Welding Engineering
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Module - 4
Arc Welding Processes
Lecture - 2
SMAW - II

So, in this presentation we will be taking up some other aspects related with the shielded metal arc welding process, which will include the factors limiting the welding current in the shielded metal arc welding process, their effect on the development of the weld bead geometry. And what are the factors important in developing the sound weld joint using the shielded metal arc welding.

In the first presentation, we have seen that the way by which heat is generated in this process and the factors that effect, the soundness of the weld joint when the coated electrodes are used. So, the role of coating in the shielded metal arc welding process and the constituents, which are commonly used for development of the electrode coatings for the shielded metal arc welding electrodes have also been covered in the last presentation.

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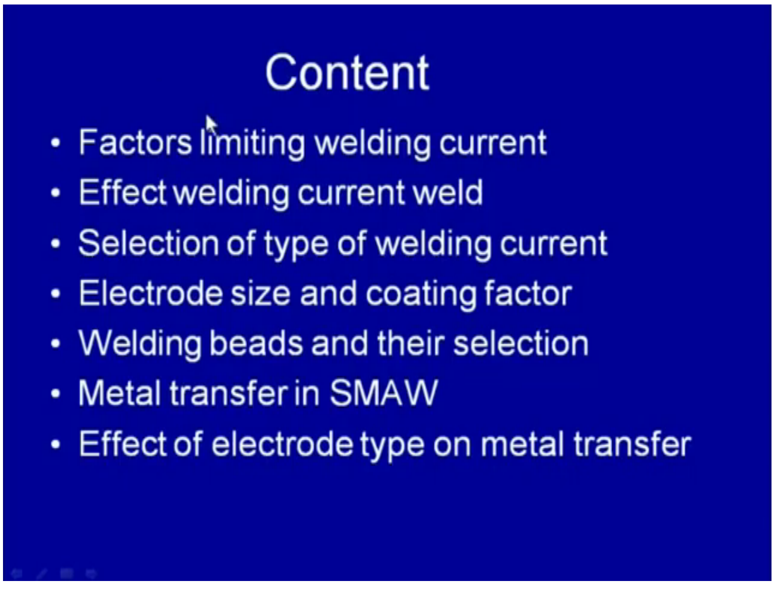

The detailed content of this presentation will include the factors limiting the welding current. Here mainly we will try to see, what are the factors that limit the upper level of the current, which can be used with the given electrode, and the lower level of the welding current which can be used, and Effect of the welding current on the weld bead geometry and the development of the sound weld joint. Similarly, we will see the effect of other welding parameters like welding speed, the arc voltage on development of the sound weld bead and the good weld joint.

Further we will see that on what basis we can make choice for the suitable type of the welding current. Whether we should go for the AC or for the DC current for a given welding conditions. So, the conditions that govern the selection of the type of welding current we will see in detail, then the electrode size and coating factor. What is the thickness of the coating has been applied in the core wire? How can we quantify and how does it affect, the soundness of the weld joint and development of the weld joint process? So, that we will also we looked into what are the different ways through which weld bead can be deposited for developing a weld joint and what are the factors that affect the selection of the suitable kind of the bead.

Also we looked into, we will see that how the molten metal is transferred from the electrode tip towards the weld pool? What are the factors that affect the mode of the metal transfer in this shielded metal arc welding process will also be looked into detail. Then we will see that how the electrode type effects the mode of the metal transfer. We know that if we have to see what are the factors that limit the welding current in the shielded metal arc welding process? For that we need to see there are two main factors that we need to consider. One is the upper, the factors limiting the upper limit of the welding current and the second the factors limiting the lower level of the welding current.

The factors that limit the upper level of the welding current is the heat generated in the core wire due to the electrical resistance heating, and its effect on the thermal decomposition of the electrode coating. So, the level of the current at which the thermal decomposition of the coating starts that limits the upper level of the welding current. Apart from that the required, apart from the required heat generation and the development of the desired weld bead. The lower level of the welding current is limited by the arc stability aspects. If we work with very low level of current so limited heat generation and low temperature leads to the frequent extinction of the arc.

So, to avoid the situation of the unstable arc it is desired that the welding current is reasonably on the higher side. So, the lower limit of the welding current is affected by the arc stability aspect. Further sometimes the lower level of the welding current is selected intentionally, so that we can have the desired limited flowability of the weld metal, to avoid the following tendency of the weld metal in odd position welding processes like vertical or overhead welding or the horizontal welding process. So, to see this in detail the selection of the process, selection of the welding current in the shielded metal arc welding process we need to see this diagram.

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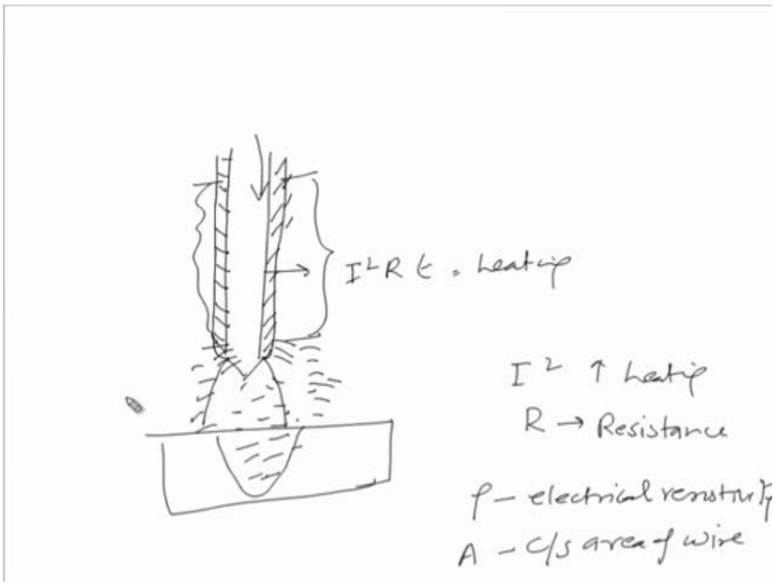

Here we have one electrode and it is coated with suitable coating. So, this coating material is expected to provide the desired inactive shielding gases by the thermal decomposition. The heat required for thermal decomposition is obtained from the arc. So, the arc which is their provides the heat required for thermal decomposition of this coating material. So, if the heat generated by the arc is only used for thermal decomposition of the coating then it will provide the required shielding effect around the arc and to the weld pool. But if this does not happen and excessive current is allowed to flow through the core wire then the high I square R T heating results in the results in the excessive heating of the coating material.

This leads to the thermal decomposition of all this coating material much earlier, and the thermal decomposition of the coating much earlier than when it is required leads to the loss of generation of the inactive gases required for proper shielding. So, if the excessively high current is used, it causes the thermal decomposition of the coating material prior to the situation when it is desired.

This leads to the situation where we are not able to have enough inactive gases around the weld pool and this leads to the poor shielding of the welding arc and the weld pool. The poor shielding of the weld pool causes the contamination of the weld pool, which in turn leads to the, development of the porosity inclusions and a presence of other gases in the arc zone.

So, this is one aspect that affect the upper limit of the welding current. If we see here, higher is the current higher will be the heating. But this is also affected by this, electrical resistance heating is also affected by the factor like R. R indicates the resistance which is offered by the core wire in the flow of current. So, this resistance of the core wire is effected by the diameter of the current its length and its material. So, these are the three aspects the affect the electrical resistivity of the material. That is one and also the cross sectional area of the wire which is governed by it is diameter.

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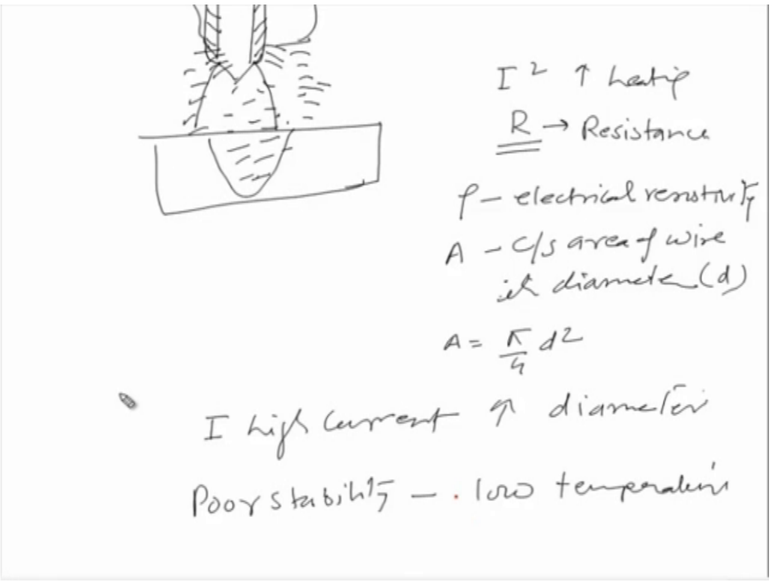

So, we have a cross sectional area of the wire from the pi by four d square, where d is the diameter of the core wire. Larger is the diameter greater will be the cross sectional area and if greater is the cross sectional area lower will be the resistance for the flow of current. So, if by using the large diameter electrode we are able to reduce the resistance for the flow of current then in turn it will help in reducing the electrical resistance heating.

So, if you want to use the high current then if I is high, then we need to use the large diameter electrode. So, large diameter electrodes will reduce the resistance for the flow of current through the core wire which in turn will decrease, the electrical resistance heating. Thus it will allow the use of the high current without causing much thermal decomposition of the electrode coating material.

So, this is one thing that effects the upper limit of the welding current. Similarly, the lower level of the welding current is limited by the poor arc stability. So, poor arc stability is caused by the low temperature in the arc zone and very less heat generation. So, the low temperature and the low temperature caused by the less heat generation leads to the poor availability of the charge particle in the arc gap, which in turn offers great resistance for the flow of current. This in turn leads to the poor stability of the arc and sometimes even arc tends to get extinguished and its ignition becomes difficult.

So, the level of welding current which allows to have the smooth and stable arc is found suitable for the welding purpose. So, the lower level of the welding current is mainly limited by the arc stability. So, here we need to set and the select welding current in such a way that the required heat is generated continuously and the arc is also stable so that the heat generation can be effectively used for melting the fringe surfaces.

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Effect of welding parameters

Welding Condition	Effects on weld
Current in excess of optimum	• Excess spatter and flat & wide deposit. • Deep crater and penetration • Electrode overheating.
Current less than optimum	• Slag difficult to control. • Metal piles up. • Poor bead shape & poor penetration.
Voltage in excess of optimum	• Deposit irregular and flat • Arc wander. • Porosity & Spatter.
Voltage less than optimum	• Irregular piling of weld metal • Arc extinctions. • Little penetration.

Now, we will see the three important welding parameters which are commonly used and controlled properly for developing the sound weld joint. These parameters are the welding current, arc voltage and the welding speed. So, if we select the optimum set of the welding parameters then we will get the desired weld bead profile, proper penetration and proper deposition rate. Otherwise, it will lead to a lot of spatter, unfavorable weld bead geometry and improper penetration.

So for example, if we set the current too high side, then the optimum value of current for a given welding condition, then ((Refer Time: 11:10)) it will lead to have the excessive spatter and, flat and wide bead is obtained. The deep crater is obtained at the end of the weld and the penetration is also obtained. Further higher, too high current causes the excessive electrical resistance heating of the core wire and which in turn leads to the much earlier thermal decomposition of the coating material, then when it is required for producing the inactive gases to shield the weld pool.

Similarly, the use of the less current than the optimum causes a difficulty in control of the slag and metal starts to pile up due to the poor fluidity. Because the less heat generation leads to the poor viscosity in fluidity of the weld metal and this leads to the piling up of the weld metal. The poor weld bead shape is obtained a the poor penetration is obtained and all these effects are mainly attributed to the generation of a less heat due to the low welding current than the optimum one. Similarly, in excessively high voltage than the optimum causes the irregular weld bead and the flat weld bead. Further the arc tends to wander here and there and makes the placement of molten weld metal difficult due to the wandering of the arc.

Similarly, the porosity and spatter also is found to be on the higher side when the too high voltage than the optimum one is used. On the other hand the use of the voltage less than the optimum one leads to the irregular piling up of the weld metal and sometimes even extension of the arc, due to the poor potential difference between electrode and work piece. Further it causes the little penetration in the weld joint. On the other hand the application of the optimum travel speed is desired for supplying the desired amount of heat to the base metal.

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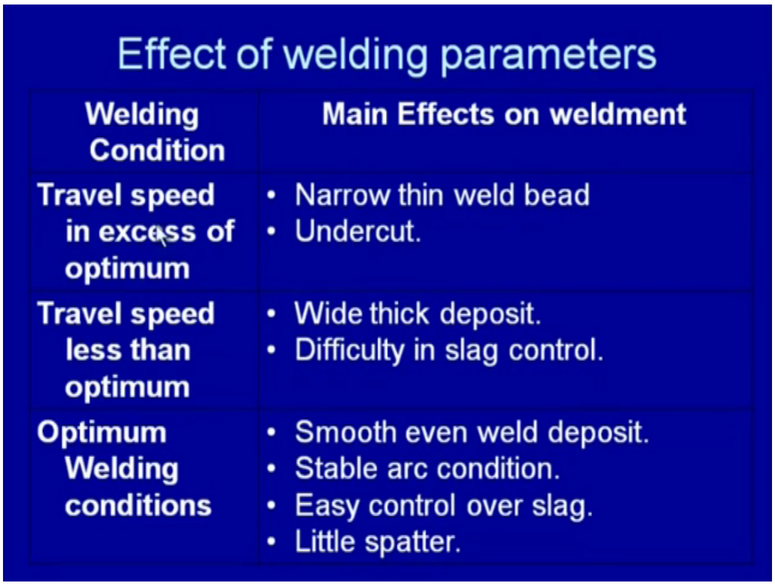

So, that desired weld bead and penetration can be obtained, but if we do not set the proper travel speed of the arc, then the too high travel speed leads to the thin weld bead and also causes the development of undercut weld defect. The travel speed less than the optimum one leads to the wider thick deposit and also imposes difficulty in control of the slag. Under the optimum welding conditions we get a smooth and even weld deposit stable arc conditions and easy control over the slag and the little spatter. So, these conditions when we select optimum welding current optimum arc voltage and optimum welding speed.

Then this in turn results in desired amount of the heat being supplied to the base metal for proper penetration, melting and development of the smooth weld smooth weld bead geometry. Further, now we will see that after looking into the factors that limit the upper and lower level of the welding current and the factors that effect, the welding related factors that affect the development of the sound weld joint. We will see, what are the factors that dictate the selection of the suitable type of the welding current? The welding current we will use either the AC or the DC type. So, what are the factors that effect, the selection of the suitable type of the welding current? This includes the thickness of the plate.

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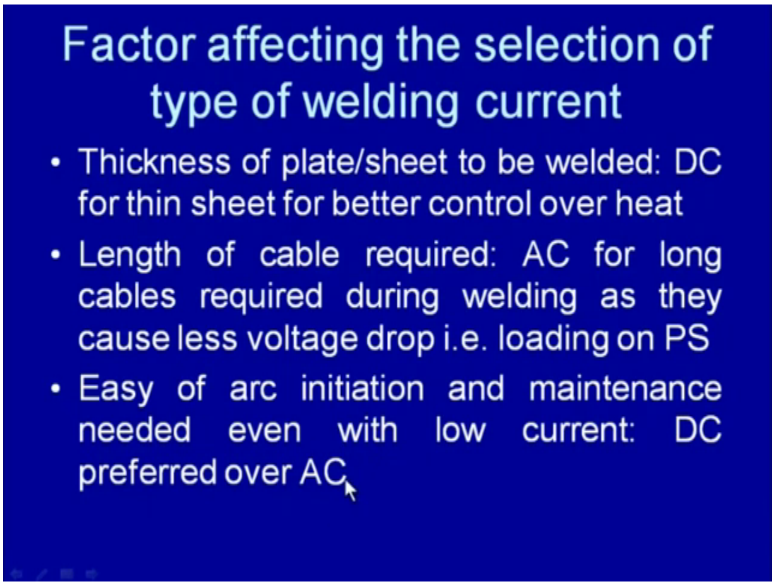

For example, if the thin plate is to be welded then we prefer DC so that the better control over the heat being supplied can be obtained. If we do not do this the generation of the equal amount of heat in case of AC may lead to the melt ((Refer Time: 15:16)) kind of defects in development of the weld joint. Another factor similarly, if we want to weld the thick plates, and we want to deposit we want to have the more heat in the base metal side then also the DC is preferred by using the reverse polarity, by using the state polarity where the more heat is generated in the base metal side. Similarly, the length of the cable to be used during the welding, if a very long cables are to be used during the welding a, then AC is preferred because it causes the less voltage drop, and so the less loading on the power source.

This in turn decreases the cost associated with the power consumption. Another factor that affect the selection of the suitable type of welding current is a kind of arc initiation and the maintenance which is required. For easy arc initiation and maintenance even with the low current the DC is preferred over the AC, because in case of the DC the magnitude and direction of current remains constant.

And once if it is fixed then we can have this smooth and stable arc even with the very low level of current. While in case of the AC there is a continues change in magnitude and the direction of the current so when the current passes through the 0 level arc tends to get extinguished. That is why initiation and maintenance of the arc becomes difficult especially with the low level of the welding current.

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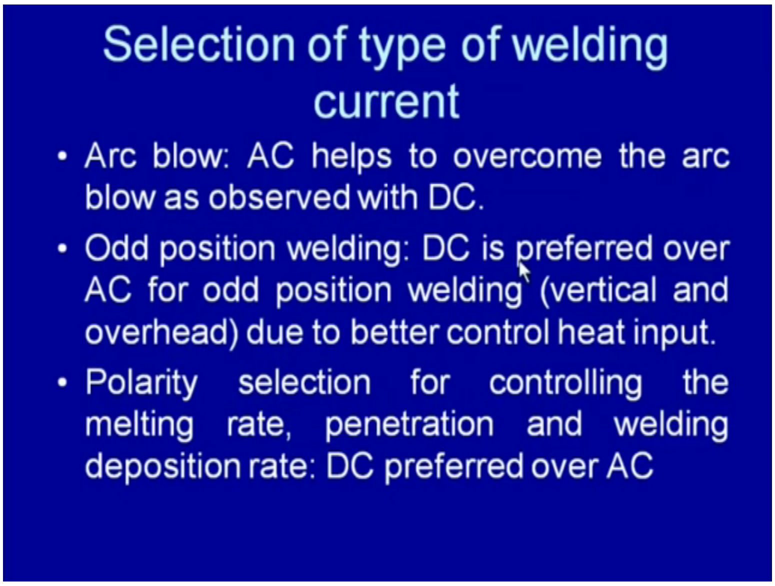

Further AC is preferred when the arc blow is observed which is commonly observed in case of the DC. So, in case of the DC when the arc blow is observed to take care of the arc blow to avoid the arc blow AC is preferred. Similarly, in odd position welding where the proper control over the weld metal is very crucial the DC is preferred over the AC. So, that molten weld metal can be placed and deposited in the places where it is desired without much falling tendency of the weld metal because the DC offers the better control over the heat put during the welding. So, if we supply very less heat in odd position welding process.

Then the fluidity of the weld metal will decrease and this in turn will decrease the tendency of the weld metal to fall down especially during the vertical and overhead welding conditions. So, the DC is preferred for odd position welding than the AC. Then the polarity selection, if we want to use a particular kind of polarity then of course DC is preferred because in case of AC polarity keeps on changing in every half a cycle. This polarity selection many times is desired to have the desired melting rate, desired penetration and the deposition rate.

So, for example; if you want to have the more heat in the electrode side then the reverse polarity that is electrode is made positive and if you want to have the more heat in base metal side then the state polarity is used. So the factors that are related with the melting rate penetration rate and the welding deposition rate desired offer are dictated by the polarity being used. So, if you want to use a particular kind of polarity then the DC is preferred over the AC.

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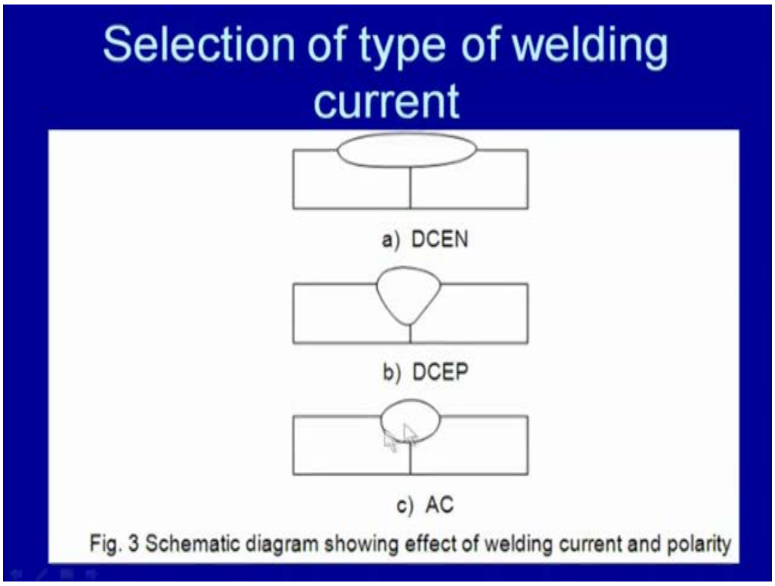

If we see that how the polarity effects and the type of welding current effects the weld bead geometry. So, DCEN the weld bead wider and the flatter bead is obtained with the narrow penetration. While in case of the DCEP the narrow bead is obtained, but it causes the deeper penetration and the optimum width and the penetration is obtained in case of the AC current.

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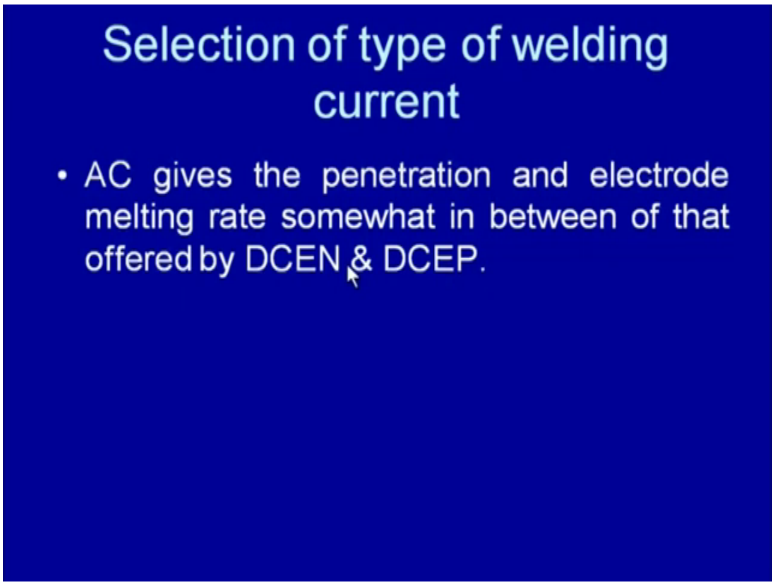

AC gives the penetration and the electrode melting rate somewhat between to that of the DCEN and the DCEP. So, if the control over the heat input is not a very important factor for developing the sound weld joint then AC is preferred. Provided we are able to have the smooth and the stable arc for producing the uniform heat.

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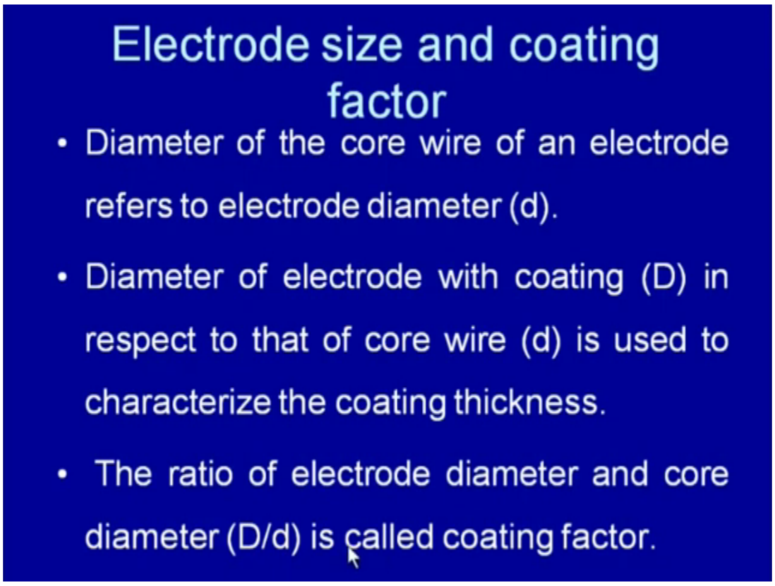

Now, we will see that what are the factors that are used to designate the electrode, and identify the electrode size. What is the coating factor which is indicating, the thickness of being used for developing thickness of the flux or the coating being used for developing the welding electrode. So, if we talk of the electrode size then the size of the core wire being used to make an electrode indicates the electrode diameter. So, the diameter of the core wire of an electrode refers to the electrode diameter this is a smaller diameter and small d. And the diameter of the electrode with the coating is capital D in respect to that of the core wire is use to characterize the coating thickness.

So, if these are the core wire diameter and if these are the diameter of the electrode with the coating that is capital d, and the ratio of these two is used to characterize the coating thickness. So, the ratio of the electrode diameter and core wire diameter it is capital d divide by small d is called the coating factor and this indicates, what is the thickness of the coating being used for developing the electrode.

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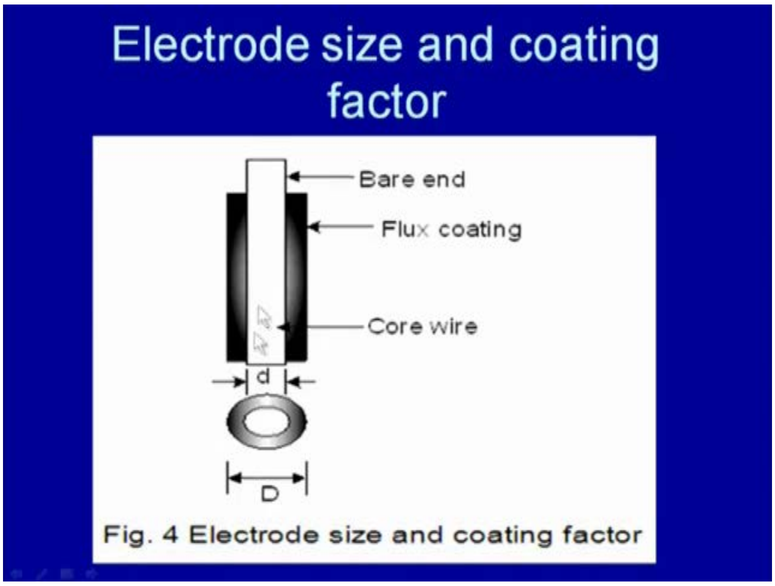

This diagram schematically shows that if this is the electrode then this white portion inner one part indicates the ware and the core wire of the electrode and say, if its diameter is small d and the diameter of the electrode with the coating. This outside the core wire is this coating that is the dark in a shade and an outside diameter. If the diameter of the electrode with the coating is measured then it is capital d. Ratio of the capital d divide by the small d indicates the coating factor.

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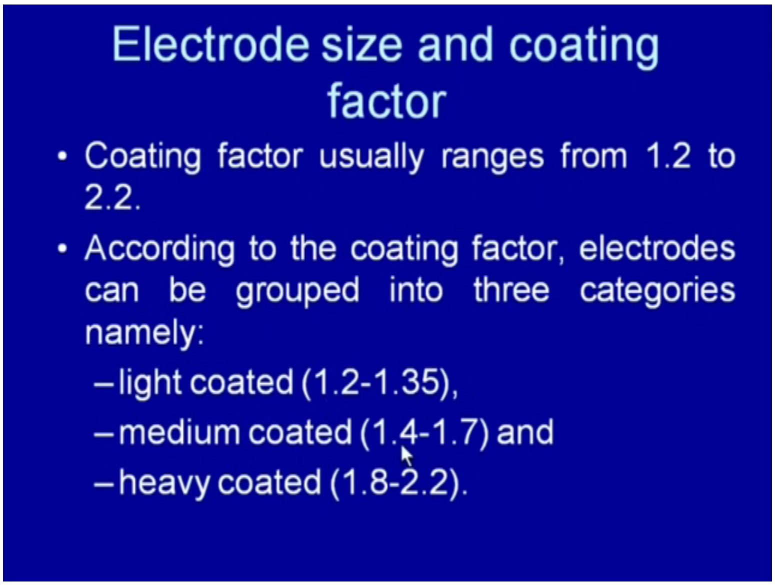

So, based on the coating factor we can have the light coated, medium coated and the heavy coated electrodes. Say coating factor usually ranges from 1.2 to 2.2. So, according to the coating factor we can classify the different electrodes in three categories. These are the light coated this coating factor ranges from 1.2 to 1.35. The medium coated electrode its coating factor ranges from 1.4 to 1.7. And heavy coated electrodes have the coating factor from 1.8 to 2.2. Heavier means higher is the coating factor greater will be the thickness of the coating around the core wire. So, this in turn affects the quality of the weld joint being made in respective of the three parameters.

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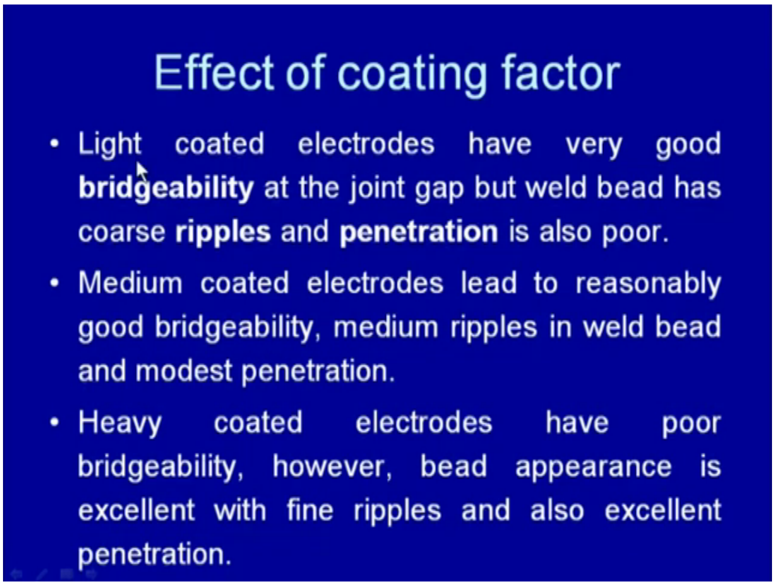

One is bridge ability another is the shape of the weld bead which is being formed and third is the penetration. These are the three factors which are significantly affected by the coating factor being used. For example, light coated electrodes have the good bridge ability at the joint gap, but the weld bead has the coarse ripples and penetration is also poor. So, this is the fact of the light coated the light coating on to the electrode which is measured using the low coating factor that is in the range of 1.2 to 1.35 as we have seen the slide.

Now, the medium coated electrode lead to have the reasonably good bridge ability, medium ripples in the weld bead and the modest penetration. So, we can say results in the optimum kind of the weld bead, where the ripples are medium visibility is reasonably good, the weld bead penetration during the welding is moderate and the heavy coated electrodes offer the poor bridge ability while the weld bead appearance is excellent with the fine ripples and also it results in very good penetration. So, one is good in terms of the bridge ability and another side heavy coated electrodes are good in respect of the penetration. The weld bead profile, which is obtained in respect of the ripples which are obtained over the weld bead.

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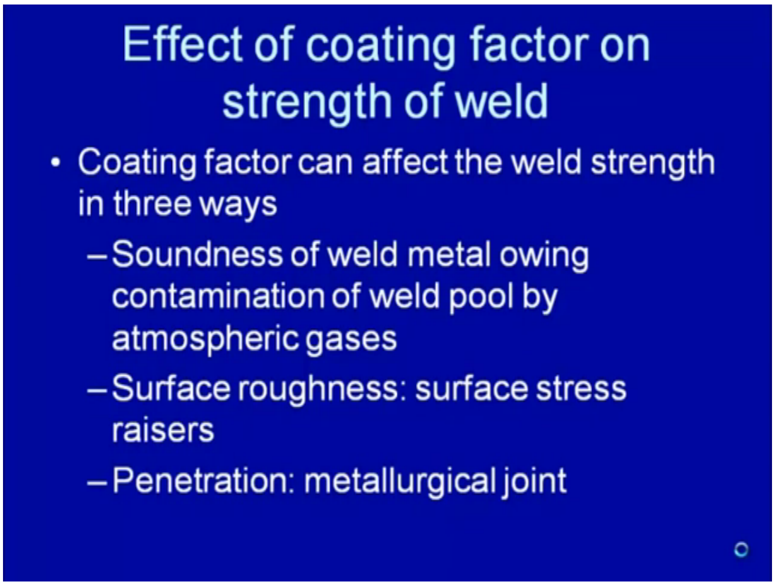

Weld bead coating factor effects the strength of the weld joint and this effect of the coating factor on the strength of the weld joint can be understood in the three ways. One is that how the coating factor is affecting to the soundness of the weld joint, the second how the coating factor is able to effect the melting as well as penetration to the weld joint. As well as how the coating factor affects the surface roughness of the weld bead which is being generated, so these are the three different aspects. We know that the coating factor indicates the ratio of the external diameter of the electrode divided by the core diameter and it can range normally from 1.2 to 2.

So, when the coating factor is low say 1.2 then this indicates the thickness of the coating is very limited so if it is say 1.5 and 1.6 thickness of the coating is more. If the coating factor is 2 then it means the thickness of the coating is too much. So, more is the thickness of the coating over the core wire of the electrode means more will be the amount of the inactive gases which will be generated for production of the weld pool.

Thereby it will lead to the better protection of the weld pool from atmospheric gases and so it will increase the soundness of the weld joint. In general greater higher is the coating factor better will be the soundness of the weld joint because the more coating factor will provide the better protection to the weld pool from the atmospheric gases. Thereby, it will be reducing the presence of the inclusions and the atmospheric gases in form of the porosity and the blow holes.

Similarly, if the coating factor is more then it will be generating lot of slag which will help in reducing the cooling rate as well as will help in developing the smoother weld bead. Smoother weld bead means the lower surface roughness and reduced surface roughness is reduced ((Refer Time: 27:30)) at the surface of the weld joint, which in turn will decrease the possibility of the stress raisers. So, more lower is the surface roughness higher will be the strength due to the represents of the reduced amount of the surface stress raisers and the penetration or the metallurgical joint is the third factor. If the coating factor is more it will be resulting in the better penetration.

So, that it will be helping to develop the better metallurgical weld joint which in turn will be leading to the higher strength of the weld joint. So, coating factor if it is small if the coating factor value is low in general we get the poorer strength as compared to the that of when the weld joint is developed using a higher coating factor. Now, we will see that another way by which the electrodes are electrode size is characterizes the length.

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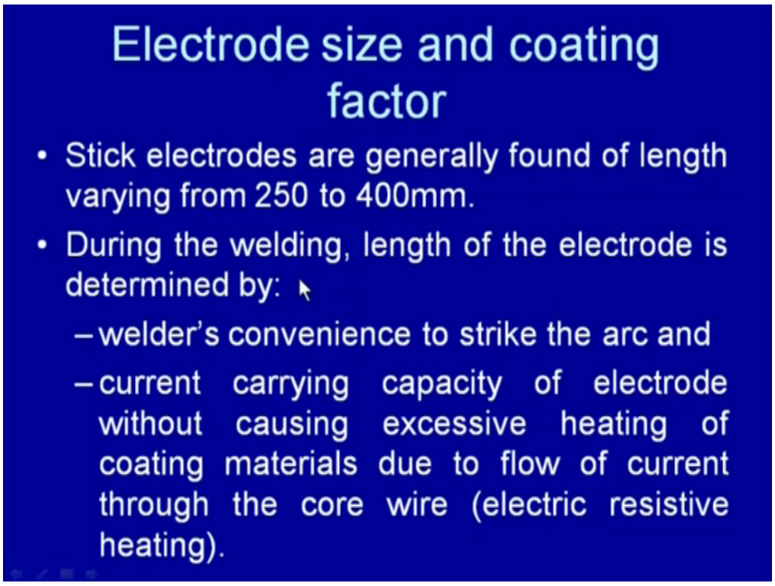

So, the stick electrodes are generally found of the length varying from 250 to 400 ampere. The selection of the optimum length of the electrode is determined by the two factors. One is that how conveniently the welder is able to strike the arc and handle the weld metal during the welding and the second is the kind of current capacity. How the current capacity is being affected by the electrode extension without causing much excessive heating, because if longer is the electrode length, then greater will be the electrode extension and which in turn will be causing the higher electrical resistance heating of the core wire.

Higher electrical resistance heating will increase the tendency of the damage to the electrode coating material. This in turn will lead to have the limited flow of current without any damage. So, the current capacity is basically a decreased with the increase of the electrode length. That is the second factor. The length of the electrode is dictated by the two factors, one the convenience with which the welder can handle the arc and deposit the weld metal properly and the second is the current carrying capacity.

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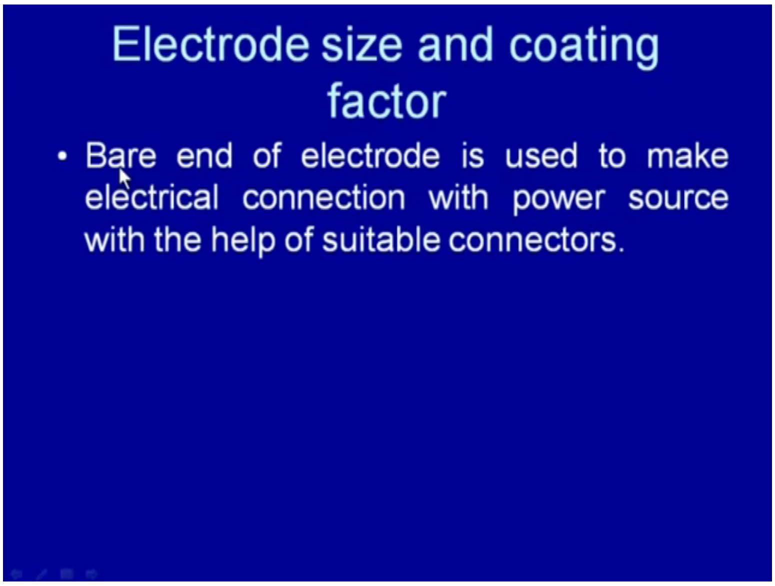

So, greater is the length of the electrode lower will be the current carrying capacity of the electrode for a given diameter of the core wire. Further one end of the electrode is not coated with the material and it is kept bare, so that the suitable electrical connections can be made with the power supply for required flow of the current. Now, these electrodes need to be classified so that one can use them effectively and one can select them properly.

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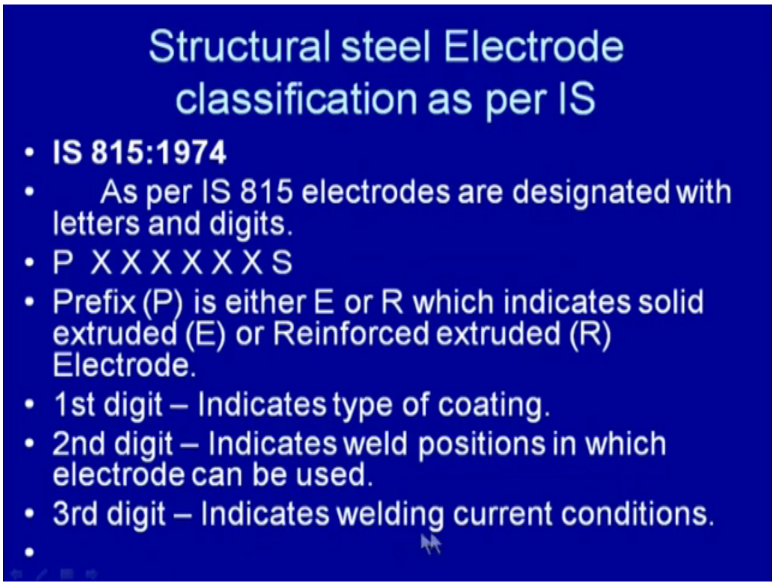

So, according to the Indian standard 815:1974 the electrodes can be classified using the letters and the digits. It includes one prefix and another suffix these are not mandatory and these mainly are given by the manufacturers. Apart from these they are six letters which are there for a specific purpose. So, P basically prefix indicates the method of manufacturing the electrode which has been used for manufacturing the electrode. There are two common types of the prefixes one is E or R. E indicates the solid extruded electrode and R represents the reinforced extruded electrode.

These two indicates the method used for manufacturing the electrode thereafter the first digit indicates the type of the coating. Various types of the coatings are there like the cellulosic, basic and the rutile type, so particular number as is assigned for a particular type of the coating, while the second digit indicates the welding position in which electrode can be used whether it can be used in flat, horizontal, vertical, overhead or in all welding positions. The third digit indicates the level of current or the range of current in which an electrode can be used.

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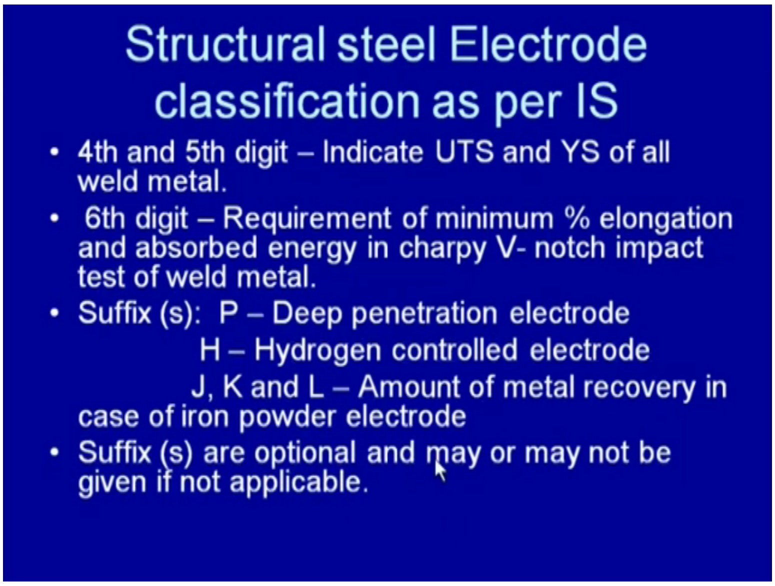

Further the fourth and fifth digits indicates basically set of the three numbers which indicate the ultimate tensile strength and the yield strength of the weld metal. So, set of the three digits a forming the combine combining ((Refer Time: 32:36)) and the fourth number indicates the ultimate strength and the fifth digit indicates the yielding strength of the weld metal. Sixth digit indicates the requirement of the minimum percentage elongation and the energy observed in the Charpy v notch impact test of the weld metal. While the suffix indicates the various letters which are used to indicate the characteristics of the electrodes.

Like P is used for the deep penetration electrode, which will have the capability to melt the base material to the greater depth and H is the hydrogen controlled electrode, which are basically used for the hardaneble steels. And the weld joints which are sensitive for the hydrogen induced cracking and, for the better quality weld joint. J K and L indicates the amount of the metal which can be recovered from the electrode having the large amount of the iron powder.

So, depending upon the amount of the weld metal recovery from the electrode, which is having the iron powder, so it can lead to have so for the different percentage of the recovery the different letters are given like j k and l. ((Refer Time: 33:58)) the suffixes are optional and may or may not be given it is not mandatory to use. Now, we will see that when the weld joint is made a molten metal is deposited in the in the gap between the plates to be joined or in the group. So, how will be applying the molten weld metal in the gap between the plates to be joined? That indicates the way by which the weld bead is developed so the method of developing a weld bead is governed by the various factors that we will look into.

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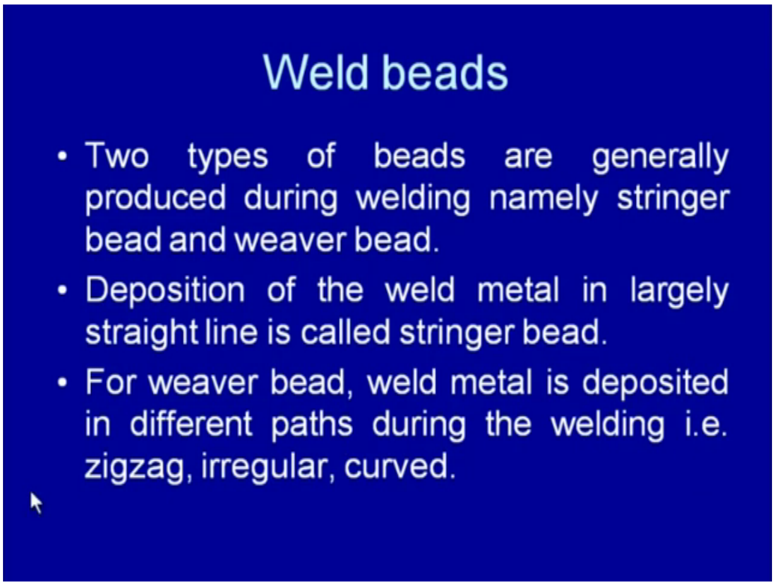

There are two types of the beads which are commonly developed during the welding these are the stringer beads and the weaver bead. The stringer bead is one when weld metal is largely deposited in a straight line, then we call it as a stringer bead and a weaver bead is deposited, when weld metal deposited using the different paths during the welding these are the very zig-zag irregular or the curved shape. So, to show this we will be using a this schematic diagram to show what are the different ways through which metal can be deposited.

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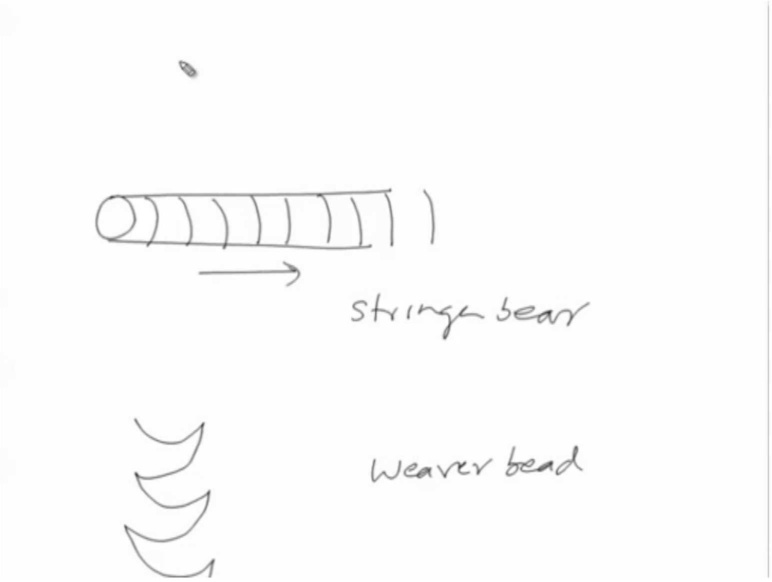

So, especially this in case of this stringer bead the weld metal is allowed to deposit in the straight line like, this one and not much movement is given to the arc and the electrode. So, this one is called a stringer bead. While in case of the weaver bead the arc is manipulated in different ways and these manipulations may be in different forms like one is like this. These are the different paths through which we can keep on moving or…

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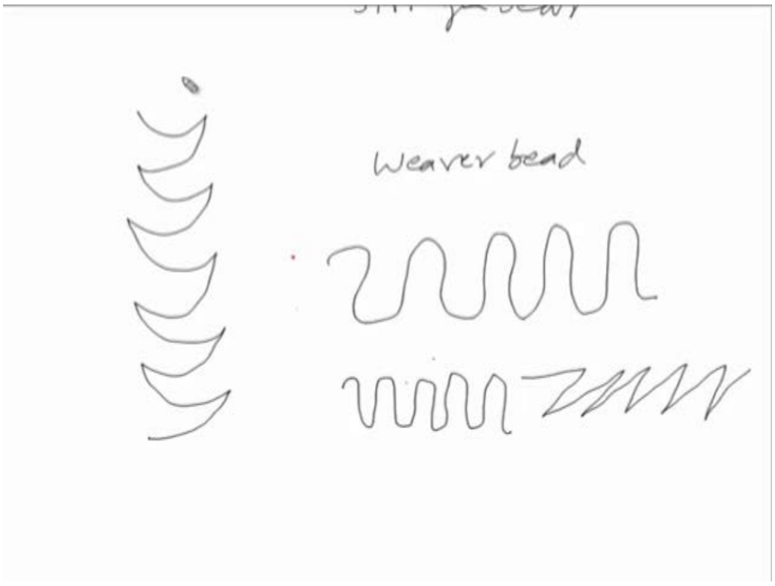

We can have the different movements like this for depositing the weld metal during the welding and there can be different pitches and the widths which can be covered during the welding like this also can be used. So, when the arc is moved in different way to deposit the weld metal using the different patterns. So, the weld metal is not deposited in a straight line but arc is moved in very zigzag curved and irregular paths to deposit the weld metal and there are different situation when these two types of the beads are used.

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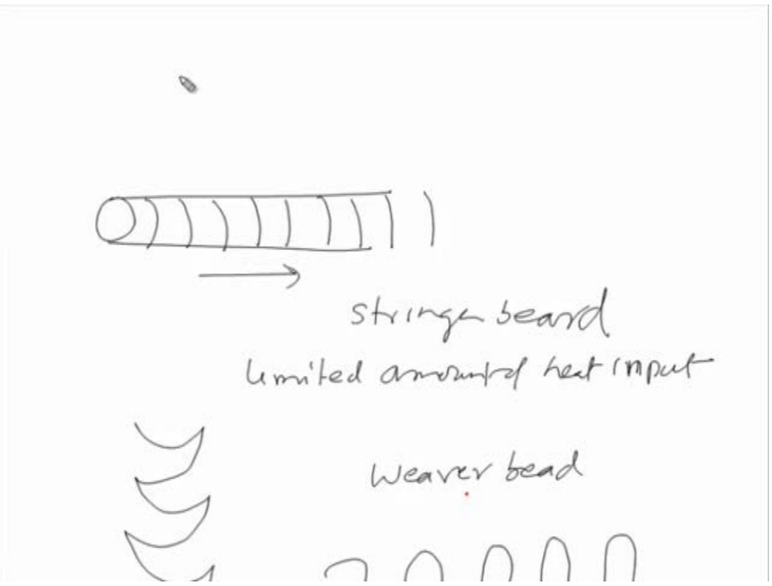

For example, if we want to deposit the weld bead with very limited amount of heat input then stringer bead is preferred. But if we want to use the lot of heat to deposit the weld metal we want to apply more heat more, and more amount of heat during the welding then the weaver bead is used. This weaver bead is commonly used when we are working in a odd position.

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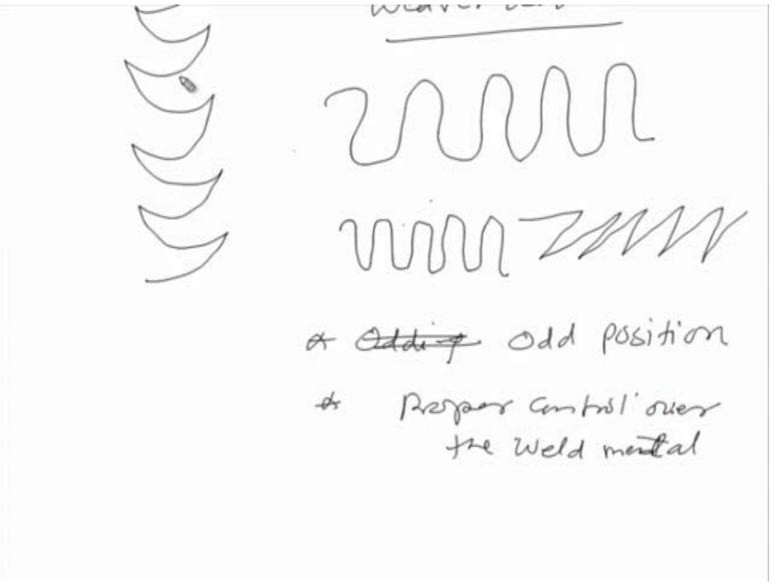

We are using the welding in odd position and this odd position welding especially, the vertical and the overhead welding condition or we want to have the proper control over the weld metal. Sometimes it is found difficult to control the weld metal properly. So, to control the weld metal properly without having any falling tendency the different movements are given to the arc. So, that the molten metal gets enough time to solidify and produce the weld metal and the weld joint is desired.

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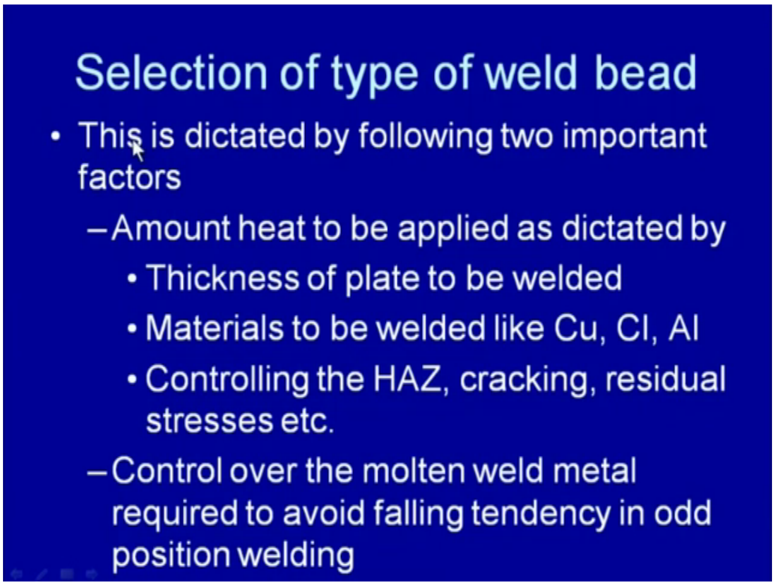

So, if we see here the selection of the proper kind of the bead for the welding is mainly dictated by the amount of heat that we need to supply during the welding. So that sound weld joint can be made and the requirement for optimum amount of heat required for developing sound weld joint is manly dictated by the thickness of the plate to be welded. Greater is the thickness of the plate to be welded more will be the amount of heat desired. So, for this purpose we can use weaver bead where we will be able to put a lot of heat during the welding metal. Then metal to be welded like the copper cast iron or aluminum.

So, sometimes if the thermal conductivity of the metal is too high or the fluidity of the molten metal is too high, then for the high thermal conductivity metal systems, it is required to apply lot of heat during the welding so that they can be brought to the molten state. But in case of the metals which are having very high harden ability like cast irons it is desired that the not much heat is supplied during the welding. So, instead of weaver bead the stringer bead is preferred for the cast irons. Similarly if we want to supply very less amount of heat during the welding for controlling the width of it effected zone, for controlling the cracking and the developing the least amount of residual stresses.

We will be preferring the stringer bead instead of the weaver bead so that the width of the heat effected zone cracking tendency and residual stresses can be reduced. So, amount of heat to be supplied during the welding dictates the type of the weld bead to be used. If we want to use the less amount of heat for developing the sound weld joint then we will be using the stringer bead otherwise weaver bead will be used. Another aspect that effects the selection of suitable type of the weld bead is the kind of control, which is desired over the molten weld metal, so that it can be placed in the desired position and the weld joint can be made in.

So, proper control over the molten weld metal and so as to avoid the falling tendency especially in odd positions the weaver bead is preferred over the stringer bead. Because it will help to manipulate the weld metal, in such a way that the following tendency is reduced and the weld metal also gets some time to solidify when the weaver bead is moved.

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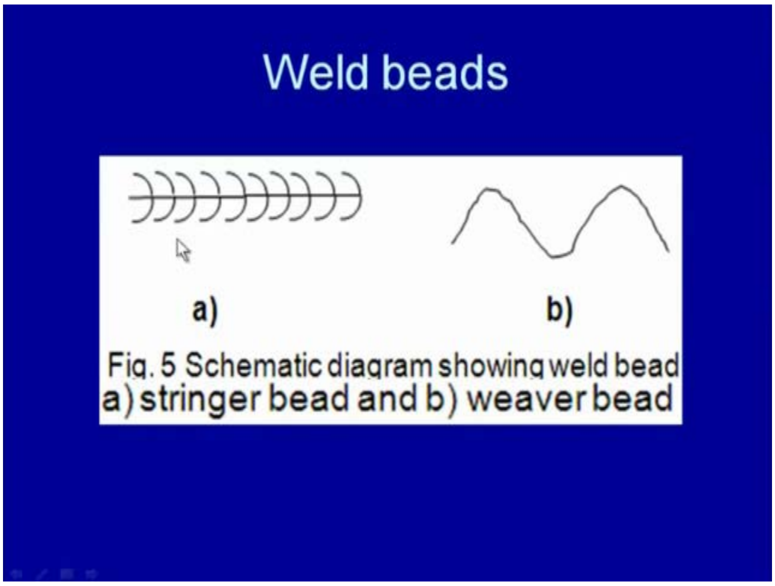

So, this is what we can say the stringer bead is shown and the weaver bead when different patterns are used for developing the beads. Weaver bead helps to apply more amount of heat in per unit length during the welding.

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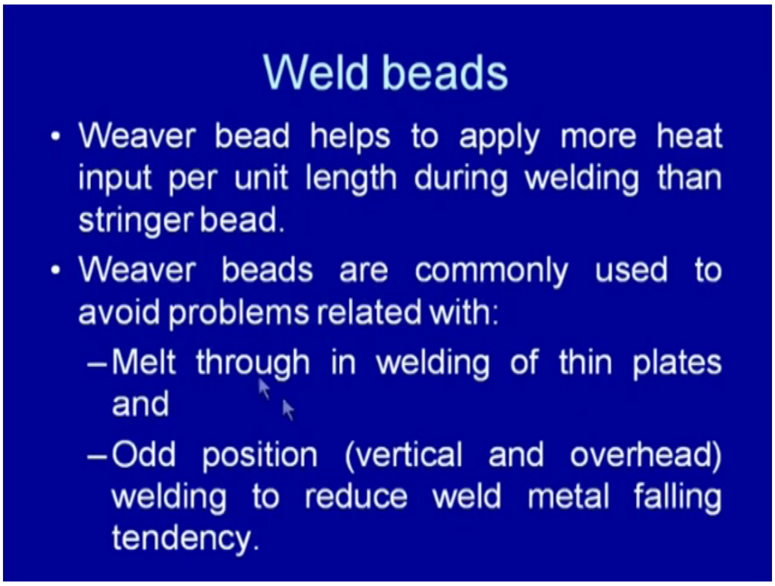

Than stringer bead so the weaver beads are commonly therefore, used to avoid the problems related with melt through in the welding thin plates, so if we want to reduce the amount of heat and we do not want to keep on supplying the heat at one place. Then the arc is moved in very random manner so that the amount of heat supplied can be reduced and the melt through tendency can be reduced. In odd positions like vertical and overhead welding conditions to reduce the weld metal from the falling the weld weaver bead is also preferred.

Now, we will see that since the shielded metal arc welding process is a consumable arc welding process, where the heat generated by the arc is used for melting the base material as well as for melting the electrode also. Whatever electrode is melted it is transferred to the weld pool. So, the molten metal transfer from the electrode tip to the weld pool is important to be considered because it effects, the soundness of the weld joint and the quality of the weld being bead.

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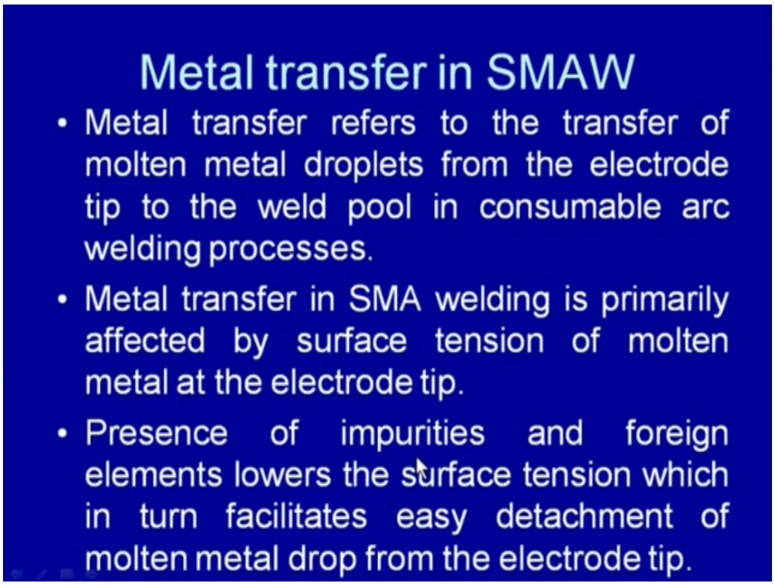

So, to see the metal transfer refers to the transfer of the molten metal in form of the droplets from the electrode tip to the weld pool. In case of the consumable arc welding processes, metal transfer in SMAW process is primarily affected by the surface tension. The mode by which molten metal will be transferred from electrode tip to the weld pool is governed by mainly the surface tension of the molten metal at the tip of electrode. This surface tension in turn is affected by the temperature and the quality of the molten metal.

So, the presence of the impurities and the foreign elements lower the surface tension. So, if there are impurities like sulphur or the impurities like oxygen nitrogen and other gases are present in the arc environment then they will be reducing the surface tension and which in turn will be facilitating the easy detachment of the molten metal drop from the electrode tip.

So, if the impurities are present in any form due to any reason then this will facilitate the easy detachment of the molten metal drop from the electrode tip and this in turn will effect the way by which it is been transferred from the electrode tip. So, we know that the metal can be transferred from the electrode tip to the weld pool in four common ways. One is short circuiting mode of metal transfer, globular mode of metal transfer, the s p transfer and the tip transfer. So, depending upon the welding conditions in use we can have the different types of the metal transfer.

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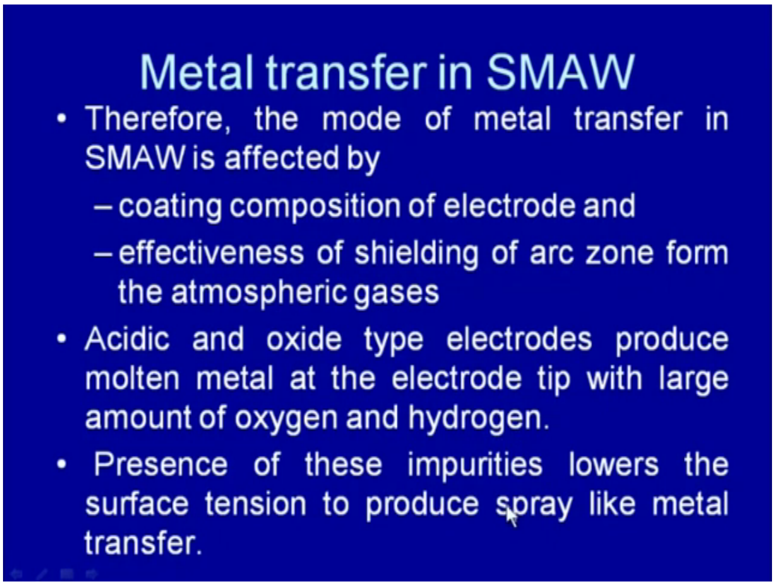

Therefore, mode of the metal transfer in the SMA welding is affected by the coating composition of the electrode. So, the factors that affect the quality of the molten metal at the tip of the electrode that is the kind of impurities, which are present in the molten metal hanging at the tip of the electrode, they will be effecting the mode of metal transfer in the SMAW process. For example, one factor is the coating composition if the coating composition is such that it will help to eliminate all types of impurities. And gases from the arc environment and this will lead to have the cleaner molten metal at the tip of electrode.

It will not be decreasing the surface tension and so it will be leading to have the globular transfer. While those situations where there is possibility to have the lot of contamination of the molten metal at the tip of electrode they will be leading to have the ASP transfer. The other factor is the effectiveness of the shielding gas. If the effectiveness of the shielding gas being formed around the arc zone is poor, then the atmospheric gases will be entering into the arc zone, will be decreasing the quality of the molten metal at the tip of electrode which in turn will facilitate the easy detachment of the molten metal droplets from the electrode tip. So, the acidic and the oxide type electrodes produce the molten metal at the tip of electrode with large amount of oxygen and hydrogen.

So, if we use acidic and oxide type electrodes they will be resulting lot of oxygen and the hydrogen with the molten metal. This in turn will be facilitating the significant reduction in surface tension which will be producing the spray kind of the transformer ASP kind of a metal transfer. So, the presence of the impurities will be lowering the surface tension and the reduced surface tension will be facilitating easy detachment of the molten metal drops from the electrode tip, and which in turn will be producing the spray kind of the metal transfer.

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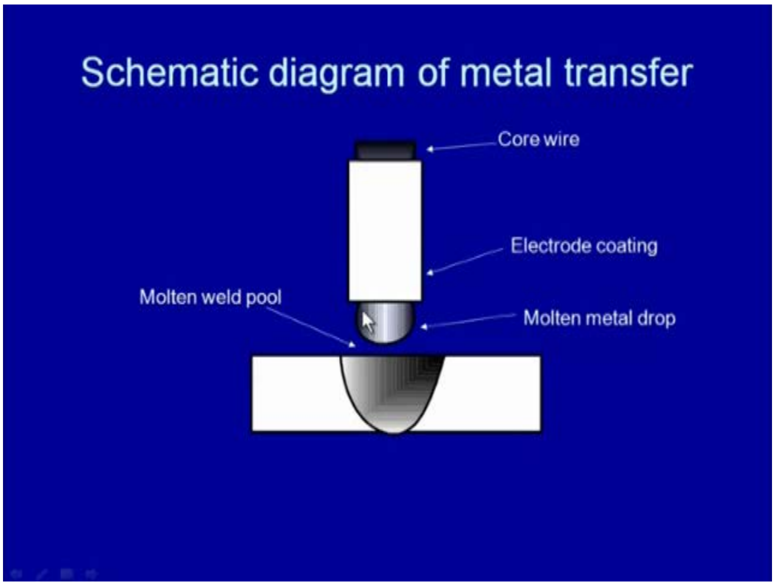

So, here if say electrode tape and the drop of molten metal is being formed. If the surface tension of this drop is low then it will tend to detach easily under the gravitational forces and will get transfer. But if the impurities are limited then high surface tension will lead to have the larger size of this drops, and which in turn will be causing the globular transfer.

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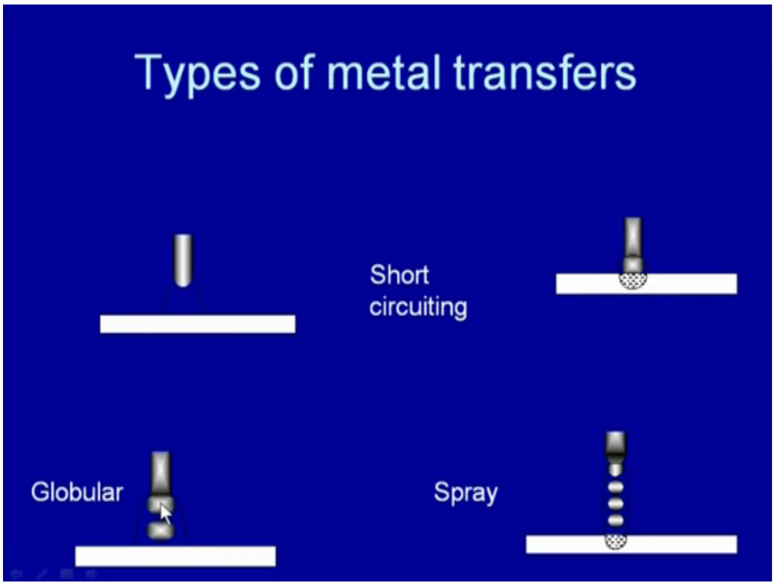

So, depending upon the kind of contamination electrode coating composition we can have short circuiting transfer globular or spray transfer. So, in short circuiting transfer is observed when the molten metal drop grows to such an extent that it touches to the weld pool short circuiting takes place and then it gets transferred. While in case of the globular transfer the drop gains to such a large size that even if the diameter of the drop is greater than the electrode diameter.

And then it ultimately falls down by it is own weight. When in case of the spray transfer the lower surface tension, and the high current leads to the detachment of the molten metal drops at the stage when they are of the very small size. This leads to have the appearance like spray of the molten metal drops from electrode tip to the weld pool and thus producing the spray transfer.

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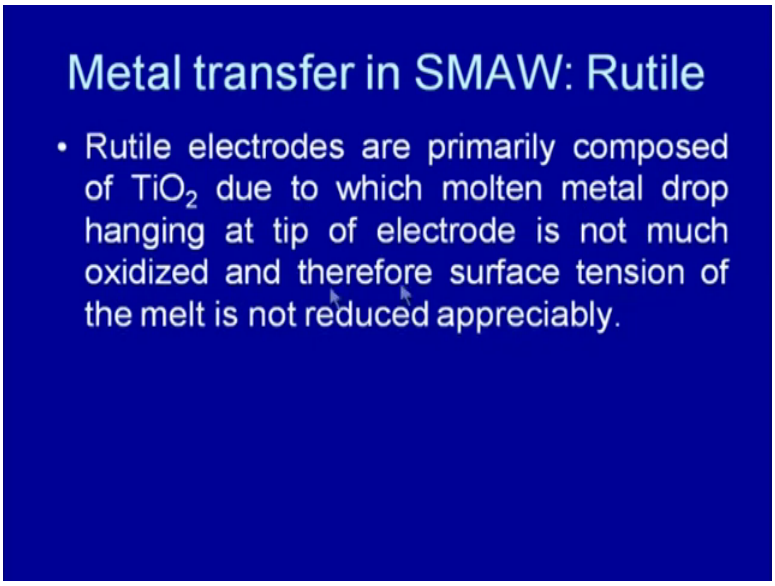

Now, if we look into how the different types of the electrodes will be affecting the mode of metal transfer. So, rutile electrodes are primarily composed of the titanium and due to which the molten metal drops hanging at the tip of electrode is not much oxidized and therefore, surface tension of the melt is not reduced appreciably. Hence, the rutile electrodes produced more globular and the less spray transfer.

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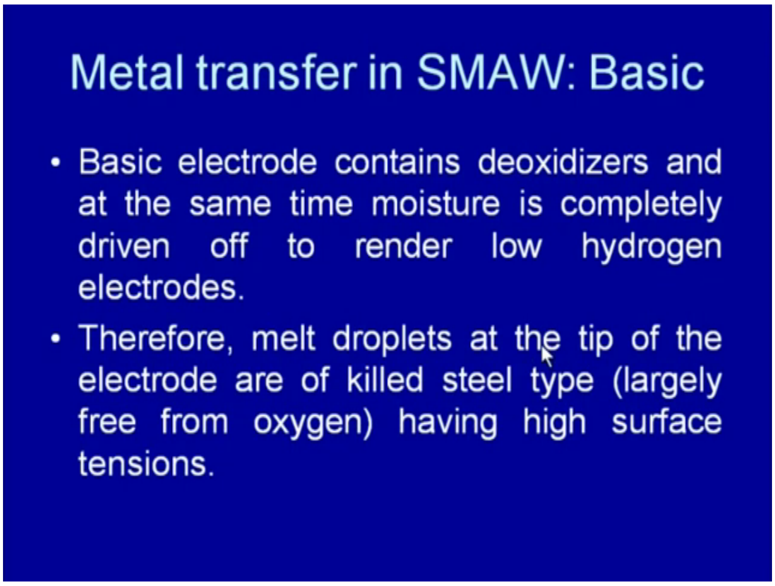

The basic electrodes contain lot of deoxidizers and at the same time moisture is completely driven off to render the low hydrogen electrode. Therefore, melt droplets at the tip of the electrode are of the killed steel type and therefore, it will be having the high surface tension which in turn promotes the globular transfer. Since, the high surface tension of the molten metal resists the detachment of the drops from the electrode tip.

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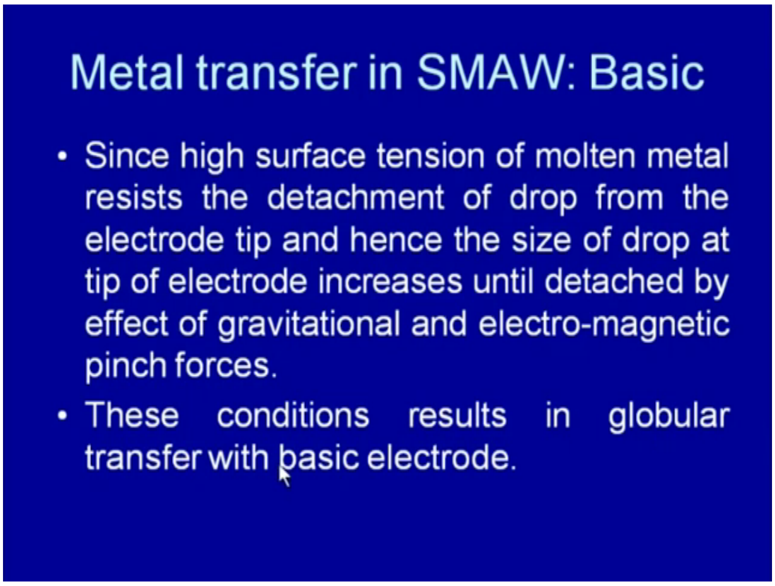

Hence, the size of the drop at the tip of electrode increases until detached by the effect of the gravitational force and the electromagnetic pinch forces. So, this conditions result in the globular and globular transfer with the basic electrode.

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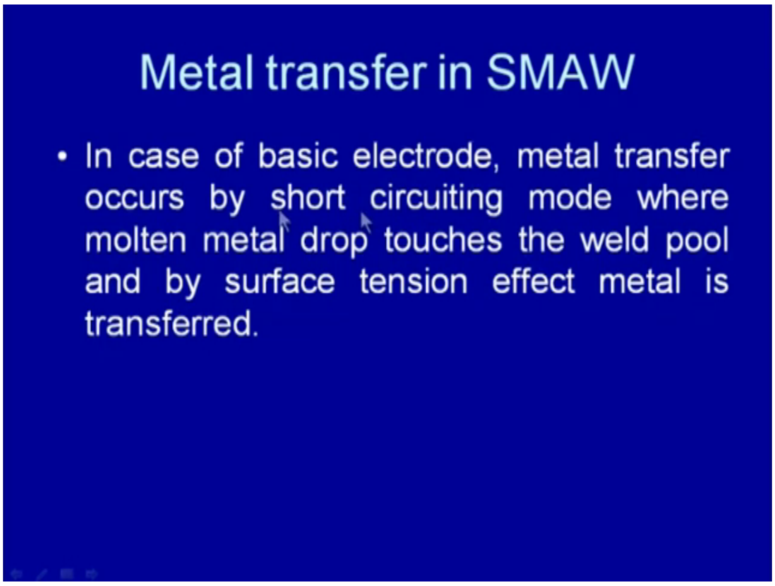

Metal transfer in case of the basic electrodes the metal transfer occurs by the short circuiting mode, where the molten metal drop touches the weld pool. And by the surface tension effect metal is transferred, but for this it is necessary that the gap between the electrode tip and the weld pool is very limited.

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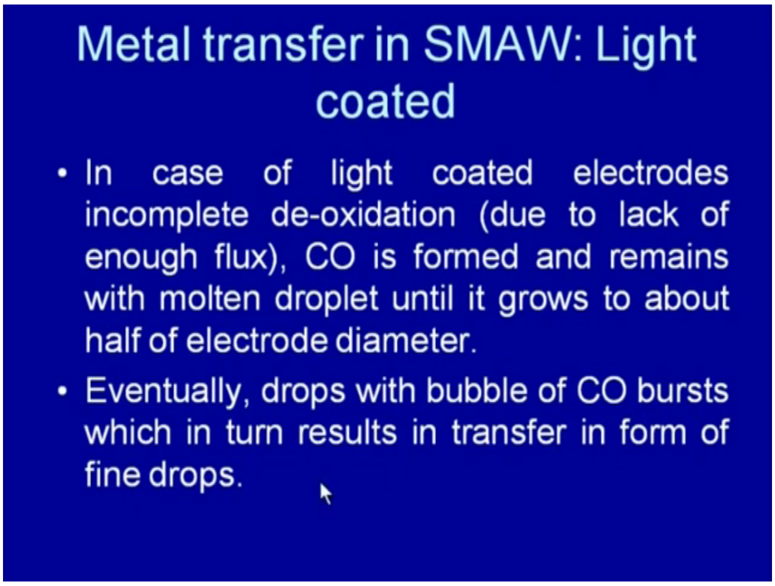

So, further if we see in case of the light coated electrode if the proper shielding is not been provided the de-oxidation of the molten metal drop at the tip of electrode is not occurring then this will be leading to the formation of the C O. This in turn will be remaining with the molten metal drop until it grows to about the half of the electrode. Eventually the drops with the bubble of the C O burst, which in turn causes the spray transfer in form of the fine droplets, but these are also be causing lot of the spatter.

So, in this presentation now we will try to summarize the things which have been discussed and which have been presented. We have seen what are the factors that limit the upper and lower level of the welding current and the effect of the welding parameters, like welding current or voltage and the welding speed on the development of the sound weld joint has been seen.

We have also seen that what are the modes, through which metal transfer can occur in the shielded metal arc welding process, and how the type of the electrode affects the mode of the metal transfer. Further, we have seen that what are the ways, through which the weld can be deposited during the welding, and what are the factors that affect the selection of the suitable kind of the weld bead for developing the sound weld joint. So, with this we conclude this presentation.

Thank you for your attention.