Welding Engineering
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Module - 4
Arc Welding Processes
Lecture - 1
SMAW- 1

So, dear students, this is the fourth module of the subject welding engineering. Earlier we have covered in module 1 regarding the introduction, module 2 was based on the physics of arc welding Process. Module 3 was based on the welding power sources, or the power sources, which are used for the welding purpose. This module is, mainly based on the arc welding processes, which are commonly used for development of the weld joint. So, in this connection we will be taking up in this lecture mainly the shielded metal arc welding process.

This is one of the most commonly used welding process for the general purpose welding. In addition to the general purpose welding, this is also used for the weld surfacing and some of the critical applications joint. In this presentation mainly we will be covering the common arc welding processes, what are the common arc welding processes used for developing the weld joints? Then we will be taking up the line outline of the shielded metal arc welding process, along with the block diagram and the main electrical circuit used for the arc shielded metal arc welding process.

The way by which heat is generated in this shielded metal arc welding process and the important factors, that affect the heat generation in this process, how do they affect speed and the development of the ((Refer Time: 01:58)) weld joint? In addition to that we will also see that, what are the approaches used in the shielded metal arc welding process for shielding the weld pool, so as so to develop the weld joint? Thereafter, we will see that, what are the important welding process parameters for the shielded metal arc welding? How do they affect the heat generation aspects?

What are the factors that affect the open circuit voltage to be set in first before starting the arc? What are the factors that affect the upper and lower limits of the current that can be used with this kind of the process? So, starting with the presentations we will be seeing that in arc, in all arc welding process mainly one arc is generated between either

consumable or non consumable electrode the base material. This arc will be, generating the heat and which is used for melting the base material or the faying surfaces of the base material.

In consumable arc welding processes, the heat generated by the arc is also used for melting the electrode or the filler materials so that, the joint between the components can be made. So, the main purpose of the arc is to develop the heat so that either melting of the electrodes or and the melting of the base materials can be realised for developing the weld joint. In all arc welding process, apply the heat generated by an electric arc for the melting of the faying surfaces of the base material. So, depending upon the way by which arc is generated whether it is established between the consumable electrode, or the non-consumable electrode and the base material, where how the arc is shielded to protect the weld pool from the atmospheric contamination.

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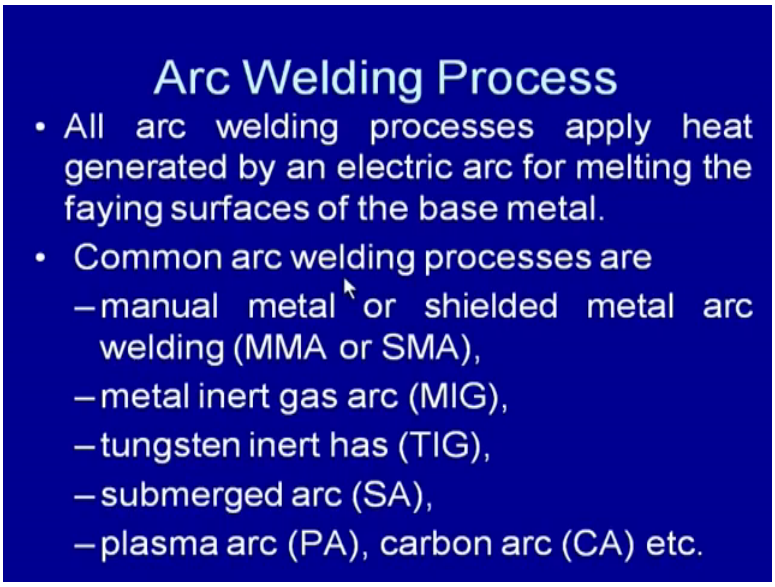

So, those things have led to the development of the variety of arc welding processes like one is the manual metal arc welding, also known as shielded metal arc welding process and in abbreviation forms these are termed as MMAW or SMAW processes. Metal inert gas process, it uses the inert gas for shielding the welding arc and the weld pool so as to protect the atmospheric contamination. At the same time, it uses the consumable electrode and this process is commonly known as MIG, or the metal inert gas arc welding process. The, another process is the tungsten inert gas process in which the inert

gas like, helium and argon are used for shielding the weld pool, to protect the atmospheric to the protect the weld pool from the atmospheric contamination and the non consumable tungsten electrode is used.

Similarly, in submerged welding process, the abbreviation is as said W and here arc is submerged under the granular flux. That is why it is termed as submerged arc welding process. Similarly, we have the plasma arc and the carbon arc welding process in all these processes an electric arc is established between either, consumable and non-consumable electrode. The heat generated by the arc is used for melting the faying surfaces of the base material and the filler material or the electrode depending upon the kind of process, which is being used.

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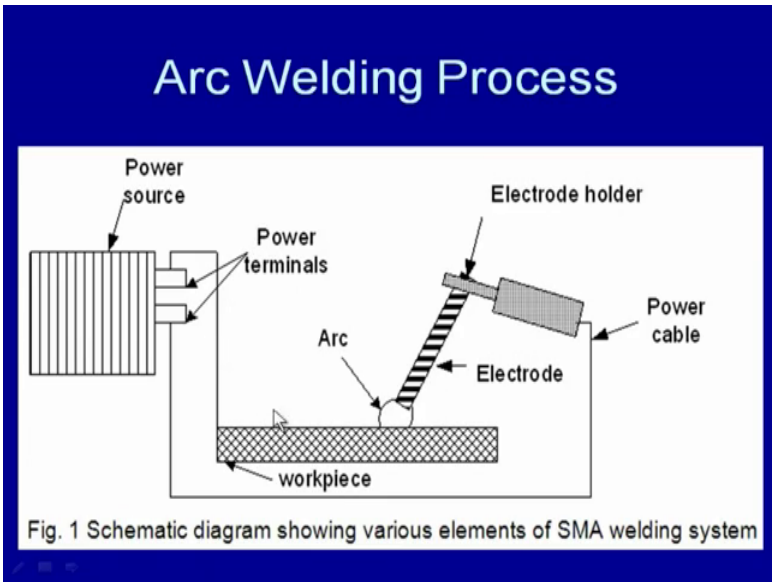

One of the simplest schematic diagram for the shield metal arc welding process showing that this is a power source, which delivers the required power supply their power supply may be of the AC or the DC kind. But it should have capability to offer the desired the open circuit voltage and deliver the current in amount, which is desired for developing the required heat. So, the electrode is electrode is connected to the electrode holder and then the holder is connected to the ((Refer Time: 05:58)) terminal of the power supply. Another terminal of the power supply, is connected to the work piece so as to complete the electrical circuit for the flow of current through the, when the arc is established.

So, basically arc is established using either field start or touch start method and once the arc established then required heat is generated and this heat is used for melting the faying surfaces of the base material. In this, particular process even the consumable electrode is also brought to the molten state. The, melting of the consumable electrode also takes place, so melting of base material and melting of the electrode both leads to the development of the weld pool and on the ((Refer Time: 06:43)) of the weld pool results in a weld joint. So, if you go into the details of this shielded metal arc welding process.

This heat generated by an electric arc between, the base material and the consumable electrode in this process the electrode is consumed continuously during the process. So, the electrode is continuously fed towards the work piece so as to maintain the gap between the electrode and the work piece, otherwise arc will get extinguished. So, arc tip containing is melted continuously and the molten metal is transferred continuously towards the weld pool. But to maintain the arc gap between the electrode and work piece electrode is also fed continuously towards the work piece and it is moved, at the same time along the line of the weld.

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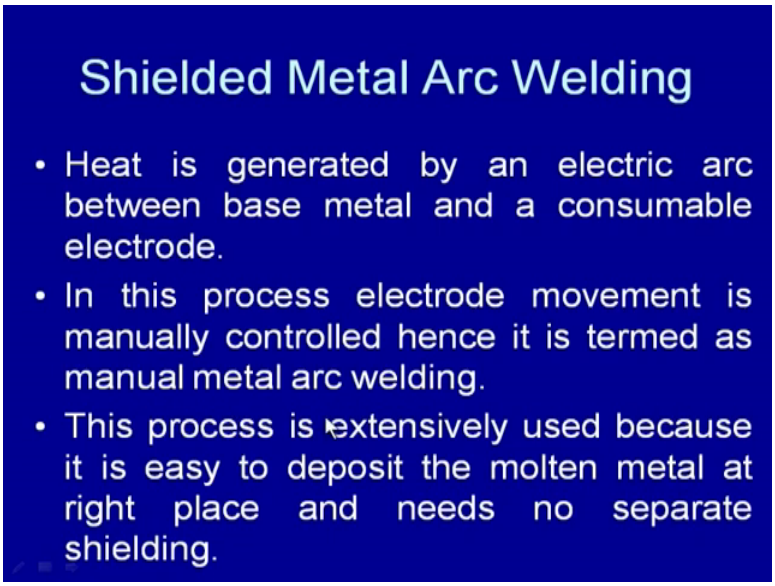

So, in this process electrode is moved manually for controlling the placement of the molten weld metal in the between the weld joints. Therefore, it is termed as the manual metal arc welding process. Since, the arc is controlled manually, that is why it is termed as manual metal arc welding process and the desired shielding to the weld pool. To, the

arc is provided by the combustion of the hydrocarbons provided in form of the coatings around the electrode core wire. That is why it is termed, as the shielded metal arc welding process.

So, this process is extensively used because it is easy to deposit the molten metal at the right place and it needs no separate the shielding. Whatever required shielding is, whatever shielding is required to protect the weld pool from the atmospheric contamination, it is obtained by the thermal decomposition of the flux material which is there in form of the coating in the electrode. So, this process because of this easiness to deposit the molten metal in between the plates to be joined this process is very extensively used. But this process is having some inherent problems like, somewhat poor shielding.

This leads to application of this kind of the welding process for comparatively less sensitive applications. So, to weld the metals, which are having the less sensitivity to the environment and atmospheric gases this process is commonly used. Now, we see that what are the locations and situations where this shielded metal arc welding process can be used effectively. The, first situation is this that to weld the metals having the less sensitivity, to the environment and the atmospheric contamination. So, the metals like iron, steels and the cast irons, which are comparatively less sensitive to the atmospheric contamination can be welded successfully using the shielded metal arc welding process, because these metals are less sensitive.

So, these are not very easily attacked by the atmospheric gases, to form their undesirable compounds and to have the undesirable effects on the properties of the weld joint. Similarly, to develop the weld joints for the less critical applications the SMAW welding process is also used for those for developing the joints, which are considered to be ((Refer Time: 10:36)) on what less critical in terms of their effect on the performance, in terms of their criticality in application from the economical and from the accident point of view. So, if the joints are less critical in nature can be developed using the shielded metal arc welding process, because this process does not provide very effective shielding that is why these this process is good for those metals which are comparatively less sensitive.

Since, the shielding is also not very effective that is why it is used for somewhat less critical applications. Further, it is used for the general purpose welding and surfacing applications for developing the weir or collagen resistant surfaces. These ((Refer Time: 11:30)) is also effectively used where great flexibility is required for developing the weld joint, where we cannot put in either the flux to use the submerged arc welding process. Or where application of like GMAW is not very effective, under those conditions and the locations SMAW welding process is very effectively used. So, the next is what kind of current, we can use? What kind of voltages we can work with for the shielded metal arc welding process? This process can use both AC and DC accordingly we have to select the suitable power supply.

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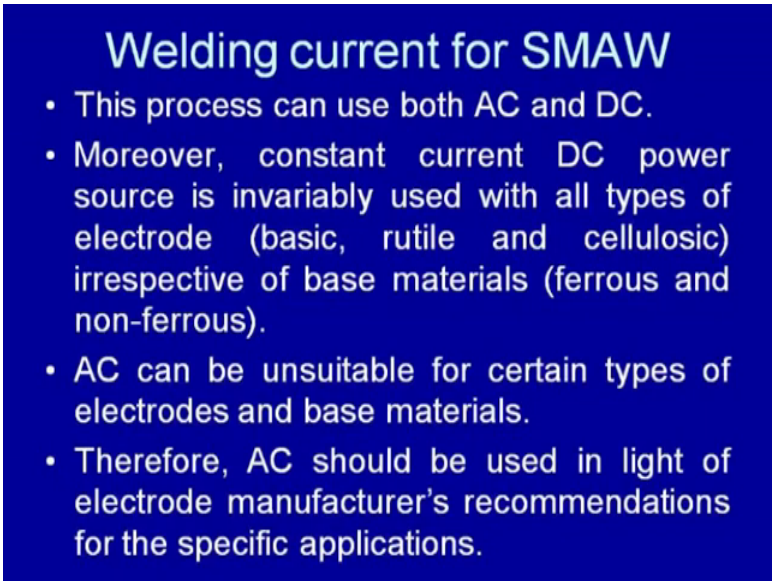

The constant current the DC power source is invariably used for all types of the electrodes whether it is the basic type, or rutile type, or the cellulosic type irrespective of the base material, whether it is ferrous or the non ferrous kind. So, it is common to work with the constant current type DC power source, so that we can generate the heat uniformly using the constant current despite of having the changes in arc length, because electrode is controlled manually. Similarly, the AC is found unsuitable for the certain types of the electrodes and the base materials and that is why, AC should be used only in light of the manufacturer's recommendations for specific applications of the electrode.

So, if we see this the DC welding current is commonly used for all types of the electrodes, for ((Refer Time: 13:07)) to the base material to be welded. AC can be unsuitable, so the manufacturer's recommendations should be kept in mind while using AC in the shielded metal arc welding process. In general, we see that heat generated during the shielded metal arc welding process in the arc by the arc, it will depend whether it is AC or the DC welding is being done. Whatever, the polarity is being used heat generated at the anode or cathode is generally found greater than that is generated in the arc column.

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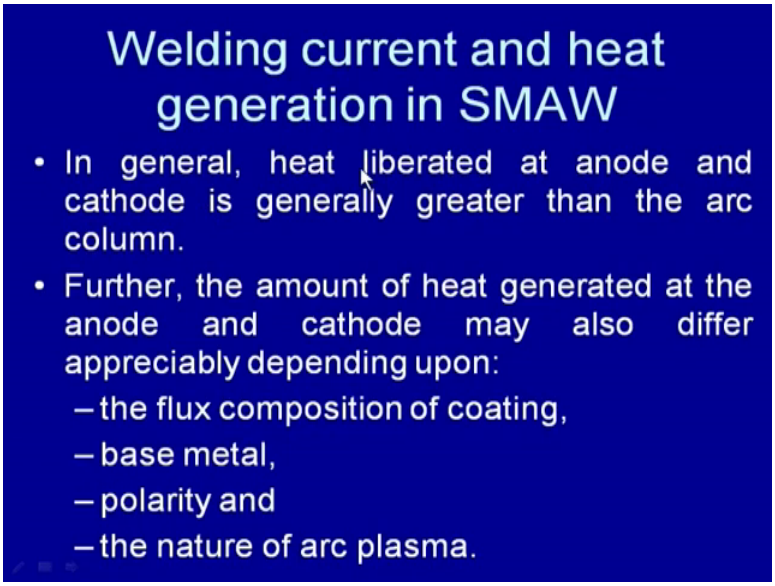

The heat generated in the anode or cathode sides matters significantly because they dictate the melting rate of the electrode, or melting of the base material. So, the amount of heat generated at the anode or cathode may be governed by some other factors like the flux composition on the coating, whether the coating is having the low and ionization potential elements or not. If, there is a large amount of the low ionization potential elements in the coating, then they will reduce the arc voltage by producing the large number of charge particles, thereby reducing the power of arc and so the heat generated is reduced. The, base material is those base material what kind of electron emission capability is there of the base material, which in turn effects the arc voltage and accordingly the heat generation.

Polarity what kind of polarity is being used, whether it is the straight polarity, or the reverse polarity in case of this straight the heat is more generated on the work piece side and in case of reverse polarity, heat is generated over on the electrode side. Similarly, the nature of the plasma which is being formed nature of the plasma means, what gas is being used for developing for shielding the welding arc? Or what kind of gas is present in the arc environment? They will be effecting the arc voltage and the variation in arc voltage due to the gases present in the plasma zone, will be effecting the heat generation in the plasma.

But the melting of the base material or the electrode is primarily governed by the heat generated at the anode or cathode side. So, further the distribution of the heat generated at the anode and cathode side as I have said, determines the melting rate of the electrode and the penetration into the base material. So, if it we are using straight polarity where electrode is negative and work piece is positive, so the heat generated at the anode side will be more which will affect the penetration. The, extent of melting taking place in the base metals in the base metal side while the heat generated in the cathode side will affect the rate, at which electrode will be melting.

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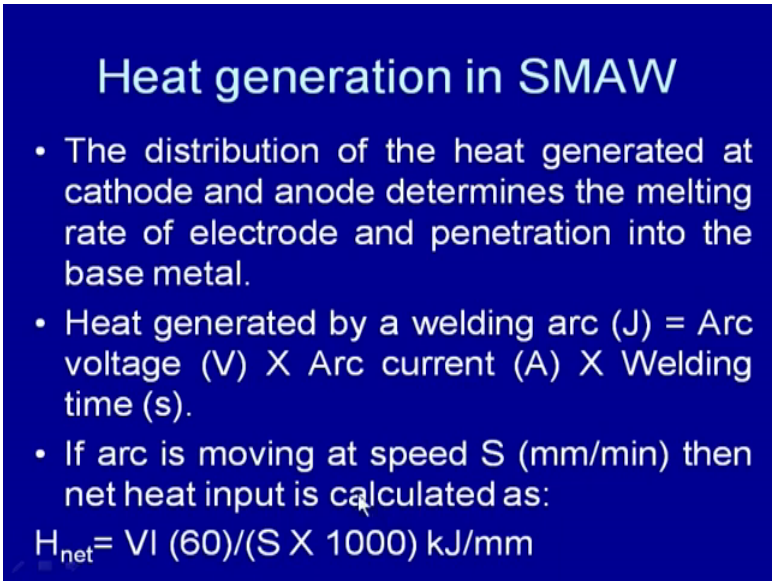

So, the heat being generated the amount of heat being generated in the anode or in the cathode side. They will be determining the rate of melting of the electrode and the extent of penetration which is taking place into the base material. So, the heat generated by the

arc in general as is given by the arc voltage ((Refer Time: 16:31)) and the time for which the current is allowed to flow. Since, arc is continuously moving in the shielded metal arc welding process. Then the amount of heat being supplied per unit time is reduced and it is obtained using the equation.

Where the net amount of the heat being supplied to the base material is given using the equation like, H net is equal to net amount of the heat being supplied is equal to the product of the VI, that is arc voltage. The, welding current multiplied by 60 divided by the S that is the welding speed and multiplied by 100. So, this gives us the heat being supplied in kilo joule per mm. This is the typically unit, of the net heat supplied during the arc welding, which can be calculated using the welding speed in terms of the mm per minute, the VI that is the weld arc voltage and the welding current.

So, this equation is used for calculating the net amount of the heat being supplied during the welding, when the particulars welding parameters setting is used. Further, when the heat is generated the melting of the base material and melting of the electrode takes place. So, development of the high temperature in the arc region leads to the increased reactivity of the molten weld pool. The electrode molten electrode material with the atmospheric gases present in arc region and around the weld pool.

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So, to avoid the effect or any undesirable effect of the gases present in the arc region or around the weld pool, the suitable shielding gases must be provided, so that the weld

pool can be protected from undesirable effect of the atmospheric gases on the weld pool. The, development of the undesirable micro constituents in the weld metal, which will otherwise ((Refer Time: 18:45)) mechanical performance of the weld joint.

So, to avoid the contamination of the molten weld metal from the atmospheric gases present around the welding arc, protective environment must be provided. In the different welding processes, this protection is provided using the different approaches like in some of the welding processes, like MIG metal inert gas welding process and the TIG tungsten inert gas welding process, inert gas at atmosphere is provided. While inactive gases, are used in case of the metal active gas that is called GMAW the gas metal arc welding process where, instead of the inert gases like helium and argon carbon dioxide is used for the shielding purpose.

So, we can use either inactive gases like the carbon dioxide or the inert gases like helium and argon. Further, like in submerged arc welding process the molten flux cover is used, to protect the weld pool from the atmospheric contamination. So, depending upon the process arc welding process the different approaches are used for, shielding the weld pool from the atmospheric contamination.

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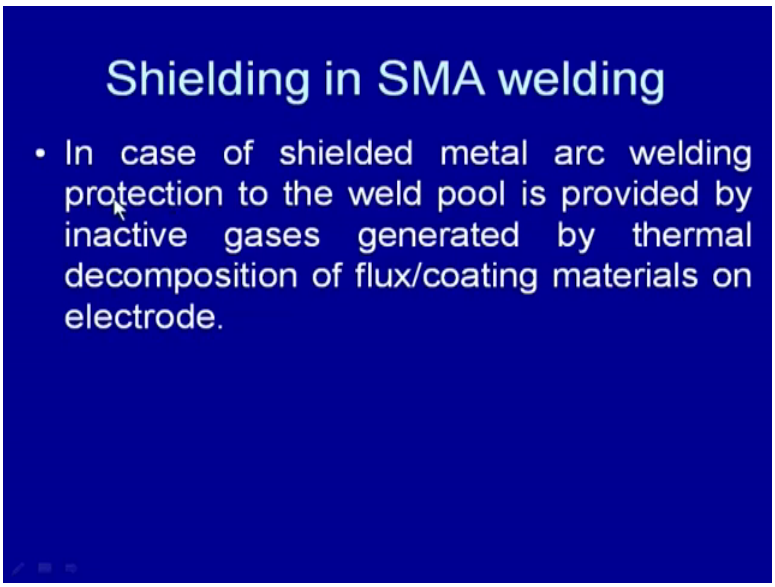

So, in case of the shield metal arc welding process protection to the weld pool is provided by providing the inactive gases around the welding arc. These, inactive gases

are generated by the thermal decomposition of the flux, which is present in form of the coating material on to the electrode.

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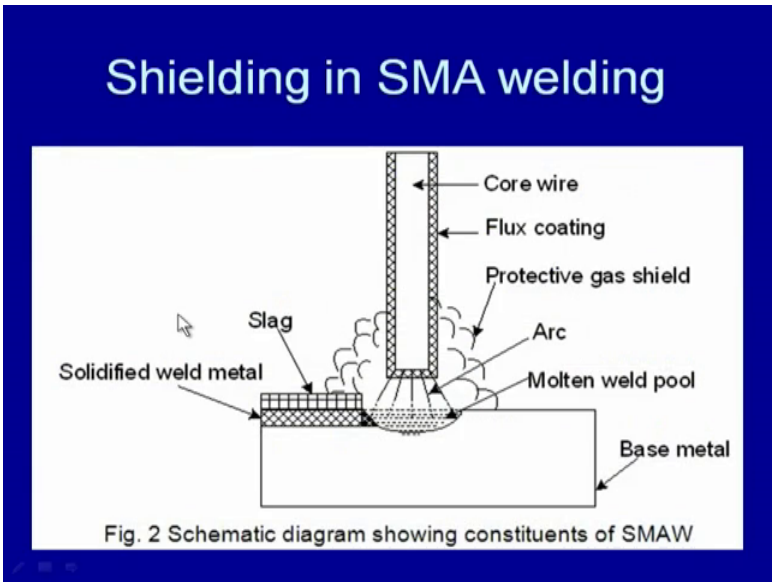

So, if we see that how these gases are generated if this is a core wire of the electrode and the electrode is covered by the flux material or the coating material. These coating materials are mainly hydrocarbons and some other micro constituents about which we will be talking in detail in the subsequent section of this presentation. So, this coating material under the effect of the heat generated by the arc is decomposed. When, these hydrocarbons decompose they generate lot of the inactive gases like carbon dioxide, another oxides which help. These gases form a cover of these gases around the arc and around the weld pool.

That is how they provide protection to the weld pool and to the arc from the atmospheric gases, so a cover of the protective gases is formed around the arc in order to protect the weld pool. As the electrode move is forward the molten weld metals, solidifies and results in the metallic continuity to produce the weld joint. So, this is how the shielding in the shielded metal arc welding process is provided. The, shielding of the weld pool by the inactive gases in this process is not found to be very effective, because of the two regions. One is that, the gases generated by the thermal composition of the coating material do not necessarily form a proper cover around the weld pool and the arc.

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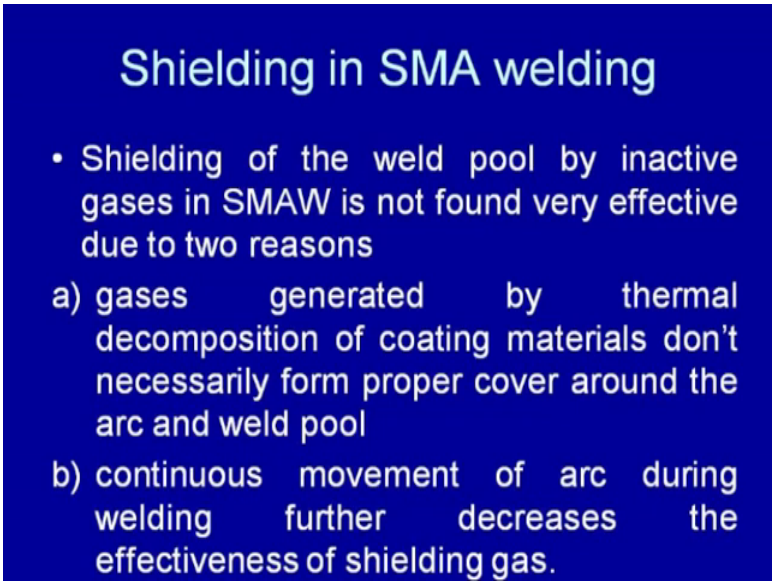

So, the kind of the gases generated by the thermal composition of the coating material they under the normal conditions, they form cover around the weld pool on their own. There, is no deriving force to form a perfect complete shielding cover formation around the weld pool. That is why, a very weak cover is formed by these inactive gases around the weld pool, which in turn leads to the poor shielding of the molten weld metal by this approach of the shielding of the weld pool. Another aspect is that electrode is moved continuously during the welding, which further decreases the effectiveness of the shielding process.

Once if the arc is developed for continuous welding and for depositing the molten metal all along the weld line, it is necessary that arc is moved continuous along the weld line. So, that the metal can be deposited in the places where it is desired, but the loose cover being formed by the inert gas enactive gases being developed due to the thermal composition of the coatings. The, shielding is poor and that is why the movement of the arc during the welding decreases the effectiveness of the shielding, by this process.

Further, the improper cover being formed the thermal decomposition of this shielding gases leads to the ineffective shielding. Because, of this ineffective shielding normally the weld joint produced is found to be contaminated by the oxides, nitrites and hydrides. So, the presence of these undesirable constituents in the weld metal decreases the

cleanliness of the weld joint, the decrease in cleanliness of the weld joint in turn decreases the mechanical performance.

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So, hence the SMAW welding process is not usually recommended for developing the weld joints for critical applications. Since, the weld joints are produced using the conditions which are not are very effective to protect the weld pool from the atmospheric contamination. That, is why invariably the weld joint is not very clean and which in turn decreases its mechanical performance and that is why these, are not recommended for critical applications. Similarly, due to the poor shielding these shielding offered by a SMAW welding process for the weld pool.

These processes is also not used for welding the reactive metals, which are having very good affinity with atmospheric gases like aluminium, magnesium, titanium, chromium and the stainless steels, which are having high percentage of the chromium. So, all the metals which show high affinity to the atmospheric gases, they are not normally recommended to be welded by the shielded metal arc welding process. However, for the general work purpose welding and less critical applications the shielded metal arc welding process is commonly used.

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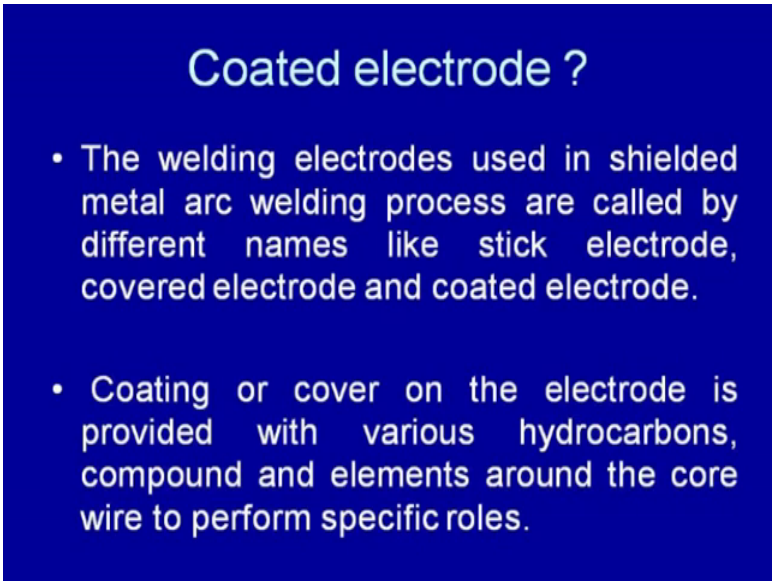

Next is that, what are the way is and the through procedures and the principles through which the shielded metal arc welding electrode is developed, in order to produce the weld joints which is reasonably good and acceptability is also good. So, for this purpose the electrode is made by providing the proper coating material around the core wire. To understand this, we will see this here using the schematic diagram.

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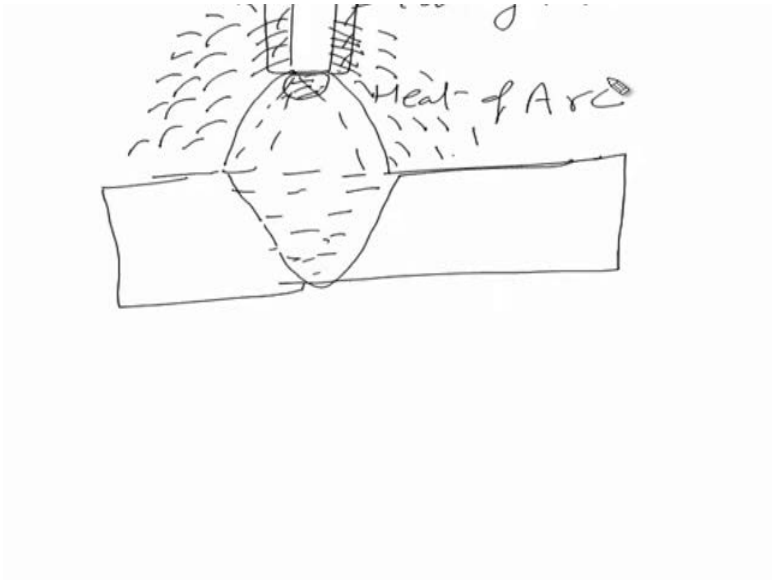

Here, we see any consumable electrode is for the shielded metal arc welding process, is made of one core wire like this. This core wire, upper end of the core wire is kept

uncovered and the remaining portion is coated reusing the suitable coating material. So, this outside we have coating this coating material and this one is core wire, this core wire can be made of the material which is to be deposited in the weld metal. May be similar, to that of the base metal or may be of the slightly different in composition.

Especially when the different combination of the mechanical properties are required in the weld joint for specific purposes. So, the core wire is covered with the coating material and here when the arc is developed between the base material the weld pool is generated by the heat of the welding arc. So, this is the welding arc molten metal is formed the tip of the electrode by the heat of arc. So, continuous thermal decomposition of the coating material takes place. When, this coating material is decomposed inert gases are inactive gases are formed around the weld pool.

So, these inactive gases will be forming a loose cover a comparatively weak cover around the weld pool and the arc region, to protect the molten metal from the atmospheric contamination. This is one of the, major roles of the providing the coating material apart from this coating materials are expected to perform many other functions. So, what are the main objectives of providing the coating material around the electrode that we will see in detail.

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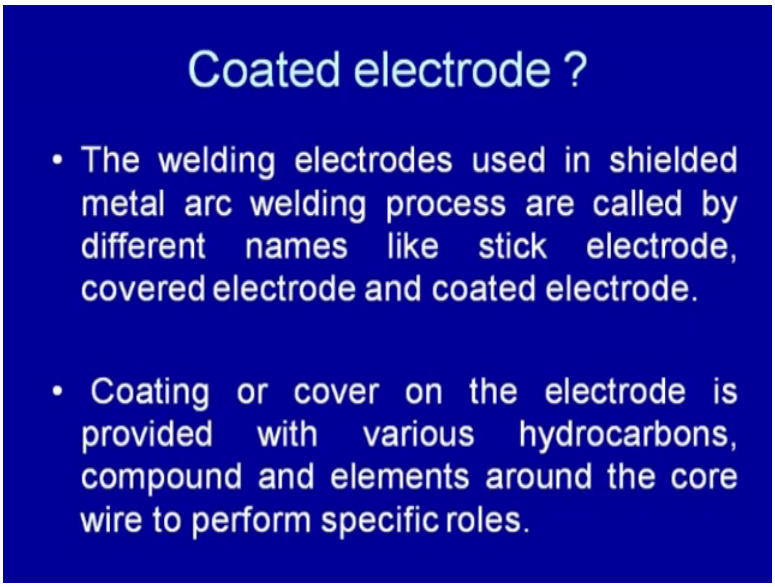

So, the welding electrodes used in shielded metal arc welding processes, are called by the different names like stick electrode. Since, the electrode is in form of one stick which

is covered with the coating material and it is also called cover electrode, because suitable coating material is covered around the core wire and also known as the coated electrodes. Because these core wires, are coated with the coating material so coating or cover on the electrode is provided with various hydrocarbon.

So, various hydrocarbons their compounds and elements are provided, all around the core wire to perform there is specific roles. The, typical and the commonly used the constituents which are provided in form of the coating material, around the core wire are listed here and along with their specific role say for quartz.

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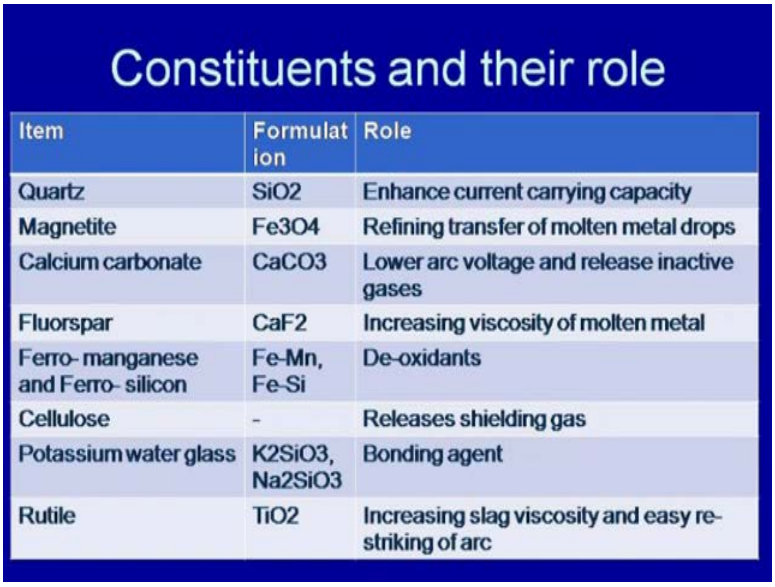

Quartz is used to enhance the current carrying, current carrying capability of the electrode, well the magnetite is used for refining the transfer of the molten metal drops. The, calcium carbonate is used to, lower the arc voltage and release the inactive gases. So, decomposition of this the calcium carbonate results in the development of the inactive gases, which will be forming the there a cover around the weld pool to protect it from the atmospheric contamination. Fluorspar is used, for increasing the viscosity of the molten metal this is especially important for the vertical and overhead welding positions where we want the active viscosity of the molten weld metal is high enough.

So, that the tendency if the molten metal molten weld metal to fall down is reduced. Further, ferro manganese and ferro silicon are used as de oxidants, because the molten metal whether it is of the iron or steel or the cast irons. They will be reactive the

atmospheric gases and these are required to be remove. So, whatever oxides have been formed in the weld metal those need to be removed, the de oxidants like ferro manganese and ferro silicon are added. These, will be de oxidizing the oxides, which have been formed to remove them from the weld metal.

Cellulose is also used, for developing the inactive gases which will be released by the thermal decomposition to protect the weld pool from the atmospheric contamination. So, this cellulose on thermal decomposition releases the shielding gases for protecting the weld pool potassium and water glasses are used as bonding agent for bonding the variety of constituents, which are being used for the different purposes. Similarly, the rutile is used for increasing the slag viscosity and easily it is striking of the arc. So, each type of the constituent which is there in form of the coating material is used for performing a specific kind of role, so varying the concentration of these varying amounts of these constituents in electrode, results in the different types of the characteristics in the weld pool, the arc striking capabilities, and the effectiveness of the shielding.

According to the needs, the different amount of the different constituents is regulated so that either, say the amount of the fluorspar and the rutile can be increased in order to increase the viscosity of the molten welds metal for odd position welding like, horizontal or the vertical and overhead position welding purposes.

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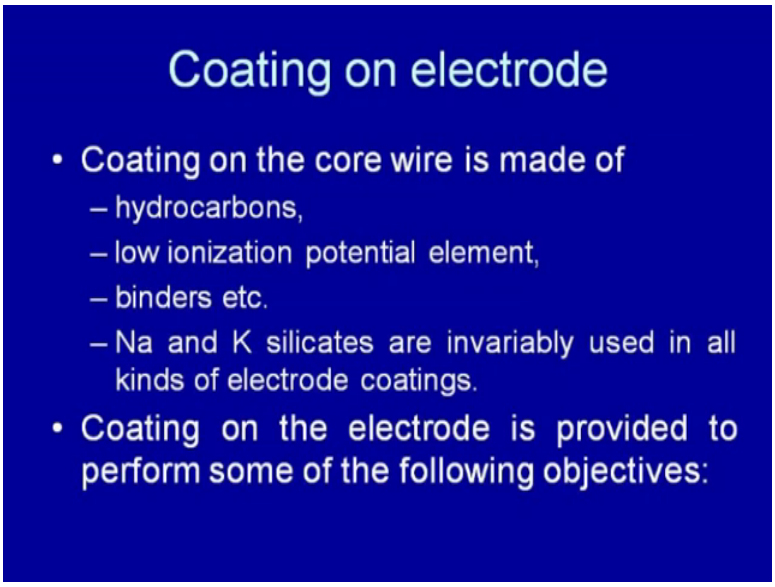

So, if we see the common list of the material, which are commonly which are used for developing the coating around the core wire is hydrocarbons, the low ionization potential elements. The, binders the sodium and potassium silicates which are invariably used in all kinds of the coating material, so coating on the electrodes are provided to perform for some specific objectives. One by one, we will see what kind of objectives and specific objectives are there of the electrode coatings. So, first one when the coating is provided it should help to increase the arc stability and this is realised, why with the help of low ionization potential elements like calcium and potassium.

When, these elements are added the electrons are easily emitted by these low ionization potential elements, when arc is striked. Under the presence of the easily released electrons in the arc gap, increases the arc conductivity, increases the conductivity of electrical connectivity of the gap between the electrode and the wok piece, which helps to strike the arc easily. When these charged particles in form of the free electrons and the ions are present in the large quantity the flow of the current between the electrode in work piece becomes easy, which in turn helps to increase this stability of arc.

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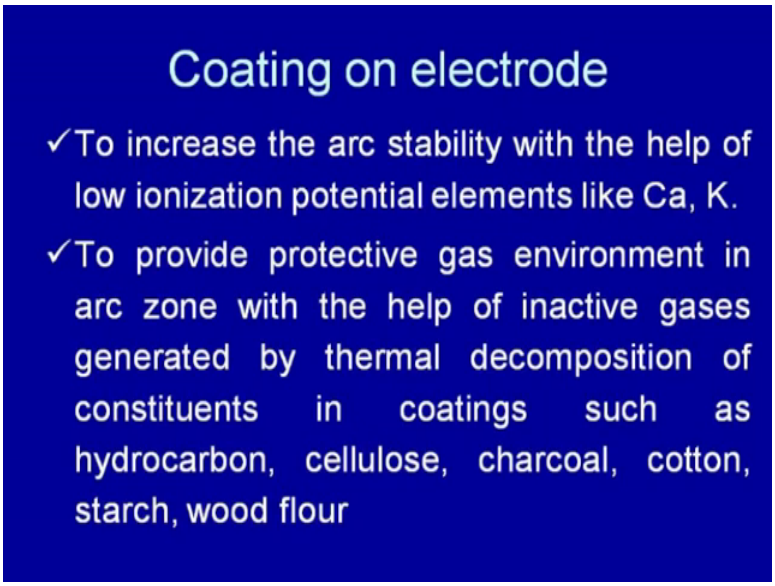

Further, to provide the protective gas environment in the arc zone with the help of inactive gases, which are generated by thermal decomposition of the micro constituents in the coating such as hydrocarbon, cellulose, charcoal, cotton, starch, wood flour. These are the constituents, which are added in form of the coating material coating materials, so

when these decompose under the influence of the welding arc heat they provide the protective gases to protect the weld pool.

These are the inactive gases, these are not the inert gases but they have to protect the weld pool from the atmospheric contamination. However, the protection is not found to be very effective. Another role which is played by the coating materials is to remove the impurities from the weld pool by forming slag such, as constituents present in the coating. Such as, titanium, fluorspar, china clay, these react with the impurities and the oxides in the weld pool.

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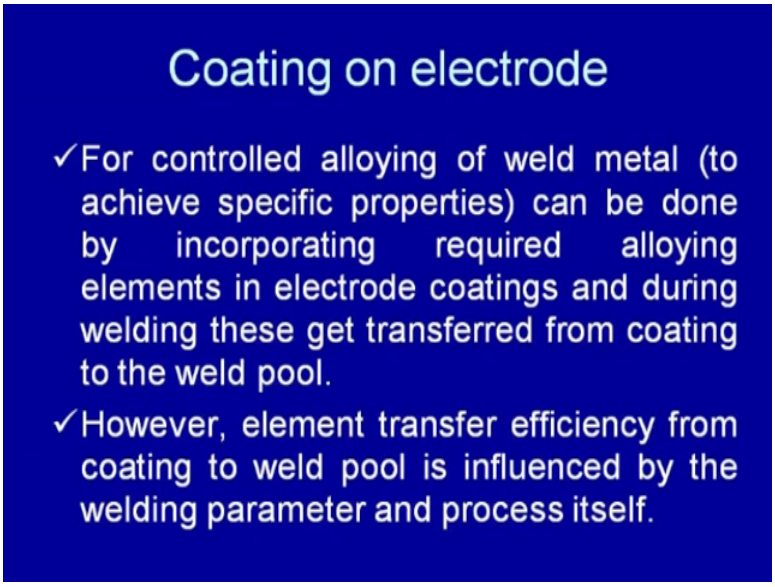

So, another important role of the coating material is to form slag by reacting with the impurities being formed in the weld pool under the high temperature conditions. Once these impurities are, removed the weld metal is cleaned and this material is removed in form of the slag and the slag being of the lower intensity, it starts floating over the surface of the weld pool which, in turn helps to cover the weld pool from the atmospheric contamination and atmospheric exposure and at the same time, it also reduces the rate of the heat loss from the weld metal to the atmosphere.

So, it tends to decrease the rate of cooling experienced by the weld metal during the welding. So, this is another role performed by the slag cover formed during the shield metal arc welding process. So, you can say that one important role of the coating material is to remove the impurities being formed in the weld pool by forming the slag.

Then, another role of the coating material is to have the controlled alloying, of the controlled alloying in the weld metal so that the specific set of the properties can be obtained.

So, for this purpose whatever element we want to add in the weld metal that is included, in the in form of coating material. So, that when coating melts and then core wire melts, coating melts and this leads to the transfer of the alloying element to the weld metal. When, it is transferred across the arc depending upon the kind of shielding which is been provided the effectiveness of the transfer may vary with the process, or with the kind of conditions which are being used during the welding. So, for controlled alloying of the weld metal to achieve the specific properties this is done by incorporating, the required elements in the electrode coatings and during the welding these get transferred from the coating to the weld pool.

However, the transfer efficiency of these elements from the coating to the weld pool is, influenced by the welding parameters and the welding process itself. The meaning of the welding process itself means how the protection? How much protection is being provided to avoid the atmospheric contamination? How effective shielding to the weld pool is being provided? The, what kind of the welding parameter are being used? Like what arc volt is and the current is being used. For example, higher is the welding current more will be the heat generated.

Higher heat generation, will lead to have the higher reactivity of the alloying elements with the atmospheric gases. So, the element will transfer efficiency will be low in that case. Similarly, in those processes where shielding is not very effective they will be very, they will be reacting so the alloying elements will be reacting with the atmospheric gases rapidly. Thereby reducing the transfer efficiency to the weld transfer efficiency of the alloying elements to the weld pool, so if the proper protection is there welding current is low heat generation is less then it will help to increase the transfer efficiency of the elements to the weld pool.

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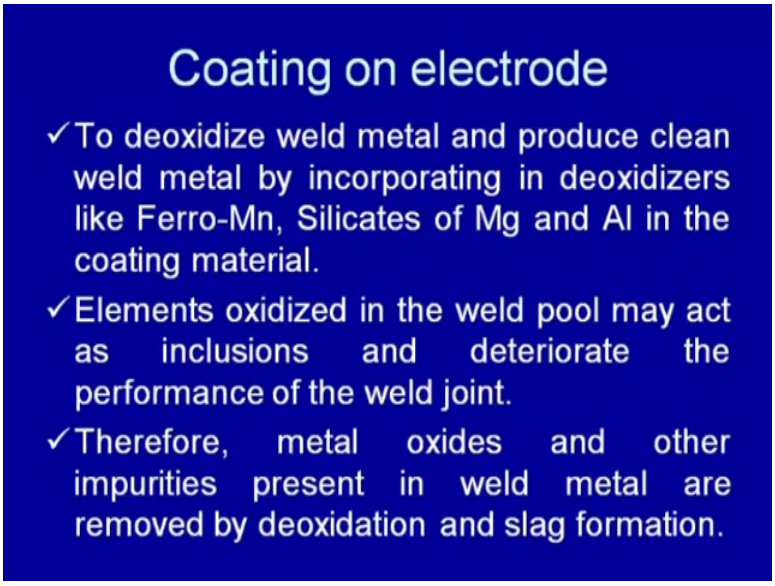

Another role which, is performed by a coating material is to de-oxidize the weld metal and produce the clean weld metal by incorporating the de-oxidizers like Ferro-manganese and the Ferro-silicon. De-oxidizers like aluminium is also added in coating material these elements oxidized in the weld pool. If not, removed properly then these will act as inclusions and which in turn will deteriorate the mechanical performance of the weld joint and these also decrease the collagen resistance of the weld joint. Therefore, metal oxides and other impurities being formed in the weld metal, must be removed by suitable de-oxidation and this will be removed in form of the slag.

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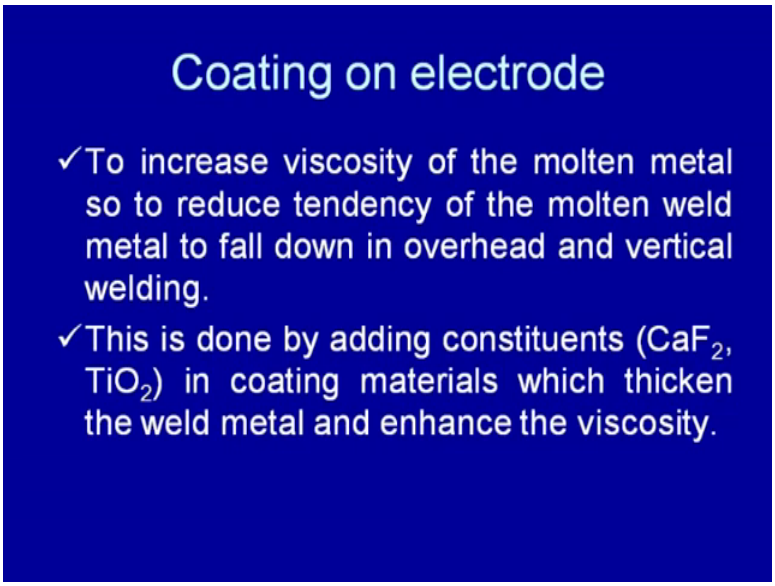

Then, to increase the viscosity of the molten weld metal sometimes the coating is modified in such a way, that the viscosity of the molten weld metal can be increased. So, as to reduce the tendency of the molten weld metal to fall down especially, when the overhead welding, vertical welding, or horizontal welding is being performed. So, if we are able to increase the viscosity of the molten metal molten weld metal then it the tendency to fall down will be decreased.

This will, help to increase the welding speed by placing more and more amount of the weld metal in the places where it is required. This is done by adding some of the micro some of the constituents, like calcium fluoride, or the titanium oxide that is called commonly called the rutile. So, if these materials are added in the coating materials, these will produce the thick weld metal which in turn helped to increase the viscosity.

Now, we will see that how to select the welding conditions in the welding parameters for generating the required arc, so that the desired penetration deposition rate can be obtained under the required the welding speed can be achieved. So, for the welding purpose in the shielded metal arc welding process we need to select the two parameters, these are called the welding current and the welding voltage.

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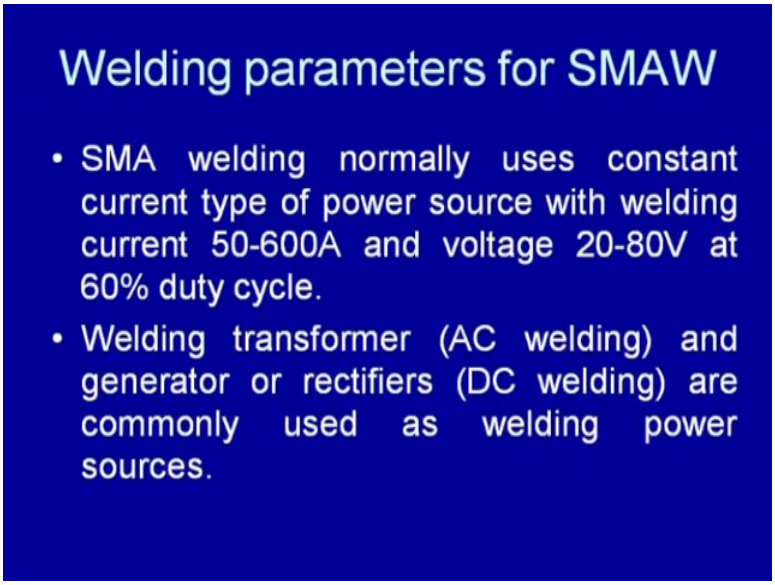

The, welding current is normally set in the range of the 50 to 600 ampere depending up on the electrode diameter which is being used. Similarly, electrode ((Refer Time: 41:37)) the arc voltage also varies from 20 to 80 higher open circuit voltage is normally set for

the electrodes, which are either bare or having the low percentage of the low ionization potential elements. So, depending upon the kind of the electrode coating composition we can work in the range of 20 to 80 volts and its common work with 60 percent duty cycle, means we can work for 3 minute, we can perform welding for 3 minutes in 5 minute weld cycle time.

For this purpose welding transformers, are normally used for the ((Refer Time: 42:18)) when AC welding is done and the generators and rectifiers are used for performing the DC welding as a power source. So, in case of the DC welding open circuit voltage is normally kept about 10 to 20 percent below then that is required for the AC welding, because in case of the DC welding we know that their magnitude and direction of then the direction of the current remains constant. That is, why arc stability problem is not that much as it is experienced in case of the AC welding, in case of the AC welding the stability problem is more due to the effect that the current and magnitude.

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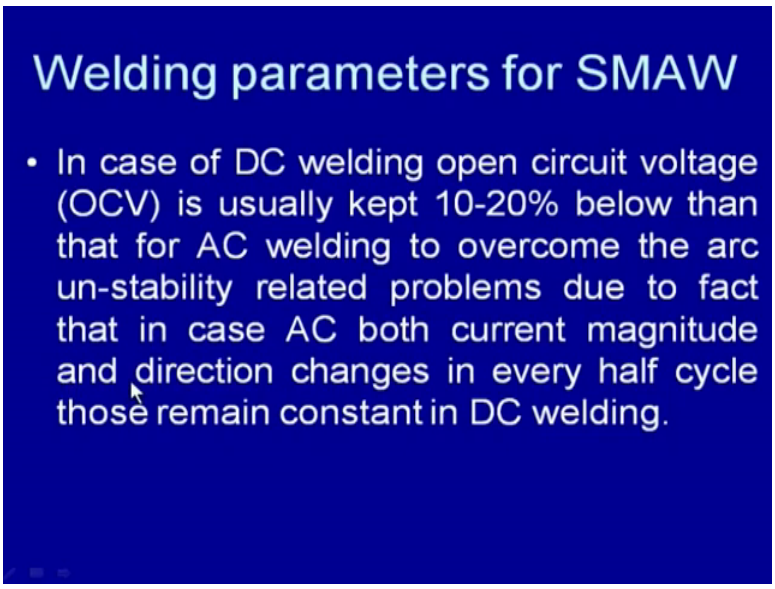

Current magnitude and the direction, both changes in every half cycle in AC and this create the problem of the poor arc stability in case of the AC welding. That is, why the AC welding requires the higher open circuit voltage then the DC welding. Therefore, we normally set the higher open circuit voltage when the AC welding is performed, the OCV open circuit voltage setting is primarily determined by the type of welding current the electrode composition.

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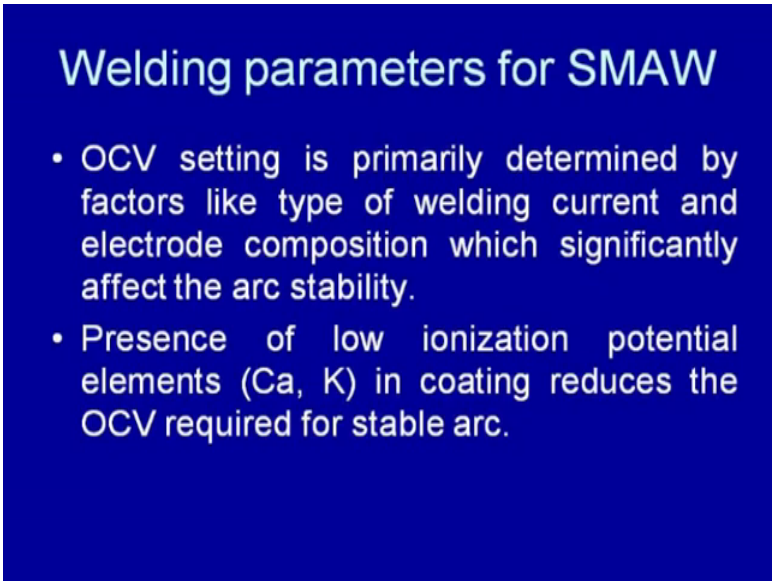

These, factors affect the stability of the arc for example, if you are working with DC we can work with a lower OCV then when AC is used. Similarly, if the electrode is having large percentage of large amount of the low and ionization potential elements then, we can work with the lower OCV and if their percentage is very limited then the high OCV need to be set in. So, that arc can be re-striked easily when it is passing through the zero current value otherwise, arc will have tendency to get extinguished, therefore if we do not set the OCV properly for a given melting current and the electrode composition.

Then, it can create problem of the poor arc stability presence of the low ionization potential elements like calcium, silicon, in the coating reduces the OCV required for stable arc. Because, the presence of these elements will facilitate easy release of the electrons required for having the charged gap between the electrode in work piece. So, that the current can flow from the electrode to the work piece side, which is required for the initiating and maintenance of the welding arc.

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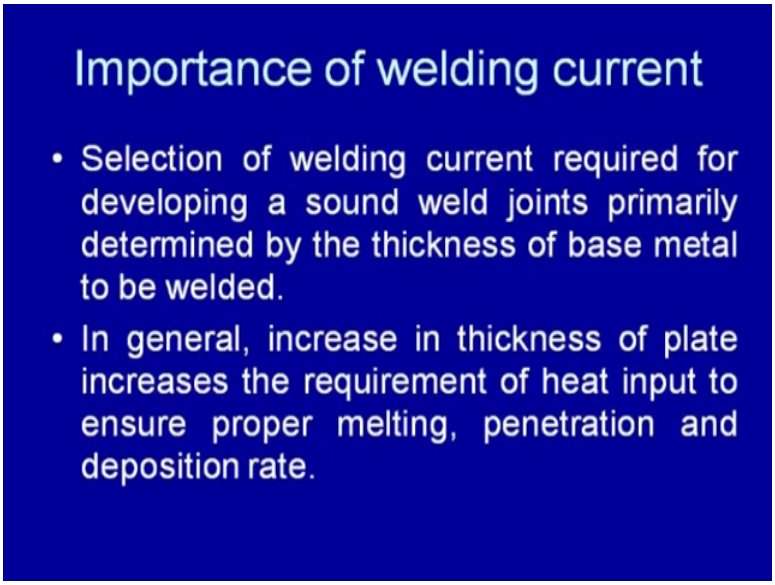

So now after the OCV or select setting the current or the character kind of the open circuit voltage, we need to select that current the proper welding current value. So, that the required amount of the heat can be generated for developing the sound weld joint and the amount of welding current, which is selected for particular welding that is dictated by the thickness of the base material to be welded. In general, thicker is the base material and higher will be the current to be set in.

So, the increase in thickness of the plate increases the requirement of the heat to be supplied for achieving the desired melting of the base material, to have the desired the penetration into the base material and to have the desired deposition rate. So, if higher is the thickness of the plate then we need more melting, more penetration and more deposition rate. Penetration and the deposition rate, it is common to have the electrodes over a range of the diameters, so this SMA welding electrode are found in the different sizes and the size is generally specified by the diameter of the core wire.

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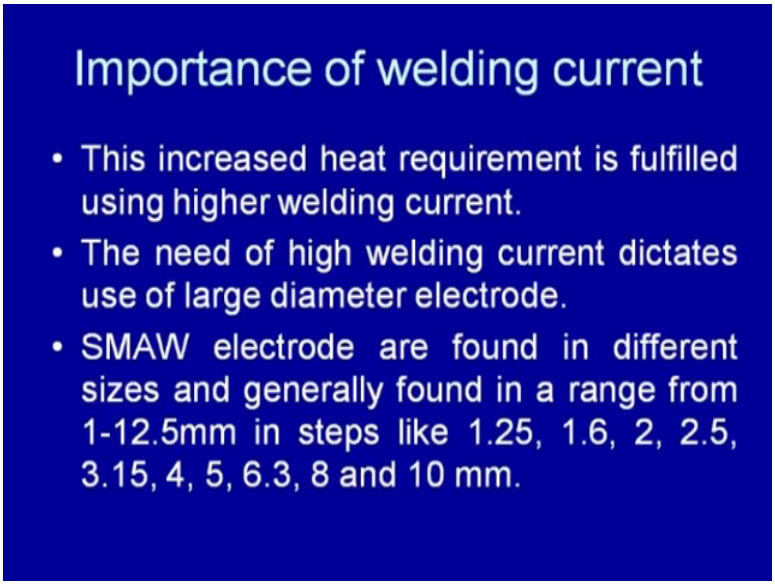

These, electrodes are found in the range of 1 to 12.5 mm size, so these sizes represents mainly to the diameter of the core wire. The, next steps like we can have the electrodes having the diameter of the core wire of 1.25, 1.6, 2, 2.5, 3.15, 4, 5, 6.3, 8 and 10 mm in the diameter smaller is the diameter lower will be the current. It will allow to use otherwise, excessive overheating will cause the thermal decomposition of the coating material and the larger is the diameter less or will be the electrical resistance heating. So, higher will be the current carrying capacity, which it can take up for the welding purpose.

Now, we will see that the proper value of the current setting is important for the welding purpose if, we set inappropriate welding current then it will lead to the undesirable effects in the weld joints which are being made. This includes that, like what upper and what lower level of the current should be set in so that is the sound weld joint can be made using the shielded metal arc welding. For, this purpose it is necessary that, what are the conditions under which thermal decomposition of the electrode coating material takes place?

What, are the conditions under which stable arc is produced? So, upper limit of the current is dictated by the conditions under which, thermal decomposition take place or the lower limit of the current is dictated by the conditions under which arc is stable. So, these are the things as far as the welding current is concerned. Now, I will summarize

this presentation and there are many other aspects related with the shielded metal arc welding process, which we will be taking up in the subsequent lecture. In this, presentation mainly we have talked that, what are the factors that effect in the heat generation in shielded metal arc welding process?

What is the importance of the clean importance of protection of the weld pool in the shielded metal arc welding process? How weld pool is protected in this particular process? What is the role of the various coating materials? Which, are provided in the electrode so that the sound weld joint can be made. Further, we have seen that, what are the important welding parameters that affect the heat generation the weld in the shielded metal arc welding process? What are the conditions that limit the use of upper and lower level of current in this process?

So, thank you for your attention.