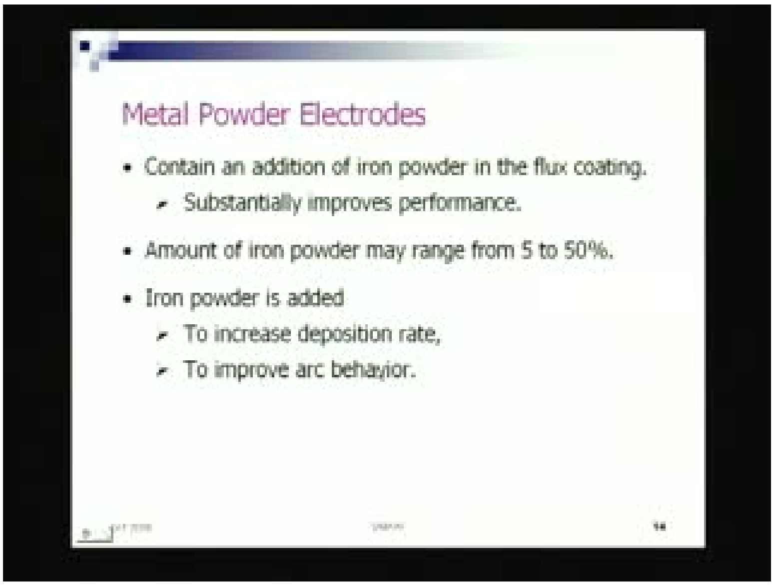
Marine Construction & Welding

Prof. Dr. N. R. Mandal
Department of Ocean engineering & Naval Architecture
Indian Institute of Technology, Kharagpur

Module No. # 01
Lecture No. # 29
Gas Metal Arc Welding – I

(Refer Slide Time: 00:30)



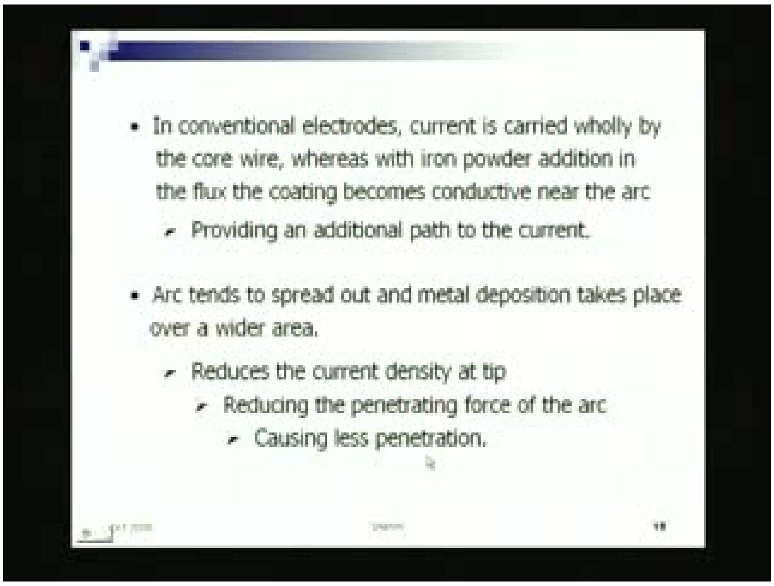
So, before starting going over through gas metal arc welding, let us take a look. And We have seen these three types of electrodes; three types of electrodes for manual metal arc welding or shielded metal arc welding. They are the cellulosic electrode, rutile electrode and basic electrode, and we have another fourth type which are referred to as metal powder electrode. This will be a worthwhile to look into this.

They are of course those last three types of electrodes, the classification have been done based on the composition of the flux coating. This also a composition. Here, interesting composition is the metal powder being added to the flux coating. There, the purpose of the flux coating was precisely for providing the necessary shielding, providing which has a, had a effect on the, on the, ionization potential, thereby the energy content of the heat etcetera.

Now, here, metal powder is being added. Metal powder means essential iron powder. So, what is happening? It contains an addition of iron powder in the flux coating; that means the previously we have seen this metal powder electrodes, it can be with cellulosic coating; it can be with rutile; it can be with basic also. There, here, additional element we are giving is a iron powder in the flux. What it is doing? Substantially improving performance.

It is improving the performance of the electrode. How? That we will see. The amount of iron powder may range from 5 to even 50 percent; that means quite high amount of the flux coating will comprise of iron powder, that can be, it is on the higher side this is on the lower side; that means below 5 percent, then we will not refer to it as a metal powder electrode. So, the range of metal powder being used is of this order. Why this is added? To increase deposition rate as well as to improve the arc behavior. Deposition rate is increasing as well as the arc behavior is increasing. Deposition rate is increasing possibly increasing the heat also. Arc behavior means the stability with the arc is becoming more, I mean better.

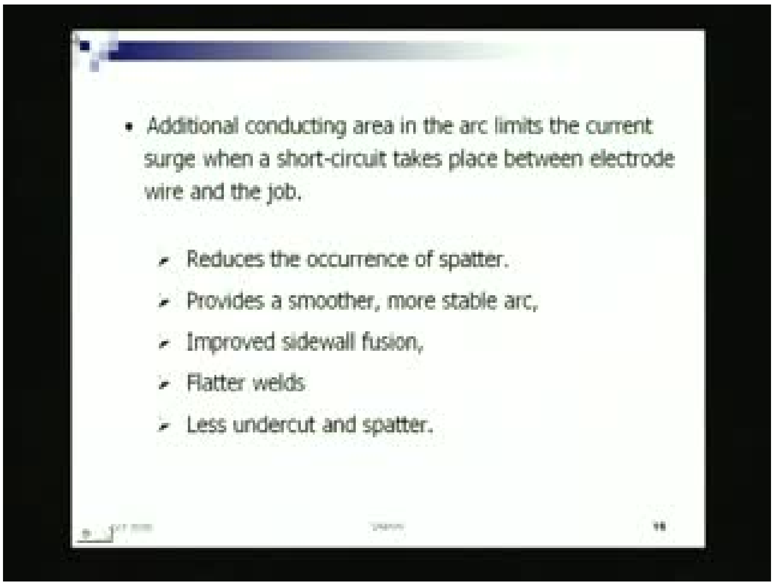
(Refer Slide Time: 02:59)



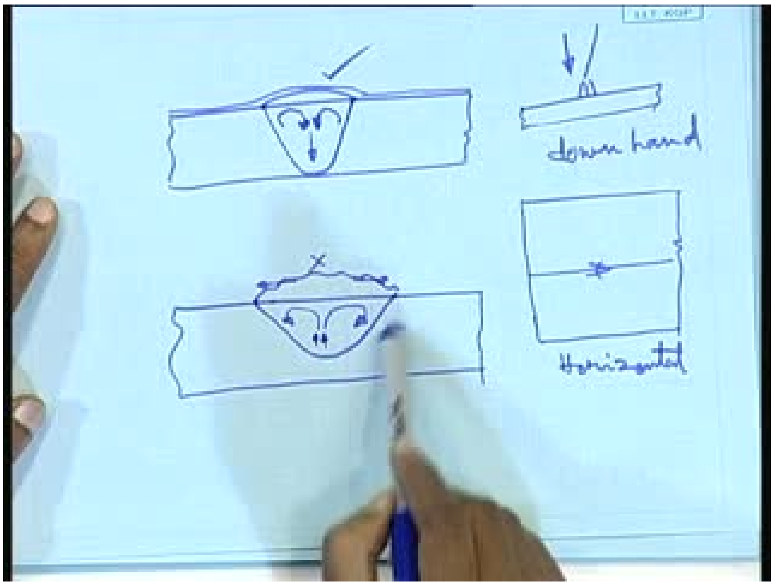
So, in conventional electrode, what happens? Current is carried fully by the core wire. That is the fundamental difference here. Here, what happens with iron powder addition? The, in the flux, the coating also becomes conductive near the arc. In the conventional electrode, only the wire was current carrying the current. Now, here, the wire is carrying the current as well as the coating, the flux coating near the arc also behaves. Its resistance decreases drastically; it means it also behaves like a conducting material, thereby providing an additional path to the current. That is what is happening. As if my current carrying area has increased, the current carrying area, conductor area has increased, so arc tends to spread out and metal deposition takes place over a wider area.

So, we get a wider arc and you get over a wider area. So, that is the advantage, but what is happening, because of this, the, in the way since it is getting an additional path, current is flowing over a wider area, wider cross section. So, thereby, the arc getting spread out. It is not a constricted arc; it is a spread out arc. So, deposition is taking place over a wider area. So, what happens? Reduces the current density at the tip that is one thing. Current density is decreasing. So, as the current density decreases, that reduces penetrating force of the arc. So, fusion depth or the penetration depth will reduce. It will cause less penetration. These things will happen.

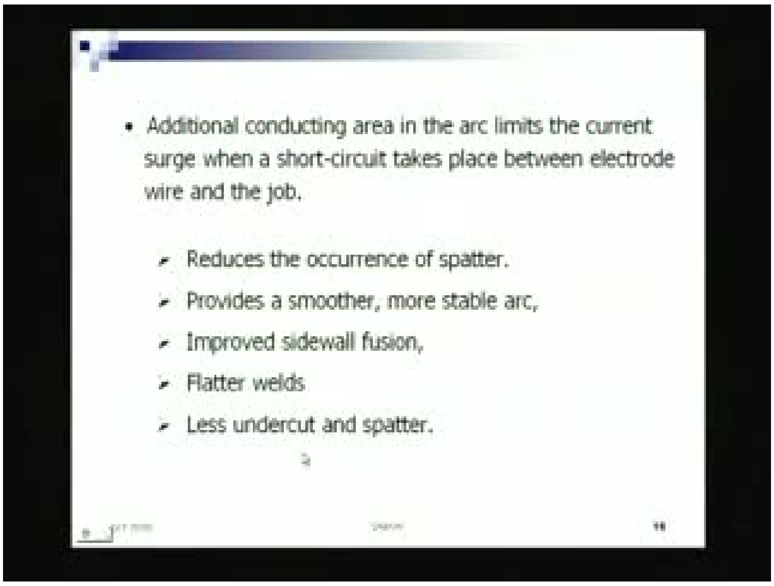
(Refer Slide Time: 04:53)



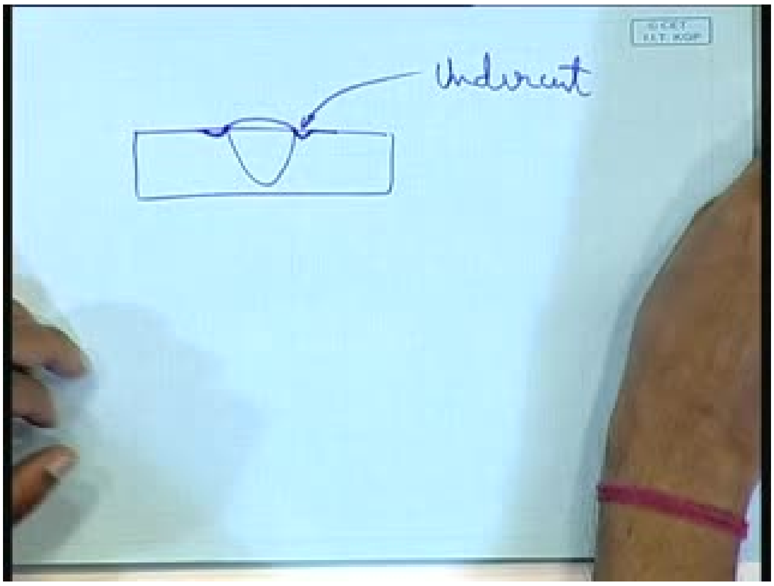
(Refer Slide Time: 05:42)



(Refer Slide Time: 05:48)

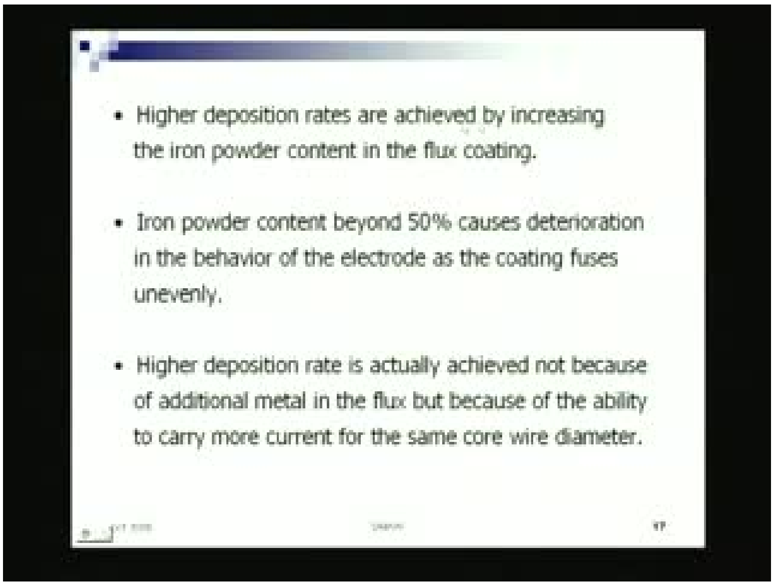


(Refer Slide Time: 05:57)



However, additional conducting area in the arc limits the current surge when a short circuit takes place between the electrode wire and the job. The current surge it is limited, it somewhat controls reduces the current surge. Thereby, reduces the occurrences of spatter. So, in a metal coated electrode, spattering will be less provides a smoother and more stable arc improved side wall fusion. We have seen in that; that means instead of having a deep penetration force, we will have a better side wall fusion like those movements we have been seeing this, this, kind of motions. You will have a better side wall fusion. It will give a flatter weld less undercut and spatter. Undercut is another defect. This is what is referred to as undercut. When a, suppose a welding is done, at times there is a some such depression takes place at the edge of the weld bend, weld bead. These depressions, they are referred to as undercut; that means the metal as if flows towards the fusion zone and there a void takes place at the surface. As if the side has got cut, that is referred to as undercut. So, less undercut is expected.

(Refer Slide Time: 06:35)



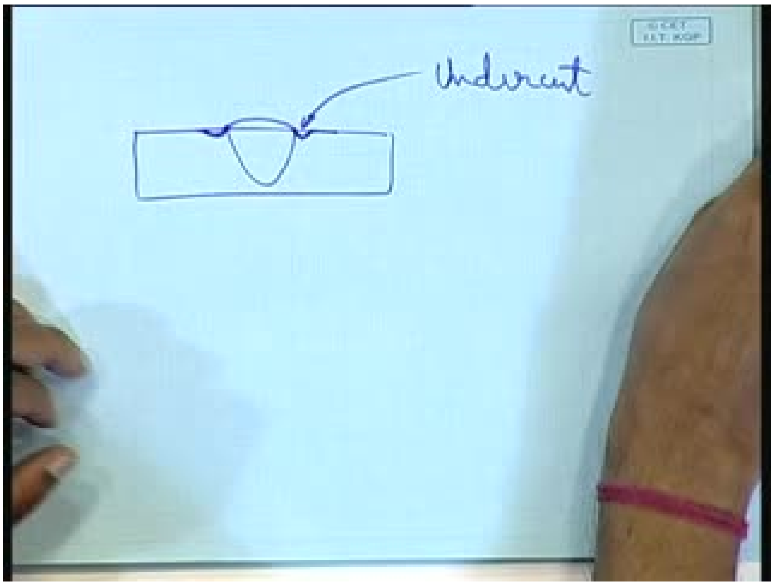
Higher deposition rates are achieved by increasing the iron powder content in the flux coating. If I want to increase the deposition rate, I have more flux, more iron content, deposition rate increases. Iron powder content beyond 50 percent causes deterioration the behavior of the electrode as the coating fuses unevenly. So, that does not mean that you go on increasing the iron content. When it becomes more than 50 percent, then it is again harmful. So, it is to be kept within 50 percent, then it is beneficial from the point of viewer achieving. Higher deposition rate, high deposition rate is actually achieved not because of additional metal in the flux but because of the ability to carry more current for the same core diameter means I can use higher current. The welding can be achieved at a higher current level. I give a more current because I have a higher conductor area. So, current carrying capacity is increasing. Thereby, I increase the current level, thereby increase the heat generated and the deposition rate as it increases.

Sir, the density of iron is also it will not deteriorate the weld…

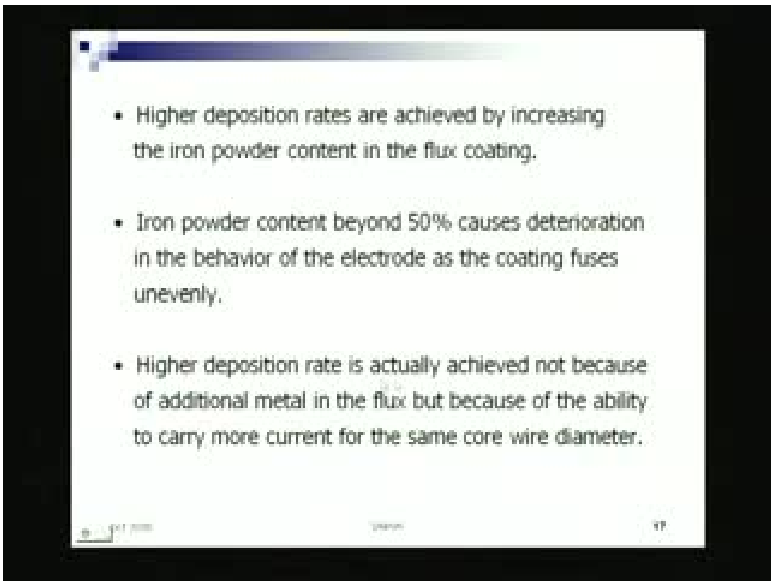
No. When, what we are thinking is that iron in that temperature will melt. Whatever iron powder is added, that also will melt. It is not that the solid iron powder will be floating alone.

It will melt in zinc. No sir because it will…

(Refer Slide Time: 08:48)



(Refer Slide Time: 09:50)

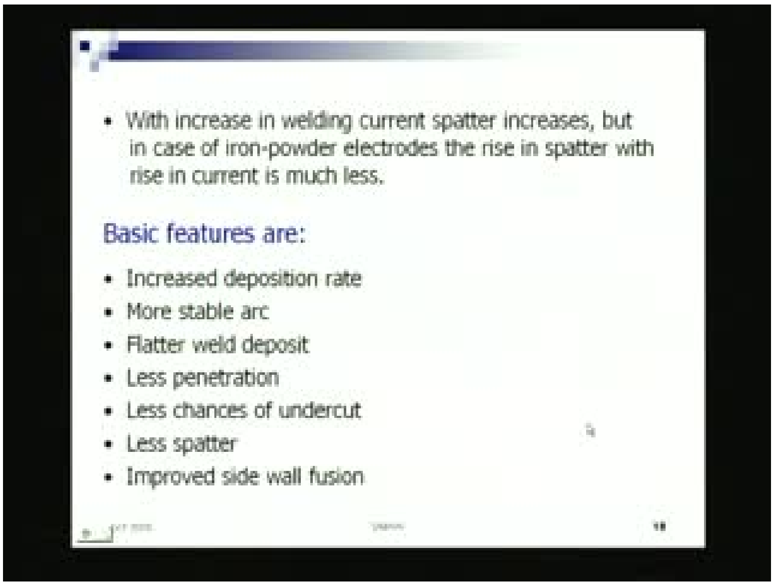


Let it that iron powder is melting and getting amalgamated, getting alloyed with the molten metal. There is no problem. That is iron; that is not the slag. Flux coating when burning and forming slag, now within the actually what happens is later also we will see the flux composition is such, we can have the flux composition in such a fashion. I can give some alloying element also in that. Suppose I want to have the metal deposit or the fusion zone chemistry I want that it should have more of silicon. For some reason, I may need or I may say I want somewhat higher percentage of manganese.

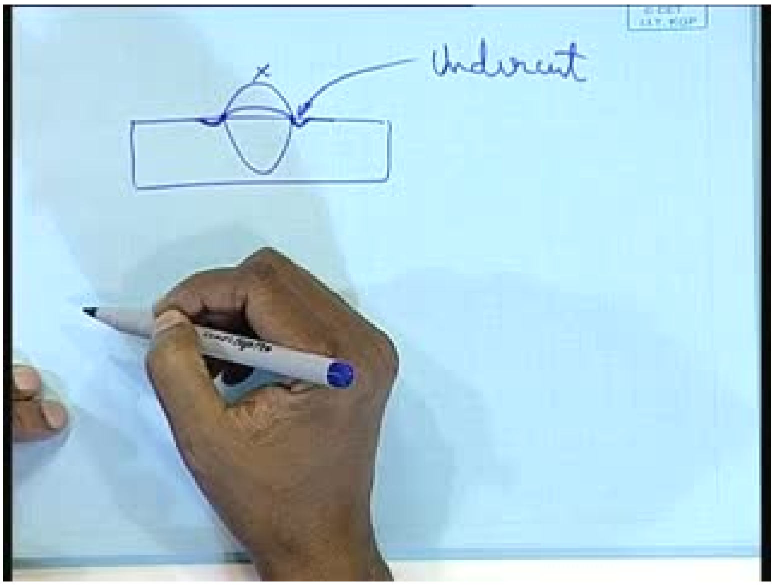
So, how do I achieve that? One of the way of achieving that would be to choose a suitable electrode wire which will have the required manganese percentage or silicon percentage plus in addition to that, I can have the coating or I can have the flux also having those elements which I want there. So, part of it, you will get defused because that is not forming the slag, that is coming out as a elemental manganese or elemental iron in this case and going in the alloy, and here, it is all iron basically with some of the certain percentage of other alloying element. So, that is getting fused with steel basically. So, that is not a problem.

So, what do you see that the this high deposition rate is not achieved because of the additional metal. Here, we are seeing we can achieve deposition rate that is not more of that iron powder, I mean that iron powder is getting melted and getting deposited. Thereby, I am achieving high deposition rate. It is not really that it is actually its increasing the current carrying capacity of the electrode such that, I can operate it at a higher current level, because for a given electrode, suppose it is cable of handling 175 ampere; that means if I use 250 ampere, electrode will get unduly heated up and it will get damaged because current carrying capacity is less like you may have seen if you are using the some say electric iron with the improper cable or electric heater in your kitchen with a thin cable, the cable gets heated up; that means the cable does not have the current carrying capacity like this a 15 ampere plug; 5 ampere plug means the plug 5 ampere plug current carrying capacity is 5 ampere. Similarly, here by adding iron powder, you are increasing the capacity. Thereby, give more current and have higher deposition.

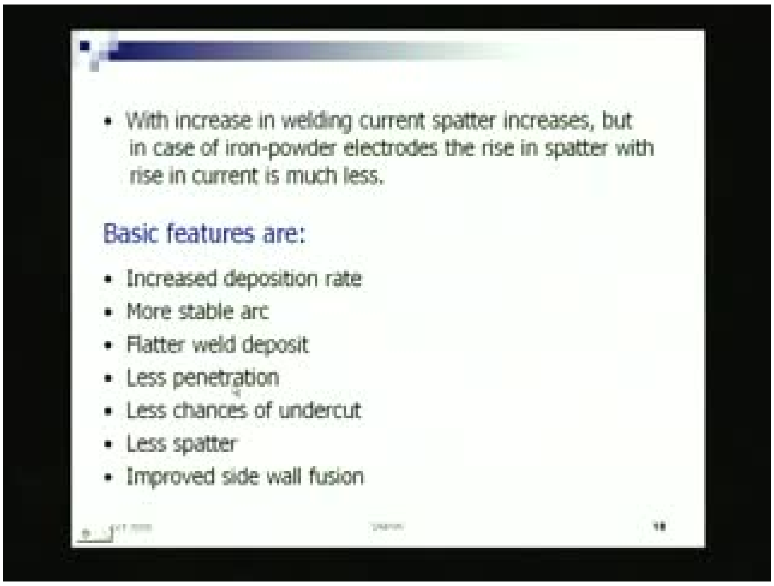
(Refer Slide Time: 11:12)



(Refer Slide Time: 11:52)



(Refer Slide Time: 11:59)



With increasing welding current, generally spatter increases. That is another increase in welding not only it may lead to overheating of the electrode but spatter also increases, but in case of iron powder electrode, rise in spatter is much less. So, that is another advantage. So, the basic features are increased deposition rate, more stable arc, flatter weld deposit means generally you get a smooth deposit not a very, I mean high crown not like this. However, it gives less penetration, less chances of undercut, less spatter and improved side wall fusion.

Sir, powder is on the inside.

Powder is in that flux mixture. You understand? I mean when the flux mixture is being made, you add iron powder there. That is how you made it like calcium carbonate, calcium fluoride plus.

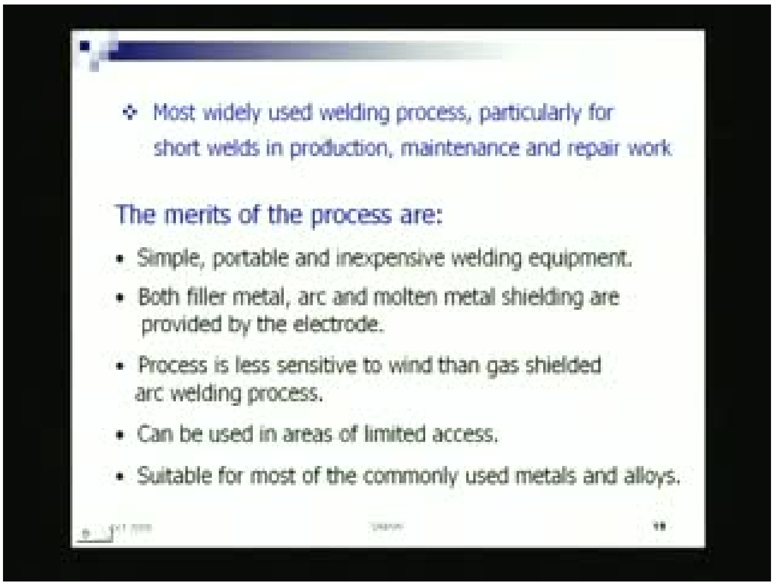
So then, it will be made out of projected carbon when it is…

No. Protective cover it is being it is providing say a basic electrode with iron powder, basic electrode the flux composition primary composition is calcium carbonate and calcium fluoride, and to that, I have added say 25 percent additional iron powder in it, and thereby, it produce the best and apply it over the electrode. Of course, they are all machine manufactured you do it. You have a machine to do that. Dry it up, you get the electrode with a flux coating. Now, when you use it that flux is having additional iron powder, that is the only difference, and

But here, again it is more liable to get corroded then what will it…

No, you are not getting. What is happening in that heat, in that arc heat? Whatever iron powder, it is in the form of iron powder only. That gets melted along with the electrode, and rest part of heat is there calcium carbonate and calcium fluoride and other whatever is there, they are burning and forming slag and giving fumes as usual. That is remaining. Instead of increasing the diameter of the electrode, I could have done that way also. Increasing the diameter of the welding wire inside, thereby increasing the current carrying capacity could have done but that has a other implications. Here, what is happening? By providing iron powder, the entire electrode is not becoming very conductive. It is only at the tip where it is getting heated up where the iron powder is just about to melt. So, that is how, that is how just the arc that is getting welded.

(Refer Slide Time: 14:23)



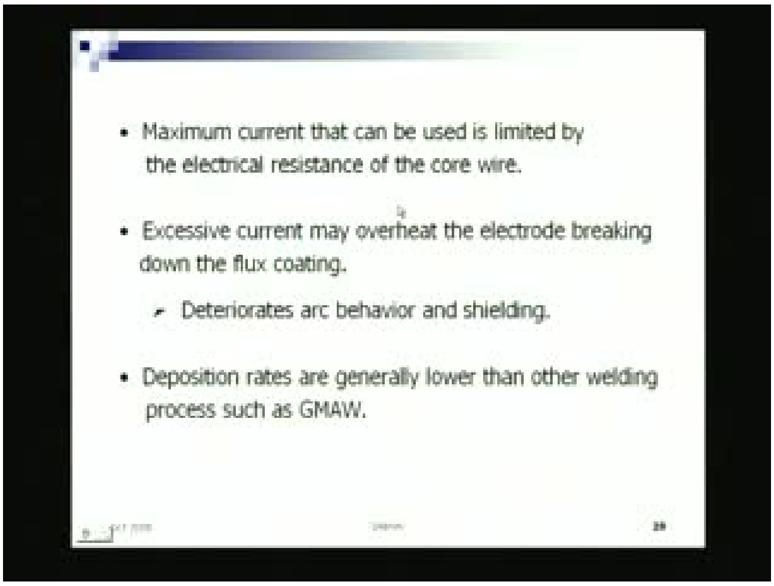
So, most widely used weld. So, what we see that this shielded metal arc welding process, this whole SMAW is the most widely used welding process particularly for short welds in production maintenance and repair work. Like in shipbuilding, you will find wherever there is, there is a long welds or unobstructed welding. One can implement machine welding, but rest all places you will have to do manual where access is difficult, where the weld length is shorter, and obviously, where you need to just locally little bit you will have to weld for repair purpose, for maintenance purpose. You have no other option other than primarily manual metal arc welding.

So, merits of this process are like it is simple; it is portable, inexpensive welding equipment. These are some of the real merit. Both filler metal arc and molten metal shielding are provided by the electrode; that means that total shielding is just by the electrode unlike in other process where you will have to give external gas or external flux. It is everything contained in the electrode. Total shielding is produced by the electrode; that means you only carry a welding torch where you know clip the electrode and do the welding. You do not need anything else.

Process is less sensitive to wind, to wind, as compared to gas shielded arc welding process. Suppose they are doing welding in outside environment, because in shipbuilding, you will have to think about that. You will have, you not always you will have a very good comfortable shop like environment. You will have to do outdoor welding. Now, gas metal arc welding which will next there that is get affected, the weld quality gets affected if there is a strong wind. Here, strong wind means just wind blowing across. It is less sensitive. It can be used in areas of the limited access like I was saying where accessibility is very difficult.

There I can use suppose this small component has to be welded. So, I can easily access with the welding electrode because that is a narrow long electrode. I can access that, that is, these are very important aspects suitable for most of the commonly used metals and alloys means you have various kinds of electrodes available. So, you can choose the right kind of the electrode for a right. For the metal, for the alloy, you are going to weld.

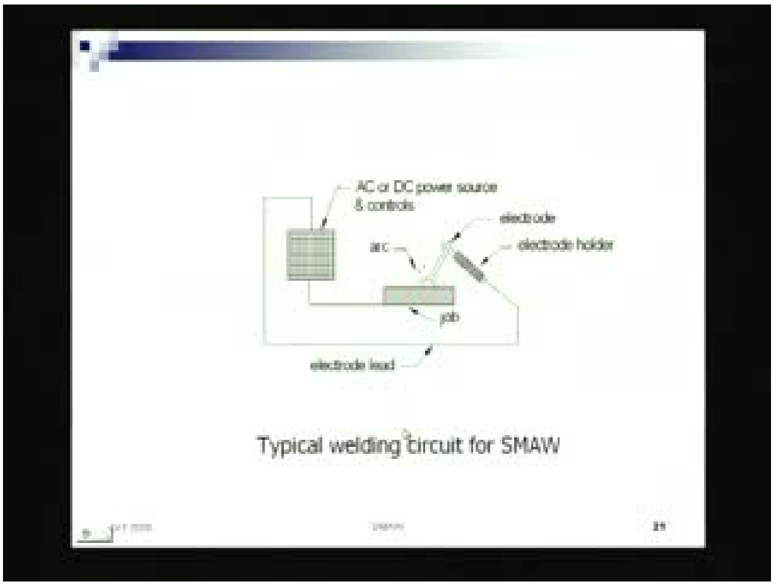
(Refer Slide Time: 17:17)



So, here, the maximum current that can be used is limited by the weld. These are some of the features limited by the electrical resistance of the core wire. So, that is what I am saying it is limited by the resistance of the core wire. Resistance depends of the diameter of the wire, depends on the length of the wire. The electrode length is fixed, diameter is fixed. So, its resistance is also somewhat fixed. So, there what we are doing by providing that iron powder and increasing the conductivity down at the electrode such that I can apply little more current to achieve more generate more heat and thereby more deposition.

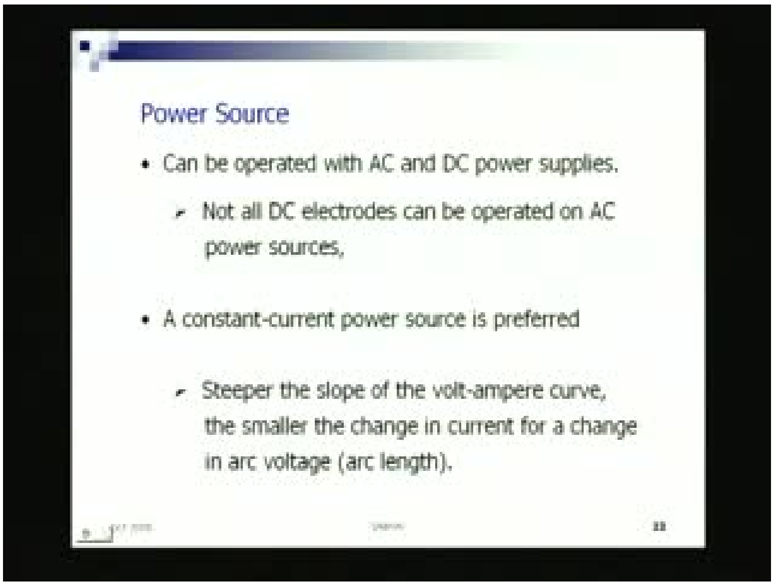
This is what I was telling excessive current may over heat the electrode, breaking down the flux coating. You may have observed while doing your workshop practice that, when you try to establish the arc and if you a very untrained hand, you will fail to do that immediately. So, there at times, it gets stuck and the whole electrode gets heated up and becomes red hot, whereas current is continuously flowing and the resistance of the electrode gives the joule heating and the whole electrode becomes the red hot. In that heat, the flux gets damaged; that means that electrode becomes unusable. We will have to just throw it. So, that electrode breaking down flux coating. So, there what is happening? Excessive current is flowing basically because it got short circuited; it got stuck to the plate. Excessive current is flowing; it is getting damaged. Deposition rates are generally lower than other welding processes well.

(Refer Slide Time: 19:05)

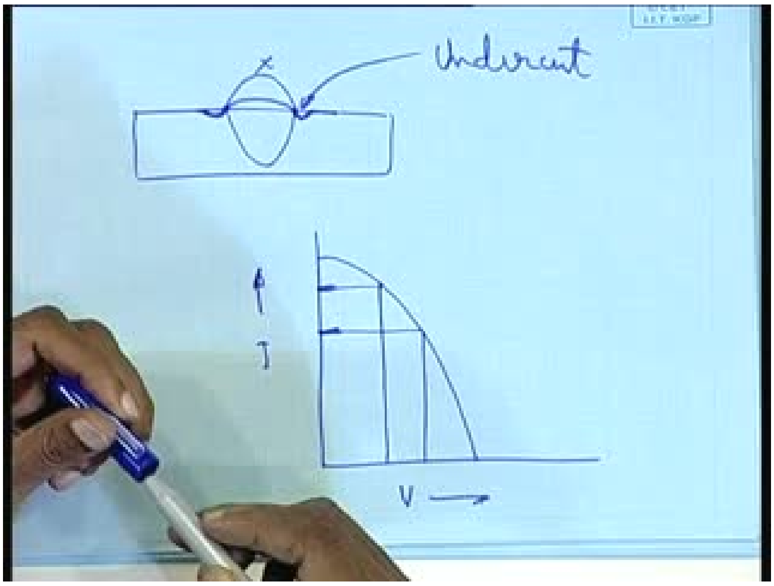


So, this is a very simple schematic of the thing. So, as you can see the power is supplied at the tip of the, I mean power flows through the entire electrode. Unlike in other welding processes, there the power is given right at the tip of the electrode as near as possible, but here, it is given right at the end of the electrode. So, over the entire electrode, the power flows. So, if it get stuck, the whole electrode will get heated up.

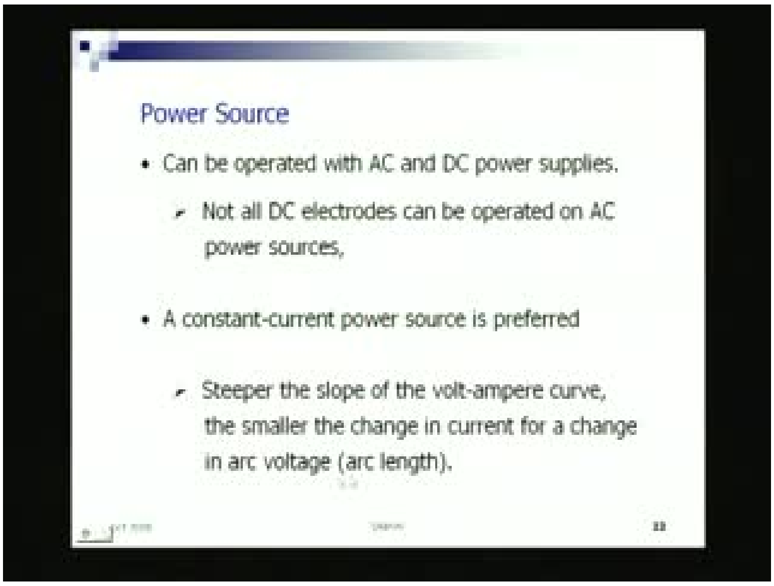
(Refer Slide Time: 19:41)



(Refer Slide Time: 20:26)



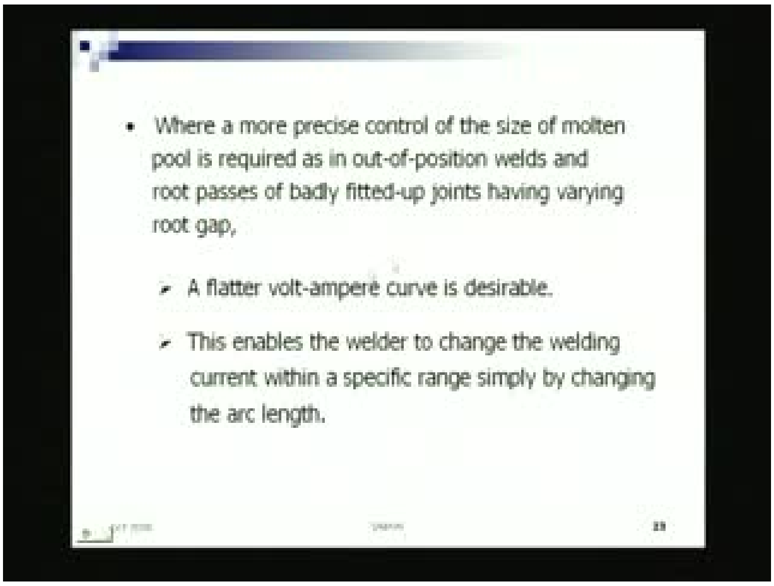
(Refer Slide Time: 20:57)



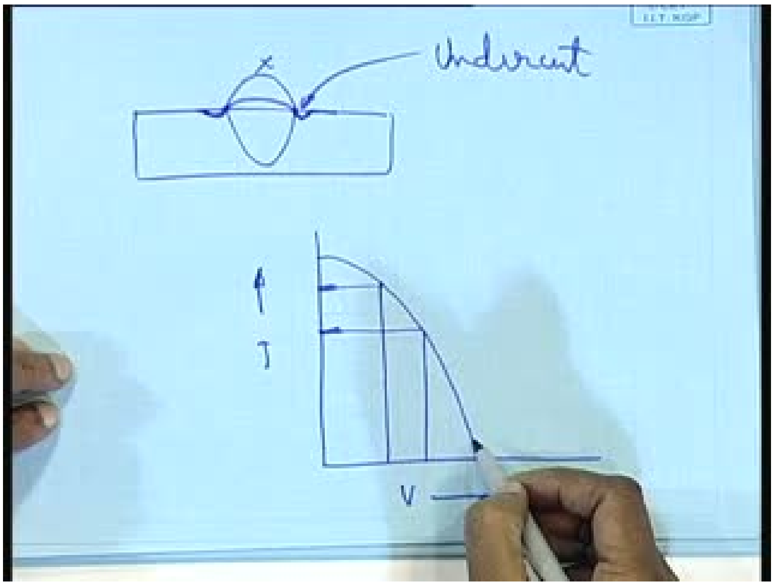
The power sources for this shielded SMAW, it can be operated with both A C and D C as we have seen but not all D C electrodes can be operated on A C power supply. They will not perform well generally a constant power source is preferred. Constant-current power source means it has a steeper slope of the volt-ampere curve; that means a smaller change in the current for a larger change in the arc voltage; that means the current this is what is a constant current power source. Say this is my current and this is the voltage plotted. So, you will have a wider change in the voltage will produce a lesser change in the current. That is how it is said constant power source. Why that is important because arc voltage is essentially related to arc length.

If the arc length increases, the arc voltage increases because arc voltage is nothing but the voltage drop across the arc length. You can think in terms of as if arc length has a resistance r a, which is multiplied by the welding current in the circuit. So, the voltage drop across the plasma column is a arc voltage. So, increase in arc voltage essentially means increase in arc length. When I am doing manual welding, my hand may shake little bit that leads to increasing and decreasing of the arc length small increase and decrease. That small increase and decrease can lead to fluctuation in the heat generated because the current will fluctuate. So, a constant current source, constant current power source will reduce that effect; that means a wider change in voltage will have a less change in the current. So, that is why a constant current power source is preferred.

(Refer Slide Time: 22:08)

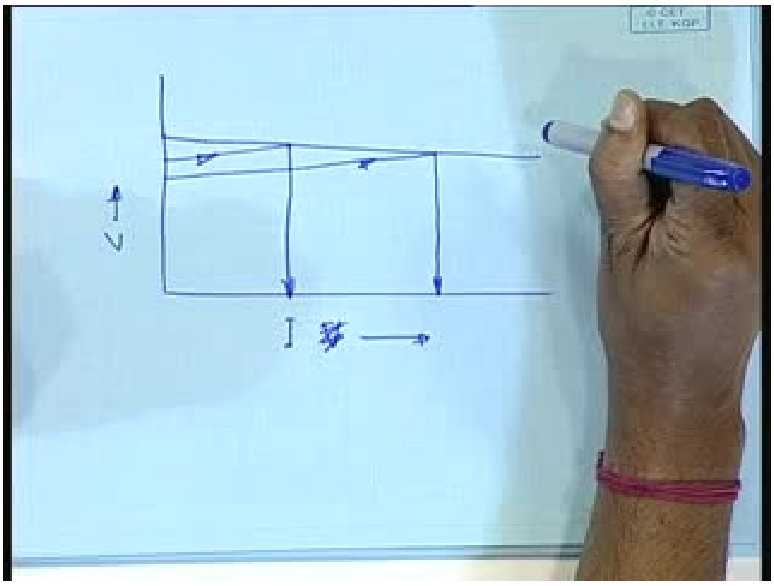


(Refer Slide Time: 22:37)



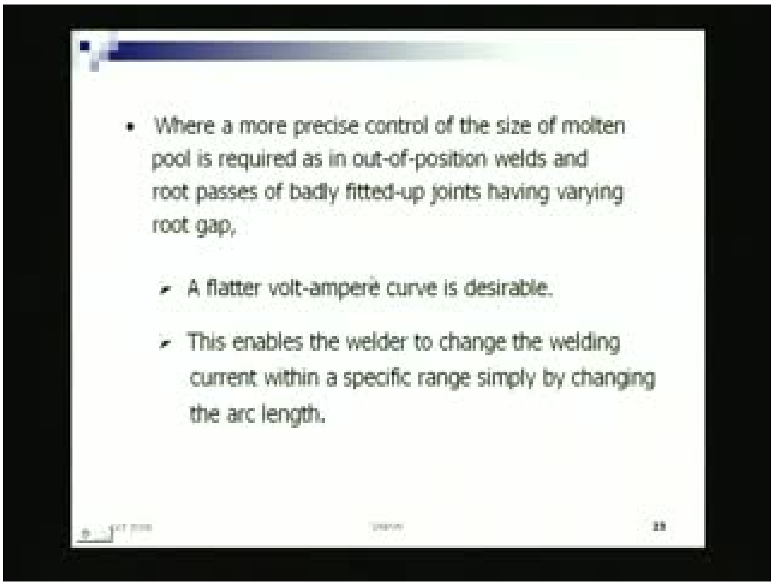
So, where a more precise control of the size of molten pool is required as in out-of-position welding root passes of varying root gap. A flatter volt ampere curve is desirable. What is that flatter? It is essentially more nearer to constant voltage type. Here, what is happening in a flatter? It is a steep characteristics.

(Refer Slide Time: 22:44)



A flatter characteristics would be another extreme would be like this. Here, you have the voltage. I am just writing the opposite, is not it?

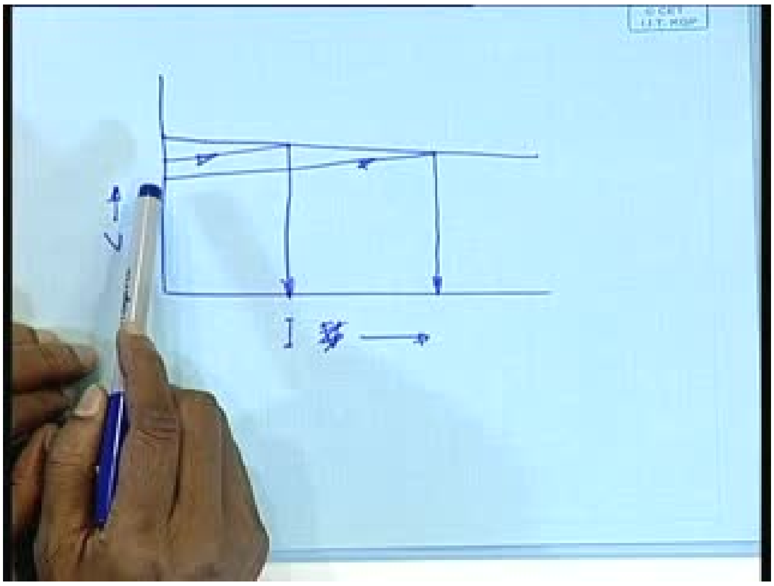
(Refer Slide Time: 23:47)



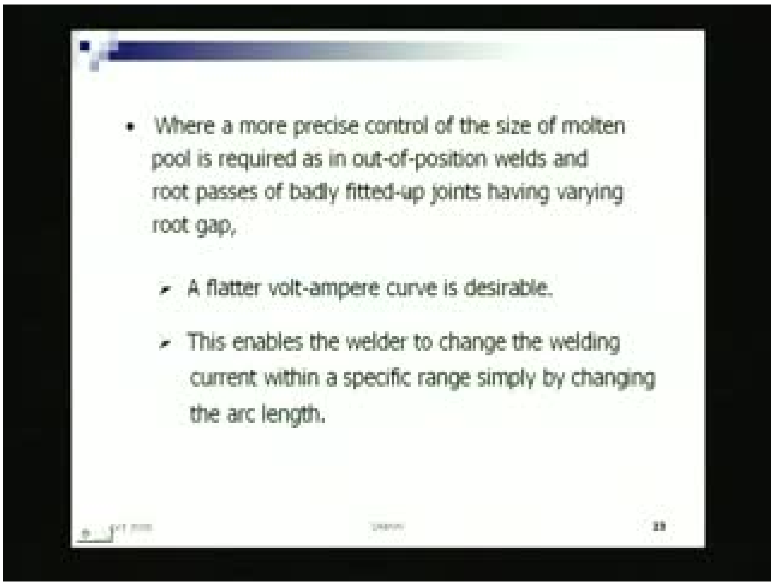
So, here, we can see a small change in voltage will have a very high change in current. Same thing probably there also you may have used; that means a small change in the voltage will have a substantial change in the current. What does that mean? That means a skilled welder, a skilled welder can just manipulate with the welding electrode and vary the deposition rate substantially. That is why it has been mentioned that, when you need a more precise control of the size of the molten pool, where it is needed like in out-of-position that could be one place or in the root passes of badly fitted-up joints.

Badly fitted-up joints means what? Where you have the root gap un-uniform very much some repair welding you were doing. Locally you have gas cut a place and you have to weld something. So, we have very uneven shape. In some places, the gap is more; in some places, gap is less. Where the gap is more, we will have to deposit more metal; gap is less, we deposit less metal.

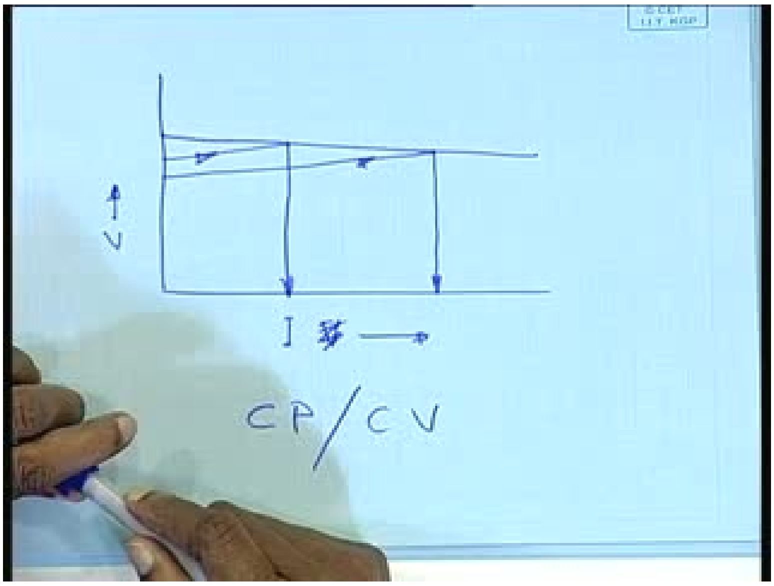
(Refer Slide Time: 24:43)



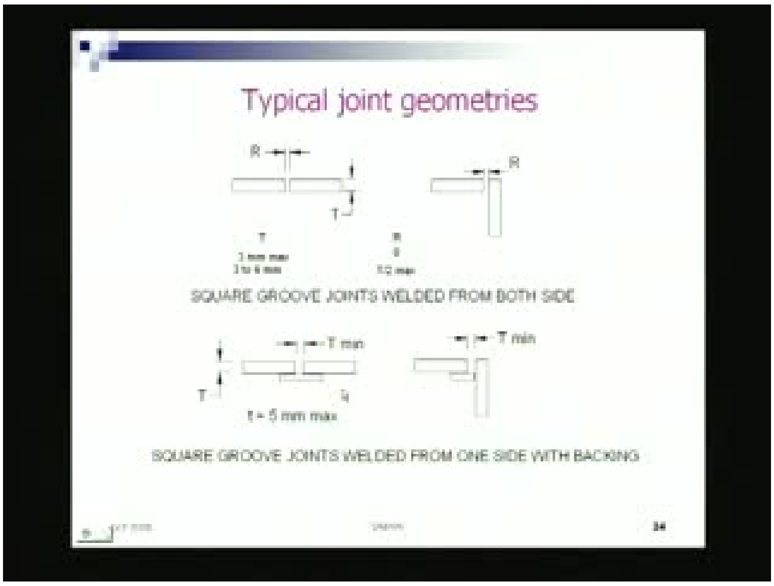
(Refer Slide Time: 24:56)



(Refer Slide Time: 25:09)

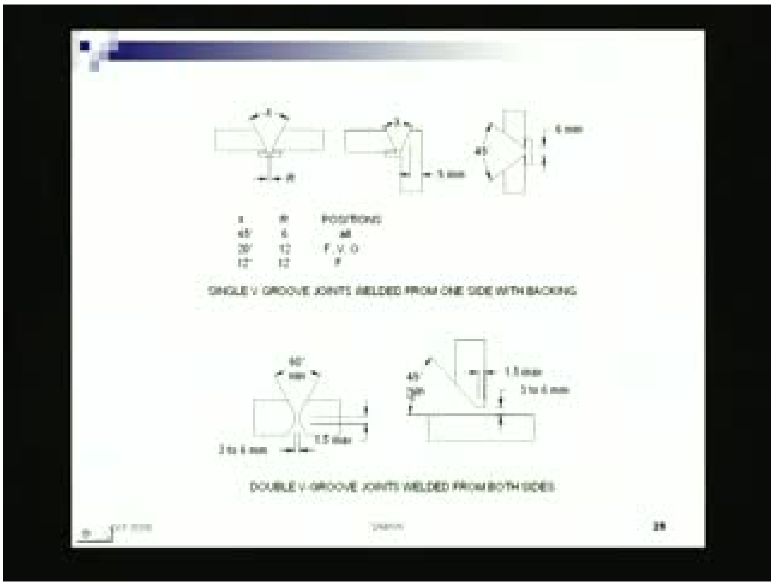


(Refer Slide Time: 25:22)



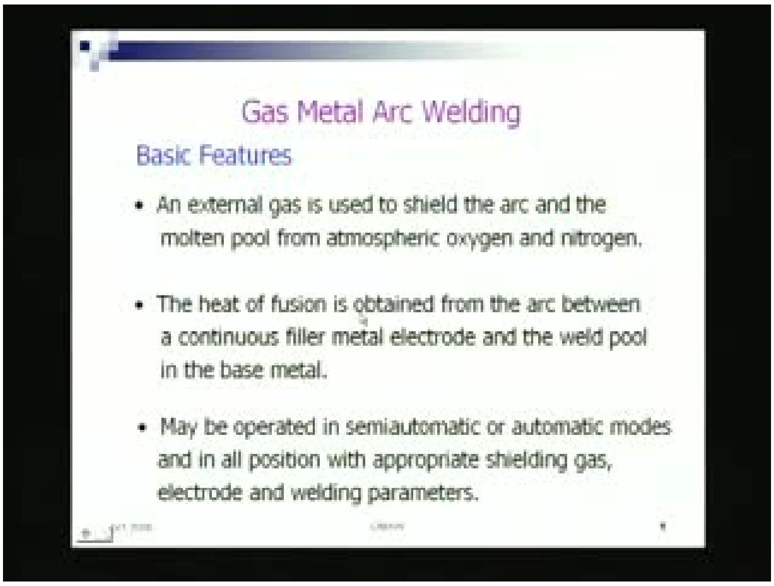
So every time we cannot go and change the setting in the machine. Instead a skilled welder, he will just change the arc length. That changing arc length is in fraction of millimeter range but a skilled welder can do that, and as you can see by doing a little change in the arc length means little change in the arc voltage. You have a very wider change in the current. So, thereby, you can change the melting rate, and thereby, the deposition rate. So, manual for a unskilled manual welder constant current is preferable. For a skilled welder, he will prefer a flatter current characteristics. These are referred to as constant C P or C V - constant potential or a constant voltage - power source like you have seen. Here, I have mentioned that.

(Refer Slide Time: 25:37)

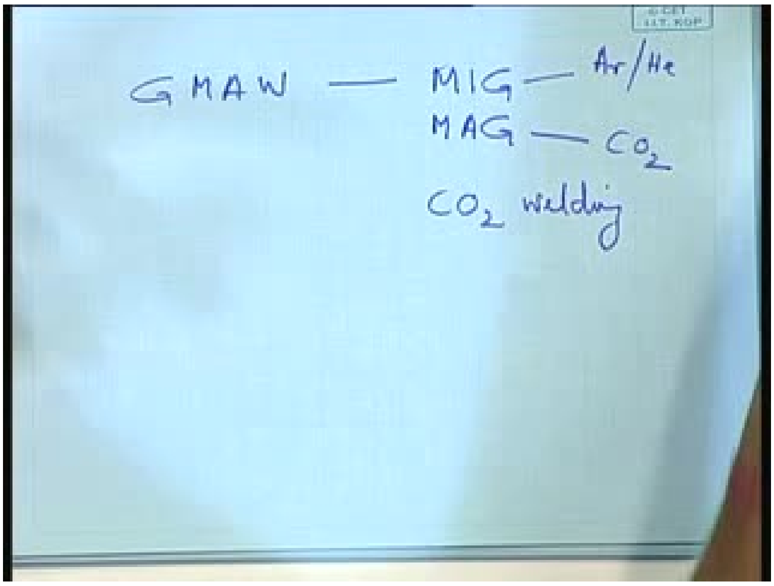


Here, the typical joint geometries. This is a butt joint with a square butt joint; this is a square butt joint with a backing strip; this is a fillet with a backing strip; this is a single v with a backing strip; this is the horizontal welding situation. This is a double v; this is a single v for a fillet weld like that.

(Refer Slide Time: 26:04)

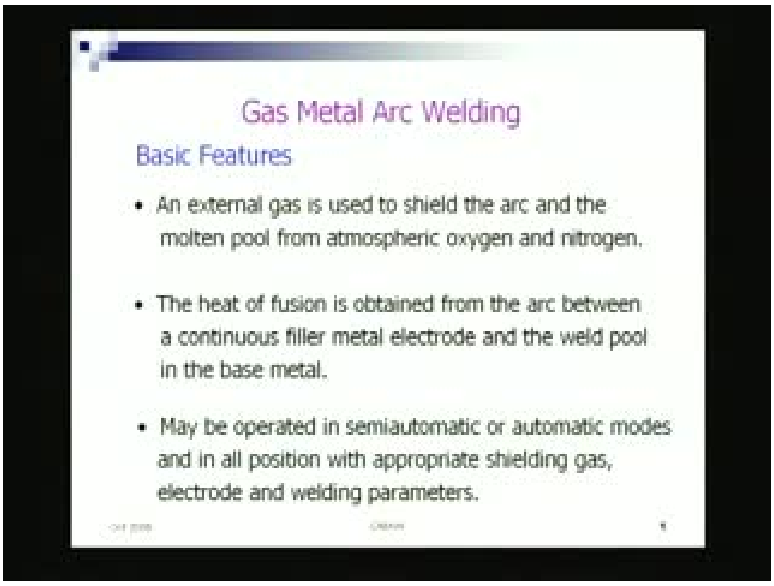


(Refer Slide Time: 26:27)



So, next, we will go over to the gas metal arc welding, gas metal arc welding process. As you can see the name, previous one was shielded metal arc welding - SMAW - or manual metal arc welding. Here also shielding is being done, but here, it is being done by gas. This gas metal arc welding or also is refer to as GMAW which has, which has some other conventional names also. May be worthwhile to know, that is, MIG - metal inert gas – no, TIG is tungsten inert gas right. So, it is MIG also called MAG. - metal active gas - Generally MIG is when you weld with argon or helium or mixture active gas is C O 2. C O 2 also at times referred to as C O 2 welding. C O 2 welding is nothing but one of the GMAW process. - gas metal arc welding process - GMAW is a universal name that is all.

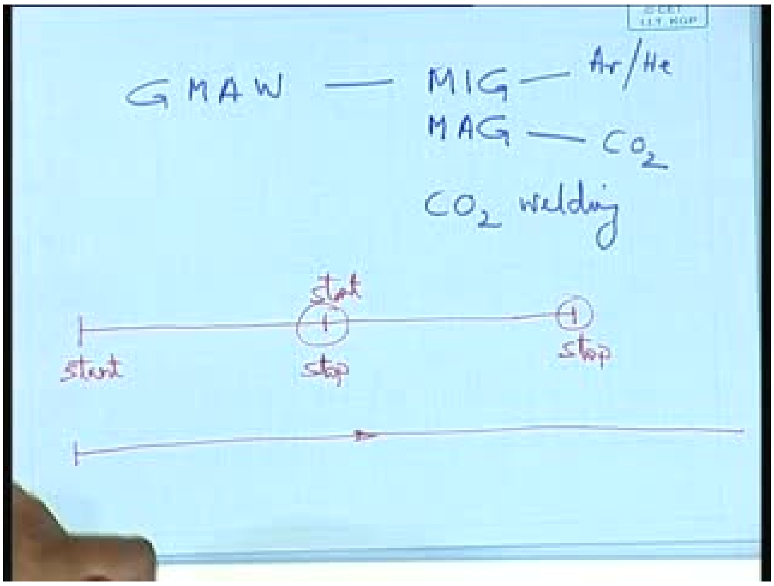
(Refer Slide Time: 27:23)



So, what we see? What are the basic features that here an external gas is used. Unlike in shielded metal arc welding, there the electrode was all in one. It was doing the arcing business; it was doing the as a behaving as a filler metal. It was also doing the shielding purpose for the arc column as well as for the molten metal everything sort of all in one. Here, what we have? We have a external gas source. External gas which is used to shield the arc and the molten pool both; that means there the molten pool was shielded by molten flux, molten slag, but here, that external inert gas which is being pumped in. That is giving the required protection through the molten core as well as to the arc, arc column because the column also needs to be protected, why? The metal transfer takes place.

The heat of fusion here is obtained from the arc between a continuous filler wire filler metal electrode and the weld pool in the base metal. This is also a arc welding process; here also the heat is generated from the arc which we have from the, the difference here is you have a continuous filler metal electrode. A continuous electrode being fed in the process there we had stick electrodes of a certain fixed length.

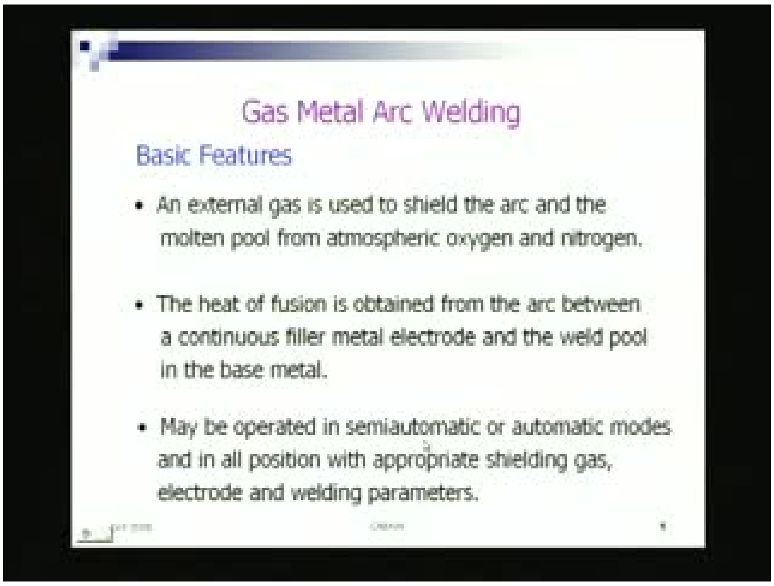
(Refer Slide Time: 29:32)



So, the process was, that means you start the welding, it ends, electrode ends. So, the small remaining part you throw off, take a new one, again you start. So, you will have over the entire welding length various starts and stops, is not it? That starts and stops will depends on the length of electrode, and having too many stops and starts are not good, because wherever you are having starts and stops means suppose one electrode welds up to this much. So, here, you have started, and here, you have stopped. Then again, you have started, and again, you are stopping here.

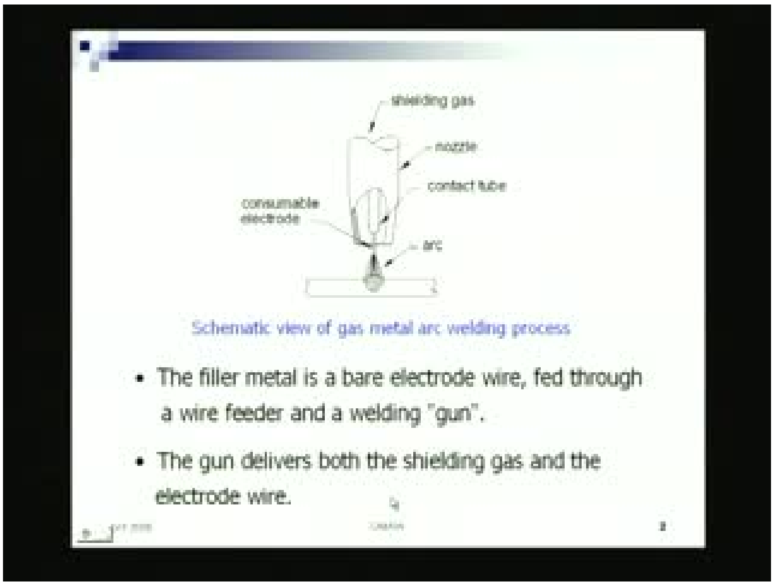
So, this start and stop business will continue. So, these places becomes vulnerable to some defects, and not only that, it is a process becomes slower every certain length. You have to throw the butt and put a new electrode; again start welding, whereas in gas metal arc welding, the electrode fitting is continuous. So, you go on continuously as long as you can. If it a continuous long welding, you just go on moving your hand as far as you can sustain. Then again stop, again start from there but the electrode feeding is the automatic through a feeder mechanism, it goes.

(Refer Slide Time: 30:32)



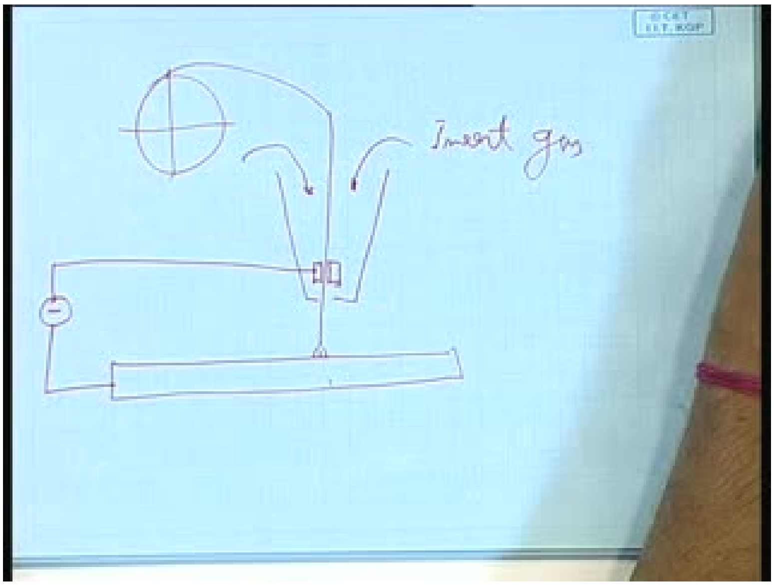
So, that is a continuous filler metal. So, it may be operated in a semi-automatic manner. That is what is semi-automatic what I have told just now told; that means the feeding is through a feeder mechanism, whereas moving the electrode is manual. So, that can be referred to as semi-automatic process or automatic means you mount it on a carriage which moves automatically and you can be operated in all positions with appropriate shielding gas electrode and welding parameters; that means this is also can be used for all positional welding overhead vertical sideways depending on proper shielding gas electrode dia and welding parameter.

(Refer Slide Time: 31:20)



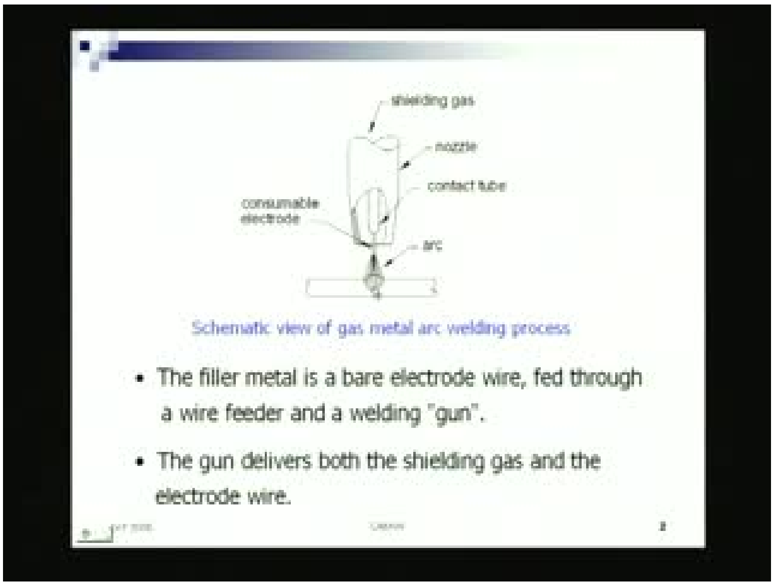
So, this is schematic of the nozzle. So, here, you will have the electrode coming out from the contact tube. Here, something we have drawn as a contact tube. The contact tube means the power is fed here at this point. This contact tube is connected to the cable. Why contact tube? That is making contact with the electrode going through. So, that is what is the contact tube. Electrode is coming out from the contact tube means here it gets the electrical current. So, one power point will be connected to this; another terminal will be connected to the job. So, thereby and the well may be you can see schematically.

(Refer Slide Time: 32:13)



So, essentially, it is like this. So, your power is connected here to the contact tube another terminal to the job and a continuous electrode is fed in, and through the nozzle, you give the so called inert gas. This inert gas provides you the necessary shielding as well as this inert gas acts for the plasma column.

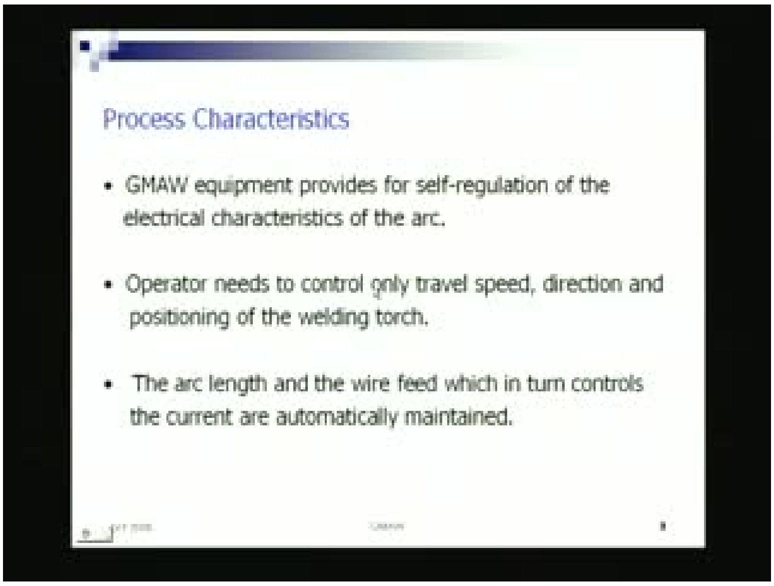
(Refer Slide Time: 33:29)



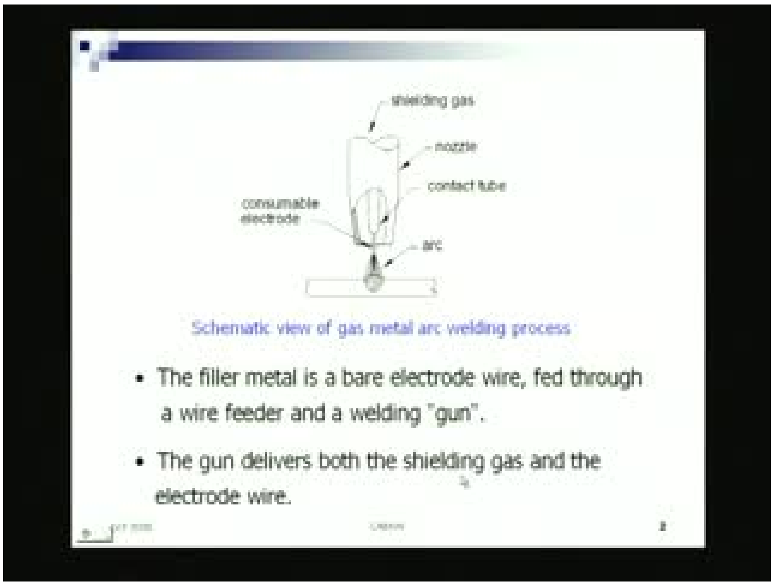
That gas gets ionized. So, what gases, gas you are giving that will determine the, determine the, property of the ionized column. That will determine how much heat is generated or that will have a effect on the heat generated, and thereby, you will have a effect of melting rate, fusion rate, fusion depth, penetrating power. So, that is what it is. So, the, here, the filler metal essentially is a bare electrode wire in the shielded metal arc welding; it was a coated electrode.

Here, it is a bare electrode fed through a wire feeder and a welding gun. This is the gun basically, I mean the, only the last part of the thing a kind of a gun where you have a trigger. You trigger it, the electrodes starts feeding. That is nothing but a switch which starts the feeder motor such that the it pulls the wire as well as the remote the machine it switches on. So, the power is also fed to the electrode. Whatever, that is what is referred to as welding gun and a wire feeder there. The gun delivers both the shielding gas as well as the electrode wire. As we can see through here, the shielding gas comes out as well as the electrode.

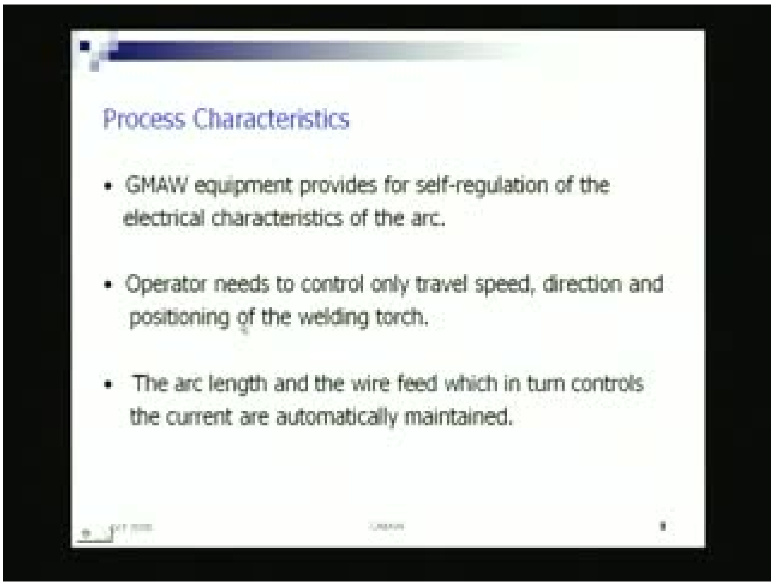
(Refer Slide Time: 34:28)



(Refer Slide Time: 35:20)



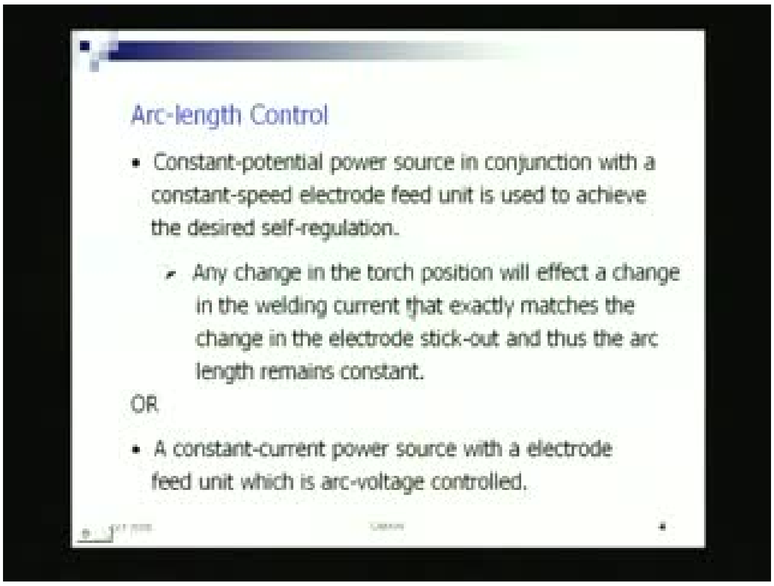
(Refer Slide Time: 35:31)



So, what are the process characteristics? This GMAW equipment, this is a one thing interesting it provides for self-regulation of the electrical characteristics of the arc. Self-regulation means since the wire feeder is a mechanical feeder; that means the electrode is getting fed automatically; that means the rate of feeding is constant, whereas in manual metal arc welding, rate of feeding depended on me on the welder. How he is because the movement of hand would be something like this. Instead of if I make the movement of the hand like this, it is different; the feeding rate is different, but here, the feeding is through a so called feeder.

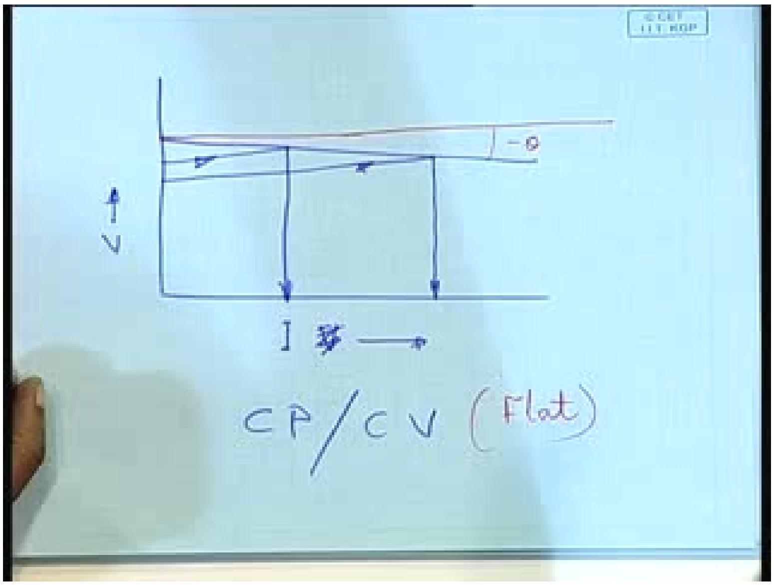
A wire feeder means mechanically it is being put in. So, it is a uniform input of wire, uniform feeding of electrode. So, that needs a regulation of the arc characteristics. It should have a automatic self-regulation. Self-regulation means control of the current. So, operator here needs to control only the travel speed; operator needs to control only the travel speed, direction and position of the welding torch.

(Refer Slide Time: 36:59)



There in shielded metal arc welding, operator also needed to control the arc length because it is not self-regulating; it is not sensing or not acting of its own unless you change it. The arc length and the wire feed, they are interconnected, because if the wire feed is too fast, arc length will tend to become shorter. The moment arc length is tend to become shorter, then the, it should be such that the current should increase burn, melt more of the electrode such that it regain the required arc length that is regulation, self-regulation. So, arc length and the wire fed which in turn controls the current are automatically maintained that is a, that means it has, it is built in with a self-regulation systems, self-regulation facilities.

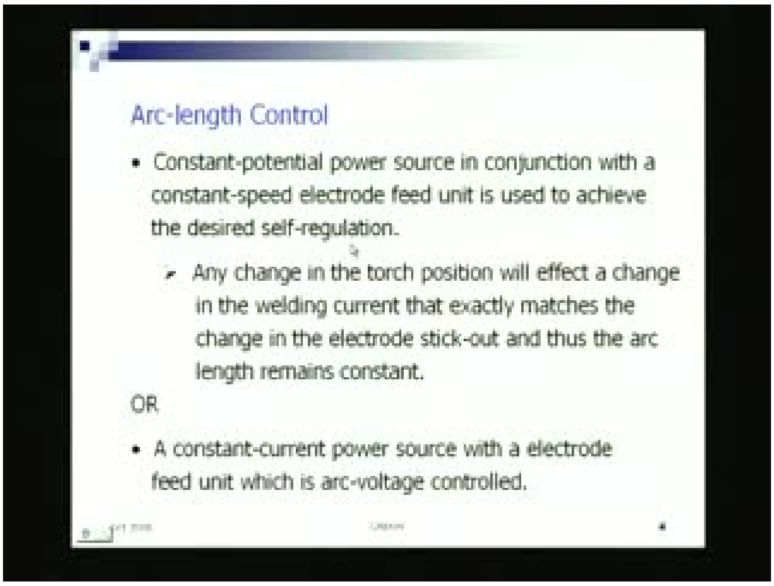
(Refer Slide Time: 37:38)



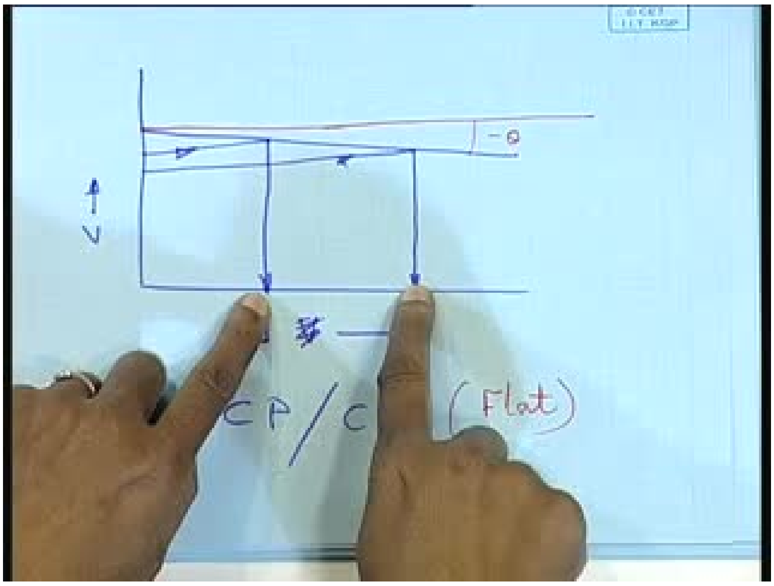
Basically, regulation of what of the arc length, why arc length because arc length co-relates to the arc current, which co-relates to the depositional rate because I need required, because at the end of the day, welding means one of the aspect you need is required deposition. Required metal deposition should take place. So, here, what is done? Constant potential power source in conjunction with a constant speed electrode feeding it is used.

Constant potential power source means power source having a voltage current characteristics like this which is also referred to as flat power source. A voltage current characteristics like this is used. Ideally it should have been horizontal, but it is, it is not horizontal in any machine. More that machine is expensive. It will, it will tend to become more horizontal, but it will never be perfectly horizontal why? This is a slope; this is a negative slope. That is the characteristics of the machine. Why this slope comes? This is actually refers to the internal impedance; more better to say impedance because it is not only resistance essentially L C R L C circuit inside, so, impedance.

(Refer Slide Time: 38:34)

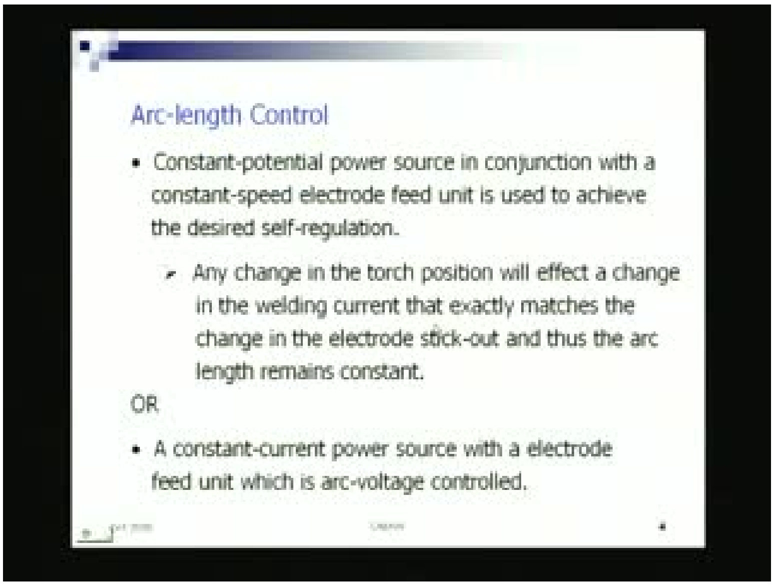


(Refer Slide Time: 38:37)

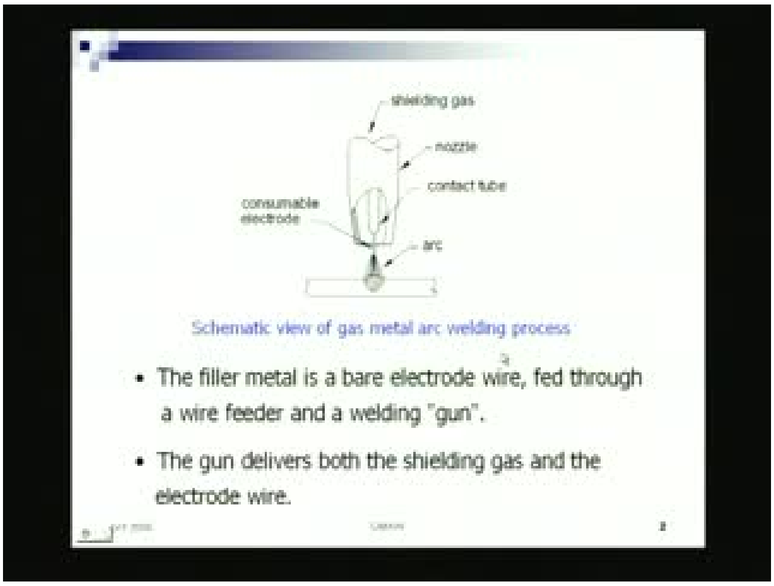


Anyway, so, obviously to have self-regulation, you need to have a flat characteristics, because thereby, as the arc length changes, it gets regularized by a surge in the current because surge in the current can be will be available from a this C P power.

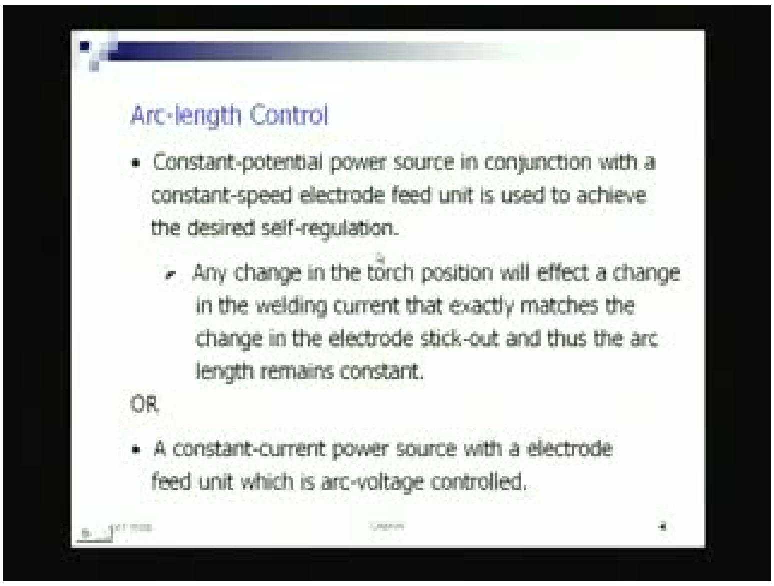
(Refer Slide Time: 38:55)



(Refer Slide Time: 39:04)



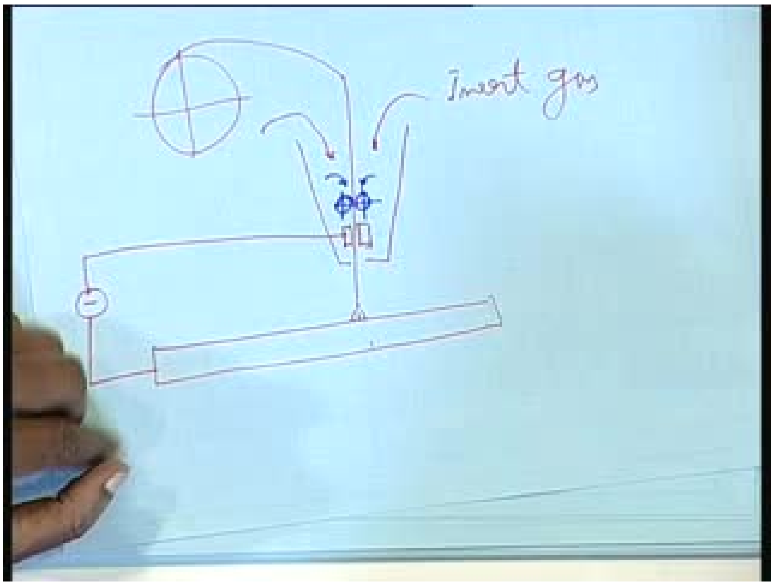
(Refer Slide Time: 39:22)



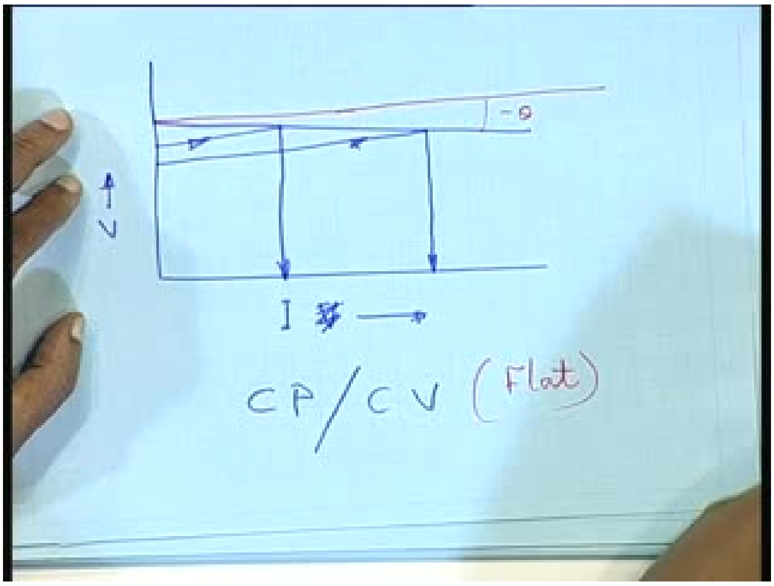
So, any change in the torch position will effect a change in the welding current. That exactly matches the change in the electrode stick out. Electrode stick out is this length, this particular length; that means length from the tip of the nozzle from where, the electrode is coming out and to the electrode tip where you have the arc. So, this length, this is the electrode stick out length, so, it exactly matches the change in the electrode stick out and thus the arc length remains constant.

So, finally, the idea is are length you will have to maintain constant because the change in arc length will cause change in current; change in current will cause change in deposition rate. So, it will be deposition will become uneven. So, generally this is used; that means constant current or constant voltage, sorry, constant potential C P or C V as you call constant voltage power source is used for gas metal arc welding. In some cases, you use a constant current power source with electrode feed unit which is arc voltage controlled. So, essentially, the feeder unit in this, what is happening? The feeder unit is simple. You have a, it is a very simple device to make this feeder unit.

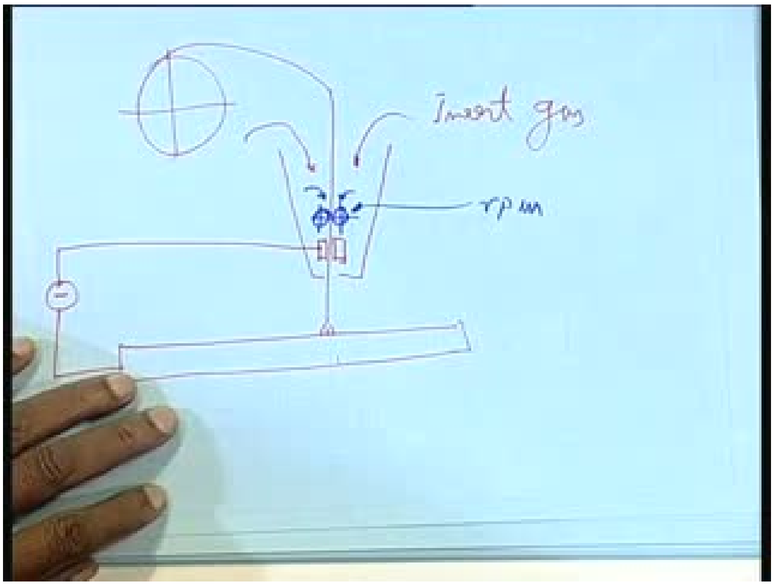
(Refer Slide Time: 40:26)



(Refer Slide Time: 41:00)

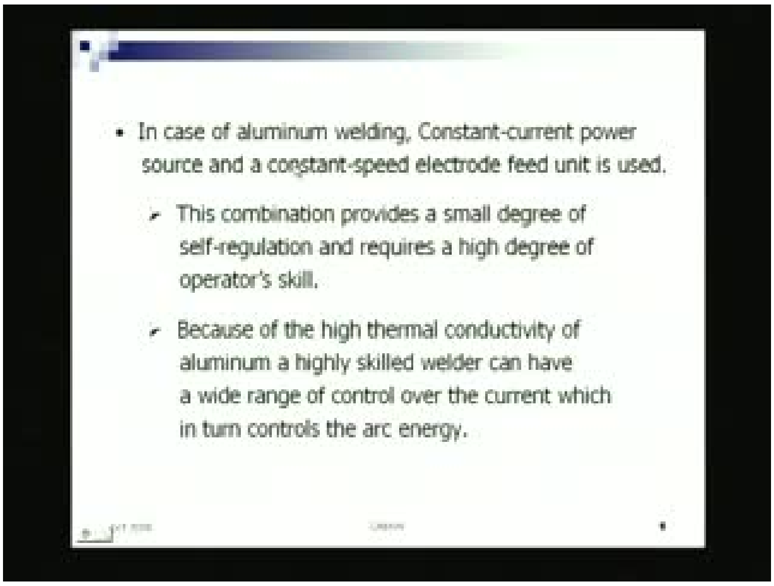


(Refer Slide Time: 41:29)

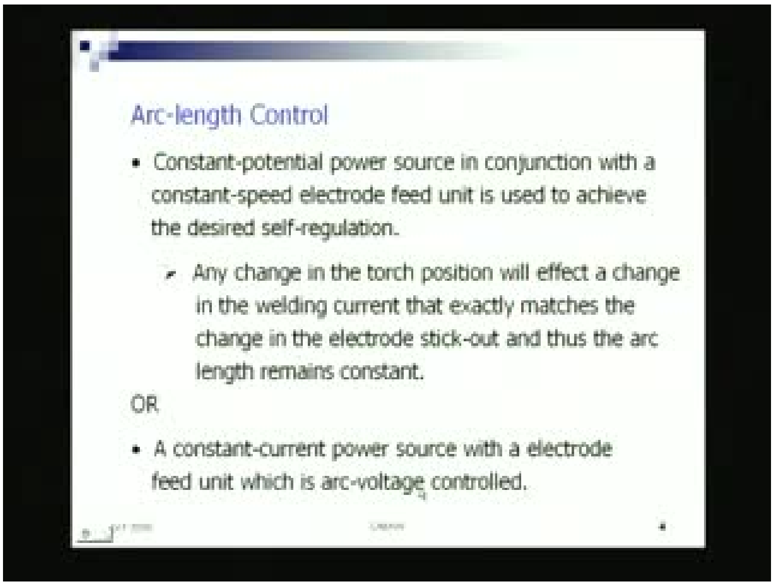


This feeder unit is nothing but you have a motor here; you have two rollers here which are motor driven. So, the moment you switch on, they starts rotating in this direction. So, it will pull the wire. So, depending on this feeder diameter and the r p m, it is rotating; it will go on feeding at the same uniform rate. Increase the r p m, rate will increase. So, constant uniform feeding mechanism is very simple and you are using a constant potential source. Thereby, whenever there is a situation of shortening of the arc length is happening or extending of the arc length, the current levels is changing and bring it back to the required current level. Whereas in the constant current power source, the variation in the arc length is controlled by changing the feeding rate; that means this, here, the r p m changes. That is more difficult. Whereas in some specific cases, it can be the other option.

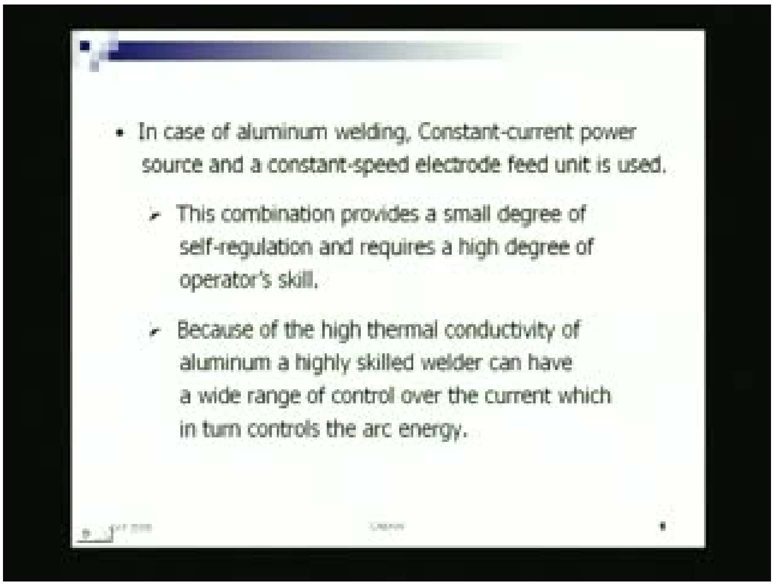
(Refer Slide Time: 41:46)



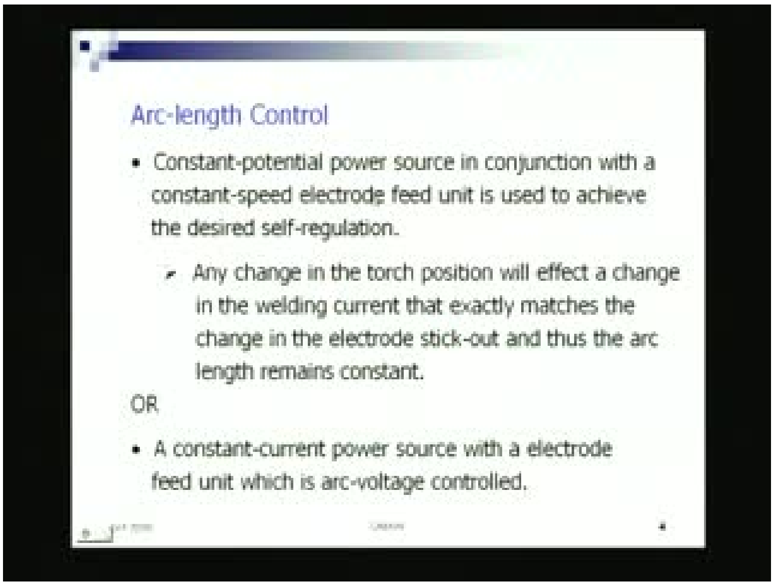
(Refer Slide Time: 41:58)



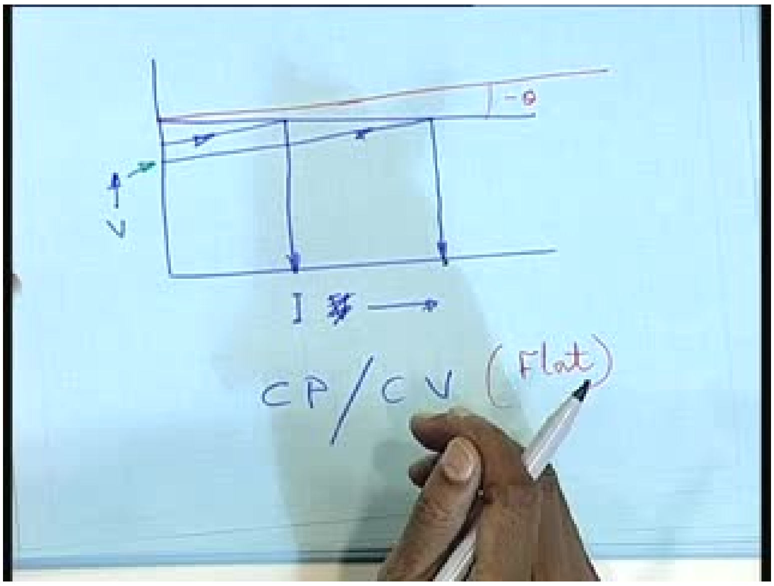
(Refer Slide Time: 42:08)



(Refer Slide Time: 42:34)



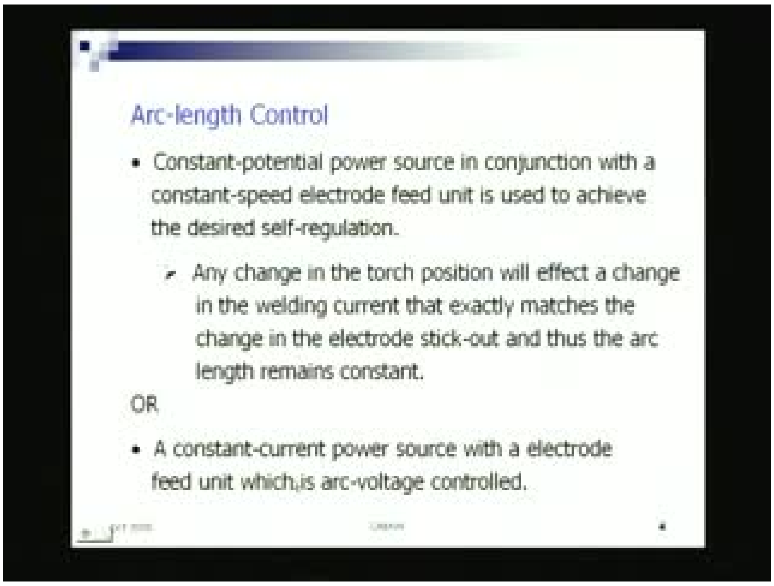
(Refer Slide Time: 42:47)



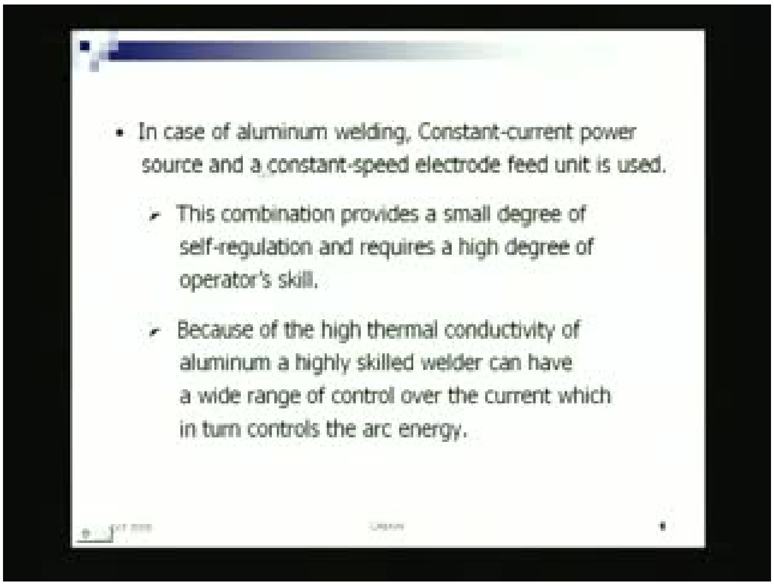
So, in case of aluminum welding, for example, constant power source is used as well as a constant speed electrode feed unit. So, that is note this a constant current power source not a feed unit which is arc voltage controlled; that means say where you can change that, but here, we are using a constant feeding also in aluminum welding. This combination provides a small degree of self-regulation. So, you do not have much of regulation; that means if you are, if you are going closer, that means the arc length is getting shorter. It does not increase the current neither it does not reduces the feeding rate.

In this, it was as the electrode was becoming shorter, it was increasing the current. Like here, you can see electrode arc length becoming shorter means what? The current is dropping; voltage is dropping. Arc length shorter means voltage is dropping. So, as the voltage comes down, the current increases. Thereby, what happens more electrode gets melted and you get back to the required arc length or required arc. That is how the regulation is done.

(Refer Slide Time: 43:18)



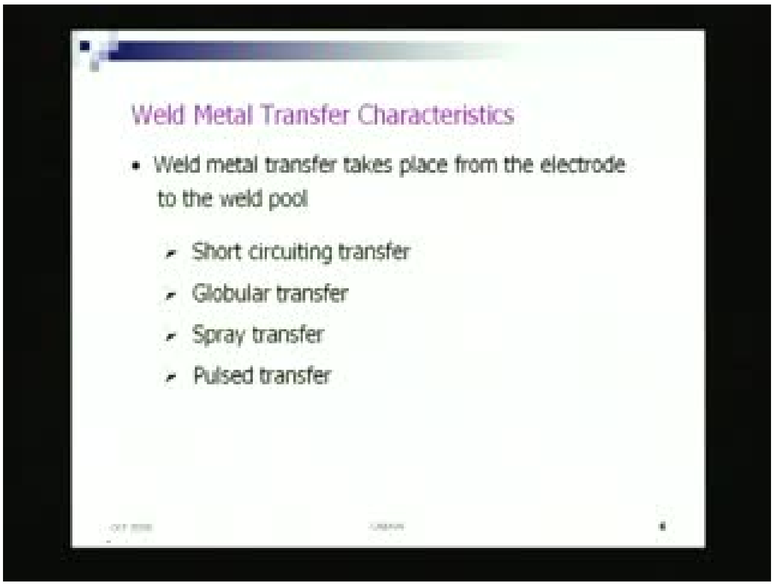
(Refer Slide Time: 43:33)



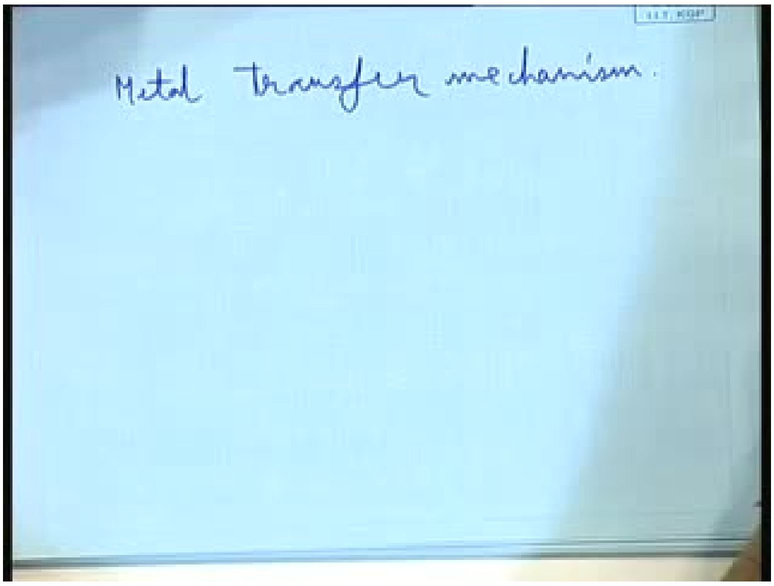
Whereas in the second case, where a constant current power source, there as the, suppose the arc length becomes shorter, then you slow down the feeding rate, reduce the feeding rate, electrode feeding rate. Thereby, you control it, but here, we see in case of aluminum welding, it is neither of them; it is, firstly it is a constant-current. Power source is being used, and with a constant speed electrode feed. Why? What happens? So, this combination providers a small degree of self-regulation and requires a high degree operator skill.

Why that is done? There must be some reason. Reason is this, because of the high thermal conductivity of aluminum, a highly skilled welder can have a wide range of control over the current which in turn controls the arc energy, because depending on the situation, he can increase, decrease the arc energy. Again the same thing like constant potential shielded metal arc welding.

(Refer Slide Time: 44:20)



(Refer Slide Time: 44:38)



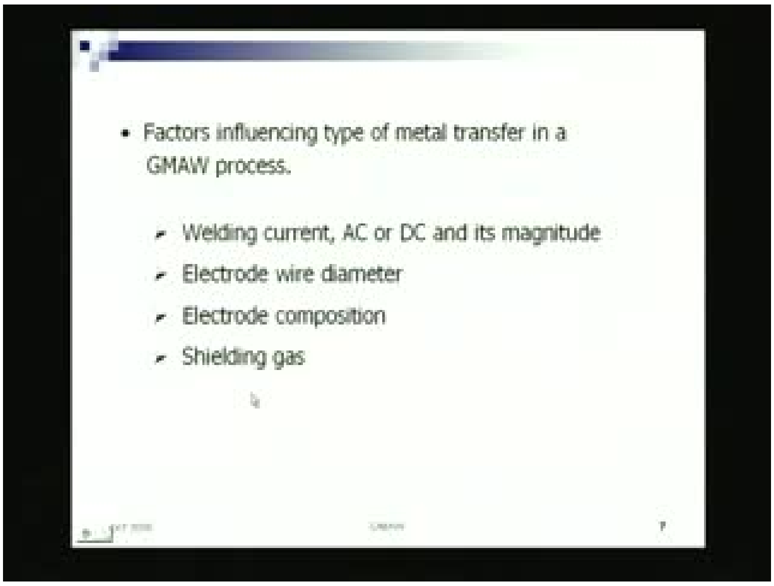
Well, here, in gas metal arc welding, there we talked about overhead welding your metal getting transferred. So, there is something called metal transfer mechanism, weld metal transfer mechanism. So, this is more relevant in case of gas metal arc welding. We can see that there are several way the metal is getting transferred which is feasible in case of gas metal arc welding. Whereas in case of shielded metal arc welding, that those variations are not there. For thus, for the reason the reason the kind of the, behavior of the plasma column, the properties of the plasma column are somewhat fixed there because the kind of gases getting coming out there depending on that.

So, the ionization potentials you cannot play much there. Also at the same time, the current level you cannot increase or decrease very much. Whereas in gas metal arc welding, these things can be changed; that means the shielding medium, what do you call? The property of shielding medium, the amount of current being used in the welding process; the diameter of the electrode also varies substantially.

(Refer Slide Time: 45:54)

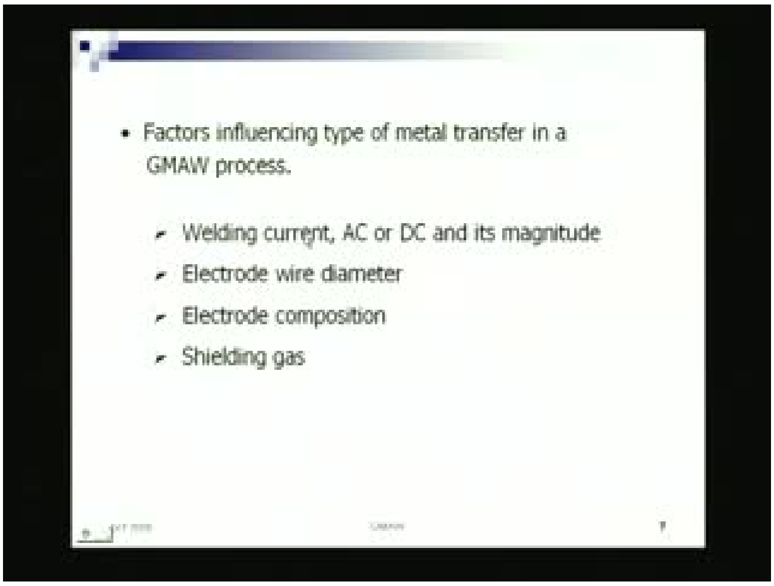
So, what do you see, the weld metal transfer characteristics. What are they? This metal transfer means what the metal transfer takes place from the electrode tip to the weld pool. What I was telling that, if it is unfavorable transfer mode, you have lot of spatters. Again there can be a favorable transfer mode wherein you can have a better penetration. So, we see there are generally four types of transfer mechanism - one is referred to as short circuiting transfer, I mean how the metal is getting transferred from the tip of electrode to the weld pool. One is through a mechanism called short circuiting transfer also referred to as dip transfer. Another is a globular transfer, spray transfer, pulsed transfer. So, we will see what are they.

(Refer Slide Time: 46:49)

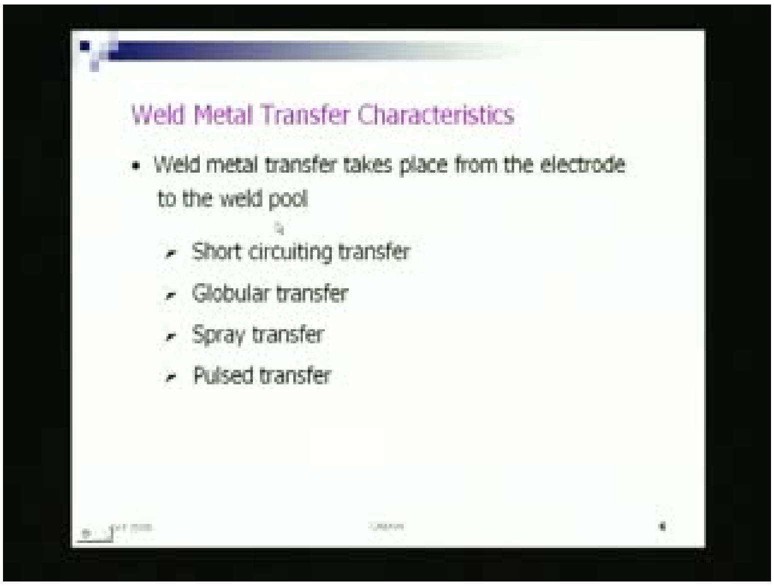


(Refer Slide Time: 46:57)

(Refer Slide Time: 47:04)

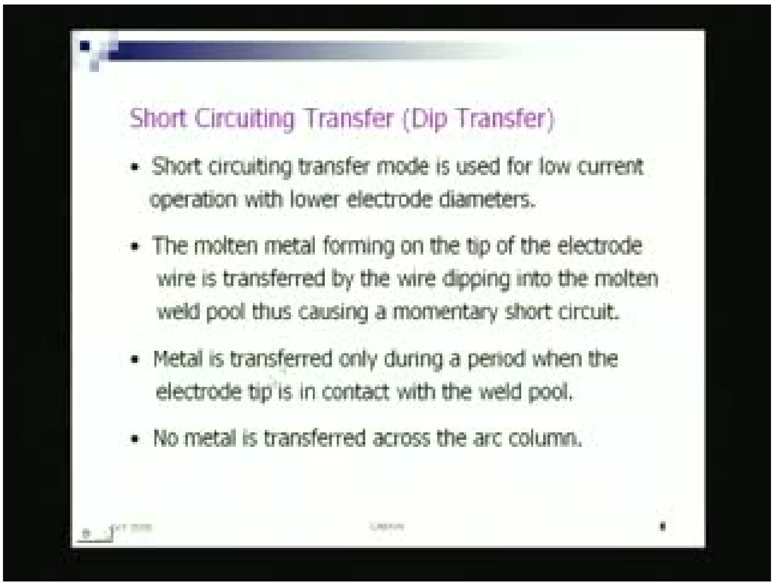


(Refer Slide Time: 47:37)



Factors influencing type of metal transfer in the GMAW process. What are the factors which will decide or which will effect a spray transfer or a short circuiting transfer or whatever. They will depend on welding current whether it is AC or DC supply and it is magnitude; that means this heavily depends on the current. What type of current it is? Whether it is alternating or a direct as well as it is magnitude. Electrode diameter, electrode composition, shielding gas will depend also on the shielding gas, why, because shielding gas, different shielding gas will have different ionization potential. So, that also effects the metal transfer mechanism. There is direct effect on the metal transfer mechanism, and depending on the metal transfer mechanism, your weld quality may change.

(Refer Slide Time: 47:50)



So, let us first see the what is that short circuiting transfer. That is also referred to as dip transfer, why? This is called dip transfer because the electrode is dipped in the molten pool. Like when we are doing manual metal arc welding, it is the electrode tip was never touching the molten pool. Only in the beginning, we did a kind of a short circuit to initiate the arc, which is also referred to as striking the arc. You have struck the arc initiated the process and you are continuing welding. Never you are the electrode tip is touching. The molten pool the moment it touches, it extinguishes the arc extinguishes because suddenly there is a drop in the current; there will be a drop in voltage. Suddenly there will be drop in voltage, there will be short circuit and the arc will go off.

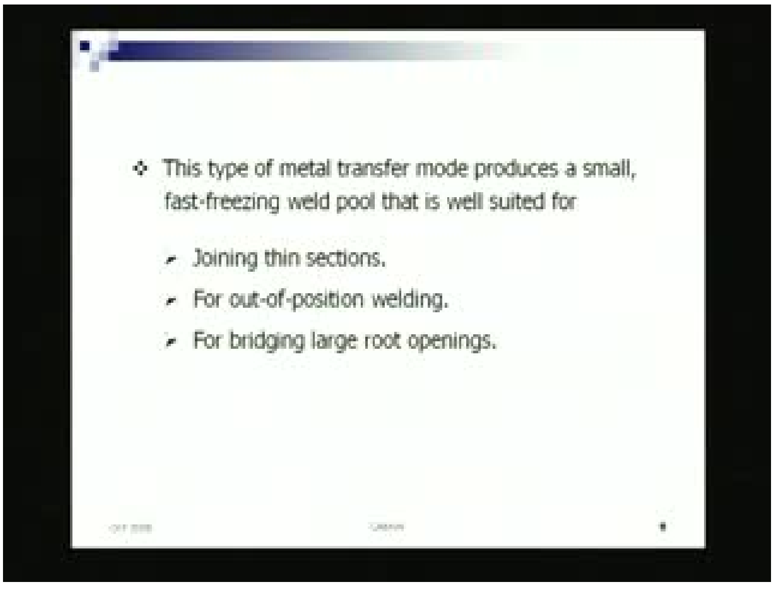
But in short circuiting transfer, it is just the opposite; it is short circuit transfer mode is used for low current operation with lower electrode diameter. Here, actually a short circuit, the moment it gets short circuited, the droplet gets transferred; that means it is a continuous process. Every at a interval, the metal droplet is just touching the molten metal. There is a current surge and the metal is getting detached. That is what happens. That is what is called short circuiting transfer also referred to as dip transfer. This method is used in GMAW where for low current operation with lesser electrode dia. Lesser electrode dia means electrode dia can be as less as 0.8 millimeter.

The molten metal forming on the tip of the electrode wire is transferred by the wire dipping into molten weld pool thus causing a momentary short circuit. That is why it is called short circuiting transfer or also called dip transfer. Metal is transferred only during a period when the electrode dip is in contact with the weld pool. You see when welding is done, metal is getting deposited. It is never like you open a tap and molten liquid is falling off or water is dropping. I mean water flowing out. That is a continuous.

There is a continuity in the flow process, but when you are welding, the metal deposition is not a continuous process. It is a discrete process means at certain interval metal is going. In between, there is nothing. Nothing means no metal is going. In between the metal is getting heated up, forming the metal bubble, and then, it is getting increasing in size or getting detached. That is how.

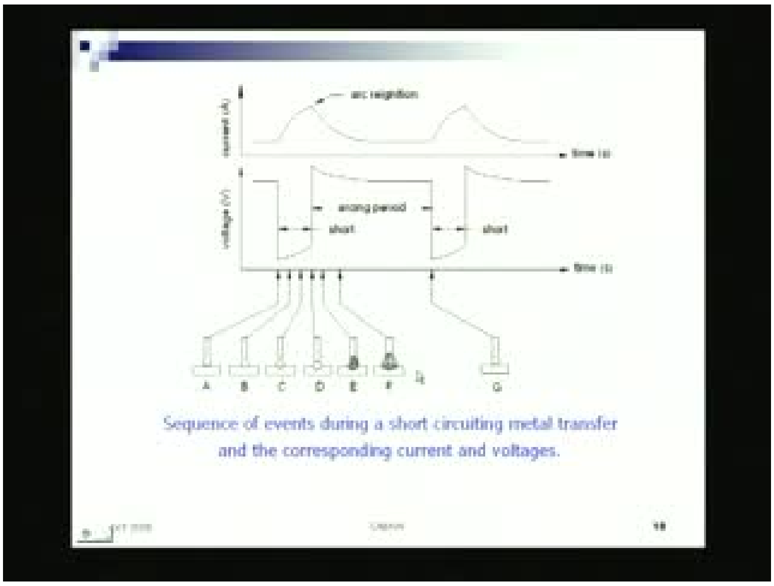
So, molten metal forming on tip of the electrode wire is transferred by the wire dipping in the molten weld pool at the time, causing a momentary short circuit. Metal is transferred only during a period when the electrode tip is in contact with the molten weld pool. No metal is transferred across the arc column. So, it is another interesting thing. We talked about metal getting transferred across the arc column. Here, actually through the arc column, there is no metal getting transferred. It is only getting touched; it is getting released.

(Refer Slide Time: 51:29)



So, this type of metal transfer mode produces a small fast-freezing weld pool. So, this method produces a small weld pool and a fast-freezing type. So, it becomes well suited for joining thin sections; that means thinner gauge steel material if you have to weld, you will have to go for a short circuiting mode. A mode of welding which will provide for short circuiting metal transfer. If you go for a spray transfer mode, it will cut through; you would not be able to weld it. These are the important aspects. So, joining thin sections for out of position welding also it is important because it is a fast-freezing type. So, overhead welding or a vertical welding for bridging large root openings.

(Refer Slide Time: 52:26)



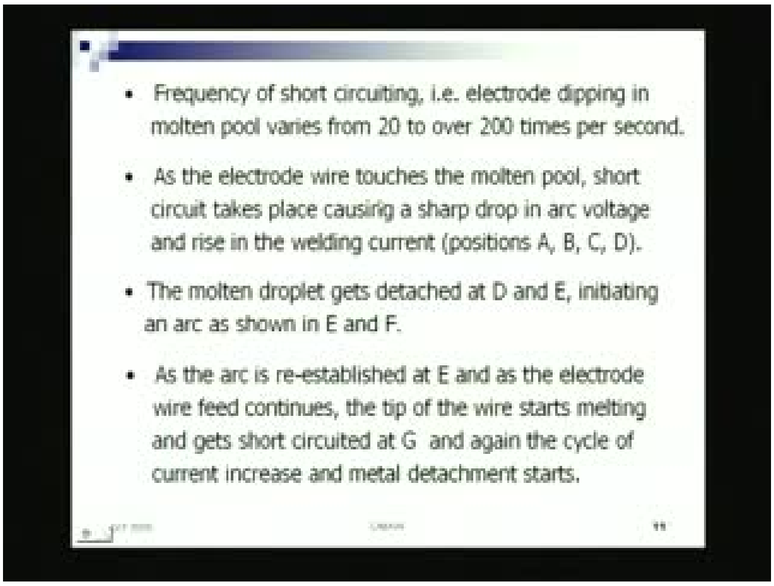
So, this is the kind of your voltage current, I mean the voltage and current sort of the, what do you call the variations will takes place over time is something like this. It is not a continuous magnitude voltage or current over the time, because what you see, the different sequences of events what are taking place something like this that at the event A, because it is a continuous process. This event A is again repeated at event G. What is happening? The tip on the action of the arc heat, the tip has got heated up, has got melted, and because of surface tension, the molten bubble, the molten metal is still sticking to the electrode tip.

You imagine the tip has got heated up. It has attained the melting temperature that tip has got melted and the molten droplet has formed and that is sticking to the tip of the electrode because of surface tension forces, because that means the surface tension forces are still higher than the gravitational pull or any other forces acting on that. So, it is sticking to that. At that point of time, you touch it to the molten pool at the B. I mean here, well, little bit we have tried to show that it has just as if you have dipped it, there is a little plunge in the surface; that means there is a molten pool. You have just dipped it.

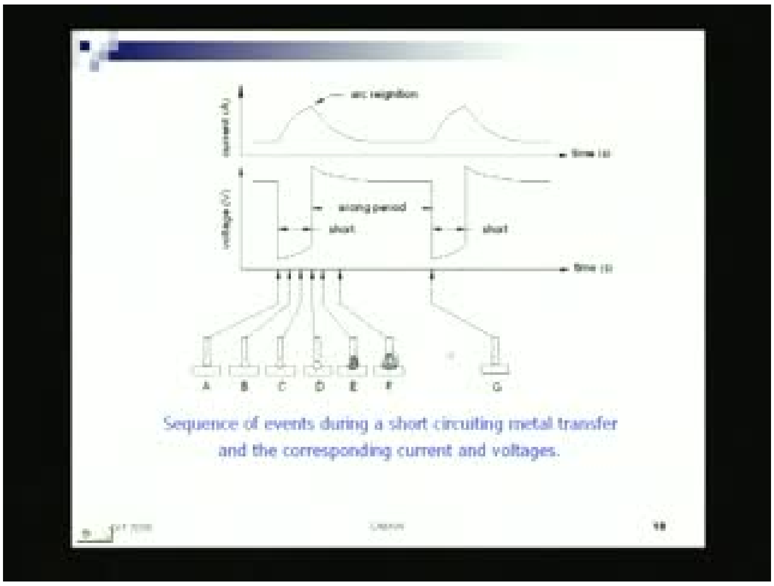
So, immediately it gets start getting detached. Here, it is not very nicely shown. It has, it should have been totally detached. Here, that making is forming means it is getting detached, and again, the new arc is initiated, because the movement its gets detached, again the arc is initiated. So, there is a momentary short circuit in this stage from stage B to D. The short circuit extent is at A, it is about to touch; B it has touched; C it is getting the effect. There is a surge in the current.

You see the peak current. From here, the current is increasing and the arc ignition is taking place at D the moment it is getting detached and the arc is started. Again the metal is melting and so on so forth. This continues that means the current increases again the current goes down and so on. This is the current profile, and the short circuiting taking place here. So, the voltage is coming to near 0. The short circuiting is just about to take at A. So, it is dropping, then again it is increasing like that.

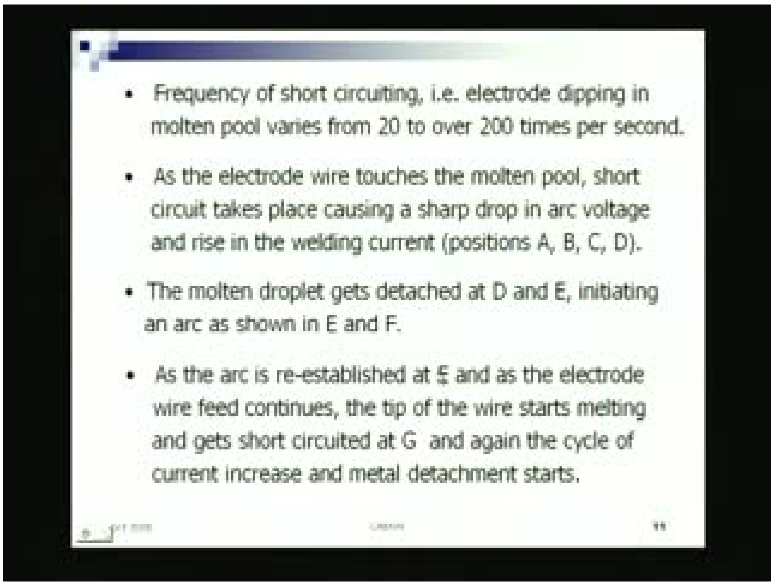
(Refer Slide Time: 55:35)



(Refer Slide Time: 56:12)

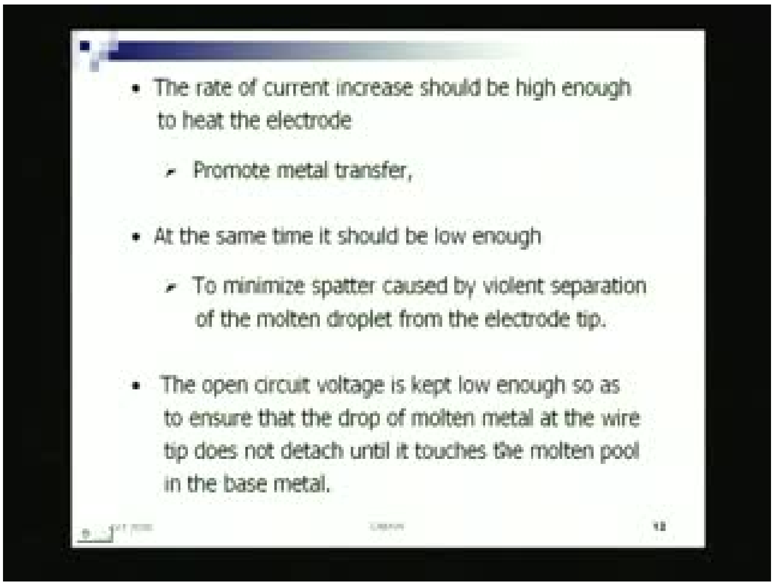


(Refer Slide Time: 56:18)



So, the frequency of this short circuiting and the, there is a electrode dipping in molten pool may have vary from 20 to 200 per seconds. So, that determines the amount of metal transferred whether it is 20 per second droplets or 200 droplets per second that will depend. So, as the electrode wire touches the molten pool, short circuit takes place causing a sharp drop in arc voltage. What I was telling? The molten droplet gets detached at D and E position indicating an arc as shown in E and initiating an arc in E and F. At D and E, it is getting detached; E and F, it is getting initiated. As the arc is re-established, again the same process continues.

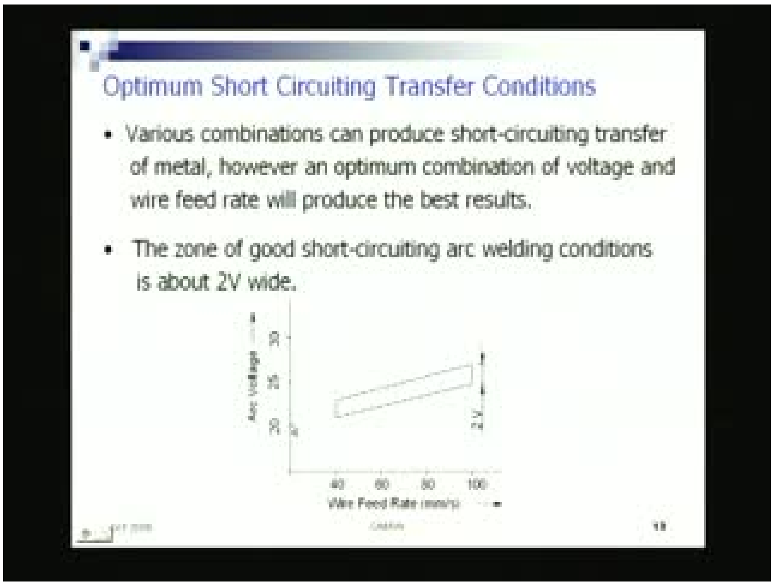
(Refer Slide Time: 56:25)



So, there rate of current increase should be high enough to heat the electrode promote metal transfer; that means rate of current increase means that current is increasing should be that. At the same time, it should be low enough to minimize spatter because the moment this we are talking about the rate of current increased means, at the time of short circuit, as the short circuit takes place, the current becomes infinite suddenly too high. There will be a kind of a expulsion of that molten thing kind of with a explosive force. So, spatter will be there too much.

So, that should be a gentle detachment not a explosive detachment. So, that is what it says. It should be low enough. High enough to do this metal transfer, low enough to minimize pattern. So, all these are done. The open circuit voltage is kept low enough. So, as to ensure that the drop of the molten metal, it does not detach until it touches the molten pool in the base metal; that means, to ensure, this is to ensure short circuiting transfer not through gravitational transfer, not through the globular transfer, because when you increase the voltage, that may lead to formation of additional energy being given such that the hollow of the molten droplet increases and overcomes the surface tension force and it detaches. That is actually a globular transfer, but here, I want a transfer taking place where it is short circuiting.

(Refer Slide Time: 58:00)



So, these are the optimum circuiting conditions. What we see that an optimum combination of voltage and wire feed will produce best result. So, what we see? The zone of good short circuiting arc welding conditions is about two volt wide; that means for different wire feed, there is a proper arc voltage to be chosen and that band is narrow around within 2 volts that say for a 60 millimeter per second. This something like 22, 23, 24 volts probably will be good enough. As I increase the feed rate, then I can increase the current voltage. This is I mean well by trial and error or by some experienced people, they said. So, we will look into little more in the next classes about the gas metal arc welding.