to the gas metal arc welding process, the power systems, which are used in filler metals, which are used in this process and the importance of the welding process parameters on production of the soundness sound weld joint.

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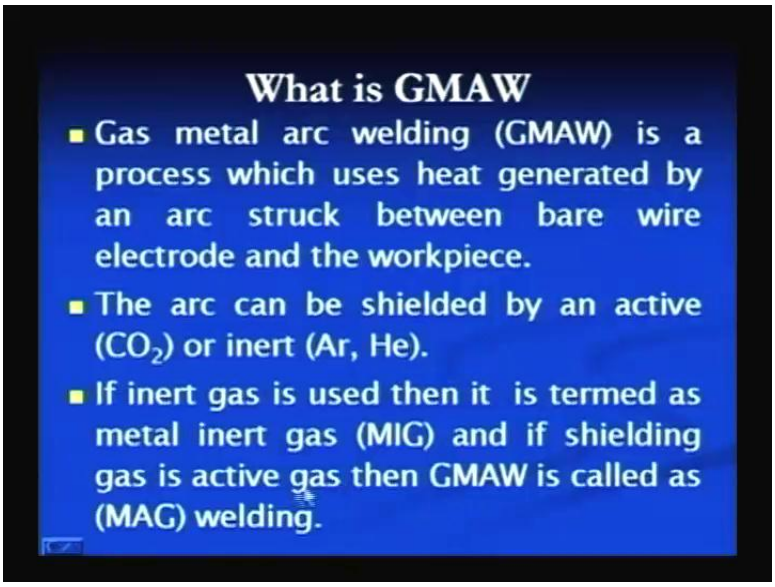

Here, for joining the reactive metals, like aluminum and magnesium, initially people struggled a lot with gas welding and shielded metal arc welding. But they were unsuccessful, because these processes, which were available in the initial stages, were not able to produce sound weld joints with, with the reactive metals. And that is why, the need was felt to develop some new processes and to cope with the difficulty in welding of the reactive metals like magnesium and aluminum.

Initially, tungsten inert gas welding process was developed somewhere in 1930. And, but the problem with the TIG or tungsten inert gas welding process is, that it is a high energy

density process, but it is useful only for the thin sheets welding. And the speed of the welding is also very low, which can be obtained with the TIG welding process.

Therefore, to meet the demand of the high welding speed and high production rates, further need was felt to develop some new process and as a result of that metal inert gas welding process or metal active gas welding process, which is also termed as gas metal arc welding process, was subsequently developed.

The gas metal arc welding process is a process, which uses the heat, which is generated by an electric arc. An electric arc is struck between the bare electrode wire and the work piece and that arc is shielded by the shielding gas. Gas may be active like C O 2 or mixture of C O 2, nitrogen and oxygen or helium or gas may be inert gas. So, accordingly, the arc was shielded by an active gas or an inert gas to protect the filler metal and weld pool from the atmospheric contamination and produce sound welt joint.

Here, in the gas metal arc welding process, if inert gas is used to protect the weld pool and the same process is termed as metal inert gas welding or MIG welding process. And if the shielding gas is an active gas, like CO 2 or mixture of CO 2 and oxygen or CO 2 and hydrogen, then the gas metal arc welding process is termed as MAG or metal active gas welding process. This process uses consumable electrode, which can be fed continuously and that is why, process can be semiautomatic or automatic and capable to produce the high welding speeds and which can fulfill the demand of the high production rate by the industry.

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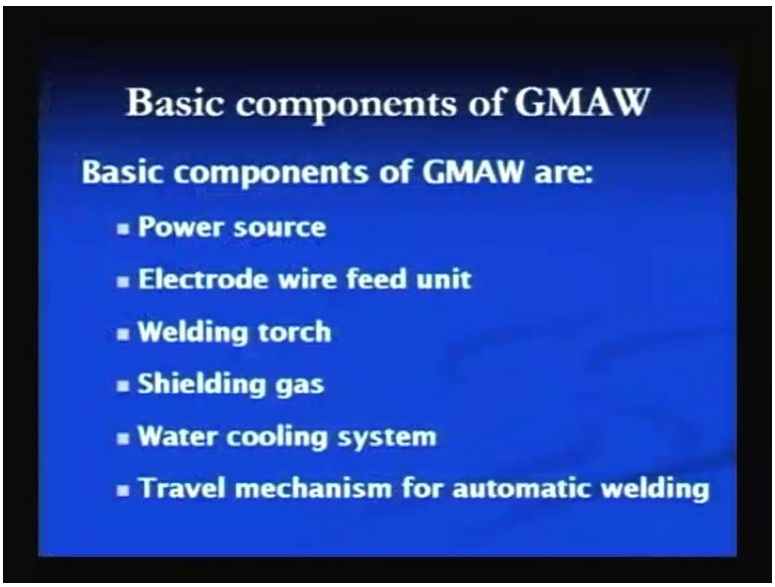

The basic components, which are there in gas metal arc welding process because of which we get high production rate even during the welding of the reactive metals, like the magnesium, aluminum, steels, stainless steels, particularly are high quality weld joints in, in, in alloys steels and carbon steels. So, these gas metal arc welding systems are, are made of the number of sub systems or sub components, like the power source, which delivers the required welding current at desired voltage. This plays a significant role in production of the sound weld joint. If the power source selection is incorrect, we may end up with number of problems. And the wire feed unit, which continuously supplies the electrode wire in the arc region to produce a stable arc and to provide the filler metal during the welding.

Welding torch, welding torch is another component, which includes the nozzle, the contact tubes, etcetera, through which electrode wire is passed during the welding to develop the arc. And it also supplies the desired current to the electrode because the power source is connected to the contact, contact tube and which is further in electrical contact with the electrode wire.

And the shielding gas provides the desired production from the atmospheric contamination. This shielding gas may be helium, may be C O 2 or mixture of the different gases. Water cooling system is required to maintain the temperature of the torch within the safe limits. So, as per the current rating of the welding torch, there can be water cooled or air cooled gas metal arc welding system.

Normally, up to 200 ampere current rating gas metal arc welding torches are air cooled and from 200 to 750 ampere current rating, welding torches are normally water cooled. So, the cooling system depends upon the current rating of the welding torch. And if the process is to be automated, then some device is used for moving the torch at the desired controlled speed during the welding.

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Here, the justification behind the use of the metal inert gas or gas metal arc welding process. This is what I have told you earlier that TIG was able to weld the reactive metal successfully, but it suffered with the problems, like unsuitable for thick plates, and thin, and thick sheets and the welding speed was low, which in turn produced very low production rate. And therefore, demand was there to develop new processes, which can cope with the need of the high production rate by the industry.

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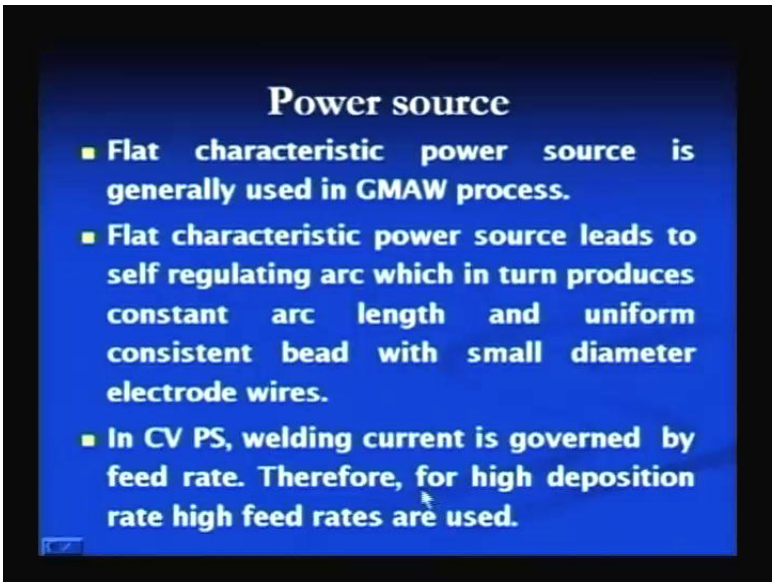

And here, we will see one by one the different components of the gas metal arc welding process, their importance and their effect on the production of the sound weld joint.

Here, the power source is the most important, is the component because it delivers the desired welding current at required voltage. So, selection of the proper power source is very important.

But in gas metal arc welding process, normally flat characteristic power source is generally used because it helps to develop the self-regulating arc to maintain the arc length. And the flat characteristic power source leads to the self regulating arc, which in turn produces the constant arc length and uniform consistent bead, particularly with the small diameter electrode. If the large diameter electrodes are to be used, then constant current type of the power sources are selected. In the constant voltage power source, welding current is governed by the feed rate.

If we need to develop more heat for welding of thick plates, then, then the feed rate is increased, so that the welding current is also increases. Therefore, for high deposition rate, feed rates are, high feed rates are used, so that high current can be obtained, which can develop, which can increase the welding current and produce high welding speed. So, for and therefore, for high deposition rates the feed rates are increased

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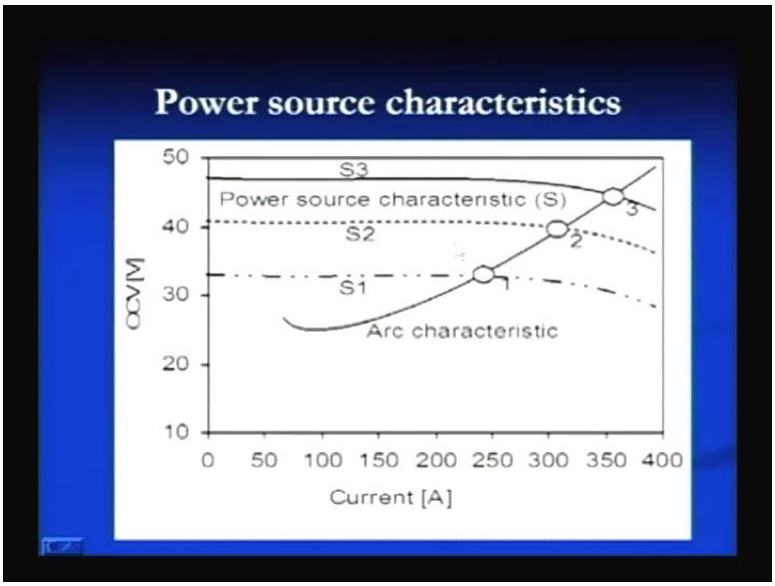

And then, the high feed rates are effective, particularly in case of the constant welding, constant voltage welding power sources. We can see, that how the constant voltage powers sources work.

Here, this is the arc characteristic or vi characteristic of the arc and the three different power sources you can see or the power source with three different open circuit voltages,

if we change, say here, if open circuit voltage has been set here, somewhere 32, 42 or say 46, then we can see, that there will be, for a given setting of the open circuit voltage during the welding, there will be very little decrease in the voltage.

So, open circuit voltage in constant voltage power sources is almost equal to the arc voltage. There is very minor reduction in the voltage, which this reduction is about 2 to 3 volts. So, here, if the open circuit voltage, which has been set is say, 34 volts, then arc voltage may be 31 or 32 volts. There is minor reduction. And if the open circuit voltage is set different, then we get the different arc voltages.

So, here, in the same way, here if the arc length also changes due to the ((Refer Time: 12:07)) region, then the change in the operating point is also noticed, that affects the welding current as per increase or decrease in arc length. If arc voltage increases, then welding current decreases and the decrease in welding current, in turn, reduces the melting rate. So, this feature is used in developing the self-regulating arc.

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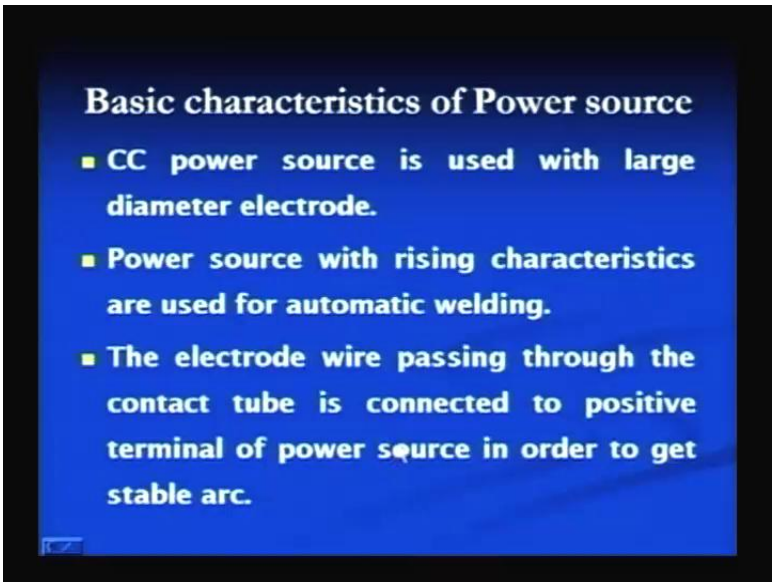

The basic characteristic of the power sources, which are used in, in, in, in the gas metal arc welding process can be of the three types. Means, all three types of the power source can be used in gas metal arc welding process like, but it is common to use the constant voltage power sources, particularly with the small diameter electrode because they offer the advantage of self-regulating arc.

Here, the constant current power sources is used with the large diameter electrodes because if the diameter of the electrode is large, we do not get the benefit of the self-

regulating arc because of poor burn of rate relationship with the current. That is why, here variable speed feed drive systems are used to maintain the arc length with the constant voltage power sources when large diameter electrodes are used. Here, power source with the rising characteristics are also used if the strictly constant voltage is required for automatic welding process.

So, if the gas metal arc welding process is to be made totally automatic, then it is preferred to use rising characteristic power source, so that strictly constant voltage can be obtained. And the electrode wire, which is passing through the contact tube is normally connected to the positive terminal of the power source to get the DCEP and get a stable arc, stable self-regulating arc. So, the DCEP with the constant voltage power sources is obtained by connecting the positive terminal of the power source to the contact tube, which finally delivers the current to the electrode in order to get the self-regulating arc.

So, here in this slide we can see, that constant voltage power sources are used with large diameter electrodes, sorry, constant current power sources are used with a large diameter electrodes. Rising characteristic power sources are used for automatic welding. And the small diameter electrodes are used with the constant voltage power sources to get the benefit of the self-regulating arc.

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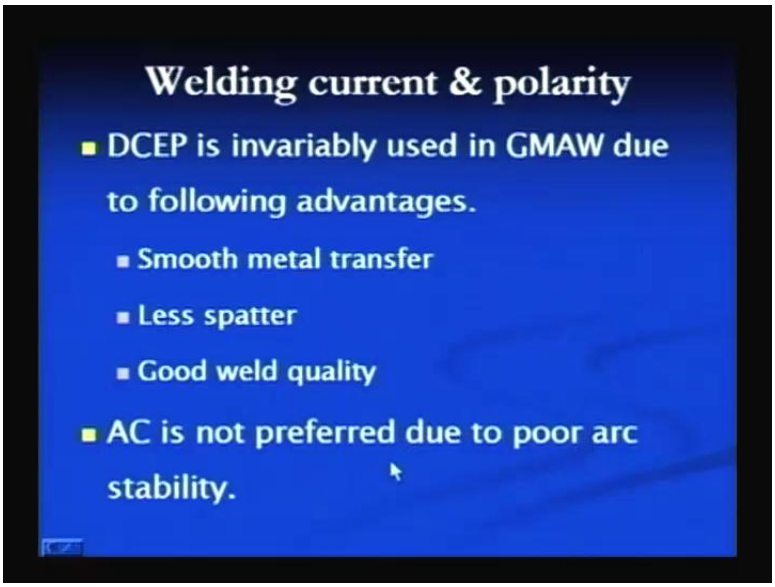

And when the DC is used, then we get the number of the advantages related with, but certain disadvantages can be there because here there may be arc ((Refer Time: 15:23))

kind of the adverse effects. But when DC is used, we can use either DC electrode positive polarity or electrode negative polarity.

Electrode positive polarity is more preferred because it offers certain advantages, like these advantages are like a smooth metal transfer is obtained, which is spatter free and free from the erratic arc and the less spatter is there, and the good weld quality is obtained. So, because of these advantages, the DCEP is normally preferred in gas metal arc welding processes.

AC is not used because the polarity keeps on changing in every half cycle and in the bare electrodes, which are used in gas metal arc welding process are not able to release the electrons easily, particularly when current is 0. Under those conditions, AC, with the AC it becomes difficult to restrike the arc. That is why, stability of arc is poor when AC is used. That is why, in gas welding, gas metal arc welding process AC is not preferred because of the poor arc stability.

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The DCEN or DC electrode negative polarity, when negative terminal of the power source is connected to the electrode, although gives the high deposition rate because in, in the DCEN one-third of the heat is generated in the electrode side and two-third of the heat is generated in the base metal side. So, that offers the advantage of the high deposition rate, but, but at the same time it suffers with the problems like poor arc stability, spattery arc or unstable and erratic arc is produced, that no cleaning action is obtained and poor bead shape is there.

So, here, when your electrode is made positive and work piece is negative, we get the mobile cathode spot. They spot from which electrons are released during the welding and that mobile cathode spot thereby, helps to loosen the oxide layer, which is formed on the surface of the reactive metals particularly. And thereby, it helps to obtain the better cleaning action.

That advantage is not available with the DCEN here because in this case, the electrode is made negative and work piece is made positive. If the work piece is, is made negative, then electrons will be released from the mobile cathode spot and we will be getting the advantage of the cleaning action.

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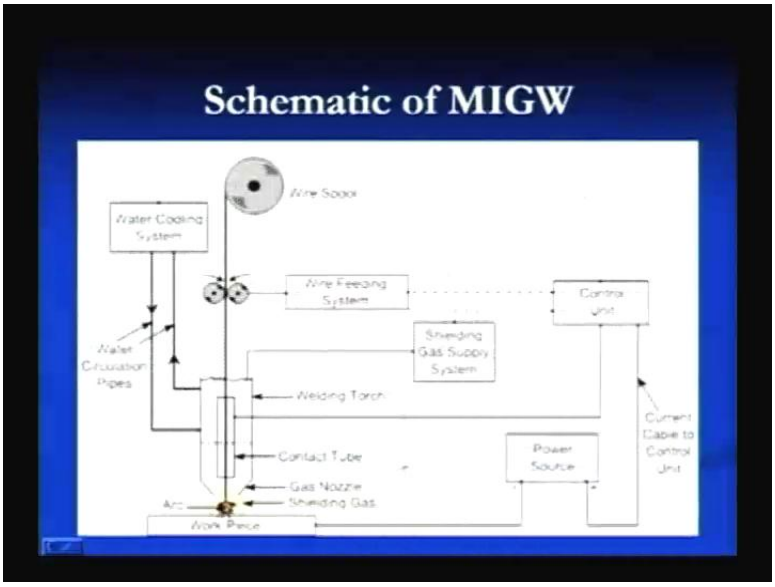

The schematic diagram of a gas metal arc welding process can be seen from this diagram here. The continuous ((Refer Time: 19:03)) fed consumable electrode is supplied through this wire feed system and this wire passes through this contact tube and then, contact tube delivers the desired current from the power source. And here, an arc is struck between the work piece and the electrode tip.

So, here we can see, there is arc and around this wire here this is the nozzle, which, through which the shielding gases are supplied to form cover of the shielding gas around the arc and the weld pool and thereby, shielding gases help to protect the molten weld pool and arc region from the atmospheric contamination.

Here, this is the contact tube, which is in firm electrical contact with the electrode wire and this entire assembly is, is called welding torch. Here, the water cooling system is

used to feed the water in, in the welding torch. So, the temperature of the torch can be maintained within the safe limit, but this system water cooling system is mainly used with the welding torches of the higher current rating, above 200 ampere. And here, the required shielding gas supply can be made from the argon or helium cylinders or CO 2 cylinders and to get a continuous jet of the shielding gases outside this nozzle and around the arc region.

And a control unit helps to feed rate of the electrode wire at the desired speed and the power supply is also connected to the work piece and to the contact tube, so that welding circuit can be completed here. So, this entire diagram show the schematic arrangement of the gas metal arc welding or metal inert gas welding process.

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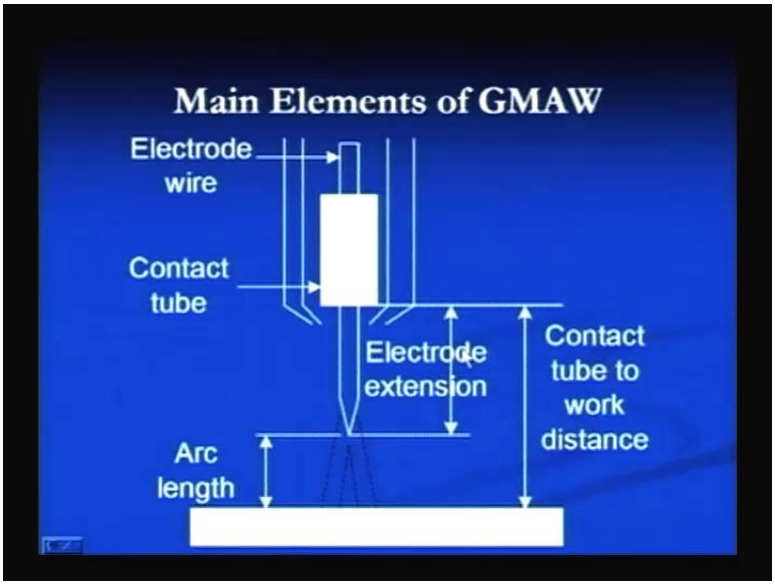

Schematically, here we can see the different main elements and the different, the dimensions and the terms related to the gas metal arc welding process. Like here, this is the electrode wire being fed through the contact tube and here, this is the tip of the electrode and the distance between the tip of electrode and work piece is the arc length here and distance between the nozzle between the contact tube and the work piece, is the electrode extension, is the contact tube to the work piece distance, and the distance between the electrode, a contact tube and to the electrode tip is this distance, is known as electrode extension.

And this electrode extension and arc length, these two parameters, play significant role in, in successful welding and the deposition rate. In general, the higher extension,

electrode extension, leads to the higher deposition rate and the same is also applicable here. Here, the arc length, change in arc length effects the welding current and so, it affects the melting rate. Here, increase in, say, in case of the constant voltage power sources, increase in arc length decreases the welding current and decreases the melting rate in order to maintain the arc length by when, when electrode is fed at a constant speed.

So, these are the main elements here, one, there is one more distance, that is known as nozzle to work piece distance. This is the end of the nozzle and from this point to the work piece, this distance is known as nozzle to the work piece distance. And this is also important from the life of the nozzle point of view, means, the life of the nozzle is effected by this nozzle to work piece distance.

An optimum distance is required between the nozzle and work piece. The too close distance adversely affects the life of the nozzle and too long distance adversely affects the shielding of the weld pool and the arc region. So, optimum distance of the nozzle to the work piece distance is also required to be maintained.

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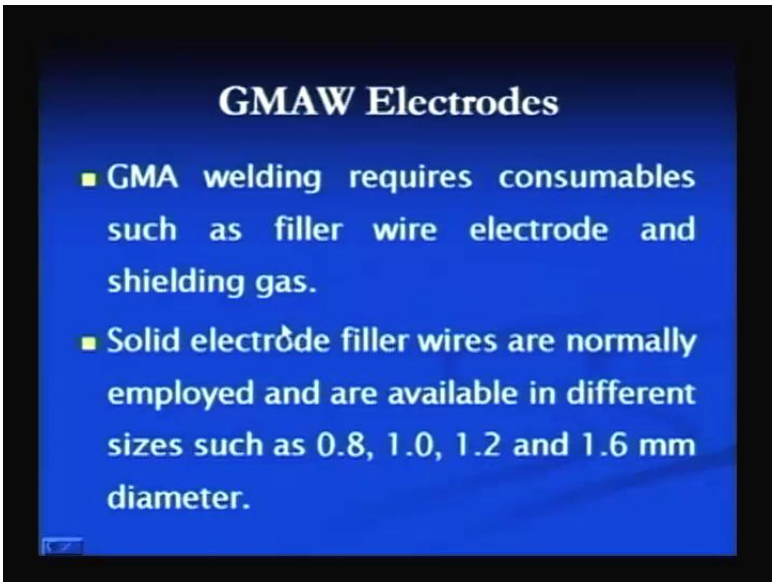

Now, the next, after the welding power sources selection as per the requirements means, whether the small diameter or the large diameter electrodes are to be used for a given application and the suitable welding power sources are selected, suitable type of current is selected and polarity is selected.

And once the proper power source polarity and type of current has been selected, next step is, to used, to use, that which type of electrode and to understand, that how the electrode of the gas metal arc welding process can affect the performance of the gas metal arc welding processes itself, that the GMA welding, gas metal arc welding requires consumables of the two types. One is the filler wire electrode and which is consumed during the welding to fill up the gap between the plates to be welded. And another one is the shielding gas, shielding gas to protect the weld pool from the atmospheric contamination.

Here normally solid electrode filler wires are used and these electrodes are available in the different sizes, from say, 0.8 to 1.6 mm in a step of 11.2 mm in diameter. And there is no limit of electrode length because electrode is fed continuously and it is consumed continuously. That is why, electrode size normally refers to the diameter of the electrode and these are the common electrode diameters, which are used in gas metal arc welding process.

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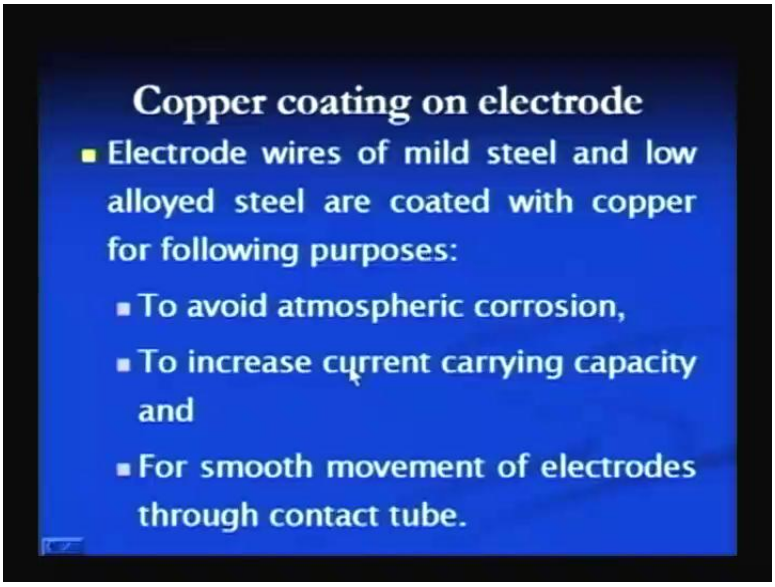

And these electrodes are normally coated with the copper to achieve the specific objectives. Like if the steel is there, steel has somewhat poor electrical conductivity, poor corrosion resistance and that is why, if the steel electrodes are coated with the copper then, then the electrical carrying capacity of the electrode and the corrosion resistance of the copper can be increased significantly. At the same time, smooth movement of the electrode through the contact tube can also be made possible by coating it with the

copper. So, here electrode wires of the mild steel and low alloyed steels are normally coated with the copper to achieve the specific objectives like to avoid, that the atmospheric corrosion of the steel or the ferrous electrode wires.

To increase the current carrying capacity of the filler wire or the electrode. And for the smooth movement of the electrodes through the contact tube. And the presence of the copper as a coating on the electrode wire has to achieve these objectives for the better performance of the gas metal arc welding process.

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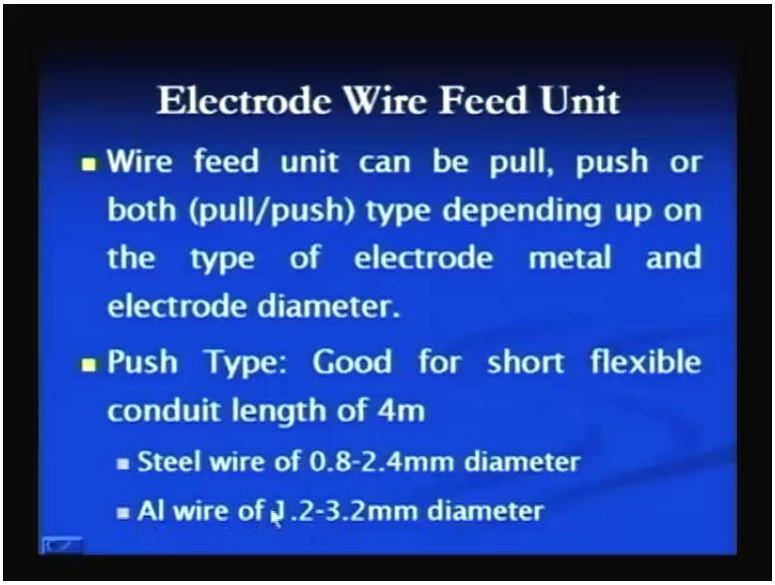

Another one is the electrode wire feed unit. Electrode wire, electrode, which is used of a required material in the different diameters is to be fed through the electrode wire feed unit in the arc region, so that smooth and continuous feeding of the wire can be achieved and a smooth and stable arc can be obtained for consistent and smooth welds.

So, here wire feed unit can be of the three types. One is pull type wire feed unit or push type wire feed unit or the third one is, where both pulling and pushing of the electrode wire is done. To feed it continuously in the region where it is required and the type of the wire feed system to be selected for a given set of the electrode material and the base material welding, it depends on the type of the electrode metal and its diameter.

Directly we can say, the type of the wire feed unit is selected on the basis of a strength of the filler wire or stiffness of the electrode wire, which is being used because electrode filler metal if is soft and of the low stiffness lowest strength, then one type of the wire

feed unit is selected. And if the wire is small and it is of the poor strength, then one type of the wire feed unit is selected, otherwise the different type of wire feed unit is selected.

So, which type of wire feed unit is to be selected for a smooth and continuous feeding of the electrode wire, that depends on the stiffness and the rigidness of the electrode wire itself, which is to be fed during the welding and that in turn depends upon the electrode metal and its diameter.

So, we will see in detail that which type of the wire feed unit should be used under what conditions. Normally, push type of the wire feed unit is good for short flexible conduit length. Conduit length is the length through which electrode wire passes up to the torch. So, here if the conduit length is lengthened up to 4 meter, then push type of the wire feed unit is good. And particularly, this is used when steel wires are to be used as a filler wire or filler electrode of the diameter in range of 0.8 to 2.4 mm.

And the aluminum wires of 1.2 to 3.2 mm in diameter, not very long conduit length is possible with the push type of the wire feeders because of tendency to bend the filler wire when it is being passed conduit pipe because lot of frictional resistance will be there between the electrode wire and the conduit surface itself when it is fed through the conduit and that under that heavy fractional forces.

And the steels wires of the small diameter or aluminum wires of small diameters, particularly can bend and can disrupt the uniform feeding of the electrode wires. That is why, the push type of the wire feed unit is used with the somewhat larger diameter electrodes.

And of the steels can be withstand with the somewhat, a smaller diameter. You can see here, the smallest diameter, which can be handled by the push type of wire feed unit is 0.8 while the aluminum, this lowest diameter, which can be handled by the push type of wire feed unit is the 1.2. So, the larger diameters are used with the somewhat soft and weak materials compared to the steel.

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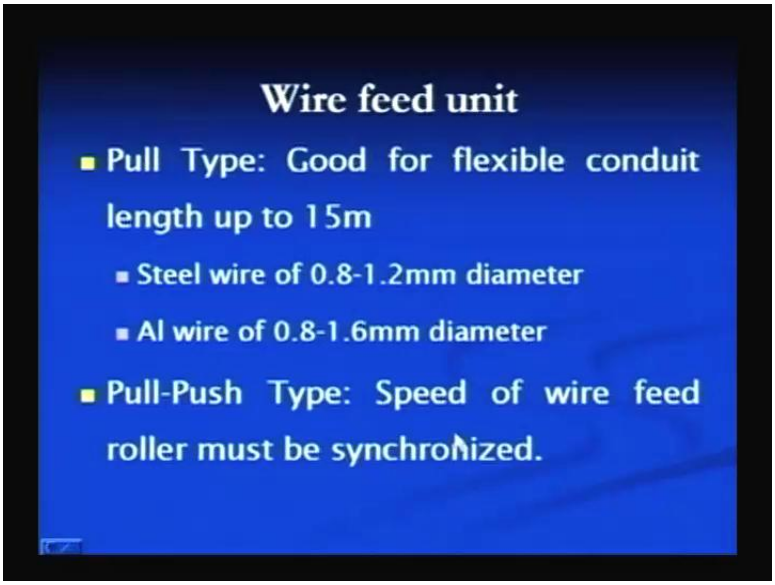

Another type of the wire feed unit is the pull type of wire feed unit. And this pull type of wire feed unit helps to obtain the greater flexible conduit length. And in the flexible conduit length, which can be used with the full type of wire feed arrangement is up to 15 meter. So, that is the great advantage, particularly, where longer cable lengths are required during the fabrication. Here, this type of the wire feed unit is used particularly with the steel wires of 0.8 to 1.2 diameters and the aluminum wires from 0.8 to 1.6 mm diameters.

Under the pulling conditions, chances for bending of the feed wires are less and that is why, even the small diameter electrodes can also be used with the pull type of the wire feed unit. But there is only possibility that if the frictional forces are too much, then the wires can break or fracture can take place due to the excessive pulling of the electrode wires.

So, to, to reduce that fracture related aspects of particularly aluminum wires, which normally get damaged due to the rubbing with the conduit surface, normally the lining of the nylon or other soft materials is made in the conduit pipe through which these wires feed, electrode wires are passed. Here, the third type of the wire feed unit is one in which pushing is done from the one end, pulling is done from another end for smooth and uniform feeding of the electrode, particularly when the electrode wires are of a small diameters and of poor strength.

And, but here only one thing is to be taken care of properly is the synchronized speed of both pull and push type of arrangements. If there is a difference, any difference in the push and pull type of the feed systems, then the wire may fracture and whole exercise may be futile. That is why, the speed of the wire feed rollers of both pull and push type should be synchronized.

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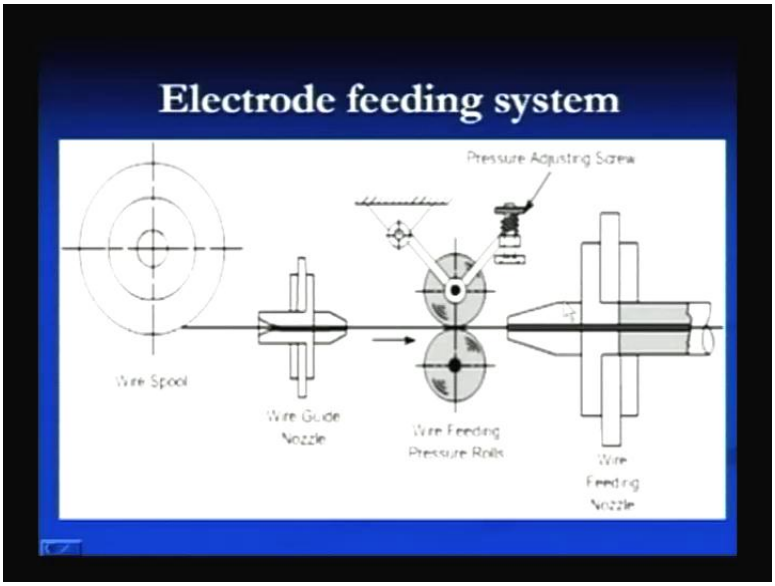

The electrode feeding system, schematically, can be seen from this diagram here. Here, is wire spool, which may be of 1 kg, which may be containing electrode wire of 1 kg, 1.12 kg or 5 kg depending upon the capacity of the spool.

The electrode wire is wrapped around this spool and one by one it is taken out or unbounded from this spool and it is passed through the wire guide nozzle, so that it, it is straightened or you can say, wire straightening kind of a function is performed here. Then, it is passed to these two rollers and these rollers are rotated in controlled way. And then, it is passed through, through this wire feed nozzle and finally, it will be passed through the torch. So, here the straightening, the wire feed press rolling and then, wire feeding nozzle. This is how the electrode wire is passed through the different components.

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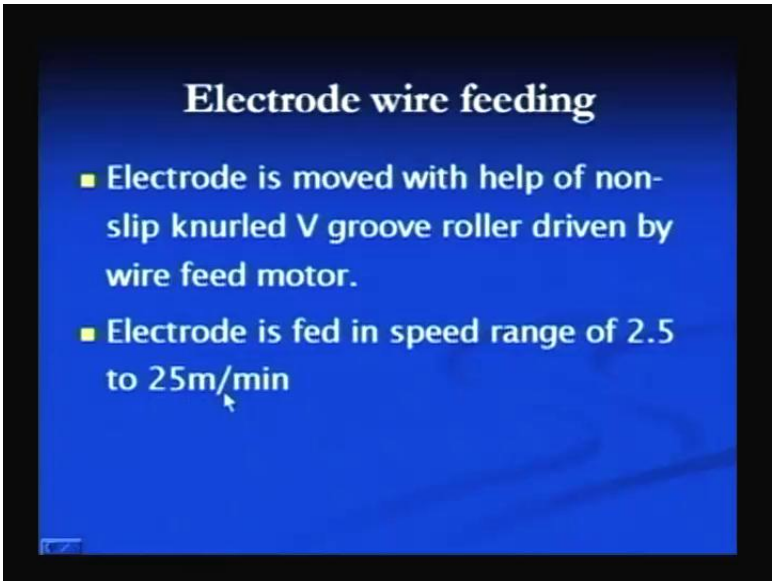

The electrode is moved with the help of a non-slip knurled V groove rollers driven by wire feed motor. Here, the rollers, which are used are knurled, means, diamond shaped impressions are formed on the active surface of the rollers, so that griping between the rollers and the wires is very effective. And the slipping of the wires, slip, between the wire and the roller does not take place. And that is the purpose behind knurling, the rolling surfaces, which are used to drive or to move the wire during the welding.

And these rollers are rotated in controlled way by using wire feed motors. And these motors can rotate at a constant speed. These rollers with the help of motor can be rotated at constant speed or at variable speed. Mostly, variable speed feed motors are used, but with constant voltage power sources, constant speed feed wire systems are also used. Here, electrode is normally fed in the range of speed of 2.5 to 25 meter per minute.

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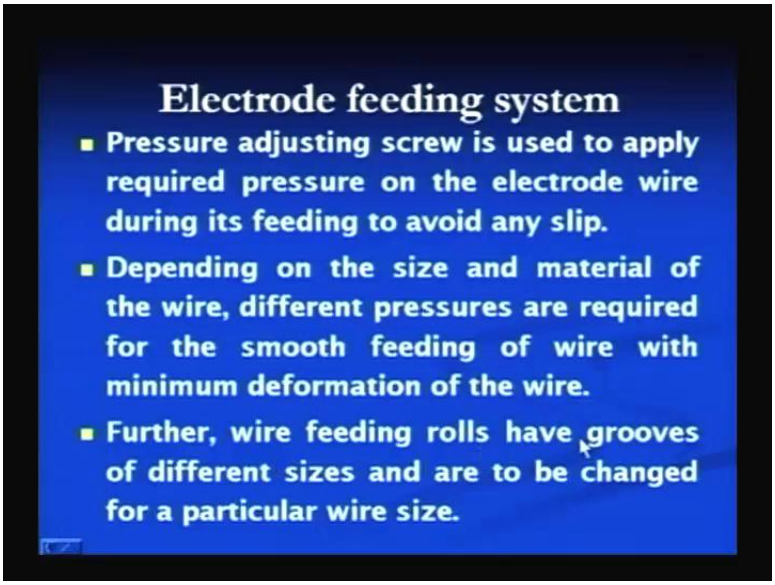

To make sure, that slipping between the roller surface and the electrode wire does not take place, pressure adjusting screw is used to apply the required pressure on the electrode wire during the feeding, so that any sort of slippage is avoided and the electrode is fed at the constant speed in the arc region. Otherwise, there will be inconsistency in the weldment and the heat generation. So, to make sure, that electrode is fed at a constant speed and the uniform conditions are maintained in the arc region and there should not be any slip, and for that as per needs and the pressure between the roller and electrode is adjusted.

Depending upon the size and material of the wire different pressures are used for smooth feeding of the wires with the minimum deformation of wires. So, depending upon the size and the material of the wire, pressure is selected in such a way, that the electrode wire does not deform due to the pressure and it is fed continuously without any slippage.

Further, wire feed rollers have grooves of the different sizes and therefore, the rollers are to be changed as per the needs. Means, with change in wire size, the rollers may be required to change to feed the rollers, to feed the electrode wire at the desired speed. And therefore, for a specific roller size, specific roller size will be suitable for specific wire, so that there is a match between the wire, which is being used during the welding and the roller, which is being used to feed the electrode wire at a constant speed.

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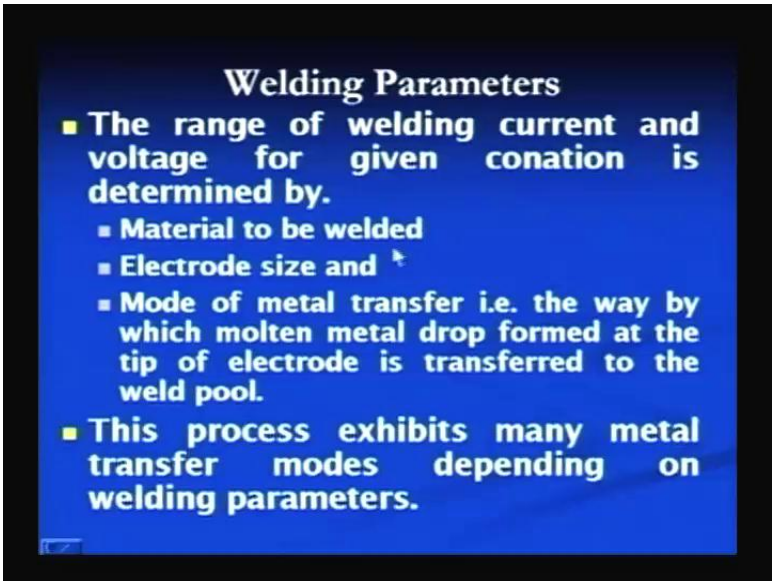

There are number of welding parameters, which significantly affects the performance of the weld joint and these parameters are of the different types, like the welding current, welding voltage, welding speed, electrode wire, wire feed rate. All these parameters significantly affect the deposition rate penetration, weld bead width, etcetera. So, that is why the importance of the welding parameters is significant and it is necessary to understand the effect of these welding parameters on the performance of the gas metal arc welding and on the soundness of the weld joint.

The welding parameters like the welding current and the voltage are important and the range of the welding current and the voltage for a given condition is determined by the material to be welded, the electrode size, the mode of metal transfer to be used. And here, material to be welded is important for selection of the welding current and the voltage. Material to be welded means, how much heat it needs for proper fusion and obtaining the proper penetration.

And in addition to the material's melting point here are the thickness or the dimension of the plate to be welded, also plays significant role in selection of the welding current. Greater the thickness of the plate to be welded, higher will be the requirement for welding current and accordingly, voltage is to be set in such a way, that it can offer the desired stable welding arc.

And the electrode size, as per the needs of the material to be welded, the larger or smaller diameter electrodes are selected and the large diameter electrodes can withstand up to the

higher current without any difficulty. So, if the thick plates are to be welded, large diameter electrodes will be selected and the large diameter electrodes will require different current and voltage setting compared to the small diameter electrodes.

And another important factor is the metal transfer, which will be required for soundness of the weld vent under a given conditions. Like, under some conditions we need the ((Refer Time: 44:00)) circuit metal transfer or dip transfer. Well, on the other conditions we need the spray transfer. So, here, as per the requirement, the suitable spray transfer is to be selected and which can be obtained by selecting the proper welding current or welding voltage.

So, that is why, these three factors like material to be welded, electrode size and the metal transfer, which is required, play significant role in selection of the welding current and the welding voltage. But this process exhibits many metal transfer modes depending upon the welding parameters.

In gas metal arc welding process, with the change in welding conditions for a given material combination and the shielding, as we may find the different types of the metal transfer modes. These may range from the short circuit metal transfer to the globular transfer and then globular transfer to wet spray transfer, wet spray transfer to the rotary spray transfer.

So, depending upon the welding current and the welding conditions, the different types of the spray transfers can be noticed. And during the welding and as per needs, a particular type of the metal transfer mode is to be selected, which can give the desired results and produce the sound weld joint.

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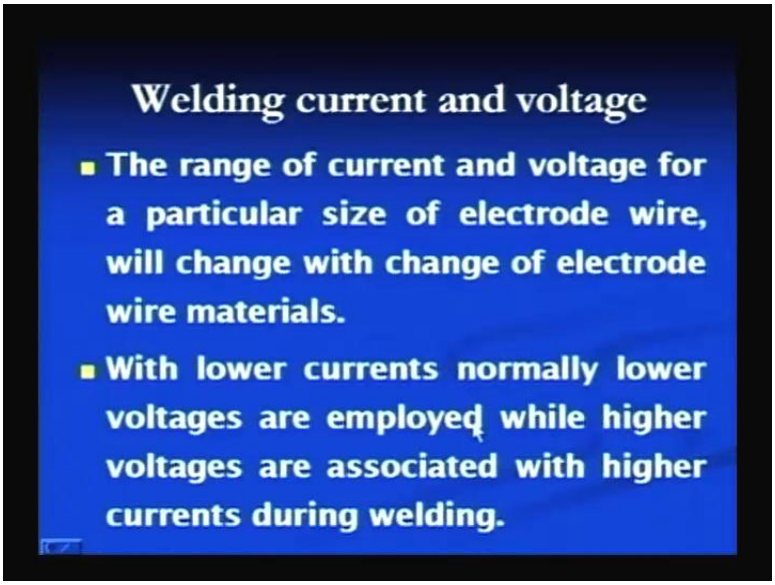

The range of current and voltage for a particular electrode size and wires, will change with the change of electrode material. Here, some of the materials can withstand up to the high current means, that they can work effectively even with the higher range of current, but that in turn, will be affected by the electrode size.

So, for a given material change in electrode diameter or for a given diameter change in material, both affects the range of current or the voltage, which is to be selected. So, according to the type of material and the diameter of the electrode, the proper range and the voltage of the current is to be selected. With the lower currents, normally the lower voltages, are applied, are used, while the high voltage are associated with the high current for welding purpose.

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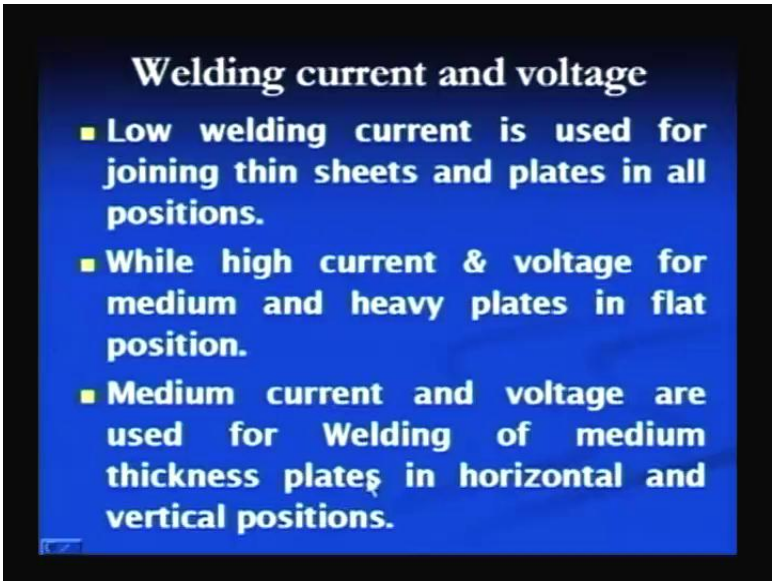

Here, low current is used when joining the thin sheets and the plates in all positions. Thin sheet welding needs special clear in terms of the heat input. Very controlled heat input is to be used for welding of thin sheets, so that the melt through or excessive heat related adverse effects can be reduced and that is possible by using the low welding current.

Low welding current for a given voltage setting will develop the lower heat input and that in turn, will help to join the thin sheets and plates effectively under all conditions. While the high current and high voltages are used for welding of thick plates in flat position.

Now, there are two reasons. One is, joining of heavy plates need, needs the high current for high deposition rates and for high penetration. And, and at the same time the fluidity in, in flat position, fluidity of the weld pool in flat position also does not create any problem. However, fluidity becomes crucial in odd position welding, particularly in overhead and the vertical position welding.

But if the high current are used to obtain high deposition rates and the high penetration or deeper penetration, then in flat position these things are, means high current and high voltage setting, can be used effectively for welding of the thick plates. While the medium current and medium voltages are used for welding of the medium thickness plates in horizontal and the vertical positions.

So, for thin sheets we have to use the low current to avoid the melt through related defects and high current is used in case of the heavy plate welding in flat position,

particularly to get that benefit of the deeper penetration and high deposition rate. And the medium current and voltage settings are used for medium thickness plates in vertical and at the horizontal positions.

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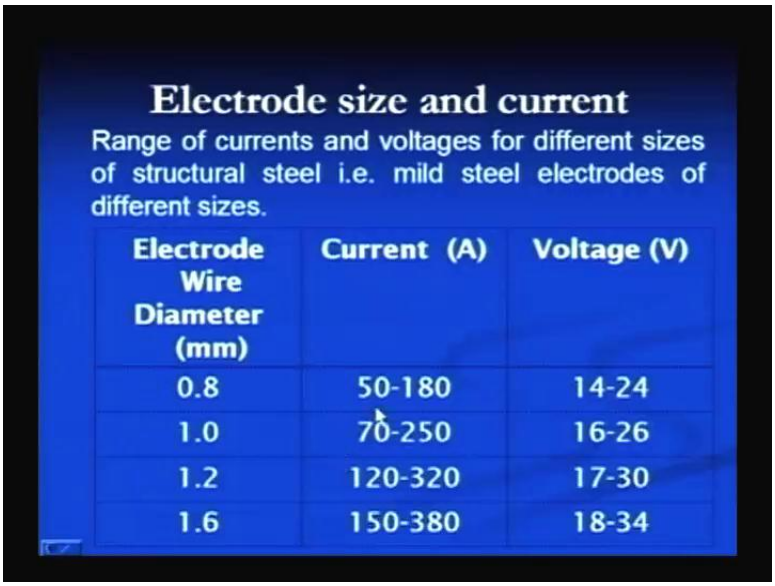

The range of the current and the voltage for the different sizes, the structural steel and mild steels have been standardized to great extent and those values can be seen from this table. The electrode wire of the diameter 0.8, 1.1, 1.2 and 1.6, the normal and the current range and the voltage range, which is to be used has been established.

And we can see here, for a small diameter electrode of 0.8 mm current setting can be in range of 50 to 180 ampere and voltage from 24, 14 to 24. For 1 mm diameter it is 70-250 and 16 to 26 volts. And for 1.6 mm diameter it is 150 to 380 ampere and 18 to 34 volts. So, these current ranges and these range of currents and voltages for the electrodes of the steels particularly, have been standardized and these are the commonly used range of the currents and voltages for the electrodes of the different diameters.

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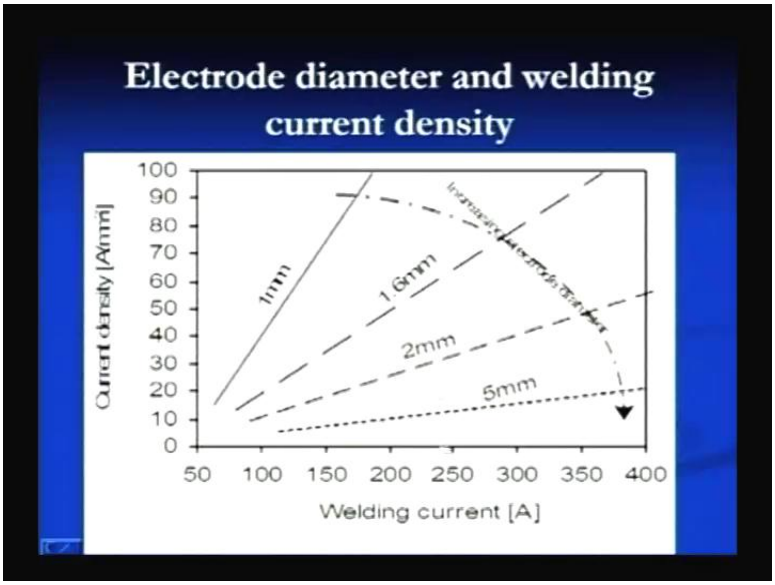

We can see here, the current density and the current value are closely, are closely related with the electrode diameter, with the, if we increase the current, the current density also increases. But increase in current, increase in current like welding current from, say 120 to 400 ampere, the current density increases gradually with the large diameter electrodes. However, the same increases very rapidly in case of the small diameter electrodes. So, the current density increases rapidly in with the increase of welding current in case of electrode, small in case of a small diameter compared to the large electrode diameter. And this current density significantly affects the melting rate during the welding.

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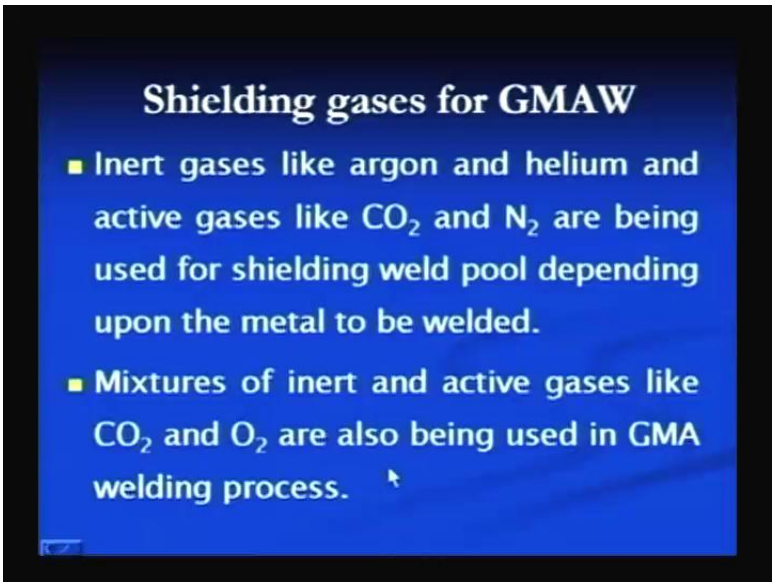

Then, shielding gases, as I have told you earlier that the shielding gas, in addition to the filler metal and the power source, also plays a significant role in successful welding of the reactive metals and the ferrous metals because these shielding gases provide the desired protection to the weld pool from the atmospheric contamination.

And the shielding gases here can be used in form of argon or carbon dioxide. The inert gases like argon, helium or active gases like CO 2 and nitrogen are being commonly used for protecting the weld pool as per the kind of metal to be welded. CO 2 or oxygen and CO 2, hydrogen and CO 2 or CO 2 and nitrogen mixtures are used for welding of the steels or the ferrous metals.

While when high quality welds are to be produced, argon is used as a shielding gas, particularly with the ferrous metals. And for welding of aluminum and the stainless steel and magnesium alloys, now the inert gas, inert gases are used as the shielding gas. Mixture of the inert and active gases, like CO 2, O 2 are also being used in GMA process, particularly this mixture is used for the welding of the ferrous metals. Okay.

So, here now, now, I will summarize this lecture. In this lecture you have seen, that the gas metal arc welding process is, is a very capable process because it can produce high production rates, high welding speeds and it is, it consists the number of important components like power source, wire feed unit, the shielding gas and the different other aspects releated with.

In, in, in this lecture these things have been covered and in this lecture will continue in the, in the second part and in which I will cover, that the things in detail related to the shielding gas, the effect of the welding process parameters, the metal transfer modes on, in, in, in the gas metal arc welding process and the different variants of the gas metal arc welding process like the pulse gas metal arc welding process and the advantages and disadvantages related with this process.

Thank you.