Marine Construction and Welding
Professor Dr. N. R. Mandal
Department of Ocean Engineering and Naval Architecture
Indian Institute of Technology, Kharagpur

Module No. # 01
Lecture No. # 25
Fusion Welding and Power Source

If we recall, we started with plate operations, plate preparation, then plate cutting, followed by plate and frame bending. Now, the question of joining them. So, welding is nothing but a technique of essentially joining. If you go back three world wars, it used to be primarily riveted ships; ships used to be riveted. However now, as we see, we have almost done away with riveting as a method of joining. It is all done by welding.

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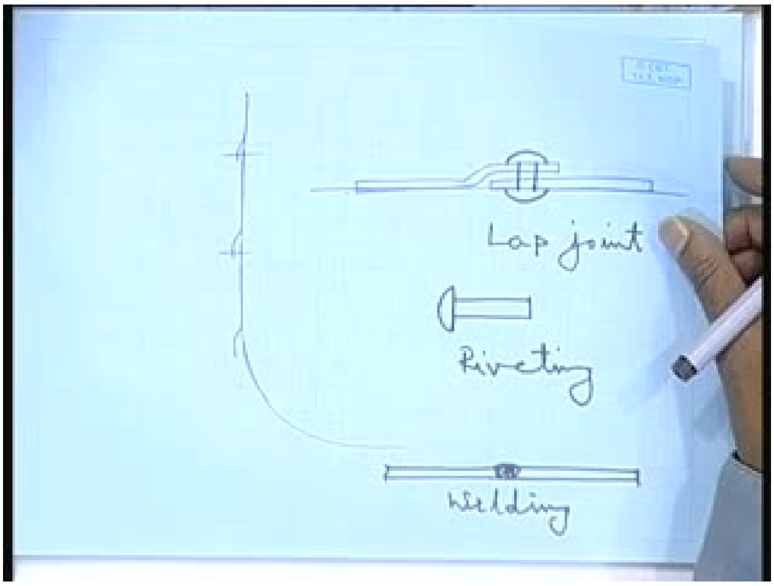

Riveting is something like this. If I look in to the hull in the context of ship building, it has to be done in this way. That means one plate is coming and it is being riveted to the other strake. It will have to go in this fashion. Here it is riveted. So, what happens?

Suppose two plates are to be welded, you have to shape the plate in this way. That means this line (Refer Slide Time: 01:37) remains flat one line. That is internal surface suppose.

When I am joining both the plates, one plate is overlapped. You drill a hole here and put a rivet. Physically, rivet will look like this. That means basically drill a hole and originally, the rivet will somewhat look like this. So, this is put in the hole, from the other side you hammer it, and make it flat; I mean give this particular shape. So, they will hold the plate together. That is the operation. That means first you will have to bend the plate at every joints. Suppose this (( )) the side shell plate, if you bend the plate all along the length like this such that you can overlap, this is referred to as lap joint.

[Not clearly audible] (Refer Slide Time: 02:44) This joint is not water proof?

No, it can be may be water proof. That means there is a design of the joints. So, how many rivets at what spacing, how compressed they are? All those are the factors. Thereby, it will be made water tight; there is no problem. However, you think of the involvement in the entire process; how much of work involved? You have to shape the plate that way. That means it is additional work to drill hole in both the plates in unition so that they match. Then, insert the rivet physically and do hammering. So, this is the process of joining.

Now, when you do welding, then it becomes much simpler. This is riveting (Refer Slide Time: 03:30). When you do welding, then you have the plate like this and another plate; you just put plates face to face as this and weld it. So, no additional work; only the work of welding; you align them and weld it. This riveting is no more done. Now, all the jobs are through welding.

When we talk about welding, what welding is? Essentially, welding is nothing but a method of joining two pieces of metallic plates. It can be non-metallic also, but here we will talk about metallic plates only – steel-aluminum welding. So, the entire process involves how two pieces of plates put together by means of welding makes it one integral plate. That means the entire continuity is established between the two plates along the welded joint; along the welded line. So, how that can be done?

That can be done by various processes. One of the process could be - you make the surface so smooth and bring them so close that a metallic bond is formed; a molecular bond is formed and the plates get joint. That can be referred to as solid-state welding. However, that is not very feasible in case of ship building. So, what would be the other method?

Other method would be - generate enough heat through friction and make the surface smooth enough so that they come together close enough to form that molecular bond. So, that can be referred to as friction welding. There can be another process that passes a current through the joint such that the interface generates sufficient heat to melt locally and then we draw the current. So, it is all defies. That means by melting; by fusion. So, through fusion what is being done? The metal is brought under a liquid state wherein the molecules are free to move around. Once the heat is removed, this solidifies and becomes one. The necessary metallic bond is found. So, that is what is fusion welding.

Here we will talk about fusion welding. While doing fusion welding, we need to have external source of energy, which will be in the form of some heat or whatever. That will melt the plate. That means raise the temperature of the plate to the melting temperature.

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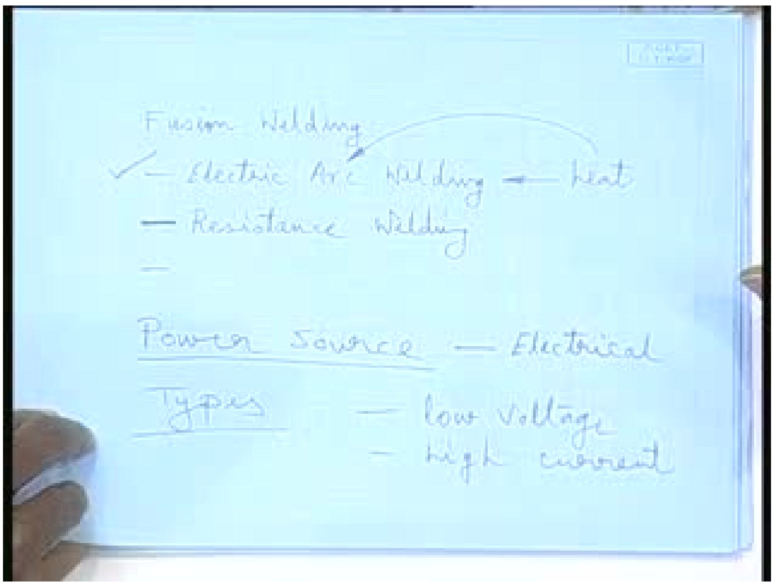

One of the processes would be using electric arc. That is how that particular welding process can be referred to as electric arc welding. As I said, other method of fusion welding could be resistance welding. That means resistance is electrical resistance. Through that it generates enough heat and the fusion and the welding take place. There are other methods also, maybe we will talk about those methods later.

Now, concentrate on these that electric arc welding is the primary fusion welding process, which is most commonly used. That means here in this case, the heat is obtained through the electric arc. To melt the plate, heat is obtained from the electric arc. There are other methods of fusion welding like - if you can think of using a so-called laser beam to melt the plate and do the fusion welding, that will be termed as laser welding. Use the resistance of molten slag; slag is nothing but that we get by burning the flux. That gives protection to the molten metal. So, resistance of the molten slag can be used which is referred to as electro slag welding. That is also a fusion welding; the heat is coming from that slag - electro slag welding.

I can use the solar energy, concentrate it, melt the plate and do the welding - solar welding. I can use electron beam, focus it to the point and that will generate intense heat, I can do the welding - electron beam welding. So, these are all explicit type of welding processes. We will not go into those, we will go up to the electro slag welding and some more. We will talk about that later. Under the heading of electric arc welding, again we will have certain different types of welding processes. We will see that later.

Now, let us see that from where we are getting the heat - from the electrical power. That means there is a something called power source (Refer Slide Time: 09:23).

When we have electrical power source, we call it electric arc welding. When the power source is a laser beam, laser welding; like that. So, all those welding - electric arc welding, resistance welding, electro slag welding, submerged arc welding, gas metallic welding - are basically electric welding. In some cases, we are using electric arc; in some cases, we are using the resistance of the metal interface or of the flux; I mean slag - burnt flux. In all these cases, we use electrical power source. So, we will look into what are the types of power source.

First, let us look into the types of power source. Generally, what you do that welding power sources are low-voltage and high-current power source. That means the power, which we get, will be able to deliver very high current. For example, our domestic power source. What is the domestic power source voltage? It is 220 volts approximately. Probably for the wiring you have, it can deliver to a maximum of nothing more than 15 amperes. That is why generally we will see the highest ampere rates socket we have is that of 15 ampere. That means definitely you are drawing current less than that. Which all equipments draw more current? Geyser, iron, air conditioner; they draw quite a heavy current when you switch on, then it falls down little bit, but still current. So, maximum is around 15 ampere and voltage is 220 volts. So, accidentally if you touch the terminals, you get really a severe shock and that shock period extends, one can collapse straight fatal; it can be fatal.

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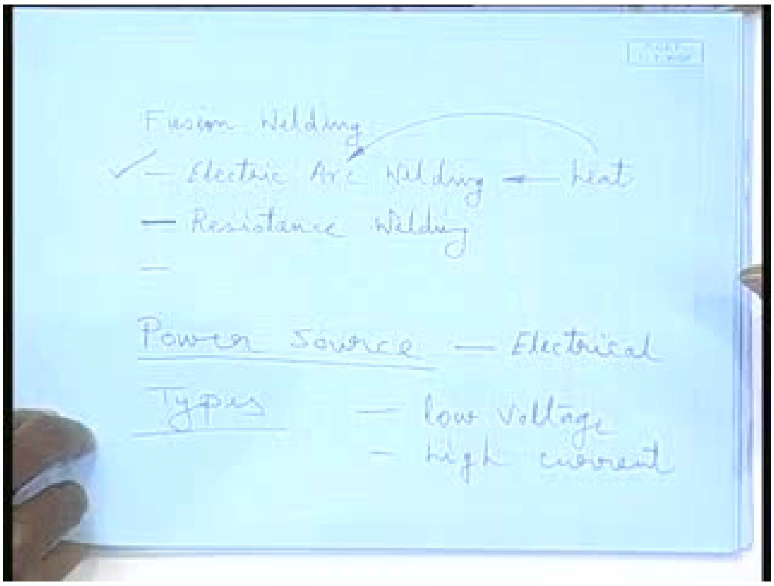

Whereas, it is just the reverse in welding power source. The open circuit voltage will be of the order of maximum - say around 80 to 100 volts maximum. Open circuit means when you are not doing any welding, you just a put a multimeter or a voltmeter across the terminal and it will show 80 or 100 maximum. That is the open circuit voltage. Depending on the capacity of the machine, current could be 100 ampere, 200 ampere, 300 ampere or 3000 ampere of that order. That means even in the low power welding, ampere will be of the order of 100, whereas as we saw in domestic power, it is only 15. Voltage is 80, whereas the ampere is 100.

Little high heat or high heat input welding or if I say more powerful welding, it could be of the ampere of 600, 700, 800 ampere. It can even go up to 2000, 3000 ampere. So, that is how it is basically a low-voltage high-current power source.

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We will come to that. It is low-voltage high-current.

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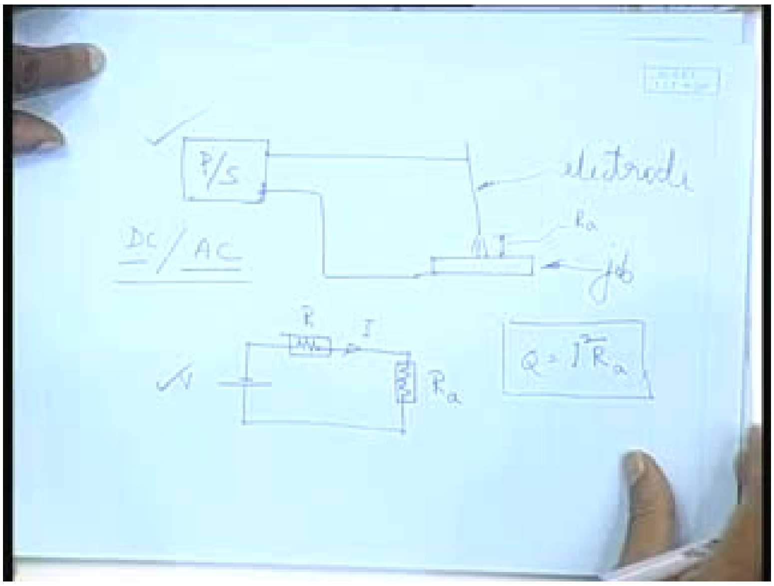

Maybe we can see how the heat is generated. If we just look into it, the entire circuitry is very simple. This is the power source. So, what you have? You have one terminal connected to the electrode and another terminal connected to the job. Generally, this is the configuration. This is electrode and this is the job so this is the work keys or the job or the plate, which is being welded.

This is the power source. Power source could be either direct current or alternate current power source. That means it could be either DC or AC. If it is DC, then either of them will be plus or minus. That also has significance; we will see that later. If it is AC, then one is live and another is neutral. So, this is the circuit.

Probably if I look in to the electrical circuit, it would be something like this (Refer Slide Time: 14:51). Let us assume a DC power source. We have like this – positive-negative terminal; there is one resistance. This is R and R a; that is all. R is the resistance in the entire circuitry. That means the internal impedance of the machine and that of the resistance of the cables. R a is the arc resistance; resistance in the arc; the resistance here (Refer Slide Time: 15:37).

If the voltage is V, then I have a current I flowing in the circuit. Then, what would be the heat generated? Heat generated would be I square R a. There is a joule heating taking place. That is how the current is important. That is how we have high current because had it been current of the order of 10 or 15 ampere, then hardly any heat would have been there. So, we talk about 100, 800, 1000 ampere so that I can have a high current. Because R a is the resistance of the R column, I cannot go on increasing. Resistance of the R column is very low. It is essentially the resistance of the plasma column; ionized gas. That is somewhat fixed because you will have somewhat size of the arc column. You cannot make it very big; the instability of the arc will come. You cannot make it very short; there can be chances of short circuit. So, it will be sufficiently small. I mean that will not contribute much; what contributes is the current.

Thereby, we see that welding current becomes one of the very important process parameter in the entire thing. That is how the welding current is the square of the current. So, how much heat is generated will depend on the amount of the current. So, that automatically tells us that if you need to weld a thicker steel plate, you need to have a higher current because to melt more metal, more heat is needed. To increase the welding speed or deposition rate, how much metal is being deposited will again depend on the welding current. If more the current, more heat is generated. So, more metal can be melted. So, welding current becomes one of the very important process variable; one of the very important welding parameter. We will see its effects later. So, that is how the current is important.

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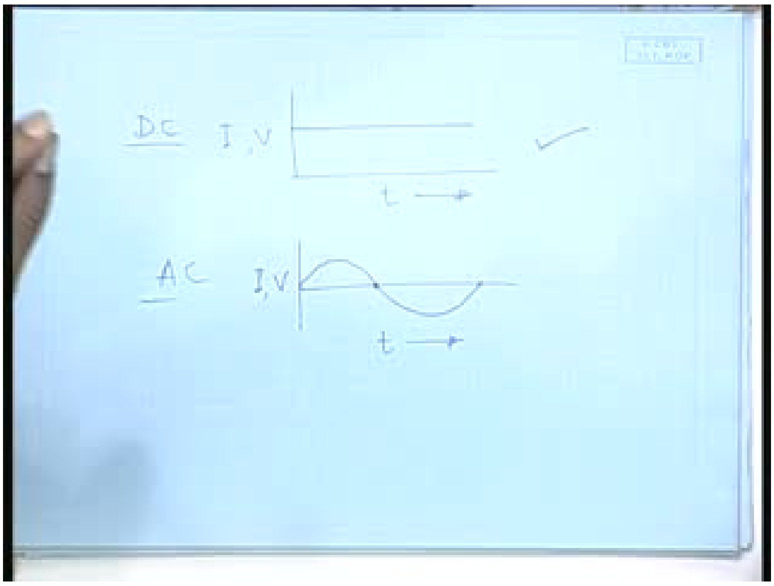

We have been talking about this power source (Refer Slide Time: 18:08), what is this power source? It can be either DC or AC. Now, we will see that if it is a DC power source, then this voltage or current would be something like this - straight with time. If it is an AC one, then obviously it will have a cyclic thing and we will be using the so-called line power. Line power means the power being generated; the industrial power, which is being generated in the power plants. So, we will use that power.

Obviously, where this so-called line or supplied power is not available, you will have to have your own generator or alternator to generate power. That is a different issue. Again the same thing - if I use alternator, I generate AC power; if I have a DC generator, I generate DC power. So, either I use a DC generator and directly use or I use an alternator, use a rectifier and make it DC if I want. If use the line power, I use a transformer. If I want to do AC welding, I do AC and I use a rectifier to get it to DC. So, either of these two (Refer Slide Time: 19:43) are used.

Now, which one to be used? Naturally the one which will give me a consistent quality, a good quality at the end of the job; I mean rather the job should have a superior quality; a job where I can control the parameters more finely such that I get the desired joint quality. Desired joint quality means the purpose of welding is barely to join two plates, but to make them integrally one. It means as if it was only one; there are no two separate plates. That means the joint should have the same physical and mechanical parameters if not superior compared to those of the original parameters or original properties of the plates. That means the welded joint should be free from all kinds of defects and also should produce a microstructure and mechanical properties that of the original plate. That means have good property.

To achieve that what do you think from common sense, which kind of power would give you better result? DC or AC to start with? Generally DC; direct current for the simple reason; you see what happens with AC. As I see with time, it increases, decreases, then at one point of time it goes off; it is 0 here (Refer Slide Time: 21:34). The power is 0; voltage or current in the circuit is 0. Again, this is picking up, going to maximum, decreasing and again becoming 0.

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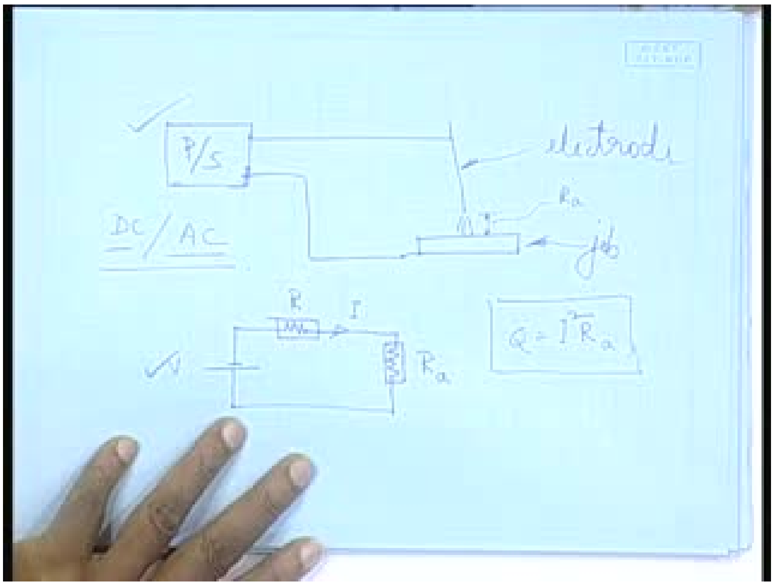

In other words, how many times the electric arc gets extinguished? If it is a 50 cycle power, 50 times or 100 times?

100 times.

I think 100 times per second. So, per second, 100 times it is going on and off. So, it is happening very fast that we do not see. Also, the heat I square R a is changing continuously. It is becoming maximum, coming down, becoming 0, and again becoming maximum. So, it is a kind of a fluctuating power. If it is a fluctuating power, then the melting rate also will be fluctuating. So, it will lead to a fluctuation in the weld deposition. That means though it is happening very fast - 100 times; I mean things are changing 100th of a second, effect is not that grossly visible, but the effect is there. Whereas, in this case, I have a very consistent power supply and consistent heat in DC. The melting rate, rate of heat generation, rate of melting, everything is uniform of a time. So, I get a very consistency in deposition in DC. So, if I use DC, I expect to get a superior quality of weld deposit.

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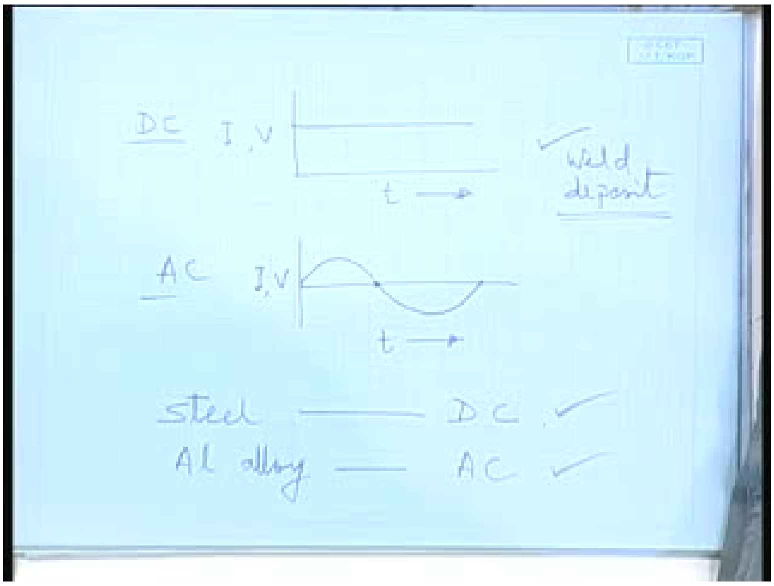

The weld deposit what is important. How I am depositing the molten metal? From the pillar metal, the electrode being melted and getting deposited. Thereby, the parent metal is also melting. Both are getting mixed up and getting solidified, welding is being done. So, weld deposit is also important. So, the quality of the weld deposit will depend on the power supply. So, a DC power supply will give you a better weld deposit.

There are other aspects In general, one can say that for steel welding, when we weld steel material for ship building purpose, we will use DC power supply. However, if you look in the road side welding shops, you will find people using AC power supply and also welding steel. I am not saying that you cannot weld steel with AC you can, but if you want a better quality and superior strength, you should go for DC. When we talk about the road side welding, means where welding things, which are of not that great quality requirement.

Say you are welding those window grills or fencing or garden gate and all that. There you do not have so stringent requirement, but when you are welding for offshore platform or a ship or a submarine, you have much more stringent requirement. So, there we will be using DC when you do weld for steel. Just for information - if have to weld aluminum alloys, that logic supersedes some other logic. Thereby, AC becomes a preferable power source for aluminum welding. There are some other requirements and some other things happen. So, AC power is used for aluminum welding. We have all these difficulties in the power, but that helps. We will see that later if time permits. However, for your information, steel is always DC for that simple reason and aluminum is AC power.

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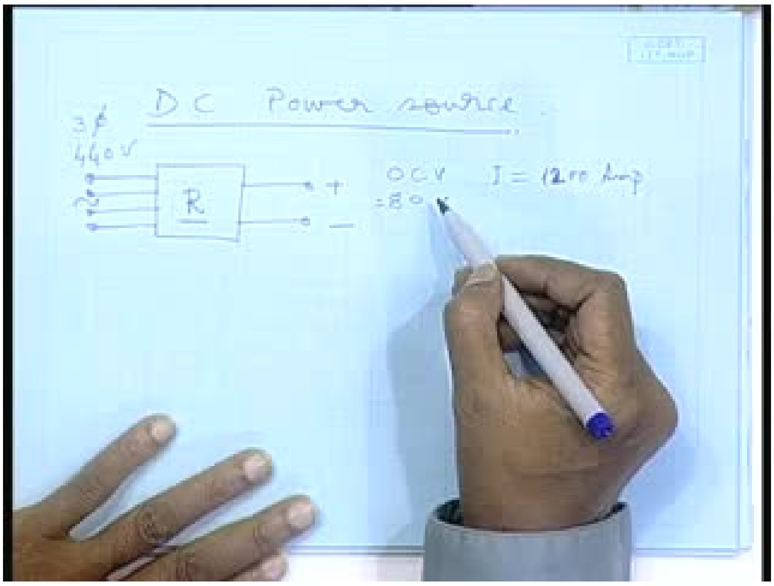

We have DC power source. DC power source means what? That means we have a device, which can deliver DC power. From where this DC power is coming? Here I have the AC line supply - 440 volts supply; the industrial power - 440 volts.

Suppose this is the 440 volts supply; 440 volts, 3-phase supply. There will not be only two wires, but there will be four wires. We are putting 440 volts, 3 phase in this machine and we are getting positive and negative; two terminals; DC. Here it will be open circuit voltage, OCV of about 80 volts and current that can go up to say 1200 ampere as the capacity of the machine. That means it can deliver up to 1200 ampere. What is this machine then? (Refer Slide Time: 27:21) This is a rectifier.

[Not audible] (Refer Slide Time: 27:27)

No, just a rectifier. Transforming means internally you have a sort of current transformer wherein you bring down the voltage (( )) boost up the current. Then, rectify it and you have a DC output. So, now, if I measure the output here, then you get the open circuit voltage.

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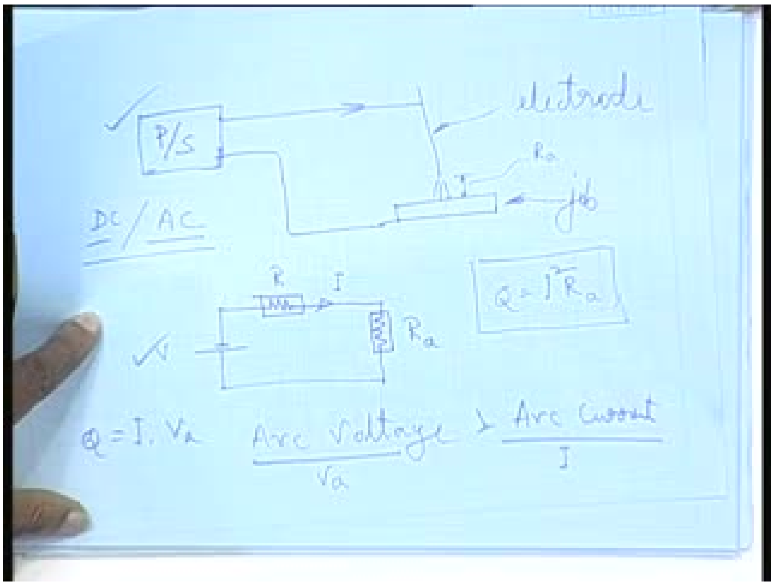

If I measure the power in the arc here, then I get arc voltage and arc current. Arc current is nothing but the current in the circuit, but the arc voltage is the voltage drop in the arc. So, more important parameters are essential arc voltage and arc current; not OCV, the open circuit voltage.

How much drop is there in the arc? That is important because that is generating the heat. That means if arc voltage is V a and the arc current is I; arc current is nothing but the welding current in the circuit. So, once again heat is I into V a; voltage drop at the arc.

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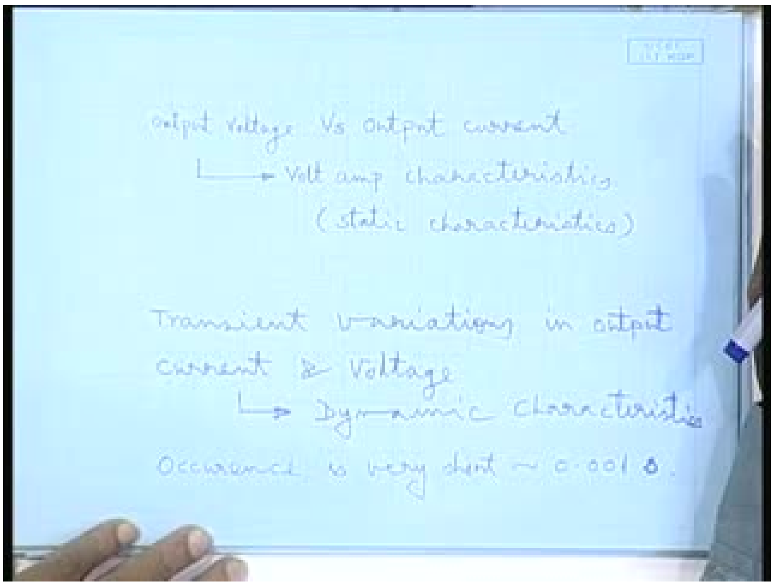

If we measure this voltage and current output at the arc, then we get a certain characteristic, certain distribution of that. Depending on those characteristics we have – if we plot output voltage versus output current; here output means the voltage in the arc and the current in the circuit. This is referred to as volt-ampere characteristics. They are basically static characteristics and are easily measurable, where I put a shunt in the arc to measure the voltage drop; then, I put an ammeter in the circuit to get the current. Like we do welding in our lab, we can measure it very easily with simple devices. So, that is the static characteristics.

Another thing is referred to as dynamic characteristics. What is that? They are transient variations in the output voltage and current. This relation of output voltage and output current is somewhat fixed for a given machine and a given power source.

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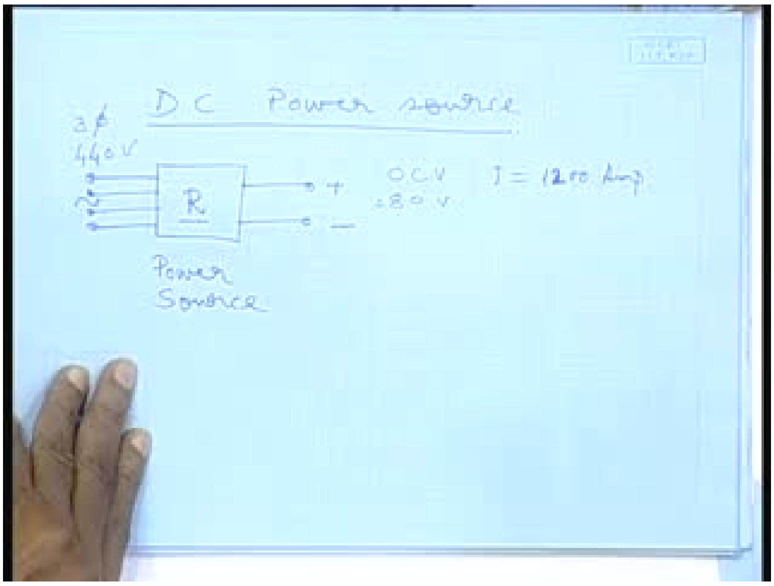

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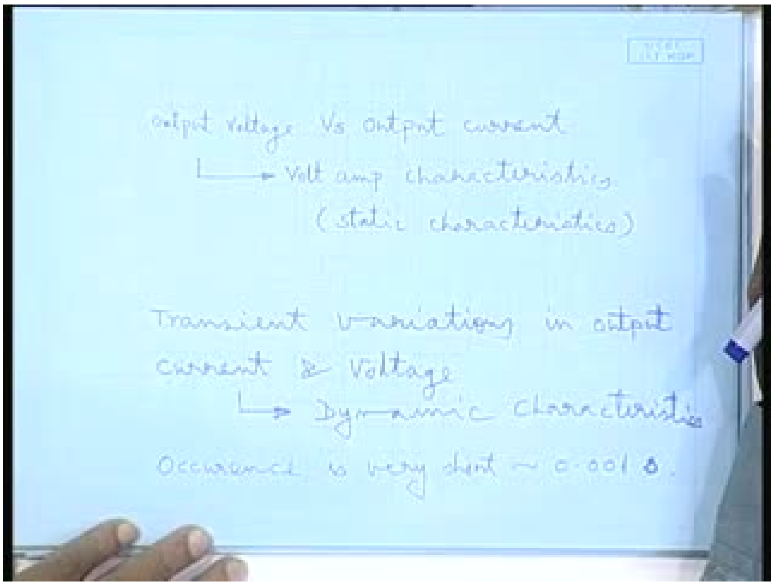

If I refer to this R (Refer Slide Time: 30:38); I have written as a welding power source, it will have static characteristics as well as dynamic characteristics. Static characteristics are the relation between the output voltage and output current; how it is behaving. The dynamic characteristics are the transient variations in this output current and voltage. These transient variations are very highly transient; means what? They are not constant; they occur for a very short period; they keep changing. They occur in a period in the order of 0.001 second; very short period.

When these dynamic phenomena are visible? They are visible when you initiate the arc. Just start the arc. At that point, whatever the variations will take place in the output current and voltage will depend on the dynamic characteristics of the power supply of that power of that machine. This is because here (Refer Slide Time: 31:57) it is a combination - it is a power supply; I am giving a 3-phase power and getting DC power. Many ways I can get that. So, depending on the characteristics, type and make of that; I mean how you have designed it, what all facilities you have incorporated, you will have certain type of static characteristics and certain type of dynamic characteristics.

We will come to static characteristics little more in detail. As far as dynamic characteristics are concerned just a few words: Because they are of very transient in nature and they occur only during the striking of an arc; means when you are just initiating the welding and then it continues. So, dynamic characteristics play a role at the time of initiation of the arc; that is one. During rapid changes in arc length; for some reason, the arc length is fluctuating. Then also, dynamic characteristics will play a role. During metal transfer across arc; the metal is getting transferred; that is happening continuously because electrode tip is melting and getting transferred.

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Which? What?

Direction of metal transfer.

No, direction of metal transfer means metal getting transferred from the electrode to the job. We will come to that little more later.

Anyway, that is how… We see that dynamic characteristics are the one which does play a role, but not very significant as such because it is primarily when you are just starting the welding, then you do not have. Again, if you do not fluctuate the arc length; if that can be very well controlled; there is not much of problem. Dynamic characteristics may play a role only in metal transfer. So, that is how we see that generally the power supplies have certain static characteristics. They do not take care; the ordinary power supplies do not take care much about the dynamic characteristics. Only very elaborate sort of circuitry and expensive machines will have a very good dynamic characteristics. That essentially means what? Just at the time of striking the arc, what you are doing? You are short circuiting it. So, there will be sharp change in the current and voltage. To take care of that sharp change in a very short time; they will be in a much fraction of a second. So, the machine should be capable of withstanding all those fluctuations. So, that is how dynamic…

In fact, if a machine has a good dynamic power supply with a good dynamic characteristics, will give us improvement in the uniformity of metal transfer. That means we will be able to achieve even higher quality of metal deposition. Reduced met weld pool turbulence - means when you are doing welding, the electrode will be just facing the metal below; will be in a molten state. It will be a molten pool of metal just below the arc. Naturally, the heat will continuously have a molten pool of metal, which will keep moving along with the arc moving. So, there will be heavy turbulence in that molten pool of metal. Turbulence is because of the metal droplets that are falling. So, that will cause turbulence and spatter. Suppose you drop something in a liquid, it splashes. That is called spatter.

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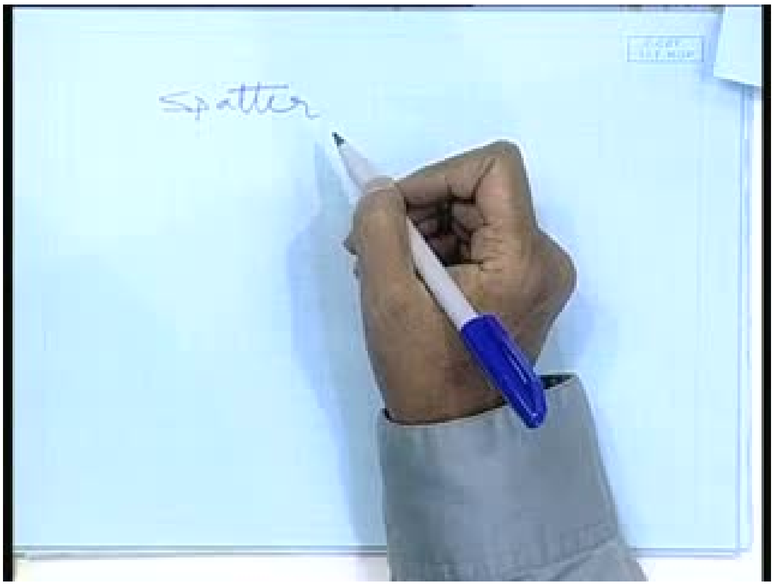

Lot of spatter is bad; lot of metal is wasted. That may give raise to certain defects also. That means if you have lot of spatter along the weld line, it indicates that you may have a bad welding done. I mean defects could be there because when the metal spatter; why? Because lot of turbulence occurred and metal got spattered; so, there can be entrapment of gas and some porosity may have formed.

Since the transient variations are less, spattering also would be less. You will have a uniformity of metal transferred. However, all these are… Essentially when you have that transient variation, striking of the arc, extinguishing of the arc means at the beginning, at the end, they mainly (( )) So, transient variation or the dynamic characteristics are not that greatly important. More role plays are played by the static characteristics.

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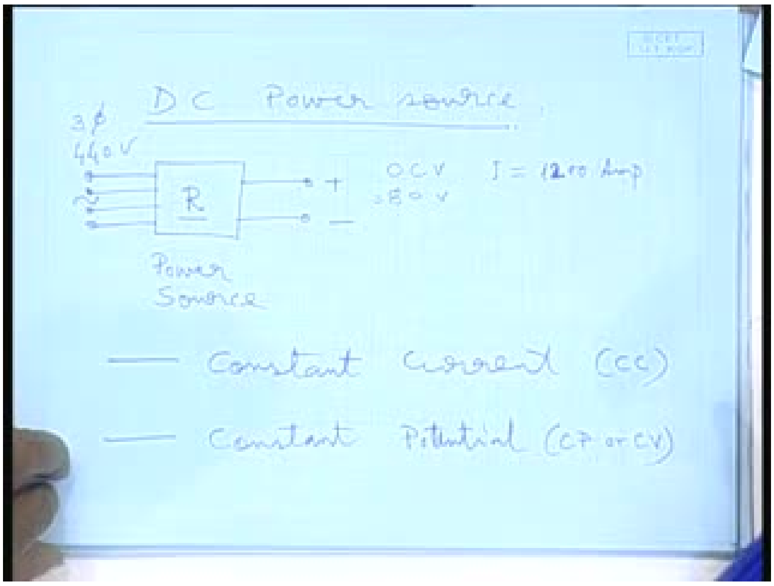

Depending on the static characteristics, generally we have two types of power supplies: one is referred to as constant current and another is referred to as constant potential or constant voltage. So, this is referred to as CC and this is referred to as CP or CV; constant potential or constant voltage. These are based on the characteristics the voltage current output by plotting the relation between the voltage current - this output voltage versus this output current (Refer Slide Time: 38:33).

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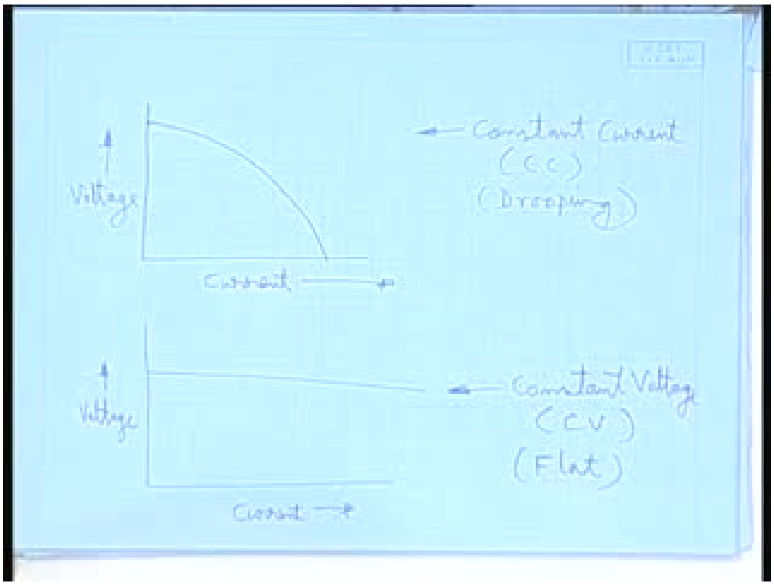

What is this? In one case, we call it constant current; in another case, we call it constant voltage. If it is a constant current, then we have power characteristics something like this. This is the current and this is the voltage. This is referred to as constant current characteristics or a CC power supply; constant current power supply or a DC power supply having constant current characteristics.

Now, tell me why we were referring to as constant current, I can see the current is changing; not only changing, it is drooping. At times people also call it as a drooping power source. I mean if somebody tells you drooping power source, you should not be surprised. That means he is referring to a constant current power source or a welding power source, which has constant current characteristics because in one power source, you can have all these characteristics. Only thing is you will have to change the settings. You change the settings to drooping characteristics; you change the settings to flat characteristics.

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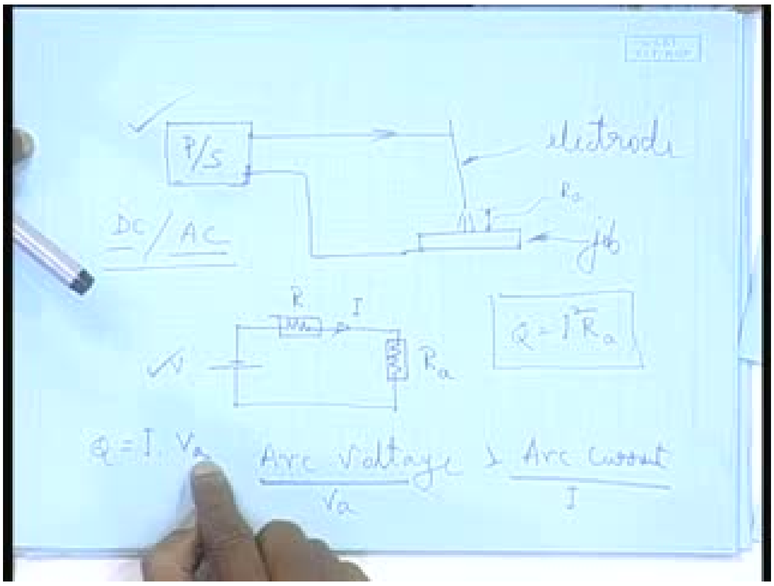

The other one is referred to as constant voltage.

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Yes, we will come. Let us draw this CV or CP and also referred to as flat. Why flat? Here (Refer Slide Time: 40:43) we see somewhat like this. Constant current means - because what is happening is we are checking into the voltage current characteristics.

Voltage current characteristics mean when I am doing the welding, I have certain arc voltage and certain arc current. Instead of arc current, it is generally referred to as welding current; certain arc voltage and welding current or whatever; voltage and current at the arc. At that voltage, what is happening to that current or the total power I into V a that we are interested in. So, what we see here? (Refer Slide Time: 41:48)

For a given arc voltage, this is the arc current; current in the arc. Now, what is liable to change here in the process? (Refer Slide Time: 42:06) Liable to change is the electrode position. Suppose I am doing a manual welding, what will happen? The weld electrode is getting consumed. When I do a manual welding, the movement of hand is somewhat like this (Refer Slide Time: 42:20). It has a translatory motion in this direction as well as in this z direction. You will have to gradually come down. So, how you are coming down, how much your hand is shaking and all that will affect the arc. Arc length will change; keep changing. If the arc length changes, then the voltage drop at the arc length will change the arc. That means V a will keep fluctuating because small minute in the arc length will have a significant effect on V a. This is because the current is very high; current is 150 ampere. When you are doing manual welding current will be of that order. It can be of that order 150, 200 ampere, 250 ampere.

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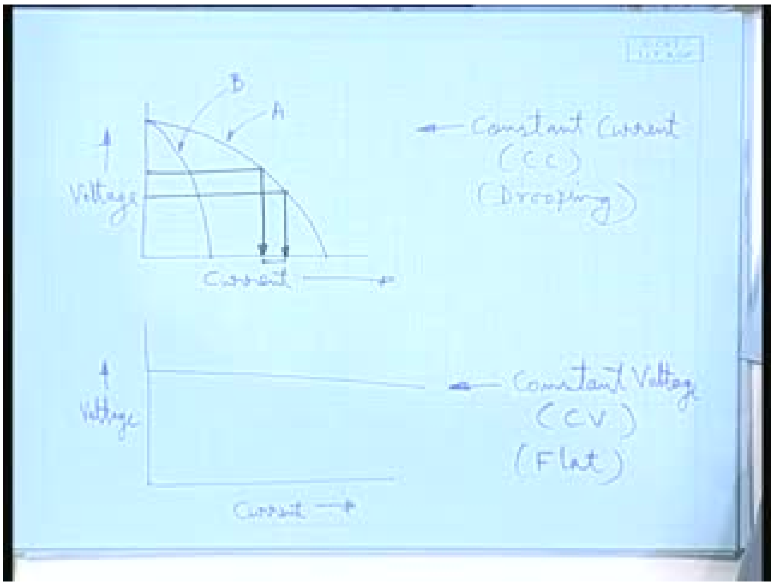

From here, suppose the voltage changes up to this much - this is fluctuation of the voltage. From here, it drops to this much or from there, it increases this much. So, current change is only this much.

Now, if I have another constant current power supply wherein I have the circuitry such or other or whatever, it gives this particular characteristic. I make it such that I have a more stiffer curve. This nature of the curve is more stiff. That means this is machine A; power source A and this is power source B. Both are having…

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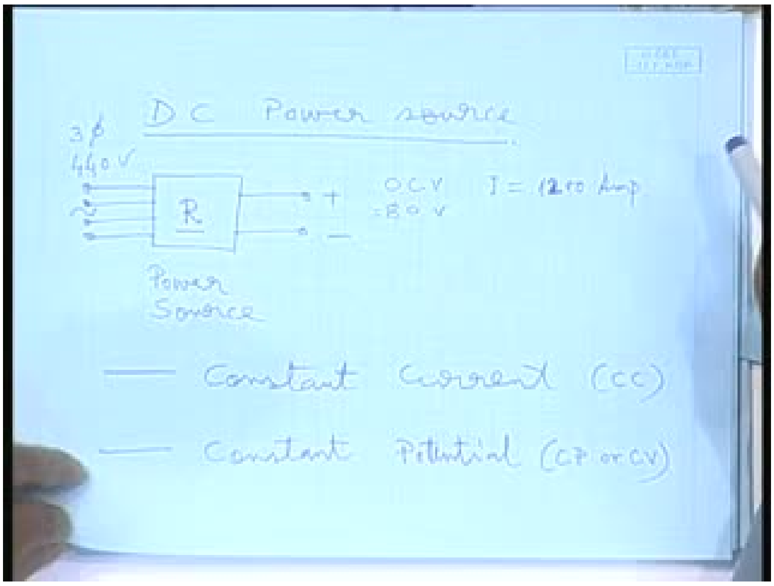

Suppose you go to the market and buy a constant current power source. The fellow in the shop shows you two machines of same capacity. That means it can deliver… Primarily, you will look for how much ampere it can deliver. You see that both are giving you 1200 ampere.

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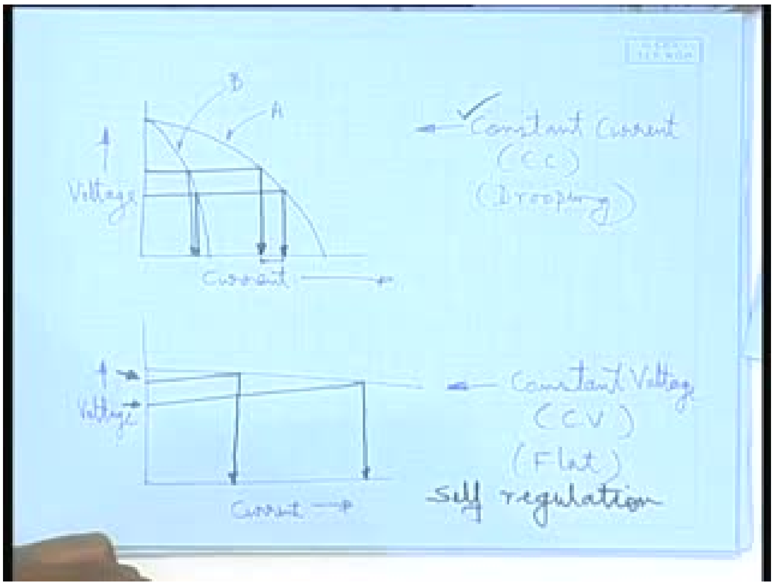

However, he is saying that machine B is much more expensive than machine A, but both are of the same capacity. Why expensive? Its volt-ampere characteristics are different; it is better. Why? Because here you see that for the same change in voltage, the change in current is hardly anything; very small. That means it is approaching to the true constant current condition. That means though my hand is not very steady in welding; my hand is shaking and the welding arc is changing, but the metal deposition is constant. The heat generated is more or less constant. V a is changing. That change is more; probably from 20 volt to 25 volts. However, current change is hardly anything. That is why it is referred to as constant current. That means for the fluctuation in the arc voltage, the change in current is less; much less. That is what is a constant current characteristic.

A machine power supply with characteristics similar to that of B here (Refer Slide Time: 45:57) is more preferable. Obviously, it shows that when I do a manual welding, it is preferable to use a constant current power source. If I do manual welding using DC power supply, it is preferable to use a constant current power source because then the weld quality will be better. This is because even if there is a fluctuation because of the welders' fluctuation in the arc, the metal deposition will remain fairly constant.

What happens in the constant voltage? What you see here (Refer Slide Time: 46:39) means that in constant current, some change in voltage causes very little change in current. Here a small change in voltage causes very high change in current; just the opposite. Constant voltage power supply is sort of opposite to that of constant current. There a certain change in the voltage, you had a very small change in current. Here the same change in voltage, you have a very large change in current.

The nature of the constant current curve is drooping down. That is why it is referred to as drooping power source. Here the nature is somewhat flat; horizontal. So, it is called flat power source. However, I have drawn a curve, which eventually goes and meets the current axis. That means there is a negative slope. Why this negative slope? Ideally, it should have been horizontal; internal impedance resistance, but you better call it impedance because it is a combination of LC RLC circuit. So, because of the internal impedance, there will be a downward slope; a negative slope.

You have this particular phenomenon here that for a small change in voltage, you have a very high change in the current. So, what does it give, why do I use this? In this, what I see then? For some reason if the arc length changes, immediately there will be a surge of very high amount of current. If the arc level decreases little bit, for some reason immediately there will be a surge of current. What will happen is instantaneously lot of heat gets generated and the arc length will come back to the original length. Hence, (Refer Slide Time: 49:16) the arc length was here, which corresponds to this voltage. For some reason, the arc length has dropped. If I further go on putting it down, then it may stub in the weld pool and the welding will stop. That means short circuit case will occur. Instead, suppose it comes down to this level, immediately there will be a surge of current. So, what will happen is you will burn off the tip of the electrode and restore the required arc length. So, this constant voltage power supply gives a kind of a self regulation of the welding arc. So, this is useful in the case of automated welding. When I have a constant feeding rate of the electrode, I can design a welding machine where I can continuously feed the electrode.

In manual welding, I have a welding stick. I weld it, it is over; I throw the stick and put a new stick and again I weld. If I have a coil of welding wire and I have a mechanism of continuously feeding, it I can continuously weld. So, if there is a mechanism wherein I can feed the filler metal, the welding electrode as such; the filler metal that melts and gets deposited, there it will be worthwhile to use a constant voltage power source. This is because feeding rate is constant and if there is any undulation in the plate or somehow the electrode is coming closer to the plate for some reason little undulations, the welding arc will become smaller. Immediately, there will be high surge of current and it will automatically change to the required arc voltage. So, that is how the constant voltage for automatic operation and constant current for manual operation.

However, again there is a thing - if a very skilled welder, who is doing some repair welding; in case of primarily repair welding - means some cracks, fractures, damages taken place, you have cut it out and that portion you are depositing metal to fill it up.

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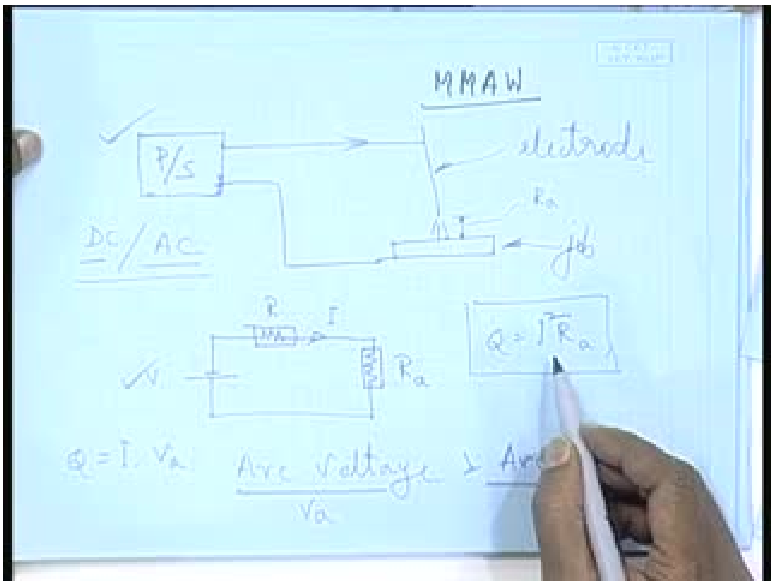

At some place, you need certain deposition; some other place, you need a more deposition and so and so forth. That amount of deposition is varying. Then, what happens is - as I have told, since deposition rate will depend on the current, if you are doing manually; a repair welding will always be manual, generally, we will not put any automation in repair welding. It will be manually done with a manual stick electrode, which is referred to as MMAW, manual metal arc welding; the general abbreviation.

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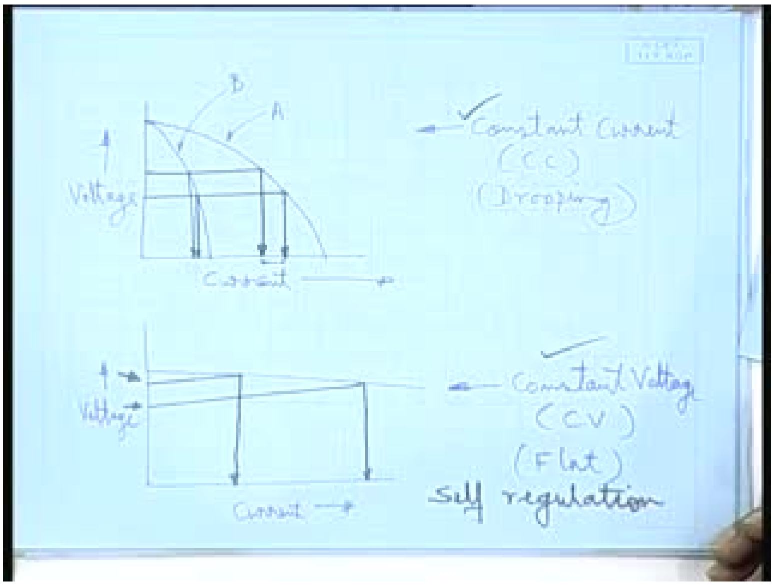

There what one can do is - one will have to change the current continuously. That is difficult. Instead, one can use a constant potential power supply, a skilled welder and he plays with the arc length. If you want more deposition, he increases the arc length; he pulls off the electrode. Those are in the fraction of millimeters; very highly skilled. If he extends a little bit, he gets much high current or deposition. So, very skilled welder can use this for specific cases.

We will stop here today. Tomorrow, we will see metal transfer mechanism and welding parameter and their effects.