Welding Engineering

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Module - 4
Arc Welding Processes
Lecture - 3
GTAW- I

In this presentation, we will be taking one of the important arc welding processes that is called tungsten inert gas arc welding process. It is also known as the gas tungsten arc welding process GTA. So, there are two abbreviations accordingly the TIG for tungsten inert gas welding process or GTA for gas tungsten arc welding process. This is one of the most commonly used welding processes for developing the high quality weld joints for critical applications. Like a arrow space and the nuclear sector because the quality of the weld offered by this process is excellent in respect of the soundness of the weld. The kind of heat input helps in develop heat input.

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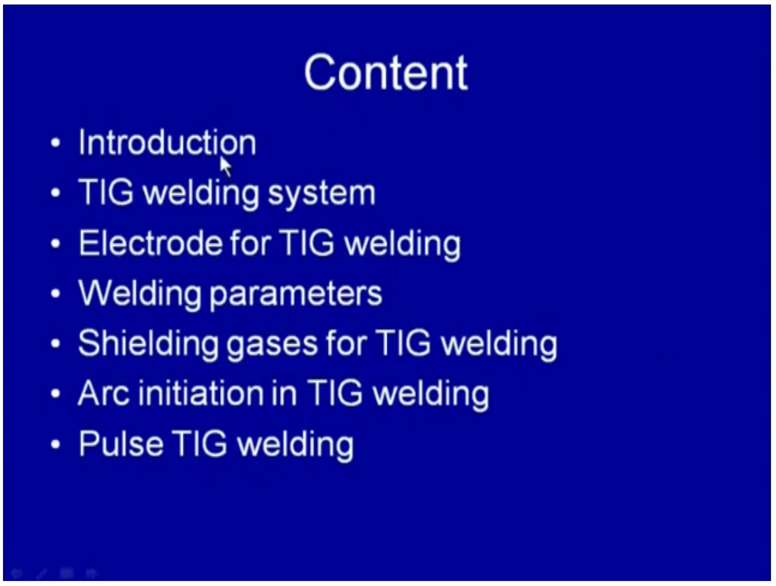

It provides to develop the weld joint is very low. Further, it turns, helps in developing the weld joints without much discontinuity is in the weld. So, in this presentation, we will be talking about what the various aspects are related with GTAW process, which includes the arc welding gas tungsten arc welding system. Then, we will be taking up the powers source, the welding current and the kind of polarity. It is used and the shielding gases which are used along with their effectiveness when welding variety of the materials so as far as content is concerned.

We will be taking up first the introduction about the need for having this kind of the process and under what conditions it was developed. How it was beneficial in the beginning? How it is being used now days? Then, we will see that one of the important constraints and components of the TIG welding system. Then, we will see the electrode, what are the common type of the electrode and their shapes, which are used for developing the weld joints using the TIG process.

Then, the important welding parameters like welding current speed and the arc voltage. Then, the common shielding gases, which are used in the GTAW process or the TIG welding process, are mainly the argon and the helium. Their mixtures are also commonly used. But they have a certain specific situations, where particular kind of the shielding gases preferred.

We will also see the methods, which are used for arc initiation in GTAW process and the pulse mode of the gas tungsten arc welding process. So, starting with this process is unique in the sense with the other process that it develops the arc for generating the heat by using non consumable electrode. So, basically arc is a generated between the non consumable electrode and the base material. The heat flow determines the amount of the heat being generated during the welding because this process can work at very low level of the current.

So, this results in the advantage of having very low heat input while developing the weld joints. That is why it is very effectively used for those metal systems, which require very less heart input for developing the weld sound weld joints. They require for welding the very thin sheets where less heat input is mandatory to avoid the melt tow kind of the conditions. So, the key advantage related with the tungsten inert gas welding process that it offers very low heat input for developing.

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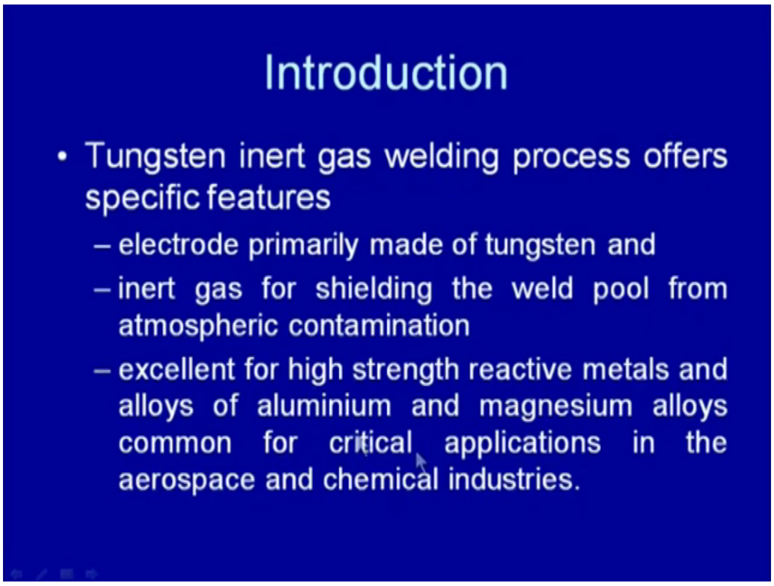

The weld joints as for and very clean weld is also produced. So, if you see the important features of this process, it basically use is the tungsten electrode, which is non consumable kind. It uses very inert gases like helium and argon to protect the weld pool. These in turn help in developing the sound and quality weld joint. Further, this effective shielding associated with the GTA process due to the smooth and stable arc and short arc length helps in developing the high quality weld joints.

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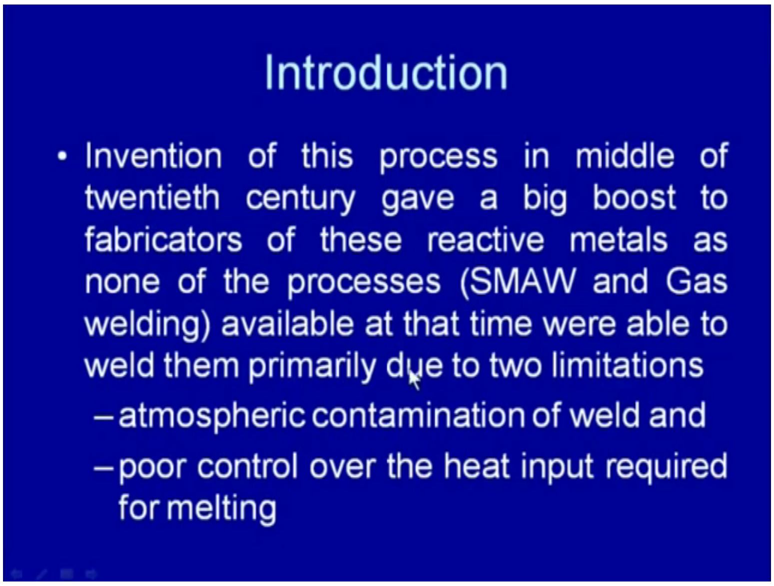

Even of the reactive metals like aluminum and magnesium, which immediately gets oxidized with the atmospheric air or the oxygen present in the atmospheric air and because of these high quality weld joints are even of the reactive metals. These are used for the critical applications in arrow space and the chemical industry and the nuclear reactors.

So, why this has been important, when it was developed because in the early nineties, nineteenth century, when this process was not there at that time, the lot of difficulties were faced. This is because of the poor atmospheric control over the atmospheric contamination when we were using the gas welding process or the shielded metal arc welding process. So, and the another was we had that time very poor control over the heat input especially while welding the thin sheets or while welding the reactive metals. So, to deal with these two difficulties, when in mid century, mid nineteenth century, the tungsten inert gas welding process was developed. It helped in protecting the weld pool in much better way. It allowed us to have the better control over the heat input.

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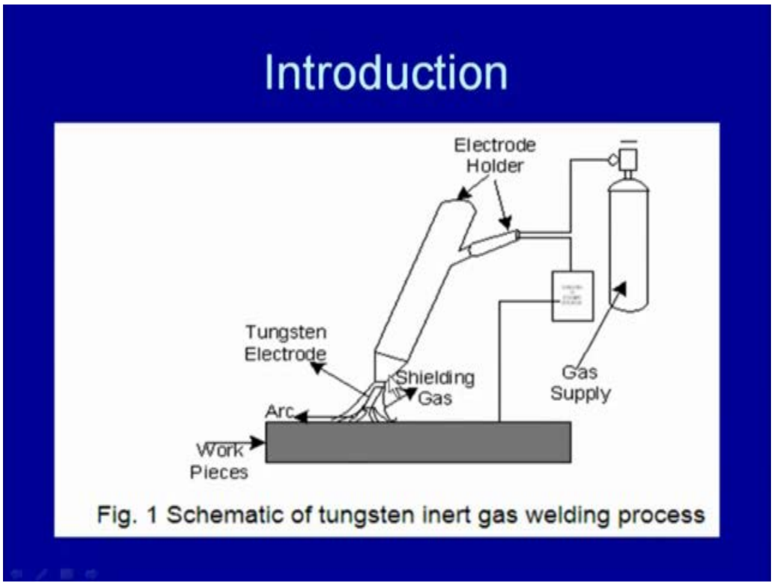

So, invention of this process in the middle of twentieth century gave boost to the fabricators of these reactive metals as none of these processes which were existing at that time like the shielded metal arc welding process and the gas welding were available at that time were able to weld the things effectively. This is because of this two limitations one poor atmospheric poor control over the atmospheric contamination of the weld and the poor control over the heat input. So, this development of the GTA process helped in achieving the better atmospheric control over the atmospheric contamination of the weld. That also helped in controlling the heat input in very effective way.

If we talk about the GTAW welding system, it includes one non consumable tungsten electrode and the base material. The arc is frigid between the non consumable tungsten electrode and the base material. The heat generated by the arc is used for melting the faying surfaces of the base material to be joined and this heat is also used for melting the filler material by putting in the arc zone to fill up the gap between the plates to be joined. Apart from this, to have the required amount of the welding current suitable power supply is used. So, one terminal of the electrode is connected to the one terminal of the power source is connected to the electrode.

Another terminal is connected another terminal of the power source. It is connected to the base material well for providing the effective shielding, gas effective shielding to the weld pool. The inert gas is also used so that weld can be protected from the atmospheric contamination. This process is considered to be good for welding of thin sheets because it allows us say to have the better control over the heat input. It can have a very smooth and stable arc when with very low level of the welding currents.

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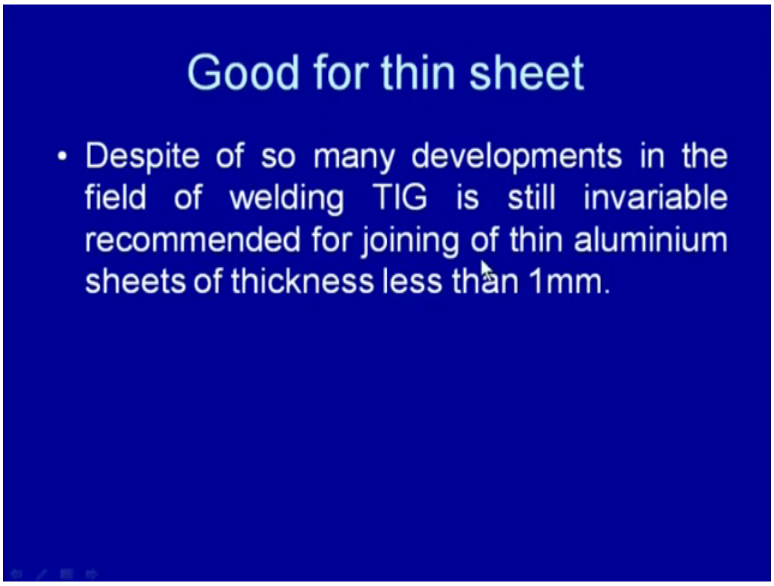

We can easily work in the range of 50 to 100 ampere current range; which will be generating very less heat and supplying the very low heat input to the base material. So, because of this advantage related with this GTAW process, it helps in developing the sound weld joints of the thin sheets. They are even less than 1 mm.

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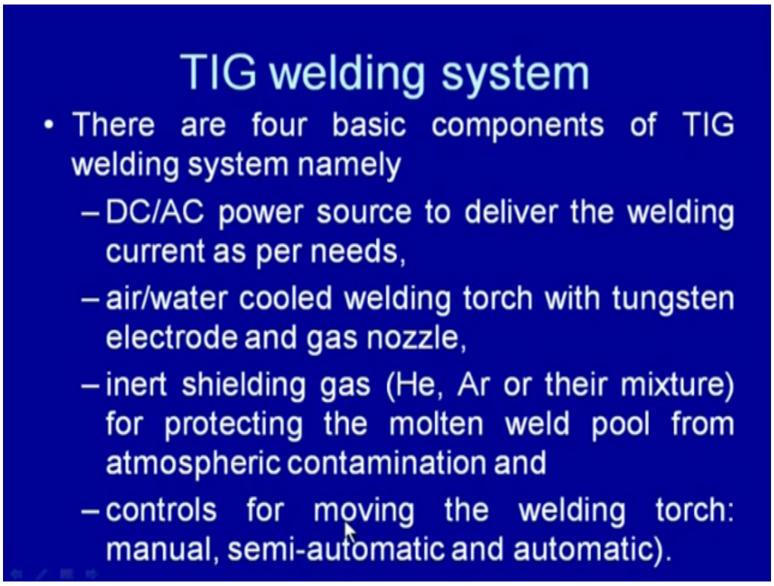

If we talk about the GTA welding system, which will be playing an important role in developing the sound weld joint by this process. This includes the suitable power supply may be AC or the DC kind which can help us in obtaining the desired amount of the welding current so that the heat can be generated. The selection of the type of the welding current is governed by the kind of metal being welded. The kind of arc stability, which is desired, is especially like the AC is used for the aluminum welding. For the better life of the electrode, DC is preferred.

Then, some kind of cooling system is used with GTAW process to maintain the temperature of the electrode within the limits so that longer life of the electrode can be obtained. So, the welding torch is cooled either with the help of the air or the water. Accordingly, the current carrying capacity of the tungsten electrode is obtained. Water cooling permits us to have the higher current capacity because electrical resistance heating, which will be causing the temperature rise in the tungsten electrode. That can be is limited by water cooling. So, all the water cooled welding torches allow us to work under the higher current with the higher current capacity.

So far, high current TIG welding systems water cooling becomes mandatory and that is range say above 150 m p l. It is common to use water cooling to maintain the welding tungsten electrode within the safe temperature limit. For the low current the TIG welding systems, the air cooling is found good enough to maintain the temperature of the tungsten electrode within the safe limits. Similarly, the nozzle temperature is also maintained within the limit so that unnecessary over heating does not damage to the electrode. The electrode is required as you say the nozzle is frequently required to be replaced.

It loses its shape after some time during the use. The third important component in the GTA system of the TIG welding system is the use of the shielding gas inert gas. Like the helium and argon is commonly used to protect the weld pool from the atmospheric contamination. Mixtures are also effectively used to have the good protection to the weld pool apart from the generation of the good amount of the heat so that the high welding speeds can be obtained. So, for those conditions especially mixtures of the helium and argon or argon with the oxygen and the nitrogen are preferred the third important thing.

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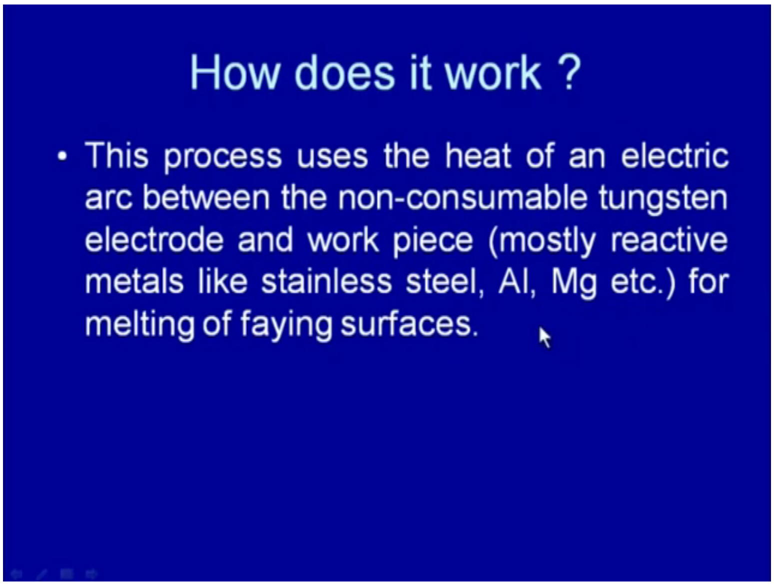

The fourth important component of the GTA welding system is some kind of control we need to have to move the welding torch during the welding so that the heat can be generated along the line, where the weld is to be made. This movement can be obtained either manually or by using the semi automatic process or the complete automatic process. So, depending up on the kind of control which is required for moving the welding torch, we can have the various variances. But, some sort of the control is required to move the welding torch in controlled way. So, the heat can be generated in the places, where desired for melting the faying surfaces of the base material.

How these processes work in that? We will see now the heat generated by the electric arc between non consumable tungsten electrode and the work piece. This heat is primarily used for melting the faying surfaces of the mostly reactive metals, which immediately reacts with the oxygen and the nitrogen gases present in the atmospheric air. These metals like aluminum, magnesium, stainless steel are effective welded by melting the faying surfaces are using the heat generated between the tungsten electrode and the work piece. So, this is how it is used for melting the faying surfaces. But, the amount of the heat generation will be governed by the kind of current which is being used and the arc voltage which is established between the tungsten electrode and the work piece.

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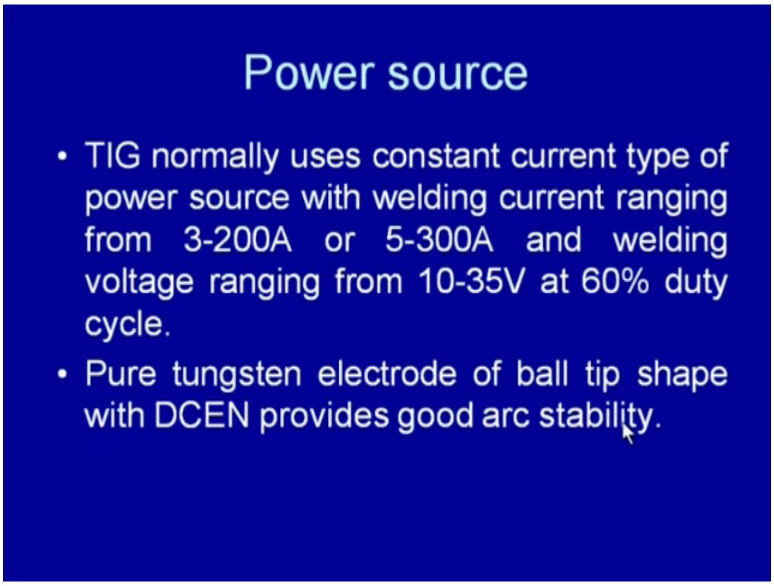

If we see the power source required for delivering the required welding current so that the heat generated can be used effectively for melting the faying surfaces is mainly governed by the kind of current, which can delivered by power source. It is common to use the constant current type of the welding power source. So, the current can be maintained during the welding largely constant. So, the largely uniform amount of the heat can be generated for developing the uniform weld depending up on the current carrying capacity.

The TIG welding systems are found to be capable of delivering the welding current in the range of 3 to 200 ampere or 5 to 300 ampere. This is the range indicting the capacity to deliver the current for higher current capacity invariably, water cooling is used. So, the temperature of the electrode can be maintained within the safe limits. The welding voltage is found to range from 10 to 35 volt especially, when we are working with the 60 percent duty cycle. So, if we compare this, the welding voltage for the GTA welding process with a s m a w or the g m a w process.

Then, we will see that those process works at much higher voltage is than the GTAW process. The reason for this is that the tungsten offers the very good electron emitting capability. So, the large amount of the charge particles is made available by the tungsten electrode in the arc gap. So, even with the low voltage, it is able to provide those charge particles in the arc gap to so as to maintain the smooth and stable arc. But, in other cases like GTAW in g m a w and the s m a w processes where consumable electrode is used the like iron and the aluminum metals; they do not have the very good electron emitting capability. That is why, they require higher arc voltage higher voltages so that arc can be maintained otherwise, it will show the tendency to get extinguished.

So, this is the reason why the GTAW process works with very low voltages while for the s m a w and the g m a w processes we need high arc voltages. Pure tungsten electrode can tungsten electrodes can be given the different shapes at the tip especially because this tip shape affects the kind of the arc. It is developed if we have very conical shape tip. Then, it will be resulting very deeper penetration and much focused arc of the small sizes developed while the ball shape the tip results in the wider arc.

But, with the good arc stability and which in turn also results in the somewhat wider bid and the narrower shallow penetration. The pure tungsten electrode is frequently given the ball shaped tip ball shape tip is obtained when working with the DCEN that is a straight polarity to have the advantage of the good arc stability. Apart from this, many other shapes can be given to the tungsten electrode.

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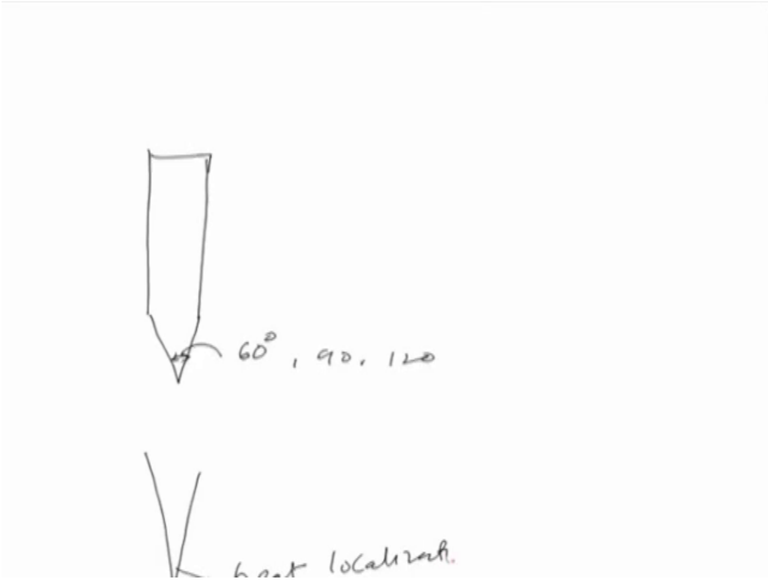

For example, we can have the tungsten electrode; the tip with the conical shape where this angle matters a lot. It is common to work with say angles like 60 degree, 90 degree, 120 degree. So, shall low is the angle smaller is the angle of the conical tip sharper will be the tip and greater will be the tendency for heat localization. So, the localization of heat in very sharp tip them end of the electrode causes the rapid degradation of the electrode tip. It in turn decreases the life of the electrode rapidly. To avoid this kind of localization, it is preferred to have either the conical tip with the larger angle or the ball shape tipped is formed.

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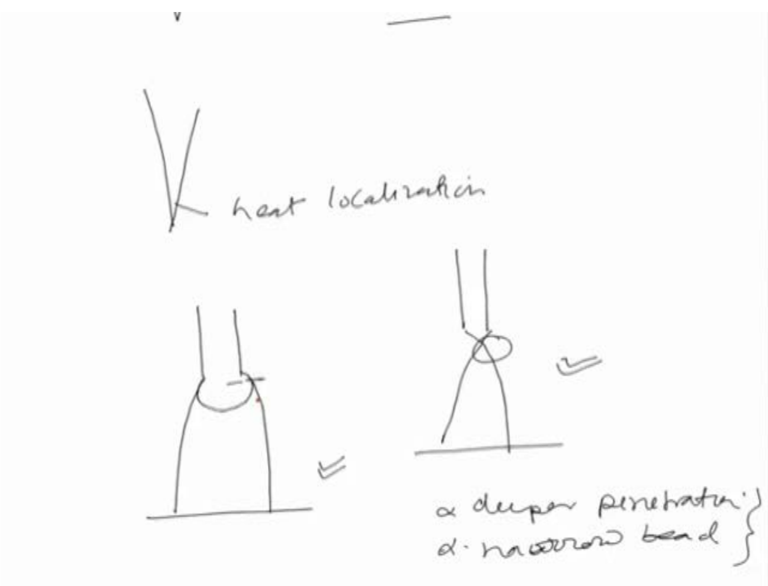

The very smooth and stable arc can be obtained instead of the case where very pointed tip is used. So, this kind of tip causes high heat localization while the heat localization is somewhat reduced in case of the ball shape. So, as far as the heat localization is concerned, the heat localization will be less in case of the ball shaped. It will be more in case of the very pointed conical shape tips. Therefore, the ball shape tipped electrodes offer longer life of electrode.

Then, the conical shaped tips with very small angles; but, the conical shape tipped electrodes offer the deeper penetration and the narrow weld bead is obtained. So, because of these advantages as per the situation, we can work with the either pointed means conical shaped electrode tip or the ball shape tipped.

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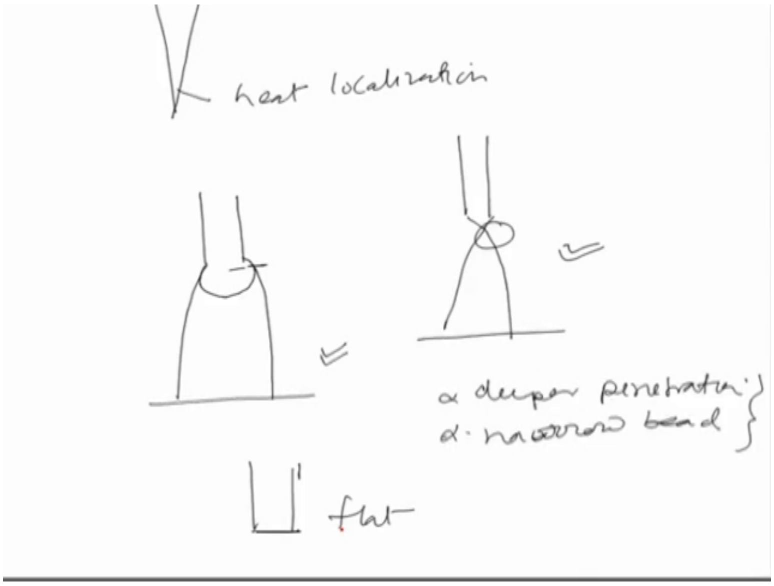

Further, we can use the flat tips. Also flat means, having very square surface. The tip of the electrode kind is also used. So, there are variety of shapes which can be given to the tip of the electrode and according to the same, they will have the difference in the shape of the arc. The localization on the heated tip of electrode in turn will be affecting the life of the electrode in continuing with this. So, to have the better life of the electrode, it is necessary that the temperature of the electrode is maintained within the safe limit. The temperature of the electrode is primarily governed by the two things; one is electrical resistance heating due to the flow of current through the electrode itself and the heat which is transferred from the arc to the electrode tip.

So, to reduce the electrical resistance heating frequently, the electrode tungsten electrodes are frequently coated with the other materials like thorium, zirconium, and lanthanum. Accordingly, they are called thorium, zirconium, and lanthanum modified tungsten electrode. These also helps, these coating helps in increasing the electrical conductivity as well as these also provide easy release of the electrons from the electrode. The easy release of the electrons helps in working of these electrodes very effectively especially from the arc stability point of view.

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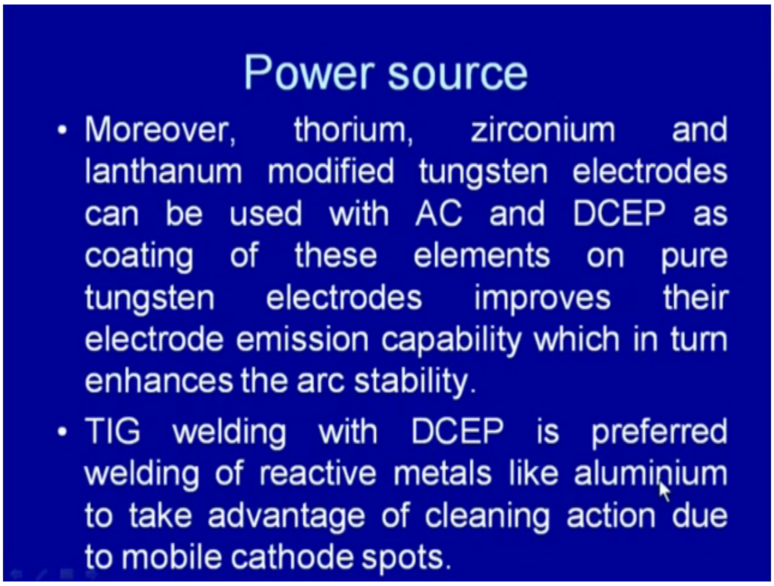

So, when the tungsten electrode is modified with the thorium, zirconium and lanthanum, it can be effectively used with the AC and the DCEP where electrode is made positive. So, the base metal is expected to release the electrons under these conditions. These coatings on the electrode improves the electron emission capability in turn enhances the arc stability. So, when this happens, the electrode life is improved significantly. Therefore, coated electrodes are preferred for the conditions where AC or the DCEP is used the tungsten electrode welding. The DCEP is preferred for the reactive metals when reactive metals like aluminum and magnesium stainless steel etcetera.

This is done to take the advantage of the cleaning action. We know that when electrode is made positive, so work piece will be acting as AC cathode. With these metal systems, the cathode, very mobile kind of the cathode spot is formed. It helps in cleaning action because the mobile cathode spot helps to loosen the oxide layer. It is being formed during the welding on to the base material. That loosening leads to the easy removal of the oxide layer from the base material. That is how the use of the DCEP helps in cleaning action during the melting due to the mobile cathode spot formation.

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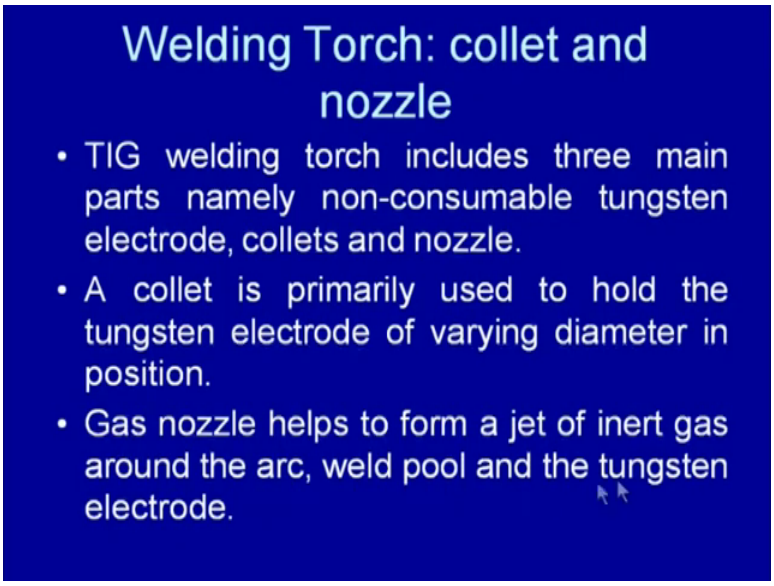

We look in to the further details of the welding torch, and the way by which electrode is used in the GTAW process. If we see here the GTAW or the TIG welding torch includes the three main components, one is non consumable tungsten electrode. Second are collets and third is nozzle. So, nozzle and outside we have nozzle and inside that we have collet. Further, the collet is held will be holding the electrode tungsten electrode in proper position. So, the role of these elements tungsten electrode will be used will be striking the arc with the base material.

Collet will be holding the electrode in position. So, collets are designed to accommodate the electrodes of the variety of the varying diameters. When electrode is placed in position and arc is strike, the flow of the gas around the arc is started. So, the gas nozzle helps to form a jet of the inert gases around the arc so that the weld pool and the tungsten electrode can be protected from the atmospheric contamination. Further, the diameter of the gas nozzle must be selected in such a way that very effective and sound jet around the arc is developed.

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So, the weld pool can be protected from the atmospheric contamination. The gas nozzle needs to be replaced due to the wear and tear under the influence of the heat during the welding. So, we know that nozzle is in very close to the welding arc. The high heat generated during the welding damages the nozzle tip. So, once the nozzle tip is damaged, it loses its shape. It becomes unable to form which sound the jet of the shielding gases around the arcs to protect the weld pool. So, because of the damage to the nozzle by the heat of the arc, it is necessary that the damage nozzle is replaced frequently and at regular intervals.

The damaged nozzles does not form uniform stream of the inert gas jet around the weld pool for protection from the atmospheric gases. So, the gas nozzle must be replaced regularly because it loses its shape under the influence of the heat. Once it loses its shape, it will not be able to form the sound and effective jet around the arc. That is why; the nozzle must be replaced at the regular interval. Now, we will see that shielding gas variety of shielding gases is used. They are allowed to flow at the different rates during the welding. So, one of the factors that affect the selection of the shielding gases and how these thing affect the way by which sound weld joint is obtained.

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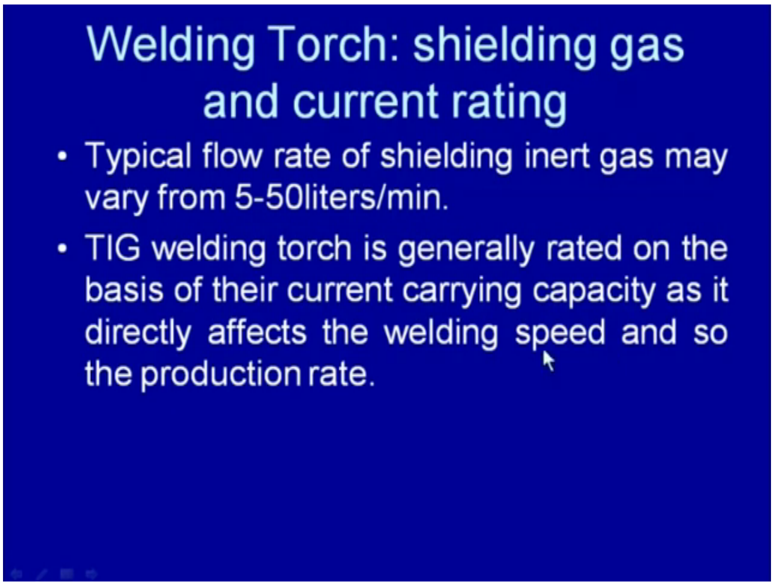

So, you see the shielding gas flow rate can vary significantly from 5 to 50 liters per minute. So, how what should be the flow rate? That will be governed by diameter of the electrode, the nozzle size and the speed at which we are moving the arc during the welding, the extent of the production which is desired. So, the welding torch is generally depending up on this flow rate. We can have ineffective or the effective shielding. The tungsten TIG welding torch is rated on the bases of the current carrying capacity.

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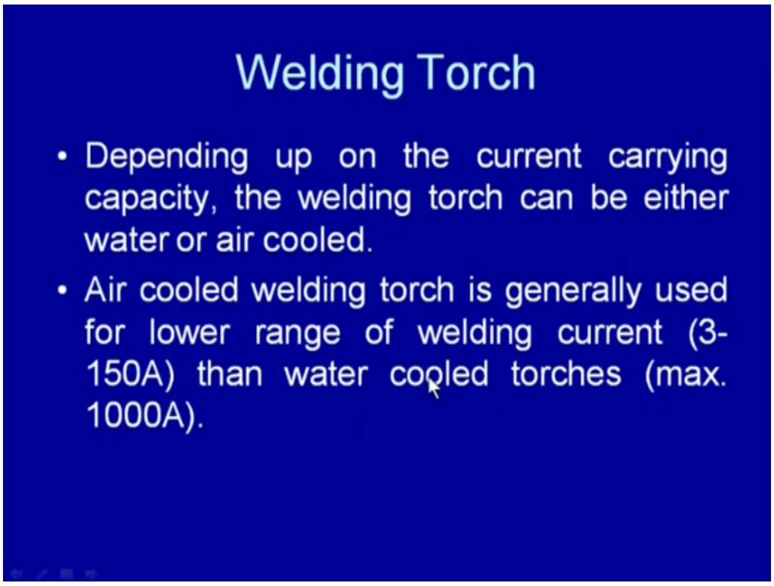

This current carrying capacity may be 200 maximum 300 amperes. It decides how much maximum current can be obtained from the power source associated with the welding torch. It directly affects the welding speed because higher is the welding current, we can draw more heat can be generated. It in turn will allow us to have the higher the speed of the melting. So, higher speed of the welding can be obtained, which in turn will help to achieve the higher the higher the production rate.

So, depending upon the current carrying capacity, welding torch can be either water cooled or air cooled. Air cooled welding torches are generally used for the low current range while the water cooled torches are used for the high current range maximum. They can go as high as up to the 1000 ampere. It's common to work with the GTA processes up to 200 or 300 or 350 amperes. So, apart from the shielding gas, we commonly use the filler material or filling in the gap between the base materials to be joined. The filler material will be used in light of the base materials. The kind of weld geometry, which is being used for developing weld joint; the filler material normally is not used when welding thin sheets like 1 mm thin sheets.

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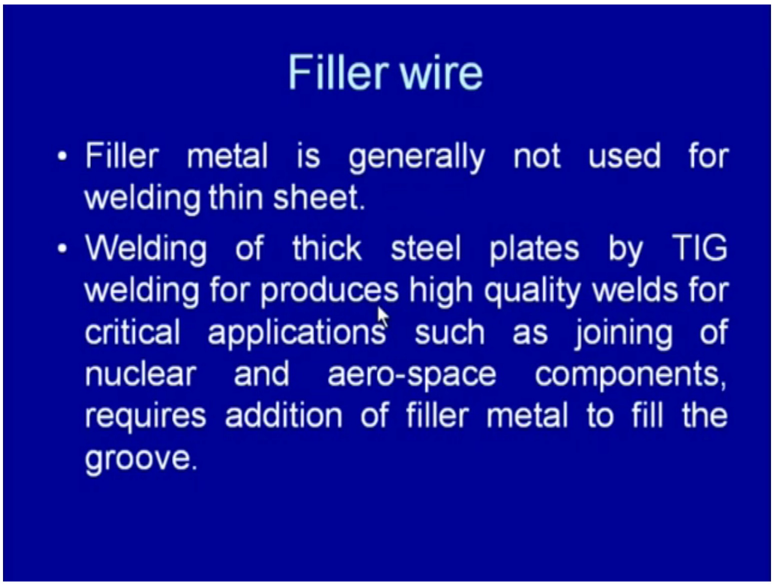

1 mm thick sheet is welded by directly melting the edges of the plates and allowing it to solidify to obtain the metallic continuity. But when thick sheets and thick plates are welded by GTAW process, the filler materials in form of rods invariably used. This is commonly used in case of the nuclear and aero space components. Under those conditions when thick plates are to be welded, the filler material is added in form of the

rods of the different sizes.

The rod is placed in the arc region so that it melts and helps to supply the metal between the plates to be joined. In this case, the spattering is found minimum or most of the metal from the filler rods, we can deposit without loss. So, the deposition efficiency is found to be much higher with the GTAW process. The filler materials may be of the different sizes, of the different diameters and lengths depending up on the base material.

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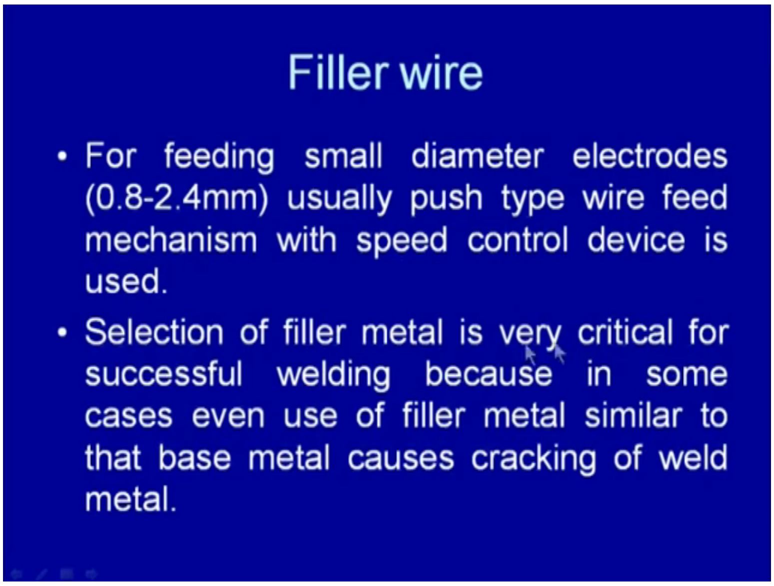

It is to be used and its thickness to be used for feeding the small diameter electrode likes 0.8 to 2.4 mm size. Normally, pull type wire feed system is used if the mechanized feeding is to be done of the filler wire. But, in most of the practical situations, we feed the filler wise manually also. The push type is preferred because it helps to feed the wire in the arc zone without the tendency to break it. Under the pull type wire feed systems, the wire will have tendency to get break to avoid that breaking tendency of the filler wire push type of the wire feed system. Mechanism is preferred or the selection of the filler material crucial in the sense that sometimes the selection of the same filler material as that of the base metal composition leads to the cracking of the weld metal.

So, sometimes the filler material is intentionally selected of that different composition so that thermal expansion coefficient and solidification temperature range of the base metal is such that it does not cause much cracking of the weld zone. So, the selection of the filler material that is why is found to be very critical for successful welding because in some cases, even use of the filler material of the similar kind similar to that the base material. It also causes the cracking of the weld material. Therefore, the selection of the filler wire should be done after giving the full consideration to the mechanical property requirement.

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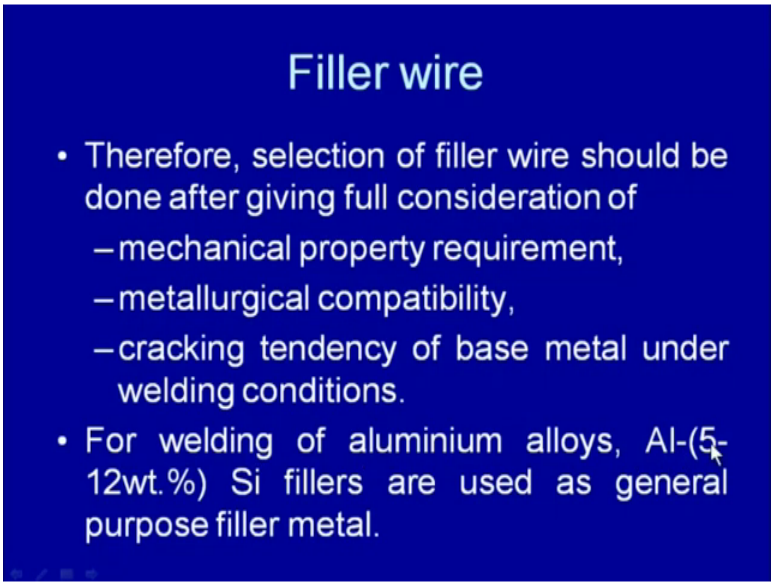

We should select the filler material such that it is able to offer the properties that will be able to fulfill the functional requirement of the weld joint. It may be which in terms of the hardness, tensile strength or the faradic performance. We would like to see that whether filler material is a metallurgical compatible or not the use of the metallurgical incompatible materials can lead to the very embrittlement or the cracking during the welding or just after the welding. The purpose may be lost as far as development of the weld joint is concern for taking the service load.

Further, we need to see that how the filler material can help in control in the cracking tendency of the weld metal. So, the cracking tendency of the base material also can be controlled using the by selection other proper filler material. For example, the harden able steel switch are very cracked sensitive due to the kind of deferential expansion and contraction experience by the base material during the welding. If we use the weld material of very of the low strength then, it will help in reducing the resolucious development in the heat affected zone.

It is found to be very crack sensitive. So, use of the low strength filler material sometimes helps in reducing the crack tendency of the heat effected zones especially, in the hardenable steel. So, with the filler material is selected properly then, that can help in controlling the cracking tendency of the base material. For example, the welding of the aluminum alloys is frequently using the aluminum silicon filler material, where silicon content can vary from the 5 to 12 percent.

This is very commonly used and very much preferred because of the very low melting temperature. It requires for the melting and very good fluidity of the aluminum silicon filler materials and a very good property it offers in for carrying the load and as well as performance of the weld joint is concerned. So, the use of aluminum silicon filler materials in case of the aluminum welding is very common for welding the different types of aluminum alloys.

So, in addition to the aluminum silicon filler materials for aluminum welding, we also use the aluminum magnesium filler materials. But these aluminum magnesium filler materials are found suitable under the certain conditions only because in other conditions it leads to the solidification cracking.

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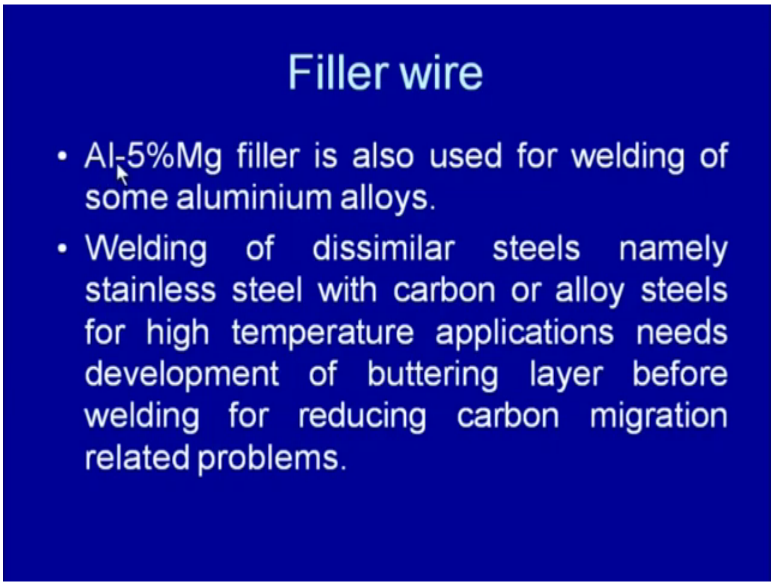

For example, aluminum 5 percent filler material is also used for welding of some of aluminum alloys. Welding of the dissimilar steels namely stainless steel with the carbon and alloy steels are high temperature applications needs development of the buttering layer before welding for reducing the carbon migration related problems. So, those steels when under the conditions, when dissimilar steels are to be welded one of the commonly encountered problem especially for high temperature applications is that of the carbon migration where high where carbon shift from the high carbon steel zone to the low carbon steel zone.

This leads to the problem of the carbon, carbide precipitation and variety of the cracking tendencies. So, to reduce those tendencies, frequently a butter layer using suitable filler material is made so that this kind of carbon migration can be reduced. We will see the kind of shielding gases which are used with the gas tungsten arc welding process.

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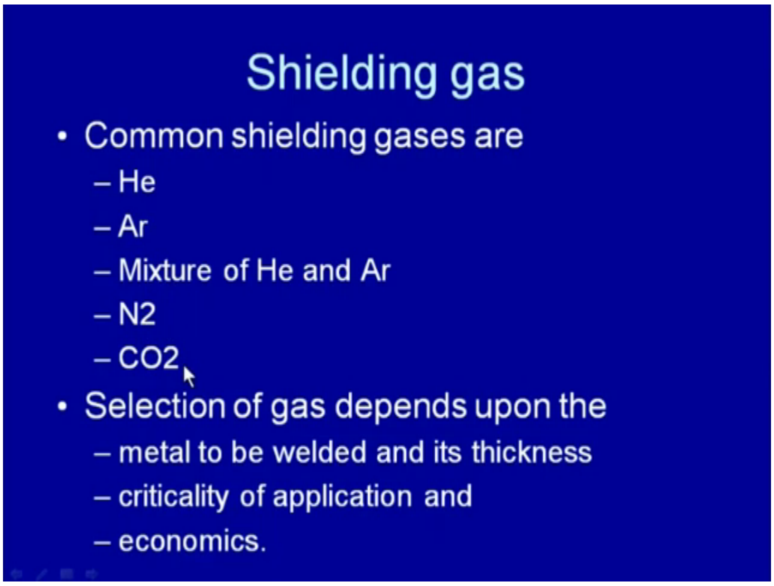

The gases are the helium argon mixture of helium and argon nitrogen and oxygen. If we see here, the first three gases or the gases mixture are the inert gases while last two are the active gases. But, these are inactive with the certain metal systems like steels when we are welding the steels while using this nitrogen and the carbon dioxide as a shielding gas. These helps us in protecting the weld pool with the reasonable degree of protection. That is why and further these gases are the cost effective also.

So, for somewhat less critical applications, the active gases are also used a shielding gases with the GTAW process. So, how the selection of the particular kind of gas would is dictated by the metal to be welded. If the metal is very highly reactive to the oxygen like aluminum, magnesium, titanium in that case, the helium and argon gases or their mixtures are very effectively used for the shielding purpose. Similarly, in case of thickness, if our welding thick sheets, if you want to develop the more amount of heat to have the desired penetration.

Then, the helium is preferred otherwise can be used for welding the reactive metals and the criticality of application. All the weld joints for critical applications are invariably welded using the inert gases like helium argon or their mixtures. So, helium is most preferred gas for the critical weld joint say as compare even if we compare with that of argon. The economics is the third factor that effects the selection of the suitable gas apart from these factors like the factors like the stability of the arc. It is also affected by the shielding gas. But, the selection of the shielding gas is mainly dictated by these factors. Now, we will see one by one under what conditions particular kind of shielding gas can be used. What are the important technological factors related with the each type of the gas?

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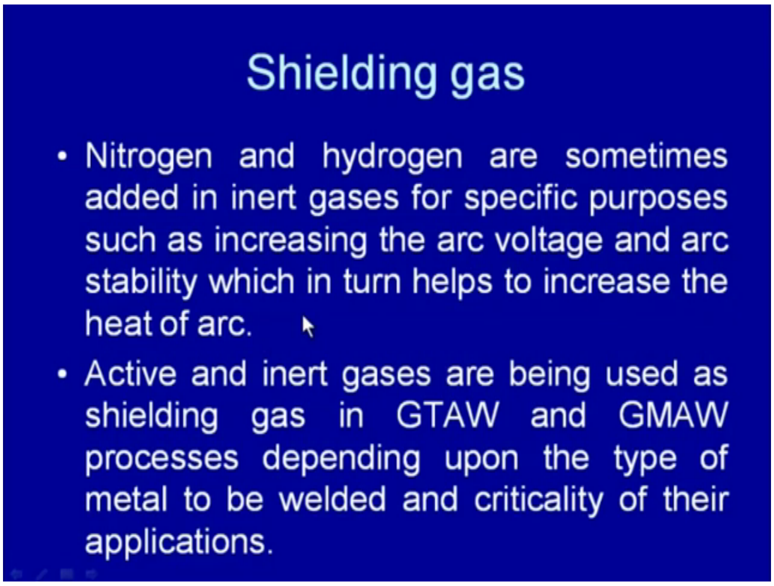

When the nitrogen and the hydrogen are sometimes added with the inert gases for specific purposes such as the increasing arc voltage and arc stability; it in turn helps in increasing the heat of the arc. So, addition of these two gases with the inert gases like argon then, this addition helps to have the higher arc voltage and better arc stability. It in turn helps in increasing the heat being generated by the arc. High heat generation by the arc with the addition of these gases helps in developing the weld joint of the thicker sheets at higher speed. Further, the active and inert gases are being used as a shielding gases in the GTAW and GMAW processes depending up on the kind of metal to be welded, the criticality of the applications, for which these are to be used. Carbon dioxide is mostly used.

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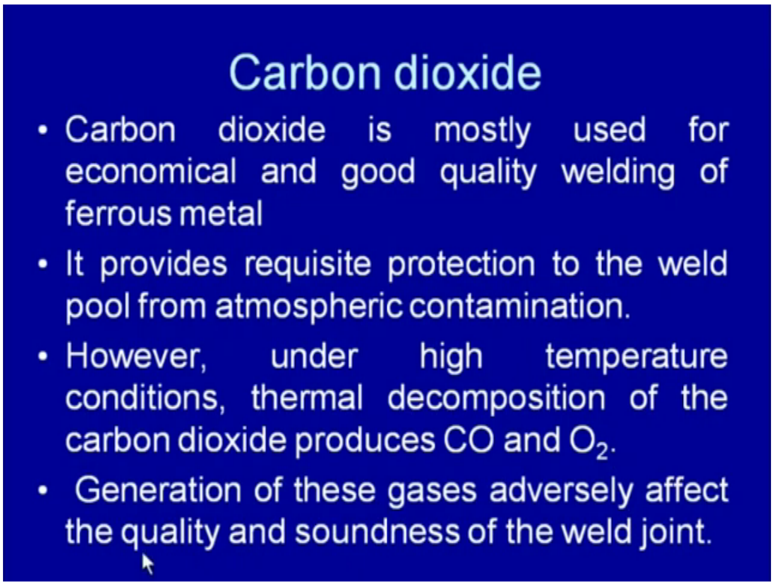

Carbon dioxide is mostly used for the economical regions and for producing the reasonably good quality weld joints of the steels and the ferrous metal systems. It provides the required protection to the weld pool from the atmospheric contamination. However, the protection under the high temperature conditions from these gases is not found to be very effective because of the thermal decomposition of the CO2 results in the CO and O2 under the presence of the oxygen in the arc environment leads to deteriorate the quality of the weld joint.

It decreases soundness of the weld joint. That is why, the carbon use of the carbon dioxide as a shielding gas for welding of steel offers the good quality. But, the quality is not very high. So, where it can be used? It can be used for the critical applications. So, use of CO2 under the high temperature conditions generates these gases like CO and O2. It in turn adversely affects the quality and the soundness of the weld joint.

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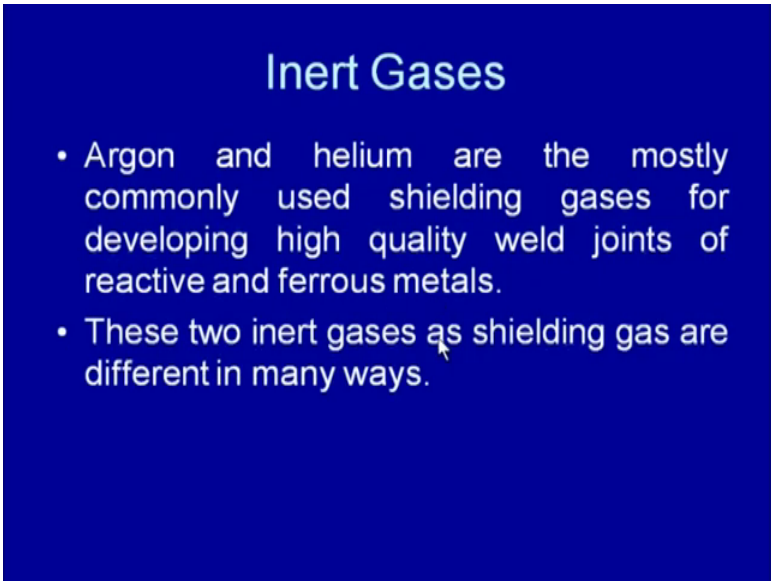

If we see the inert gases there among the inert gases argon and helium are most commonly used shielding gases for developing the high quality weld joints of the reactive metal and the ferrous metals. These two inert gases are as shielding gases. They play different kind of roles under the different conditions. Their characteristics are also found to be significantly different.

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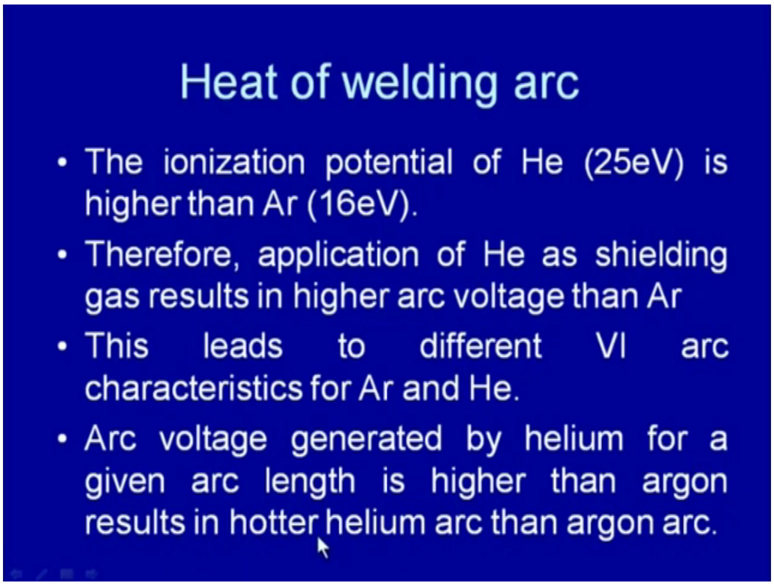

We see the ionization potential of the helium is found to be much higher than the argon. Because of this application of the helium as a shielding gas, it results in the higher arc voltage than the argon. Higher arc voltage in turn leads to have the different VI characteristic where VI curve is on the higher side. Then, when argon is used, so because of the difference in the arc voltage when helium is used then, the argon we get the different VI characteristic for the argon and the helium. The VI characteristic for the helium is always above that of the argon under the identical arc length conditions.

So, the arc voltage generated by the helium for given arc length is found to be higher than that is generated by the argon. It in turn results in the hotter helium arc than the argon arc. Hotter helium arc helps in deeper penetration in the first melting for welding of the thick sheets and the metals of the high thermal conductivity. Because of these reasons, the helium is preferred.

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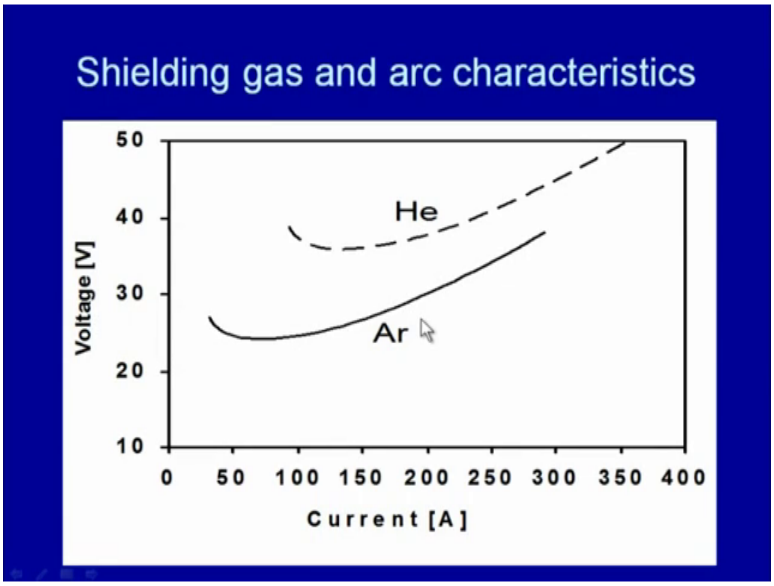

Under the certain conditions, when either thickness of the sheet to be welded is high or thermal connectivity of the metal to be welded is high as compare to that of argon; if we see the VI characteristic curve of the GTA process where in one if you are using hand in another case you are we are using argon. So, helium invariably results in the higher arc voltage. Then, when argon is used as a shielding gas, this difference is mainly attributed to the difference in the ionization potentials. Further, if we see the current level at which the arc voltage with the helium minimum arc voltage with the helium is found to be around the 120 to 150 amperes.

The minimum arc voltage is found to be at around 50 to 60 amperes. So, this offers us the difference in the way by which the helium can be used during the welding as compare to the argon. Helium actually, because of the high arc voltage, it allows us the greater flexibility in terms of the arc length has compare to that of the argon. So, we will see the further details of the difference in the effect of the type of the shielding gas on the welding performance of the GTAW process.

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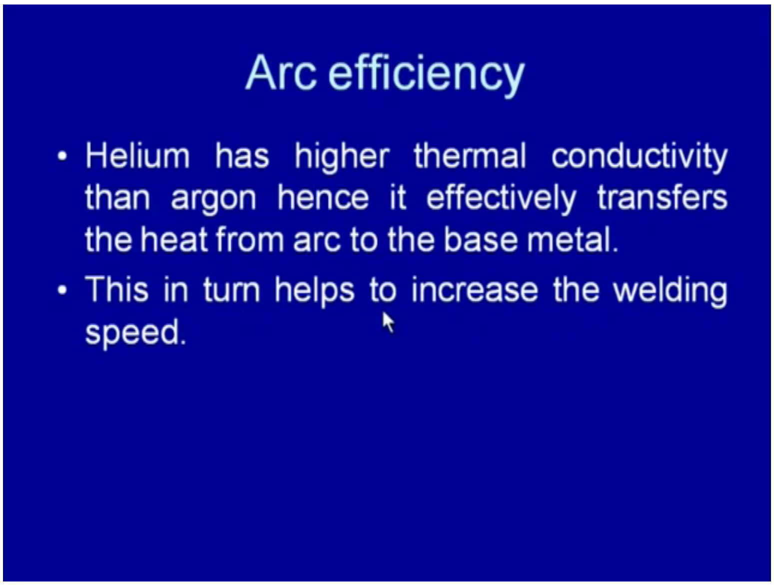

So, the helium is preferred for welding of thick plates at high speed especially of the metal systems having the high thermal conductivity and high melting point. Helium helps in generating more amount of the heat during the welding. It permits the melting at the high rate and with the deeper penetration. Further, helium offers the advantage of the high thermal conductivity over the argon. The high thermal conductivity of the helium helps in better transfer of the heat from the arc zone to the base material.

Thus, permits in more effective use of the heat being generated during the welding to the base material for melting the faying surfaces so that the weld joint can be obtained. Because of this, arc efficiency is found to be higher when helium is used as a shielding gas as compare to the argon. So, this is what has been mentioned the better arc, better heat transfer from the arc. Better transfer of the heat from the arc helps in rapid melting of the faying surfaces, which in turn allows us to go with the higher welding speed. Further, the selection of the shielding gas affects the stability of the arc.

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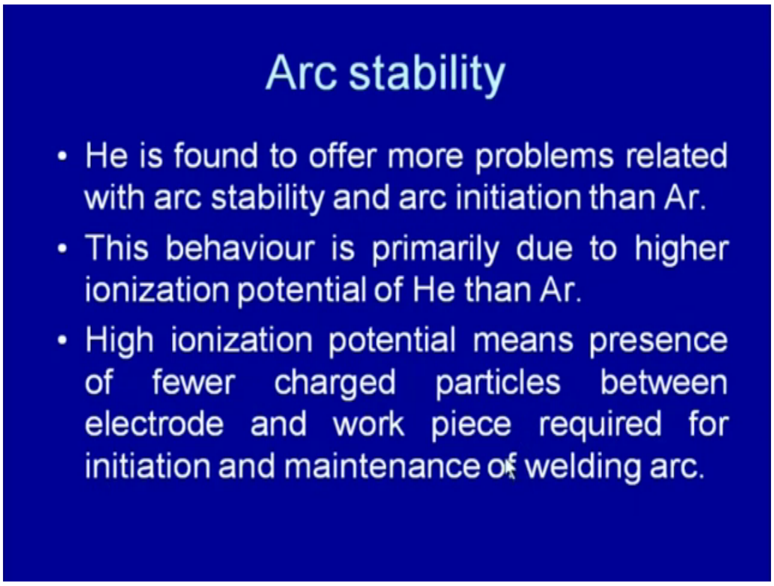

The helium is found to offer more problems related with the arc stability and the arc initiation than the argon. This difference is a problem is mainly attributed to the higher ionization potential of the helium than the argon. Higher ionization potential of the helium means the fewer charged particles it will be providing in the arc gap between the electrode and work piece. The presence of the fewer charged particles in the gap will be resulting in the difficulties in flow of current required for initiation and maintenance of the arc.

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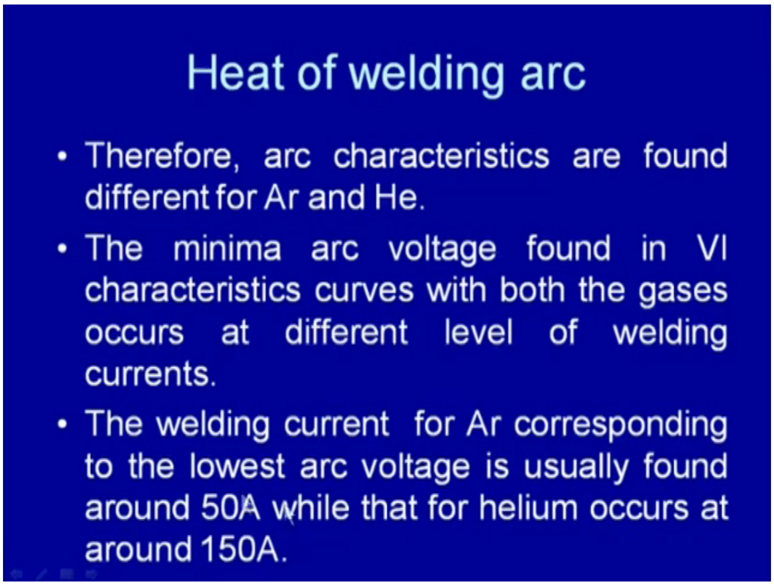

That is why when the helium is used and high ionization potential offered by the helium gas results in the presence of the fewer charge particles between the electrode and work piece. That in turn makes the initiation and the maintenance of the welding arc difficult. Further therefore, arc characteristics in case of GTAW process are found to be the different for helium and the argon.

Further, if we recall the previous diagram, where we have seen that the minima arc voltage is found in the VI characteristic curve. The both gases occur at the different level. It occurs, the minima arc voltage occurs at the much higher side with the helium than that with the argon. So, the welding current for argon corresponding to the lowest arc voltage is usually found around the 50 ampere while that for the helium it occurs around the 150 ampere. This is what we can see in this diagram. Also, if we see the two different arc lines then, for a given shielding gas the two different VI characteristics are used.

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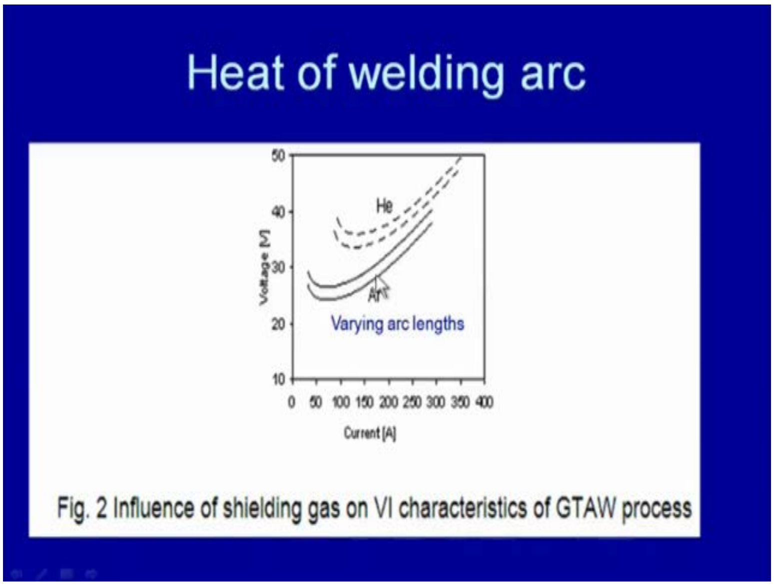

But if we changed the shielding gas then, for the identical arc lines, there will be huge change in the VI characteristic, VI carbon location. Because of this, if we see the minima arc voltage is found to be around the 50 volts for the argon. It is found around 100 to 150 amperes in case of the helium.

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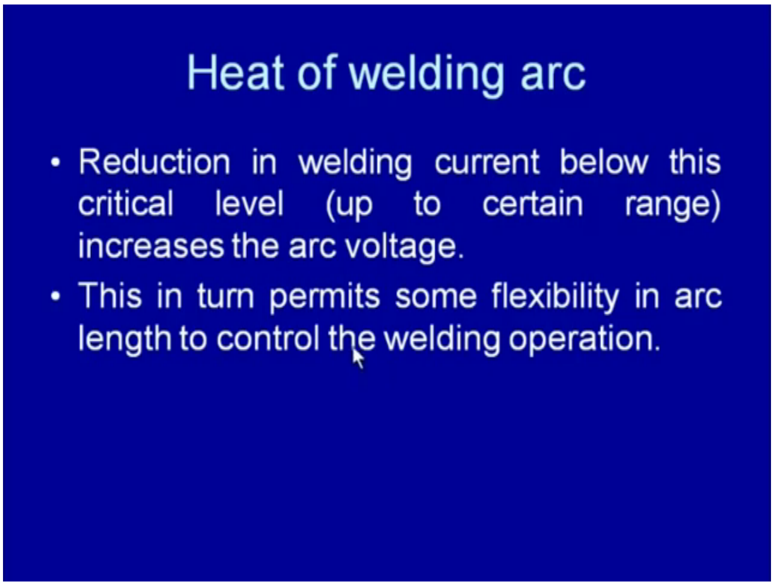

So, the reduction in welding current below this critical level of the current to certain stage increases the arc voltage. This in turn permits some flexibility in arc length control during the welding further.

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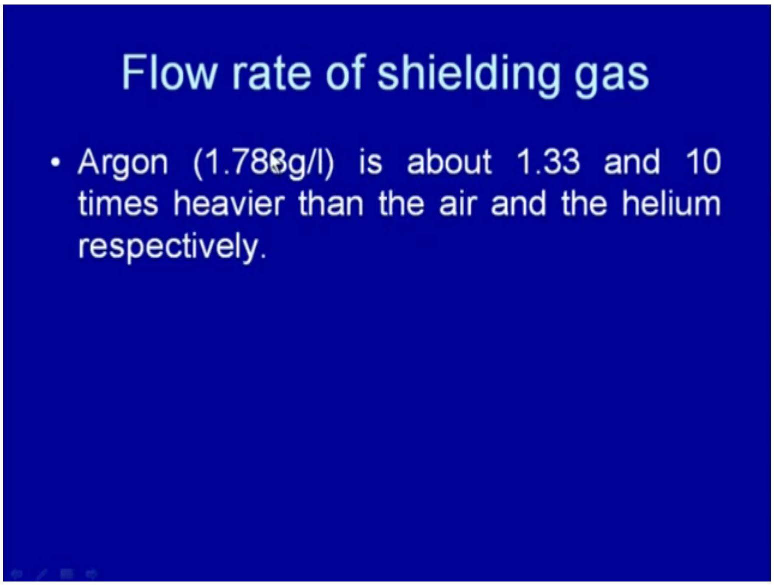

If we see the kind of the flow rate difference, which is required in case of argon and the helium for developing the sound weld joint. The flow rate of the argon for developing the sound weld joint is found to be very low as compare to that of the helium. Now, we will see that the how the flow rate conditions vary with the selection of the shielding gas.

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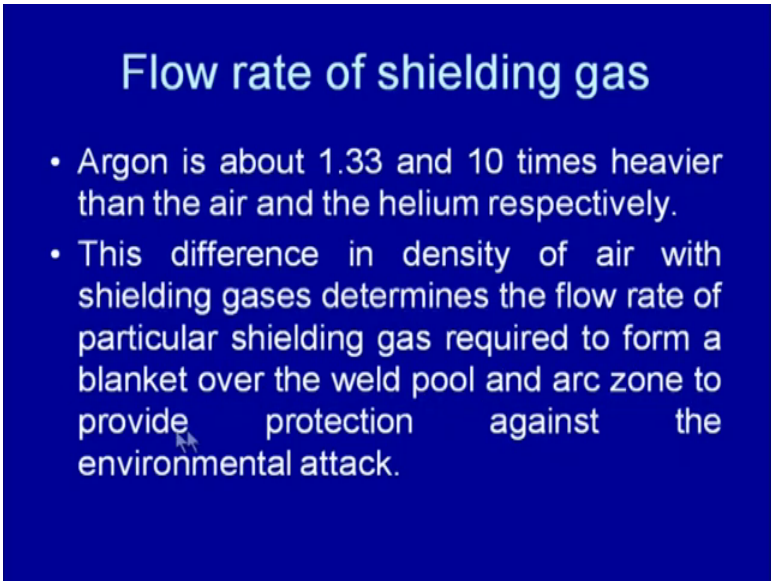

The argon flow rate is about 1.33 times and about 10 times heavier than the air and the helium respectively. If we see the density of the argon is found 1.3 times to that of the air and about 10 times heavier than the helium. Because of this difference in the characteristics of the argon as compare to the air and helium, we find lot of difference in the flow rate which is required and because of the difference in the density of air with the shielding gases.

This difference determines the flow rate of the particular shielding gas required to form blanket over the weld pool and arc zone to provide protection against environmental attack. If we see the gases coming out of the nozzle, if they are heavier than the air then, they will tend to settle down all around the weld pool. Then, we will provide the effective protection against the atmospheric contamination. But, if they are lighter then, they will tend to move up immediately after coming out of the nozzle. They will be less effective in providing the protection to the weld pool from the atmospheric contamination.

So, if we see this data, the argon is found to be heavier than the air. It is found much heavier than the helium and because of this argon flow rate required is found to be much lower than that is required for argon. We will see further in the next presentation what are the different factors that dictate the flow rate conditions required for helium and argon. How we can compare the performance of the shielding gases namely argon and helium as far as GTAW processes concerned? So now, we will like to summarize this presentation. In this presentation, we have seen that what the uniqueness in the GTAW process is.

What are the components of the GTAW system which make it? What is the role of the electrode, the power source and the kind of shielding gases which are used with this process? Now, in coming presentation, we will see some other details related with GTAW process. We will see that what are the other variants of the GTAW process like pulls gas tungsten arc welding process or the hot wire tungsten arc welding process and how can we initiate the arc in this process. Those things will be coming up in the next presentation.

Thank you for your attention.