Theory of Production Processes

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Lecture – 46
Principle of Shield arc Welding Processes

Welcome to the lecture on principle of shield arc welding processes. So now, we will discuss about the principles of the arc welding process, where the shielding is done in any arc welding process the shielding is done, now that shielding how that shielding has to be done, that is decided in different way.

So, first of all what we see is that when we talk about the arc welding, then there is some term like arc. So, this arc has to be maintained between the electrode and the workpiece or sometimes we also produce. The arc between two electrodes, and then that arc has a quite high temperature, and that is used to join the pieces or fuse the metal in a particular domain.

So, that is how this arc welding is defined. So, in that we produce the arc, and then since the arc is at a very high temperature. So, that pool molten pool which is formed, that needs to be you know protected from the atmospheric contamination. Especially, from the gases like oxygen or nitrogen which may dissolve into the pools, will dissolve into the metal, and for the undesirable phases, and they may spoil the weld itself. So, that is how you have the first of all you have the creation of arc, and then the arc welding processes are classified based on how you are given the shielding. So, or how you are making the arc.

So, first of all the arc is produced by using the electrode, in one case the electrode is the workpiece and I in of the two electrodes, one is the you know electrode which produces the arc other is the workpiece, or you may produce the arc between two electrodes, and that arc is directly concentrated on the workpiece. So, that it melts, then about the shielding, sometimes we use the coating on the electrode. So, in that case this coating material which is over these electrodes, they melt and create an atmosphere around the you know molten pool.

So, they will cover it so, these are fluxes basically they also melt, and then they create a blanket of gases on the top surface of the molten, weld pool and this basically is protecting the weld pool. So, that is a shielding is done basically so, that is you know another and another mechanism is that you use the gas. So, that gas goes onto that weld pool and that envelops it so, that way you also shield it. So, based on that, you have a shielded metal arc welding or a gas metal arc welding. So, this way you have SMAW or GMAW or GTAW, when we talk about we will talk about all this.

So, that is why you have typical welding processes like shielded metal arc welding, you have gas tungsten arc welding that is TIG, you have metal inert gas welding, you have carbon arc welding; So, submerged arc welding and all that these are the varieties of arc welding where you create the arc like if you talk about the shielded metal arc welding.

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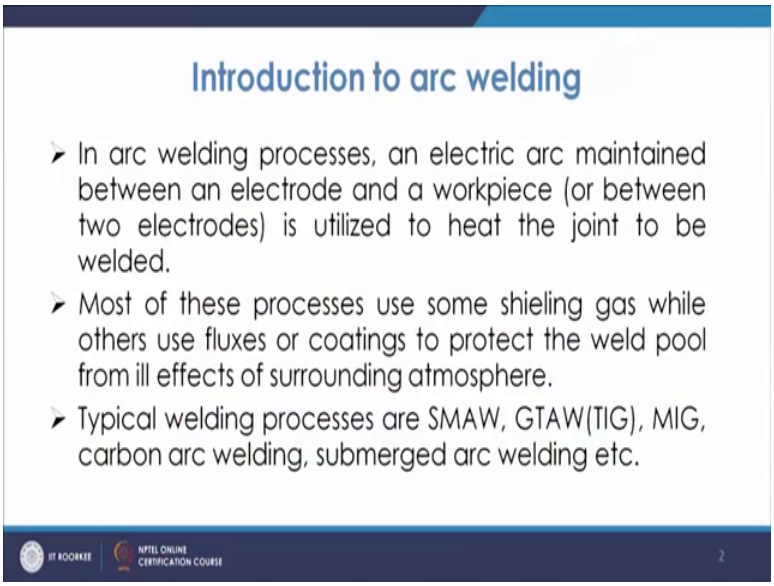

So, basically in that case you have a flux which is there and then that flux in. So, normally the electrode is coated with flux, and this is normally a you know electrode which is normally consumable, and then once it consumes it has coated with flux, this flux melts and creates one environment around the weld pool.

Similarly, you have a GTAW which is gas tungsten arc welding. So, in that, what we do is we create the arc with an electrode whose job is only to create arc, it not it does not get consumed. And the electrode is also bare. So, you use you know not there this is a tungsten electrode, and you feed the a material required in a bare form, and the shielding

is done by supplying the gas in that I mean you have a specially designed torch. So, the gas comes and the gas is normally are helium or argon used and in some cases, carbon dioxide also. So, but the tungsten electrode is there to basically create the arc.

Similarly, you have metal inert gas welding. So, in that case, what we have here? You have a basically the electrode which is consumable, and you have the inert gas which is flowing. So, that way that is why it is the metal inert gas welding, you have carbon arc welding where the arc is produced by carbon or submerged arc welding, where the arc is submerged in the granular flux. So, this way you have a different types of a welding processes. Now, we come to the first variety of shielded metal arc welding this is also known as a SMAW.

So, what is there in that collisions of a metals is produced by heat from electric arc which is maintained between the tip of a covered electrode, and the surface of base metal in the joint being welded; so, that is how the SMAW takes place.

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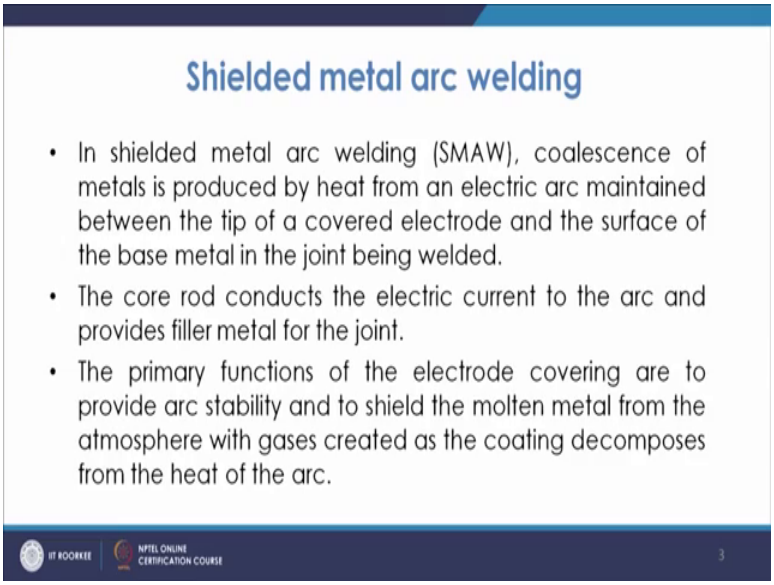

Now, here the rod which is there, that basically melts and that will basically conduct the electric current, and it will conduct the electric current to the arc, and it will also provide or it will work as a filler material for the joint. So, what happens that, the electrode which is connected a electro holder, now it has since it is a metal it is carrying the current, and producing the arc and getting consumed so, that way you are using that electrode also as the filler material in that case.

Now, what we do is that normally this electrode is having the covering. And this covering has many purposes. And basically the main purpose is, that it is stabilizing the arc, and also it will be protecting the weld metal from atmosphere because you have many gases who will try to get dissolved into the weld metal pool. And that is how it will spoil the you know quality of the weld. So, the this coating will be decomposing, and then because of the heat of the arc and then it will provide a blanket of a protection to the weld pool.

So, what is there in the case of this a shielded metal arc welding if you have to look at the schematic.

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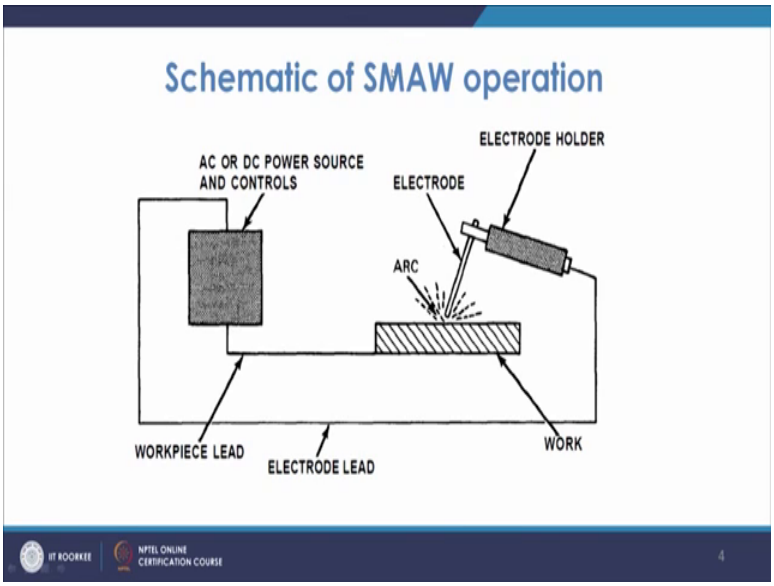

So, basically you have a ac or dc power source, which is there in this case. And what happens that, you have this is the electrode, this is the electrode which is connected to electrode holder, and this is a work this is the work on which is to be on which the welding is to be carried out. Now the thing is that the electrode and the workpiece in between there is arc which is created.

So, creation of the arc itself, there is a mechanism by which this arc is created now how this arc is created?

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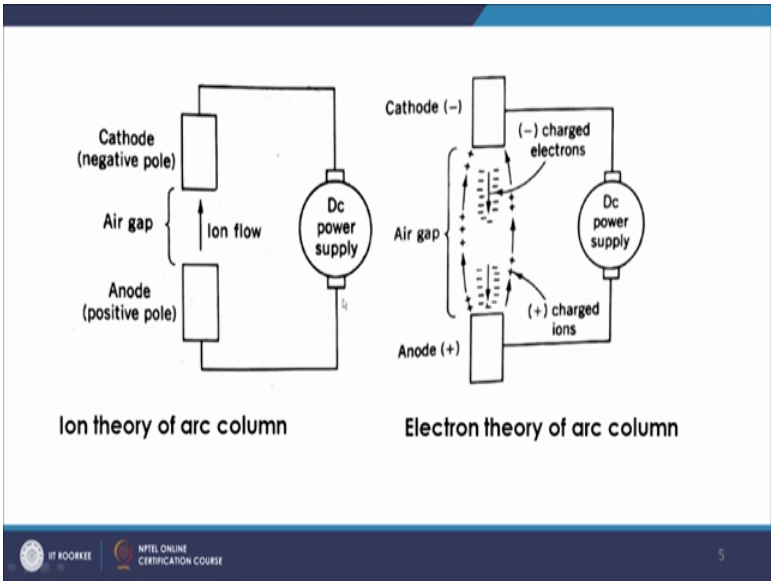

So, what happens that the creation of the arc, there are two theories for the creation of this arc. Now, there is iron theory of the arc column, now the thing is, that you have a positive electrode you have a negative electrode. So, once you have arc connecting that to a power supply, now what happens? That the ion theory of the arc column tells that you will have the flow of iron from the anode and it will move towards the cathode. So, that is the theory of the iron theory of the arc column.

Now, the electron theory of arc column tells that the electrons will basically move from the cathode and it will strike the anode. So, basically you will have the ion ion theory because since metals are positive have mostly positively charged ions. So, they will have a affinity towards going to the cathode. So, they will be moving from. So, ions will be moving from here to here whereas, this has extra atoms so, these atoms. These atoms will be moving from here to this place.

Now, what happens that when these ions will move from the anode to the cathode? In that case it will try to ionize the gas column in between. Now, this there is the gas column which is basically air, and that is basically ionized. Now, what we see is that here from the electrons are moving and they are moving through this gas column that is in between you have the plasma. Now, from here they are basically coming in between, and the there is a there is large amount of electron which are basically coming from the

cathode. And this electrons are moving at a high velocity and they are impinging they are basically bombarding this anode surface.

Now, what happens that because of the they are hitting this anode, there is a large amount of heat is generated. Now, this what happens as you see that you have a 3 reasons, one is near the cathode one is near the anode and in between you have the plasma. Now, basically that also gives a resistance to the flow of these electrons, which is coming from here. Now, the thing is that when we are using this dc power supply. In that case normally what happens that, as we know that these electrons will move from cathode to anode, and the ions will move from anode to cathode.

Now, you have three zones, one is near the cathode, one is near the anode and another is in between the cathode and the anode. Now, this is they are moving at a very high velocity and they are bombarding overrate. So, most of the energy, that is in the in the form of heat is liberated at the anode terminal. So, when whenever we talk about the dc power system, in that case since the movement of electron is fixed it is moving from cathode to anode. So, you will have the movement, I mean you have the stoppage at the anode and larger section larger fraction of the heat that is two-third of the heat is generated at the anode.

Whereas if we talk about the ac power system, in that the polarity is changing every cycle; So, you will have the equal amount of heat which is generated at the anode as well as the cathode and the that is why you have different way you apply. So, in the case of a DC system basically, you can control or you can see that how much if the if the suppose plate which is to be joined is thicker one.

You feel that the plate should be heated. So, because then that case you have to see that the plate should be connected to anode. And the electrode should be the cathode, because the plate will be heated more it will there will be more generation of heat at the plate. And in that case, you can have a better penetration in the thicker plates.

So, when you have a thicker plates, you go for the positive terminal connected to the plate and this way that is known as straight polarity. So, that is basically you can change it so, you can change that polarity.

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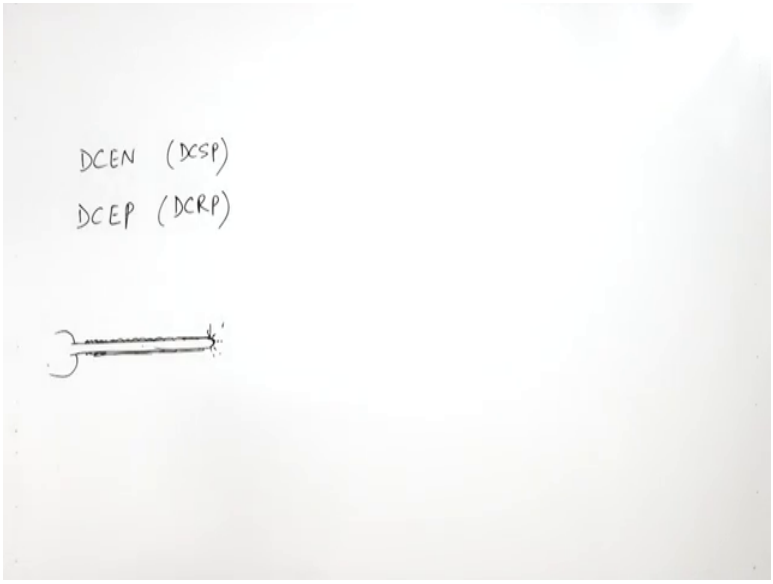

So, when you have the dc power source, and when you have electrode negative and work as positive. So, basically larger of the heat is applied or generated at the work. And that is how it is known as a dc sp also dc straight polarity. So, this is a straight polarity, now the thing is that if you are changing this direction. If you change the electrode, like you make the electrode to you know a positive terminal and the work to negative terminal. In that case it is DCEP so, that is a direct current electrode positive. And this is known as also direct control direct current reverse polarity.

So, in that case, what we see is that your maximum heat will be generated at the electrodes. So, electrode will basically become more heated. It will consume also faster. But normally the penetration is a smaller in this case, and that is normally used when you have thinner plates. So, in those cases if you have if you use the straight polarity or electrode negative and work positive, in that case there will be chances of deformation and there will be uneven weld with structure.

So, that is why in those cases you go for the reverse polarity where maximum heat will be generated at the electrode itself. And that when we talk about ac systems, in the AC system basically you have change of flow because it is goes in a sinusoidal circle cycle.

So, you have the flow of current flow of electron reversed in every cycle. So, that way you have equal amount of a heat generation at both a node and the cathode. So, that way it has the you know property in between the DCEN and the DCRP. So, this way, this is

the theory of the arc generation in the case of arc welding. So, you have two theories, one is ion theory which tells that there will be movement of ions; that is, positive ions from anode to cathode.

Similarly, you have electron theory which tells that the cathode will emit the electron will come to anode. And that is how you have three you know basically regions and that two regions at the one at cathode and one at anode and more of the heat is at the anode in case of DC you know power supplies.

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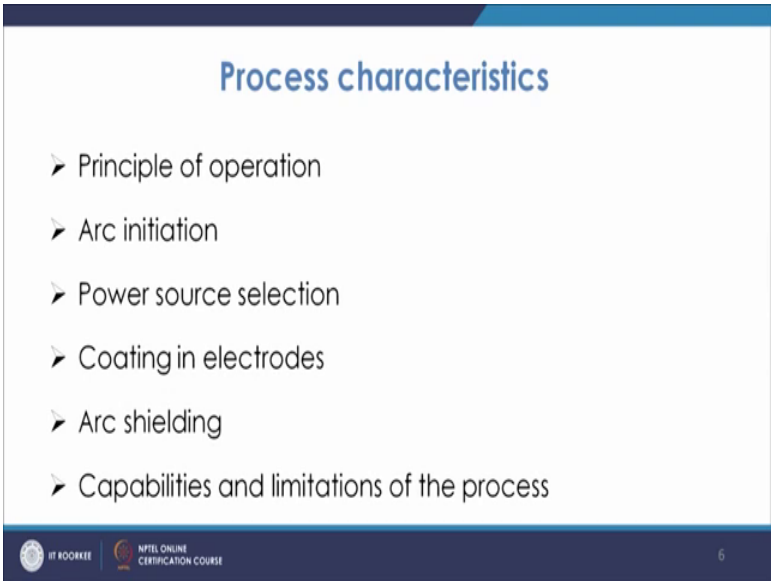

Now, we talk about the process characteristics. Now if you talk about the process characteristics, then first is the principle of operation. Now principle of operation means what is the principle of creation of arc. So, that we have already understood, that when you are connecting the one of the work and you have electrodes.

So, one is connected to positive, you know, power source another is to negative. In that case the current allows to pass electrons flow from the cathode to you know anode. So, first of first of all it is touched. So, that way it flow of electron, but then you are creating a gap. In that they try to jump so, that way there will be ionized column development. And in that basically there is large temperature which is achieved and it goes maybe about 11,000 to around or 10,000 to 11,000 degree Fahrenheit of the temperature close to 5500 or so about or degree centigrade of temperature is achieved in that column, and that is high enough to basically melt the a material which where it is heating.

So, that is how you have the basically principle on which the arc is created, and then you go on doing the welding. So, that is what we discussed about the principle of arc initiation. Then you have as we discussed you have power source selection. So, power source selection means you have either the DC power source, or you have the ac power source. So, you have you can use depending upon the situation you can use either go for dc power source, or you can go for ac power source. Then you have the arc shielding now coating in the electrodes.

If you talk about the electrodes which are used, now normally these electrodes are known as stick electrodes. So, this is in the form of a stick. And they are basically covered with certain fluxes. Now what happens that the fluxes which are used basically you have the electrode like this, and on this you have the these this way you have the fluxes which will be there, and ultimately so, and ultimately at the top you have ; so, what happens? That this is two electrode holder this is two electrode holder, and from here the this is aware at the at this point.

So, once it touches the flame will start from here. Now, being this inner portion as the conductors so, that will melt fast because of the heat. And then what happens the flux which is quoted around it, it has certain functions. Now, one of the function is that that this basically helps it to direct you know towards the weld pool, or towards the metal where it is I mean the there were the placement of the metal itself so that the otherwise what will happen if there are no flux coatings then this arcs may be going in all the directions.

So, there may be large amount of loss of these heat from the arc due to radiation in all the directions. So, you will have a that is you know a proper direction or proper stability of the arc is maintained by this fluxes. Second is that this flux once they are melted then they create a envelope of gases around the weld pool. So, in that case, what we see is that they will be protecting the weld pool from any atmospheric contamination as long as this you know silver, I mean coating is getting consumed and as you are moving for welding.

In that case you have the envelope of a shielding gas generated and that basically protects it from the you know from further contamination of that weld pool. Because the temperature is quite high, and that high temperature there may be chances of atmospheric contamination or dissolution of lot of gases into the weld pool.

Third is that it also acts as sometimes, you want to reinforce the weld pool with certain alloying elements, you can also use these alloying elements for reinforcing the that weld pool with this fluxes. So, there are many you know advantages of these coatings arc shielding, already we discussed that the arc is because of that arc the flux is able to maintain a covering over the weld metal. You have we will discuss about the capabilities. So, as we know that it has quite capable it is quite versatile very cheap process. So, you know this is one of the mostly used process in the case of arc welding.

However, there are certain limitations also. Now, the thing is that what are the limitations. So, the thing is that when we use the electrode, and we since the current passes through the electrode which has the central code portion is the metal. So, because of the resistance it gets heated sometimes, and then the covering may break down. So, that may alter the arc characteristics many a times. Then also as you know that the electrodes are to be consumed they are basically consumed as we move in the welding direction. So, at the end you are throwing the unused portions which are it is very smaller and if you have to start the fresh work.

So, you have sometimes a wastage of these electrodes. So, that wasting is there in that case. Another limitation which is there in the case of this shielded metal arc welding is that as we know that you have the making of flux, and these fluxes are the surface of the weld top surface of the weld begin lighter also they are at the so, top surface of the weld. Now that is to be removed every in every pass, if you do not remove them in that case that may create the problems, that may be forming undesirable phases that may affect the corrosion resistance property of the material or other mechanical properties.

So, these are the limitations of the this process. Now you have different varieties of a arc welding processes, and we will discuss about few more one of them is the submerged arc welding process.

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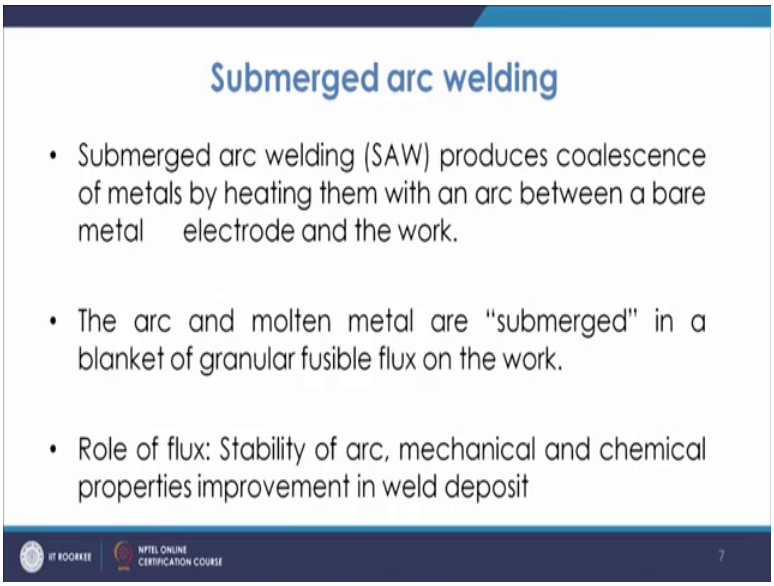

Now, in the case of a submerged arc welding process, what we see in the case of stick electrodes, what we see is that the blanket is produced by melting of the flux which is on the coated on the electrode itself. Now, in the case of submerged arc welding, what happens that the welding which is going on, now that is basically submerged under the granular flux the flux which is used is the granular flux. So, the you cannot see the arc, the arc is not seen in this case the arc is completely surrounded by the granular flux. And the flux is continuously supplied, and the that flux is basically now the flux which is in contact.

So, we will have the hoop of the flux. And where the melting takes place anyway the flux will come in contact and again, the flux will do that purpose of a making a blanket of the; so, anyway it is all anyway, it is enveloped and also that flux in that atmosphere, the arc reason is completely protected. So, you that will be physical flux, and this because that flux which is completely covered. So, it does many purpose like it will be doing the stability of arc, mechanical and chemical properties of the weld deposit are also improved in this case.

Now, in this case, since the we are using the granular flux which is there from all the sides so, we are using the bare wire. So, that wire are used and that basically the holder or the mechanism by which the wire is coming now that can be moving as the welding processes progresses, or the work on which a welding is going on that can move. So,

continuously you can so, since it is in the form of a wires. Bare wires and they are basically coming through a mechanism by which you can continuously feed the wire, so that process which is there I mean there is basically a challenge in the case of a shielded metal arc welding that does not remain here.

In this case, the arc can continue for long, and that way you can have a very large welding which is possible in the case of submerged arc welding. So, you can see the submerged arc welding here.

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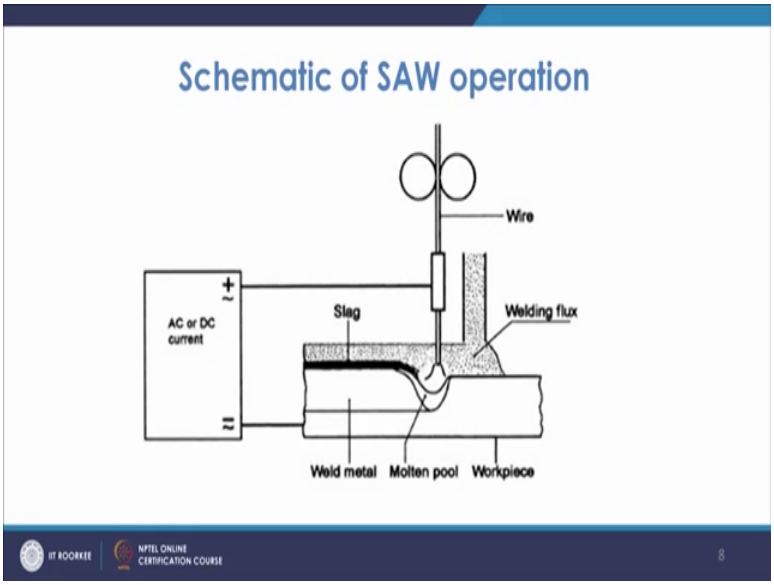

The deposits can be quite at larger rate depending upon the value of current you can use larger value of current in these cases, you can have even I mean depending upon the type of deposit or type of penetration, you can have either larger current or the larger or the even the change in the voltage values.

Now, as you see that in this case you have this is a slag. So, this flux will be coming through this hopper and the arc is created here and this way the slag will be there on the top surface. And you have the mechanism of using the unused you know so, every time this. So, you know slag I mean the flux is there this flux will be used and most of the unused flux can further be used. So, this way you have the further use of the slag, I mean, a fluxes now in this case you have as we know that principal operation is again somewhat the same because you have again, you have the electrode which is basically the bare wire and one is the work.

So, this way you have the initiation of the arc, then you have a different modes of welding. So, in the case of a submerged arc welding, you may have the manual or a semi-automatic or you can say machine type of a processes. So, how you are able to move how you are going to give the feeder of this wire or bare rod to the machine, how you are controlling in what way may automatic may way or semi-automatic way.

So, based on that you have different welding mode methods, you have materials electrodes and fluxes. So, and the materials any material are weldable are welded, electrodes as we discussed that electrodes we use the bare electrodes. And you have different fluxes preparation of fluxes are different which are used in this a welding method.

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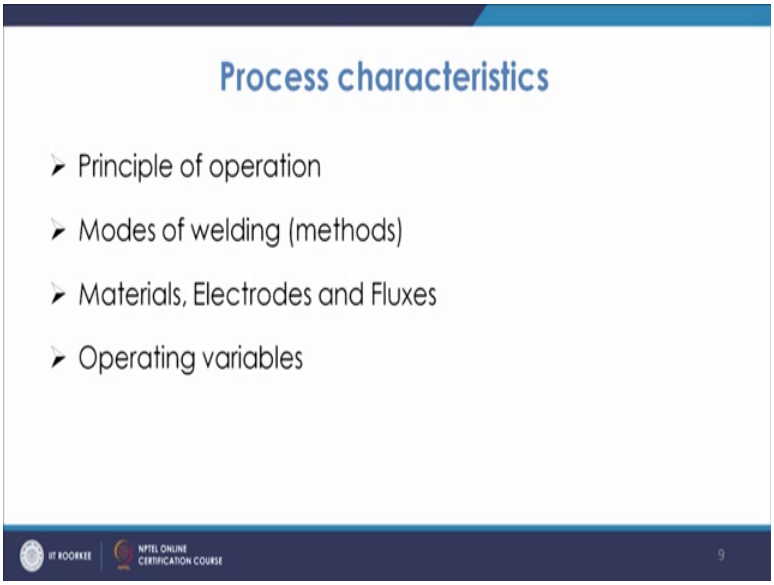

As we talk about the operating variables; now, operating variables are normally here the a welding current which is normally quite larger value is taken depending upon the degree of penetration which can be used. You have voltage also voltage basically, you know, if you take a larger voltage it will talk about the, you know, flame dispersal so, it will go and heat in the larger portions.

So, that way the that is the characteristics of a larger voltage if you have larger current the penetration will be more. So, depending upon that the operating variables can be controlled.

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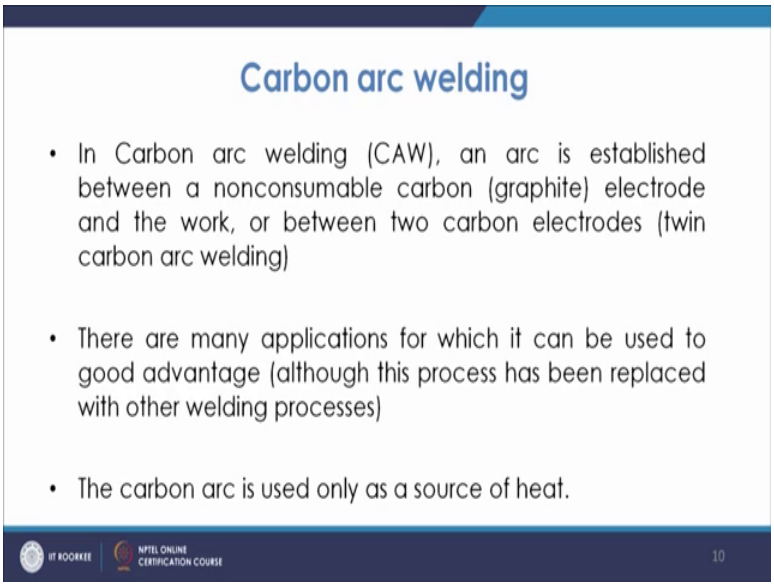

Then, the next type of a welding is also one is carbon arc welding. Now in the carbon arc welding the arc is between the non-consumable type of carbon or graphite electrodes, which are used for heating the work. And then this way either you have the twin carbon arc welding also. So, now there are many applications which can be, you know, it has many advantages.

Now, most of the this process mostly has been replaced with other welding processes like TIG or so. Now, in this case carbon is normally used as a source of heat because either carbon or graphite is used as the electrode material, and this is the schematic of carbon arc welding where you have carbon electrode and this way.

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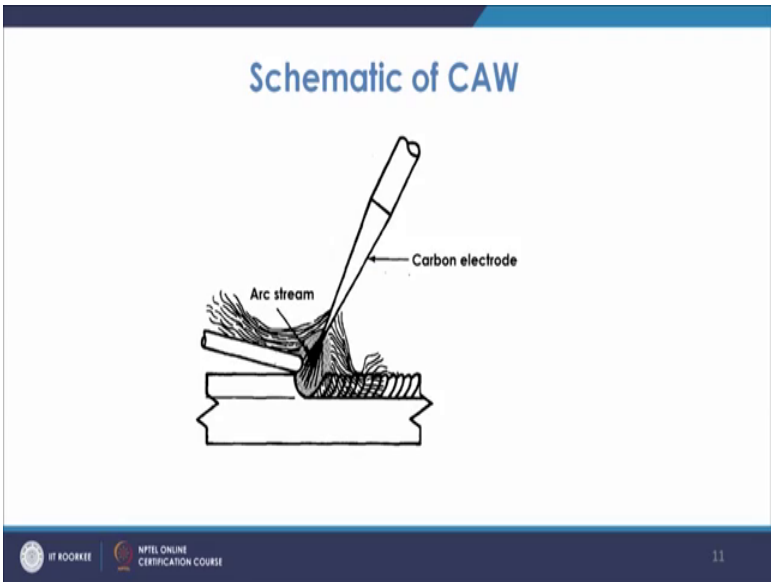

The arc stream is generated you have, and the weld bead appears like this. So, this is the one of the variety of the arc welding, we will discuss more about on the principle of generation of arc and also about the different processes in the coming lectures.

Thank you very much.