Marine Construction & Welding

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Module No. # 01

Lecture No. # 30

Gas Metal Arc Welding – II

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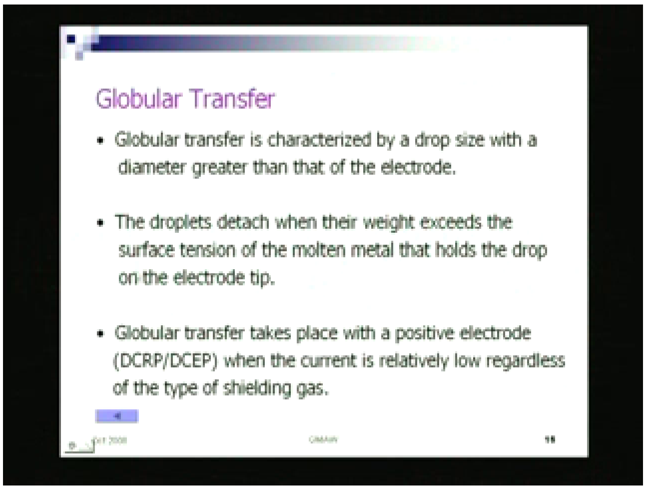

The conditions are such that, means you have the electrode DCEP means, direct current electrode positive. You have a relatively lower level of current and then, irrespective of the type of shielding gas, we have globular transfer.

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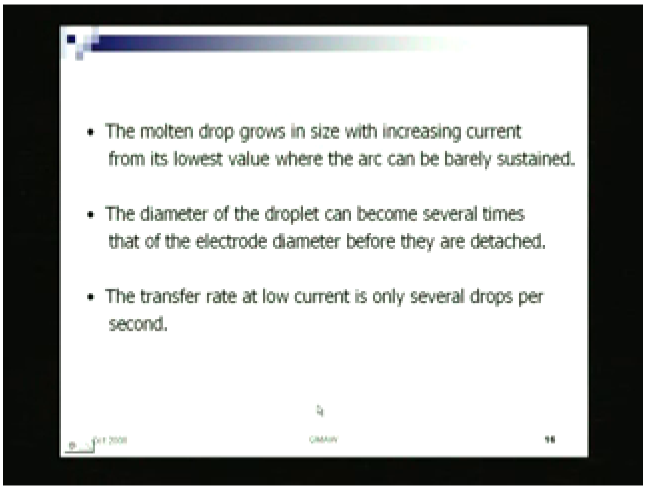

So, the molten drop grows in size with the increasing current from its lowest value, when the arc can be barely sustained. So, what is happening is the molten with increasing current, it grows its size from a lowest value when the arc can be barely sustained. The diameter of the droplet can become several times than the diameter of the electrode, which I have already said.

The diameter of the droplet will be more. The transfer rate at low current is only several drops per second at low current, means what essentially at lower level of the lower side of the current, you have globular transfer. In fact, when you go higher and higher current, then globular transfer changes over to spray transfer. So, that that is why, this low current, this term is being used. The transfer rate remains only several drops per second. Several drops, that means not in hundreds.

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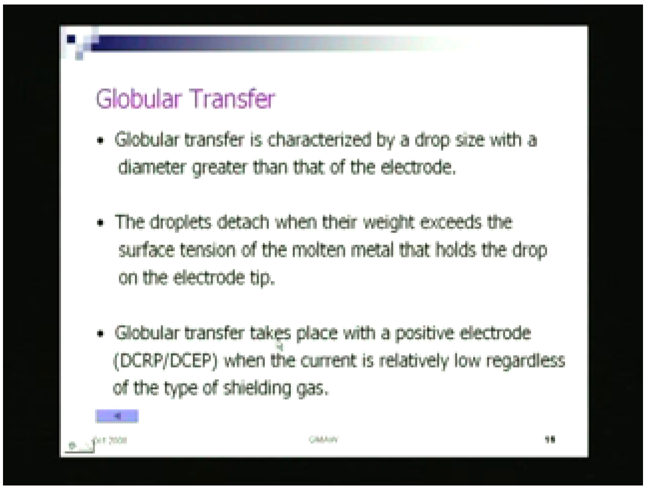

In fact, it is lesser than that. So, that is what essentially the globular transfer mechanism is. That means, in the arc, heat the electrode tip melts and the molten, that molten tip gradually grows in size because as the time is passing by, more heat, more melting is growing in size. Till such time, the weight of that molten droplet exceeds the surface tension force. It gets detached. So, that is what it is, and the transfer rate is around certain numbers of drops per second.

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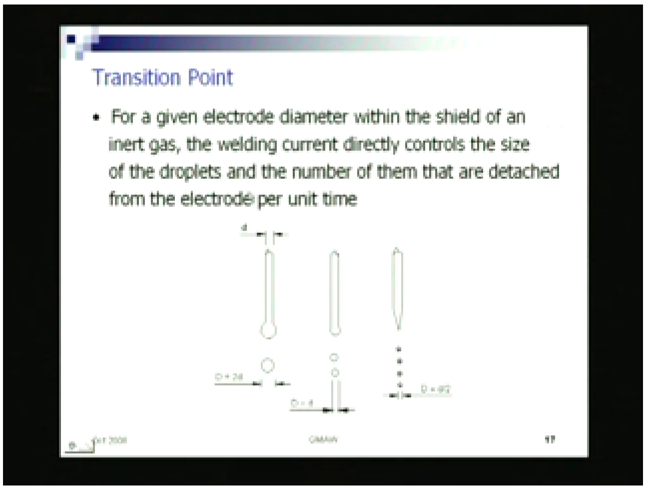

So, then we see that what is happening in transition point. So, this is schematically you can see this first figure here. It is a kind of a globular transfer as if taking place. Here, you can see the droplet size is about as if twice the diameter of the electrode. So, for a given electrode diameter within the shield of an inert gas, that means a given electrode diameter, a given shielding medium, the welding current directly controls the size of the droplet. Same electrode, same electrode diameter.

Let us assume, same shielding medium, that means same say, CO_2 or argon or helium, some inert gas shielding medium and gradually from here to there. As I am coming from left to my side, I am just increasing the current. So, what I will see? I will see there will be a gradual drop in the size of the droplet. That means, there will be a reduction in the diameter of the droplets.

So, the welding current directly controls the size of the droplets. As the welding current is increasing, droplet size is reducing, and here you can see as if here only one droplet was going in a certain unit of time. Here, 4 such mini droplets are going or in other words, from the globular, it is getting over to the spray mode, so the droplets and the number of them that are detached from electrode per unit time. So, it directly controls that. That means, as I increase the welding current, the diameter of the molten droplet reduces, as well as the number of them getting detached increases.

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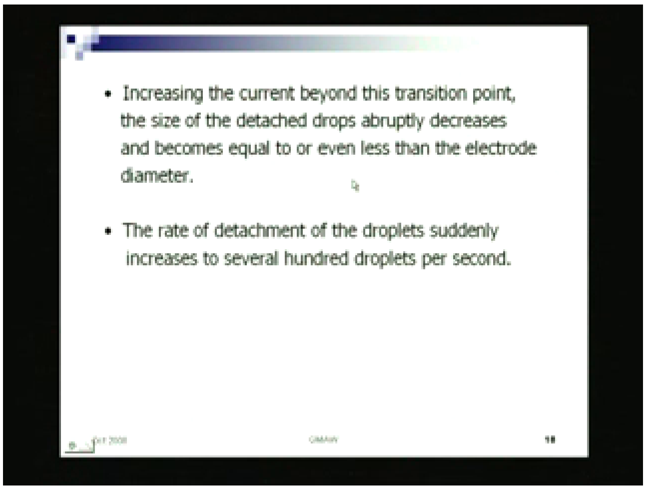

So, that is what is the transition point. So, what we see? Increasing the current beyond the transition point, the size of detached droplet abruptly decreases. So, this is abrupt. If I take these as abrupt decrease in the droplet size that means, here I have gone beyond the transition current. The size of drop, detach drops abruptly decreases and becomes equal to, or even less than the diameter of electrode. In fact, it becomes less than the diameter of the electrode. That means, fine droplets, they get so-called discharged from the electrode.

The rate of detachment of the droplets suddenly increases to several hundred droplets per second. There in globular, it was several droplets and now, several hundreds of droplets. That is why it is being referred to as if a spray transfer. That means, spray means, what it is a continuous flow of some material. Continuous flow in what sense? Discrete, but in a continuous manner and that means, several of them going per unit time.

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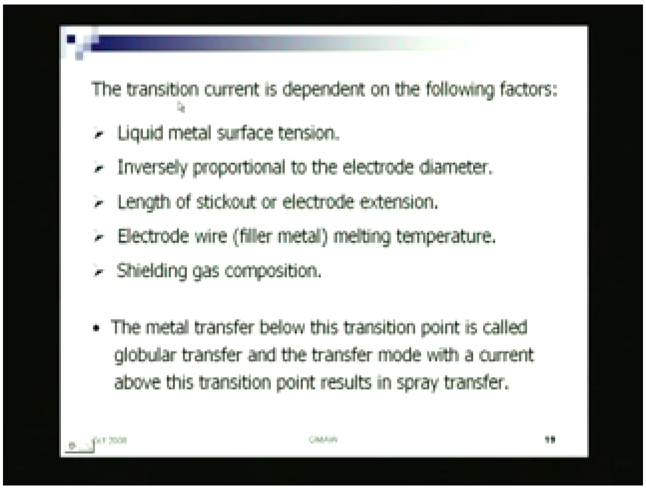

So, what we see that the transition, that means the transition current is or the transition point, where the transition is taking place from globular to spray there, where it is exceeding certain level of current. So, that current is also referred to as transition current, and that depends on these factors. That is the liquid metal surface tension. That is one thing. It is inversely proportional to the electrode diameter. That means transition current. If the diameter is less transition, current is more. That way, it will go length of stick out or electrode extension. It also matters length of stick outs is the sticking out length from the point. It gives the power to the electrode tip because the longer it is, more heat is generated there in the electrode because of the resistance of that length of the electrode which is sticking out.

So, it also depends on that. It depends on the electrode wire melting temperature. What kind of wire is being used? That is a filler metal and finally, it depends on the shielding gas composition. This also is very important what shielding gas you are using? Depending on that, it will have its ionization potential that will determine what extent also will influence the extent of heat generated in arc column. So, all that will influence the transition current, whether it will be at the higher level or lower level or what. So, we see that the metal transfer below this transition point is called globular transfer, and the transfer mode with current above these, results in spray transfer.

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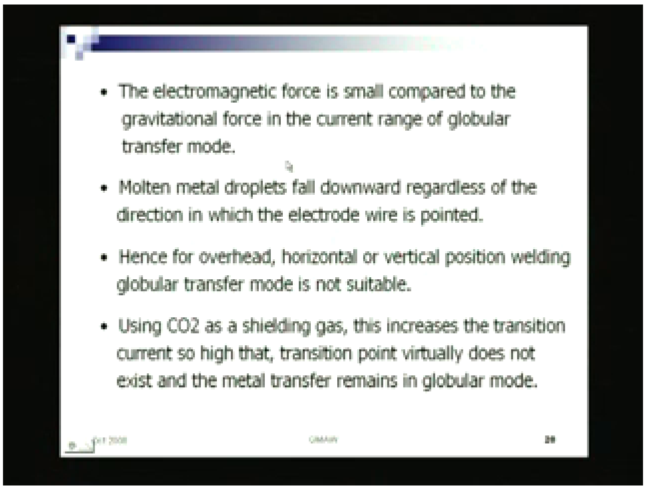

Now, what do we see that in the globular transfer? These electromagnetic forces are small. The electromagnetic forces are small compared to the gravitational force in case of globular transfer. So, that is why, if the welding mode or the metal transfer mode is that of globular transfer, then you cannot weld. Overhead positional welding will become bad because the metal transfer will be taking place against gravity. So, the weld deposit will be improper; will not be of good quality, whereas if it is spray transfer, then the situation is somewhat different. Not necessarily, it will be very good always, but situation is different because what is happening is that, there this electromagnetic force becomes more predominant because the globule size, there the droplets sizes are very small.

So, the gravitational force acting becomes somewhat, I mean that does not dominate in globular transfer. We see that the gravitational force dominates. It is more than the electromagnetic force. There it becomes comparable, even at places becomes less. So, overhead welding with spray transfer becomes feasible. So, what you see is the molten metal droplets fall downward, regardless of direction in which wire is pointed. This is case of globular transfer. Hence, for overhead horizontal or vertical position, globular transfer mode is not suitable.

Now, using CO2, these two should be subscript. Using CO2 as a shielding gas, this increases the transition current, so high that transition point virtually does not exist. What does this clause mean? This means, like we said the transition current depends on shielding gas composition, or on the type of shielding gas. Now, if the shielding gas is

CO2, carbon dioxide which is also widely used, so there we see that we never go to the spray mode. It continuously remains in the globular transfer mode only. Why? Because with CO2, the transition current level is so high, that we cannot reach that. It is not that we cannot attend that kind of current, but thing is, when we do a welding, how much current you will apply, that will not only depend on whether I have globular transfer or spray transfer, that will depend on other parameters also.

One of the important factor would be plate thickness because for a given plate thickness, if I unnecessarily give too higher current, it will cut through instead of melting and depositing metal. It will cut through the plate because it will over melt the plate, overheat it, over melt. Now, what is happening with CO2 using ass shielding gas, it requires a current level which is much higher than, what otherwise would have been required for a given plate thickness or in other words, what happened? What does that mean? That means that we cannot attain that transition point or in simple words, with CO2 welding, you only have globular transfer. That is one of the disadvantages of CO2 welding that I do not attain or I cannot attain a spray transfer mode because obviously, spray transfer mode is more preferable.

However, steel CO2 welding is used extensively for the simple reasons. CO2 is very inexpensive shielding medium in inexpensive material, and wherever there is a down hand welding, so it does not really matter or in other words, the quality we achieve is substantially, I mean is up to the desired level. So, CO2 welding is used even if it is a globular transfer.

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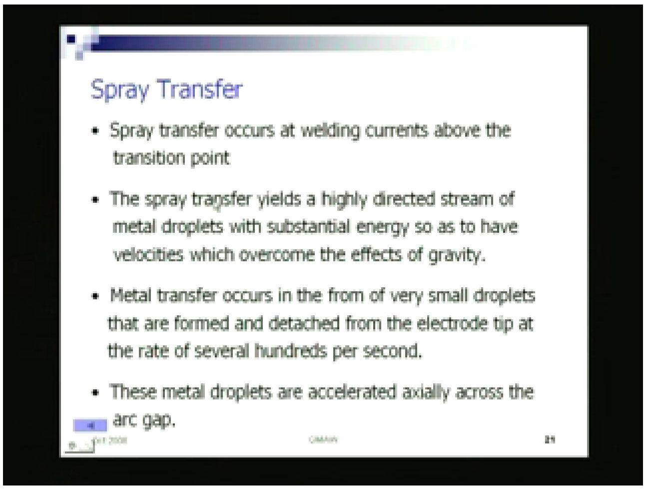

So, that is what is the so-called globular transfer mechanism. Here, we have seen the transition point and then, we come to the spray transfer mode. What is that spray transfer mode? Spray transfer occurs at welding currents above the transition point, which we had been already talking. That means, as we increase the welding current beyond, and we go beyond transition point is the spray transfer. Spray transfer yields a highly directed stream of metal droplets. It is a highly directed stream in globular transfer mode. The metal was directed depending on gravitational forces. That means, it is only vertically down, but in spray transfer if I direct it this way, so it will be a directed sort of stream of metal droplets will go, whether it is horizontal or whether it is overhead with substantial energy, so as to have velocities which overcome the effects of gravity.

This is what is important with spray transfer. That means, there the droplet sizes are finer and like a jet, they get a kind of propelled to the weld pool. That means, they are yields, a highly directed stream of metal droplets with substantial energy, kinetic energy, so as to have velocities which overcome the effects of gravity. So, thereby, it becomes that is how we can see having this property.

We can propel it to the area, or to the weld pool. We want that weld pool can be a vertical weld pool, can be a horizontal weld pool, or can be an overhead weld pool plus because of the force it has, so it attains a higher depth of penetration, that also it achieves. That means, for the root fusion etcetera, it is preferable. You can assure better penetrating power. I mean you have a better penetrating power, so you assure root fusion also properly. Metal transfer occurs in the form of very small droplets that are formed, and detached from the electrode tip at the rate of several hundred per second.

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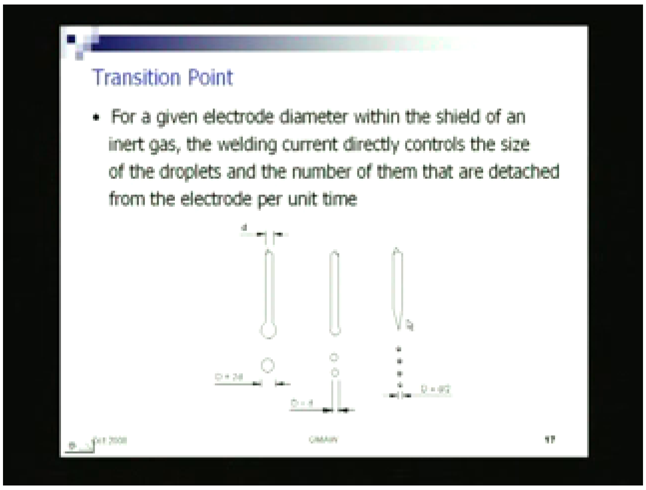

So, the droplets are in the form of small droplets. So, thereby, you see even the electrode tip in case of globular transfer. The tip remains blunt in case of spray transfer. Tip becomes very fine like pointed. It gets like that automatically. So, the metal droplets transfer occurs in the form of fine small droplets, and they are detached several hundred per second. These metal droplets are accelerated axially across the arc gap. Obviously, it goes axially. That means, wherever direction of the arc, it will go along that.

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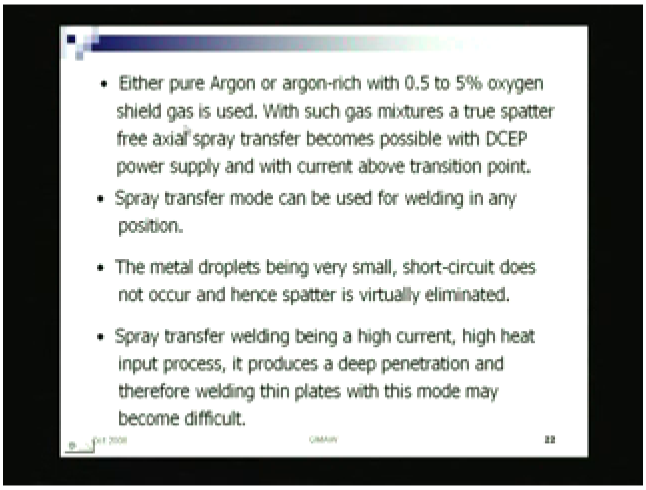

Well, here we see that argon and argon rich with 0.5 to 5 percent oxygen shielding gas, they are generally used. That means, if I use argon or argon oxygen shielding, then we attain a, I mean we can, one can attain so-called spray transfer mode with such gas mix mixture. A true spatter free spray transfer becomes possible with direct current electrode positive supply above the transition current. That means, in globular transfer, you have lot of spatter for the obvious reason. The way metal is transferred, some splashing always will take place. In spray transfer, you can almost avoid that spattering phenomena. It can weld in any position. Metal droplets being very small, short circuit does not occur. Hence, spatter is virtually eliminated.

In globular transfer, in globular transfer mode, if there is a drop in the arc voltage, how the drop in arc voltage could be? It could be by shortening of the arc length. For some reason, there is a shortening of the arc length. Then, there is a probability that the globule getting short circuited, though it is not a short circuiting mode of transfer. We are not using, we are keeping the current level at such a level, that we expect a globular mode of transfer, but the arc length being shorter, that means, improper weld setting, improper welding procedure, so there will be a risk of short circuiting on the globule.

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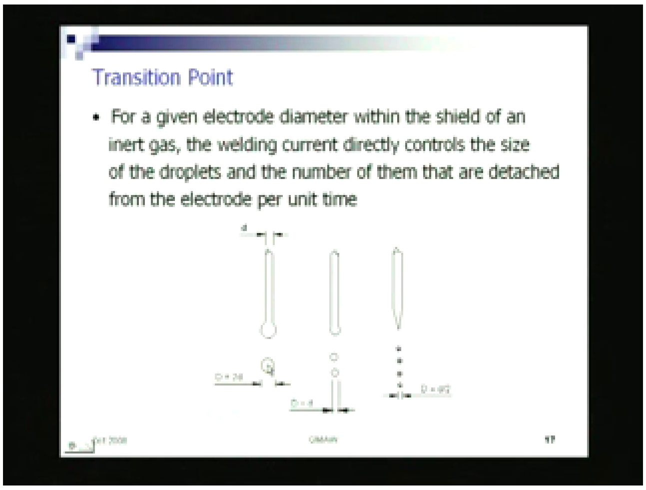

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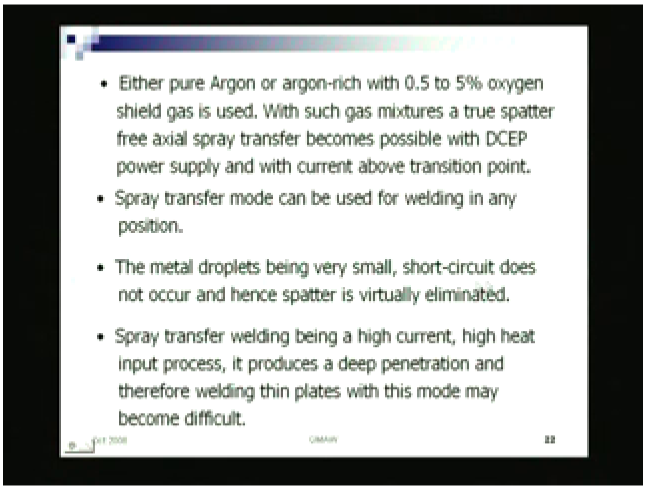

If that happens, there will be excessive spattering. Why? Because when short circuiting takes place, certainly there will be a surge of current, and there will be a kind of explosive force acting on the droplet and leading to a very high spatter. Here in case of spray transfer metal droplets being very small, question of short circuiting is eliminated because your arc gap can never become so small. So small means, like that of the droplet size because here, we can have an arc gap which can be because the droplet size is more than the electrode diameter, and the arc length can be of that order, whereas arc length cannot be so less.

So, question of short circuiting does not occur at all. That short circuit does not occur and hence, spatter is virtually eliminated firstly. So, small droplets falling that will not cause splashing of metal as well as there is no short circuiting, no possibility of short circuiting taking place, so no spatter. So, spray transfer welding being a high current, high heat input process, high current means, these are very vague term. High or low high means in comparison to that of globular transfer.

In comparison to that, that means in globular transfer, suppose you are working at a 175 ampere. Here, you might be working at 350 ampere like that. So, it produces a deep penetration and therefore, welding thin plates with these modes may become difficult. So, this is another aspect. All these we had been saying is good aspect, but if the plate material thickness is lesser on the lower side, thinner gauge material spray transfer might not be a suitable option. Why? Because it generally has a high current, like I said suppose for with argon-oxygen combination, the transition current could be around 250 ampere. Now, you are welding a 2 millimetre sheet. There the 250 ampere can be too high because the ship may get sort of burn through, it will melt through.

So, there you may require a 125 ampere current. So, there you do not attain a spray transfer mode also. At the same time, you do not need that because what is happening, the thin plates will get, you may find it difficult because it is not joining, but cutting through or in other words, spray transfer mode of welding is not suitable for thinner gauge material. In fact, thinner gauge material one is preferably short circuiting mode.

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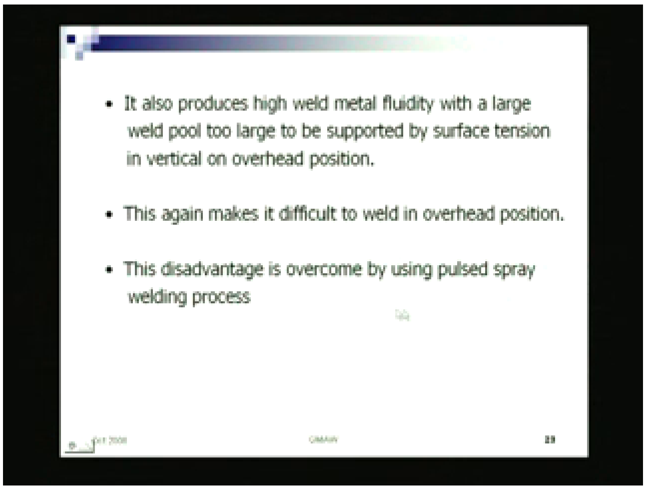

Short circuiting mode of welding, short circuiting mode of metal transfer, it also produces high weld metal fluidity with a larger size weld pool, too large to be supported by surface tension in vertical overhead position. On one hand, we can see that it has a higher kinetic energy. It can direct the spray of the molten metal towards the weld pool, thereby making it suitable for positional welding, in the vertical welding, or overhead welding. At the same time, it produces higher metal fluidity. Why? It is because it operates at a high current, and it has higher heat content. It produces higher heat.

So, automatically produces a little larger weld pool, this large weld pool. More current means, more heat for the same metal thickness. Suppose, welding an 8 millimetre plate, one with a globular mode of transfer, another with a spray mode of transfer. Here, I will have more heat input because I need a higher current to go to the spray mode. So, more heat means, more current means, more heat means, more melting. So, that will lead to a larger weld pool.

Also, then what will happen is, it becomes difficult for the larger weld pool, sustain with its own surface tension force. So, again that may create problem. So, on one hand, it solves some problem, but on the other hand, there are difficulties also. So, this again makes it difficult to weld in overhead position. So, that means, it is not a blanket solution that you go for spray mode of transfer, and you can do overhead welding. No. So, this disadvantage is overcome by using pulsed spray welding process.

So, what is happening, that means first we could overcome the problem of metal, molten metal falling off from the weld zone. Because of gravitational force from globular, we came to spray transfer, wherein we could overcome the gravitational force with higher electromagnetic force acting on the metal on the transfer of the liquid metal, but again, that is giving rise to a problem like this. It is causing a larger weld pool, and again that molten metal in the weld pool is becoming defined. That means, from the electrode metal is getting transferred, but it is difficult to hold the molten metal, and it is trying to fall off. So, what we will have to do is, we will have to reduce the heat, such that it gets the weld pool becomes little smaller, as well as the freezing time becomes faster solidifying time.

So, how can we do that? We will have to that; that is feasible through that means, some mechanism by which I can reduce the current. So, one hand if I reduce the current, it goes in to globular mode. I do not want that. So, I have to sustain the spray mode of transfer and also reduce. So, what we go for? We go for a pulsed mode of power supply. That means I give the power in pulses. When I give a high current, I have a spray transfer. Rest of the time I remain in a low current mode. No transfer, so that is what is called pulse transfer mode. Wherein, I use a pulse mode of power supply.

Till now, power supply was constant with time. That means, in spray transfer mode, say 350 ampere is required means, current and this is my time, this current. So, it was like this, say this is 350 ampere. This is say, needed for spray for a certain diameter of your, what do you call electrodes, certain shielding gas whatever 350 say, at a lesser current of around 200 ampere. It was globular; it was just globular mode of transfer.

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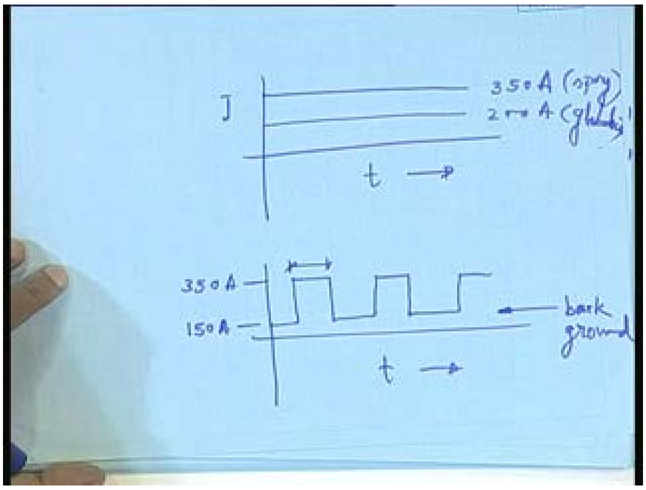

In pulsed, what will happen is, it would be something like this. That means, this is 350 because at 350, I am achieving desired spray transfer. So, I make the pulses of 350 and then, I bring it down. So, depending on the number of pulses, I am giving per unit time. So, many droplets will go. This pulse size is such; this is the microsecond size, whatever is such that in this one pulse, one droplet goes out.

So, suppose, I have say 300 pulses per second. That means, per second 300 droplets will go. Rest of the time, I bring down the current substantially below. How much? Well, that again is I am just arbitrarily writing here 150 and 350 etcetera. How much, such that the arc is sustained. It should not get extinguished. There should be sufficient current, such that the plasma column is sustained. It is not extinguished, so that is the whole philosophy. So, we will see that.

So, here what happens is that the welding current switches automatically from a low level to a high level in a periodic manner. It is just coming at the low level. This low level current is called background current. Why? Background current because that is the current it is set, wherein as such no melting is taking place, no metal detachment is taking place. So, only enough to keep the arc ignited means, to achieve ionization of the arc column to maintain the ionized arc column.

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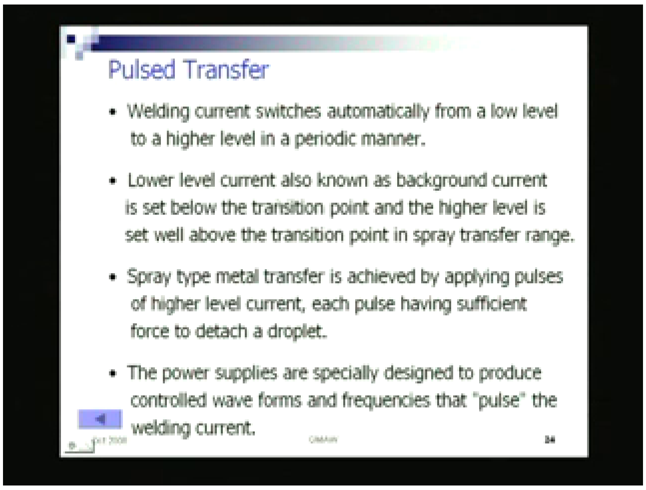

So, that is what low level current also known as. Background current is set below the transition point obviously, and it is set below the transition point and the higher level. That means, this higher level pulsed current is set well above the transfer transition point in the spray transfer range. So, the transition current could be somewhere in between.

Background current level will be much lower than that, and the higher level will be much higher than that. Much means, well above the transition current, such that I attain a suitable spray mode of transfer. So, spray type metal transfer is achieved by applying pulses of higher level current, and each pulse having sufficient force to detach a droplet like I was saying.

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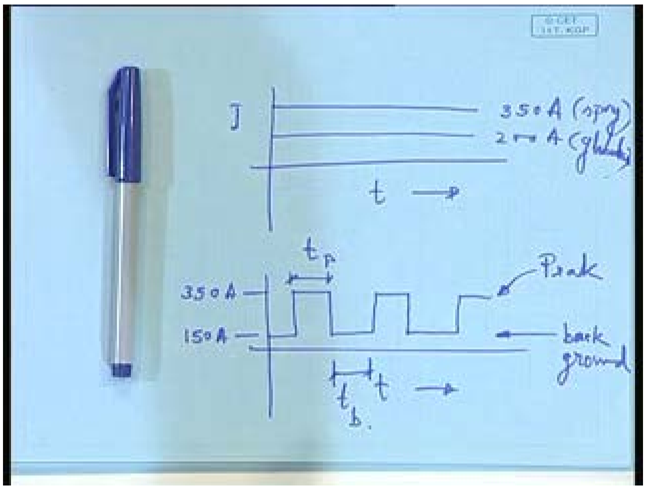

So, I can set this power supply in such a fashion that each pulse will detach one droplet. So, number of pulse I know how many droplets. So, I can control my deposition very precisely. I set the speed of the welding machine. That means speed of the movement of the torch that I know. In 1 second, it will travel so many centimetres or so many millimetres, whatever and also I know that in 1 second, how much, how many droplets it will deposit. I have an idea of the droplets.

Then, I know how much of metal in terms of grams or kilograms or whatever, it is going to go. That means, very precise control of metal deposition is possible, precise control of heat input is possible by setting the background current, by setting the maximum peak current. This is my peak current level, and by setting this, this time of the peak as well as time of the background, background current. That means, fixing the time period for which the peak current, duration of peak current will be there, time period for which duration, the background current level will be there.

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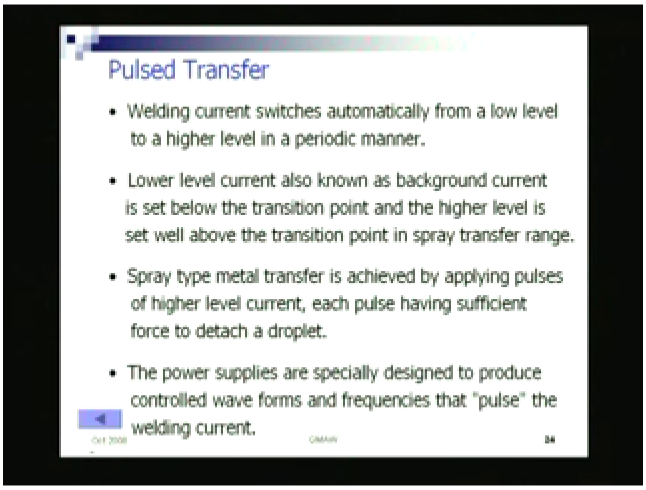

So, here the power supplies are specially designed to produce controlled wave forms, and frequencies that pulse, the welding current. Basically, I am pulsing the welding current. It is not an AC waveform, mind you. It is a DC waveform. Only thing I am pulsing it, that means it is remaining, it is not going below the so-called axis. It is not becoming negative. It is only plus 350, say this example it is playing with plus 350 to plus 150. So, it is not an AC square wave form. You said DC power; only thing the value magnitude of the power is changing over time, magnitude of the current is changing over time. So, that is what it is a controlled wave form, and frequencies. That is pulsing the current.

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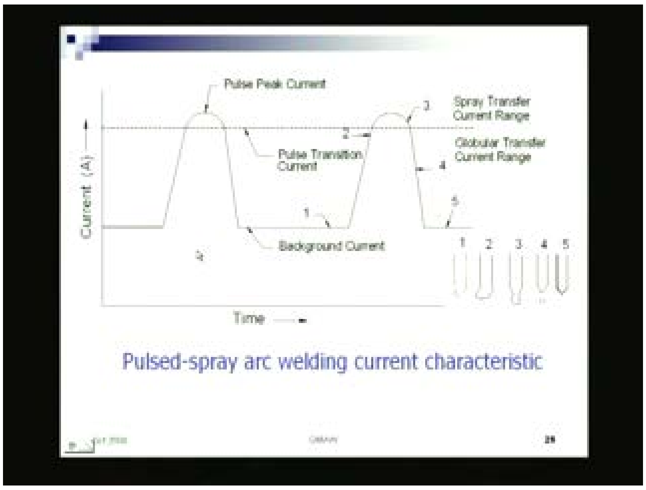

So, this is what is this. In this form, I mean it can be a square wave or like this. So, what we see here, this is a time current, and this is my pulsed peak current, background current. So, suppose this is my pulse so-called transition current. So, I keep the peak current higher than that, and this is the globular transfer, current transfer, and current range. Here, I keep the background current much less; where I have just simply the arc is remaining ignited. No metal transfer, no melting is taking place.

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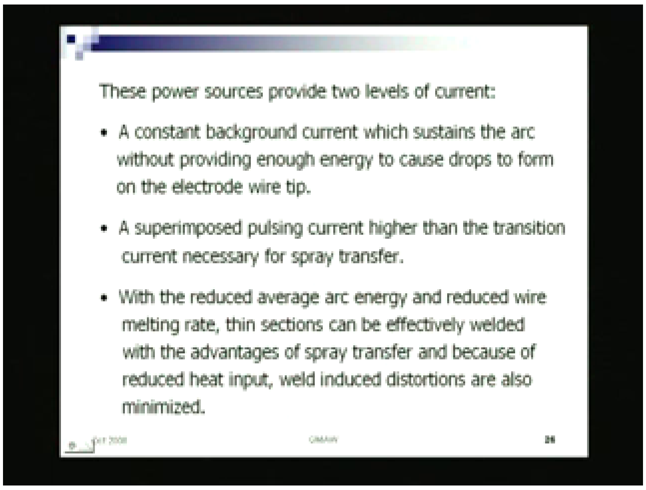

So, this pulse mode, so for pulsing this what we need is a pulse mode power supply. So, these power sources, it provides two levels of current. Constant background current, which sustains the arc or else telling which sustains the arc without providing enough energy to cause drops to form on the electrode wire tip.

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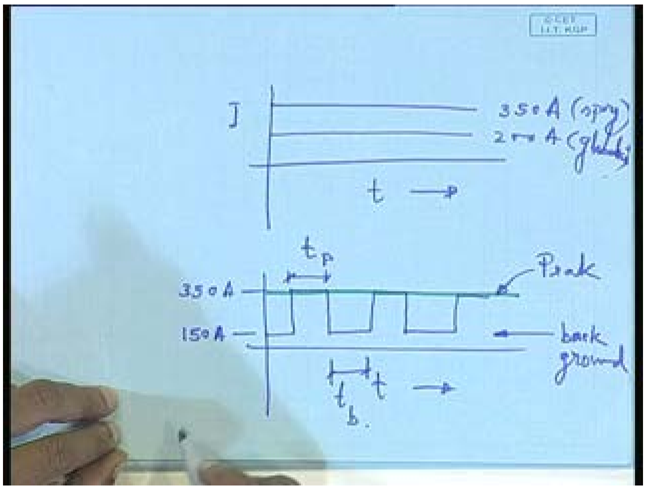

It is only sustaining the arc without causing melting of the electrode tip to that a superimposed pulsing current higher than the transition current is necessary for spray transfer. So, essentially have a continuous background current, and a superimposed wave form of like this. Wherein, I have the picks. So, what you see over all the energy is reduced because if I would have require to have the so-called spray transfer, then I would, I needed a continuous current level of this, and in this continuous current level also, the metal detachment is taking place. Not in a fully continuous fashion, but in a discrete fashion. That means there are easy time gap between two droplets.

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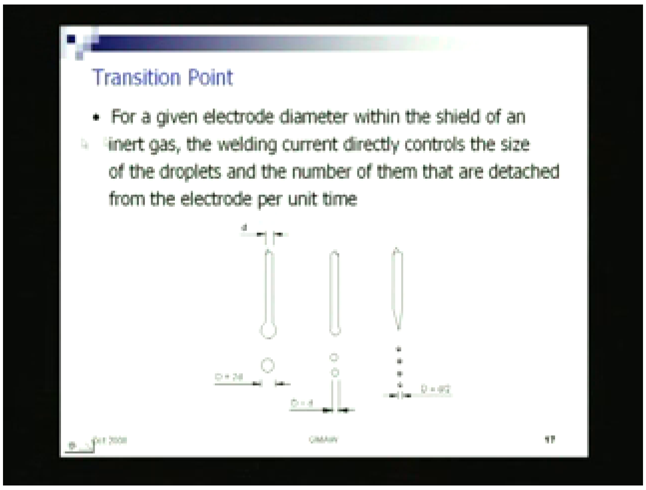

That is time gap always. This means that there is a gap between the two droplets. That means there is a time gap. So, what is happening in this time is, the time gap is here, somewhere here, somewhere here. That means, the time, the extra heat that current which is going on, that is not causing any so-called useful purpose, not contributing to melting of the metal neither contributing to detachment of the metal. It is only going as a heat in the plate.

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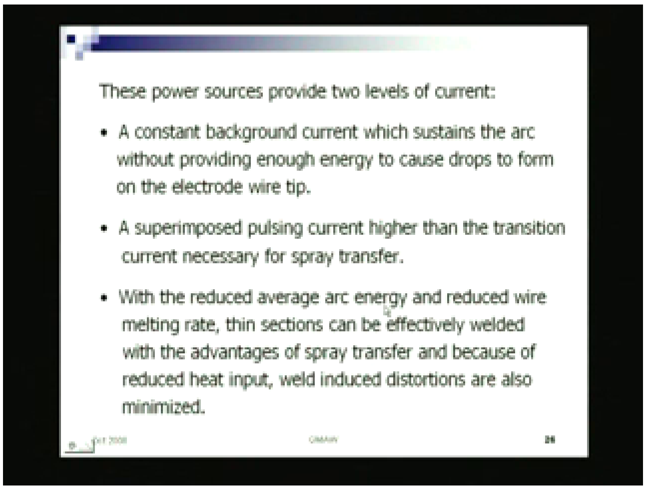

So, what happens is heating. That means, extra heat is going in this case, but here I am controlling. So, whenever there is no metal melting of detachment is taking place, the current is also low, the heat input is also low. So, in this type of wave form what we can see that the overall, we see that the average heat going in to that average arc energy. Thereby, the average heat going in to the metal plate is less. So, what it results in to welding to these distortions is also minimized.

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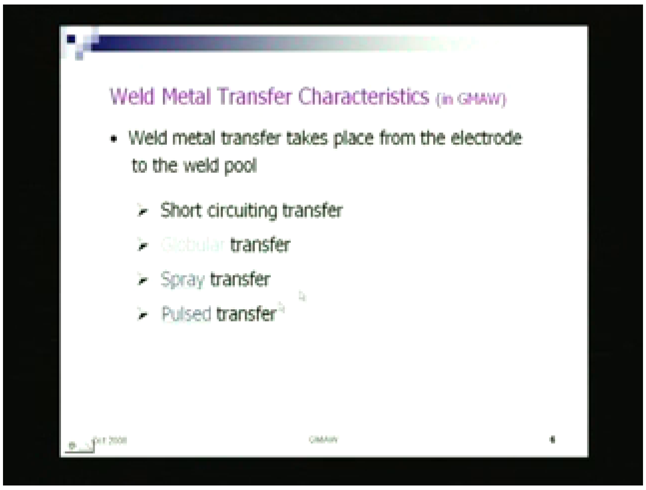

Because of this reduced heat input, the welding distortions, that means the thermal stress is developing leading to distortions are also minimized. So, that is how we see that these are the, if we go back, these are the 4 types of, 4 mechanisms of metal transfer that takes place in case of gas metal arc welding, in the short circuiting transfer, globular spray and pulsed mode of transfer.

As you can see, all these have got developed one after the other to solve some problems. That means, when you go to the pulsed mode, then that becomes very effective method of positional welding. Obviously, as a fabricator, as a designer one should try to avoid any kind of positional welding, means we should design the product in such a fashion, we should design or make the production sequence in such a fashion, as well as design the production facility in such a fashion, that we can convert all welding positions to down hand welding. That means, avoid welding, avoid vertical welding, avoid horizontal welding, and convert them to down hand. That is true, but not always that is feasible.

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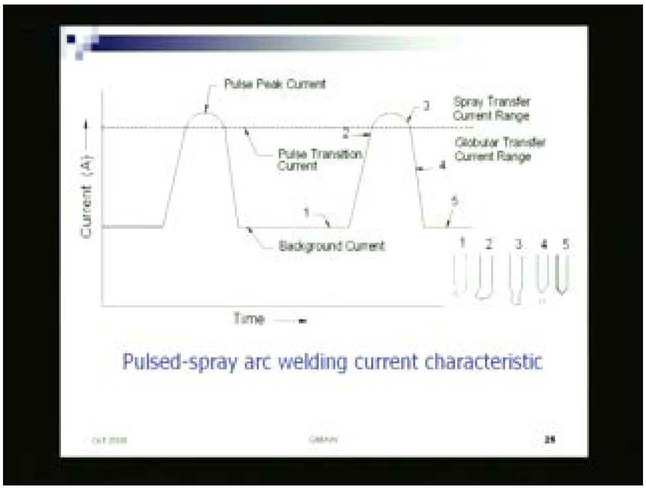

There will be situation when you will have to do positional welding, then as you find that, preferable mode would we spray. Much better mode would be pulsed. That is obviously as we switch from short circuiting to pulsed mode, obviously you are welding equipment becomes more and more expensive, sophisticated. When we talk about the pulse mode, it is essentially I mean that is not a very simple, just welding rectifier will have to have further more controls of providing such a pulse power output. Not only that, you will have to have mechanism to control this TPTV, and all that means, all these background current, this time period, this period etcetera.

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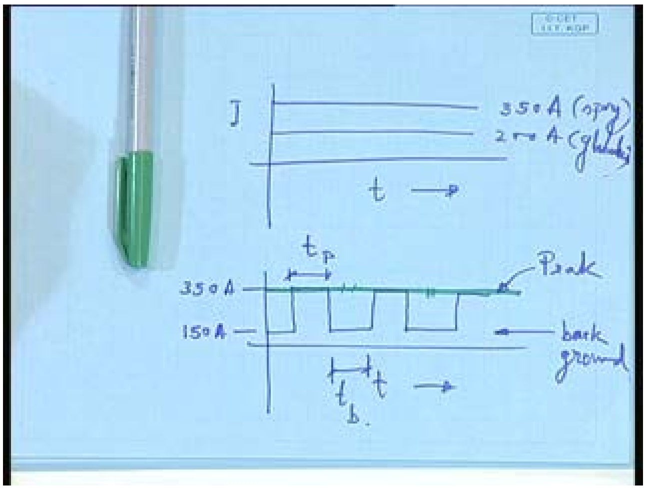

Also, as it appears that is well I want 200 droplets, means I said something again not simple. So, because one parameter you said, the other parameter will get affected. So, that means, there has to be a synergy between all the parameters. So, that is how the name of the pulsed power source is called synergic machines, also referred to as synergic machines. That means they cause a synergic between the various parameters. Various parameters are background current level, peak current level, the duration of the background current level etcetera.

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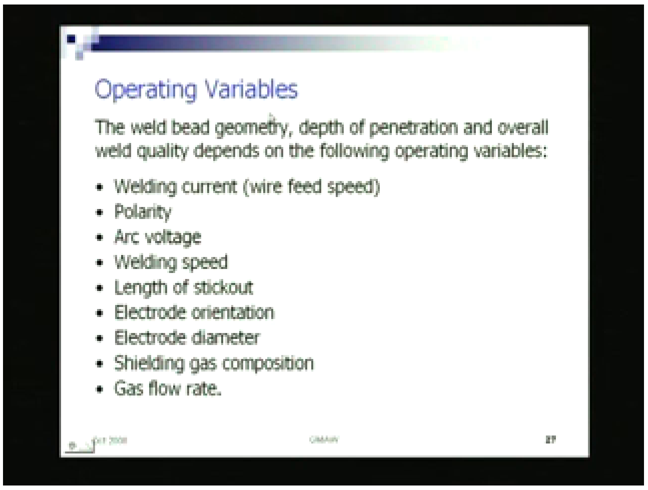

Anyway, so that is what the metal transfer mechanism is. Now, let us see what the operating variables for this gas metal arc welding are. Till now, the gas metal arc welding we are saying, so operating variables means, instead of calling them as welding parameters, I am saying that operative variables because by welding parameters, precisely we think of welding voltage, welding current and welding speed. These are 3 aspects, but there are various other aspects also which controls the end weld quality, end weld performance.

So, they are like well welding current in bracket. I have written wire feed speed. This means, governly available gas metal arc machine welding. If you want to change the welding current, what is change is the wire feed speed, the speed of feeding of the electrode wire. If you increase that, welding current automatically increases. If you decrease that, welding current decreases. Why? Because they are connected together, they are linked because if I feed more electrodes automatically, it means you need more current. Why? Because you will have to melt more amount of metal because more electrodes going per unit time means, more amount of metal is going into the weld pool. It should get melted. So, it requires a higher current, so they are linked.

Why they have been linked? It has made so-called user friendly, otherwise for the welder, it would have been difficult. How much feeding I will give for that, what current should be set, so that is done somewhat automatically in any case. So, important parameters, actually the welding current, and then obviously its polarity arc voltage. Welding speed length of stick out, then electrode orientation, all these things somewhat we have seen. We will see also again little more electrode orientation.

Electrode orientation means, I can hold the electrode perpendicular to the plate, and move. I go for welding, I can also hold the electrode inclined like this, and do the welding. I can hold it, inclined the other way, and do the welding. So, that means there can be 3 electrode orientations with respect to the plane of the plate, with respect to the weld line.

So, thermodynamics at that also has an effect on the weld performance electrode diameter shielding gas composition, and gas flow rate. So, these are the, one can say that all of them, they have together some effect on the weld performance, on the welding quality, the bead geometry, the depth of penetration and overall quality because as an end user, he will be interested only in the overall quality. He will be interested on the bead geometry; he will be interested on the how much fission has taken place, depth of penetration. So, these are the parameters which affect them.

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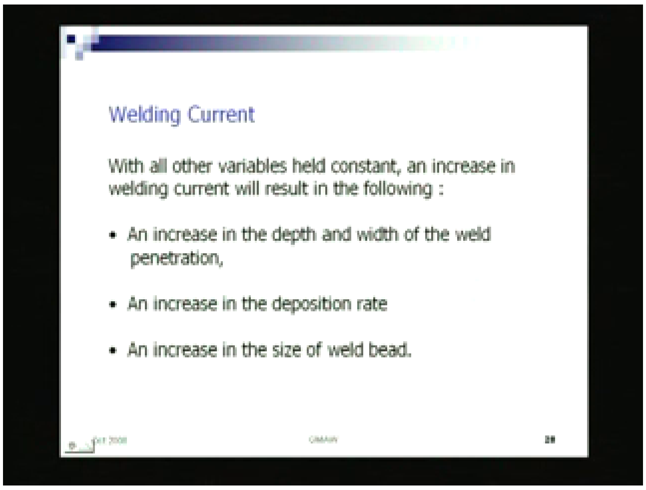

How they affect? We can see say the welding current with all other variable held constant because all are interactive. So, you will have to keep all constant to see the variation, to see the effect of variation of one of the parameter. So, welding current with all keeping constant and increasing welding current will result in the following. If we increase the welding current, what we see increase in depth, and width of the weld penetration, obviously more heat.

More current means more energy, more force, more heat. So, penetration depth will increase as well as the width of fusion also will increase. That means, weld bead will become the fusion, zone will become broader and deeper. Obviously, it will have a increase in deposition rate. Melting rate will increase. Increase in the size of weld bead, weld bead also will increase. So, all these aspects, they take place.

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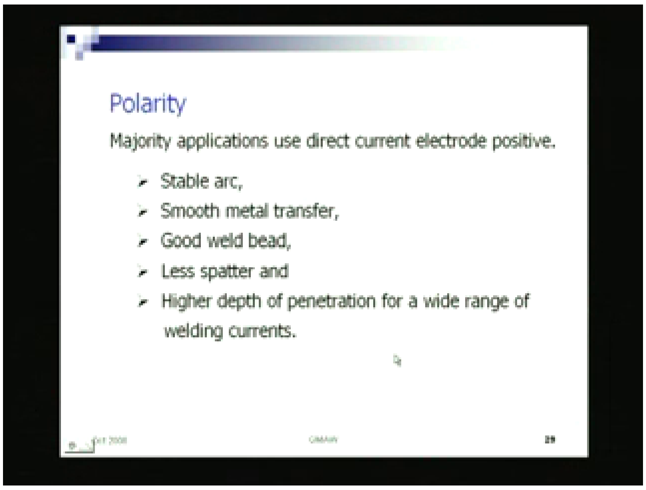

Polarity majority applications used direct current electrode positive. We are not going for other things. It is mainly keeping the electrode positive, polarity is used. Why? Because that gives us stable arc which is desirable. It gives a smooth metal transfer good weld bead, less spatter and higher depth of penetration for a wide range of welding current. So, all these are good aspects, so a direct current electrode positive polarity. That means DCEP polarity is maintain arc length, which is actually the arc voltage. Arc voltage determines or arc length determines arc voltage because this nothing, but the voltages drop across the arc length.

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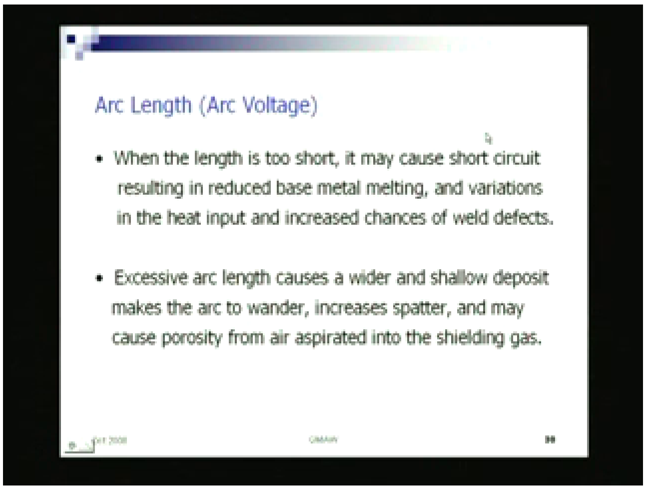

So, when the length is too short, it may cause short circuit resulting in reduced best metal. Melting may cause short circuit in case of globular transfer. Obviously, the arc length is too short. So, there can be a possibility of short circuiting. Obviously, when if it is a globular transfer mode of, it is a CO2 welding with CO2 as the shielding medium will have to have globular because you cannot attain the transition point. So, there can be a risk of short circuiting taking place, which may be little increased weld defects. Again the reverse, if the arc length is too high means have said the arc voltage too high, then it will cause wider and shallow deposit. That means the arc length is too high means, essentially you have a spread of the arc increases.

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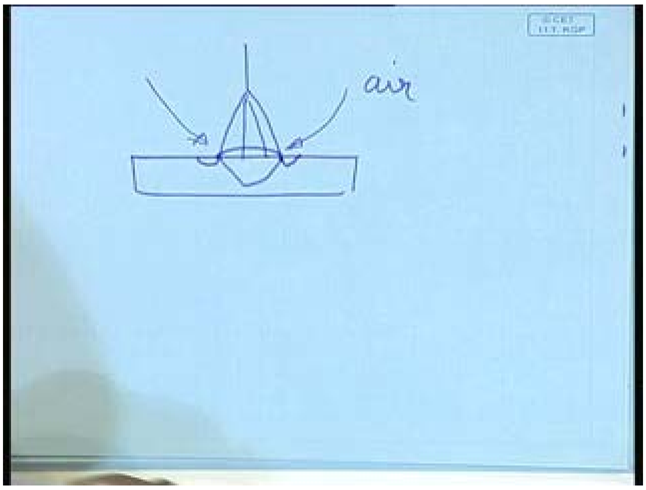

So, the fission zones becomes wider. This is speed of the arc increases as the arc length is high. Arc length is high means, essentially the arc voltage is high, and also may lead to the wondering of the arc. That means, deflection of the arc depending on the magnetic fields, it may also induce higher level of spatter, and may cause porosity from air aspirated in the shielding gas because it being longer possibility of fluctuation of the arc may take place, and if it takes in air here, respiration if it happens, then that will lead to entrapment of the air bubbles causing porosity.

In other words, too high welding arc voltage, too high arc voltage may lead to some defects like porosity. That is a main thing. Mainly two defects like porosity and increase in spatter. Too low an arc voltage may cause short circuiting and thereby, high level of spatter. So, that means obviously you will have to see the arc voltage is kept within the limits.

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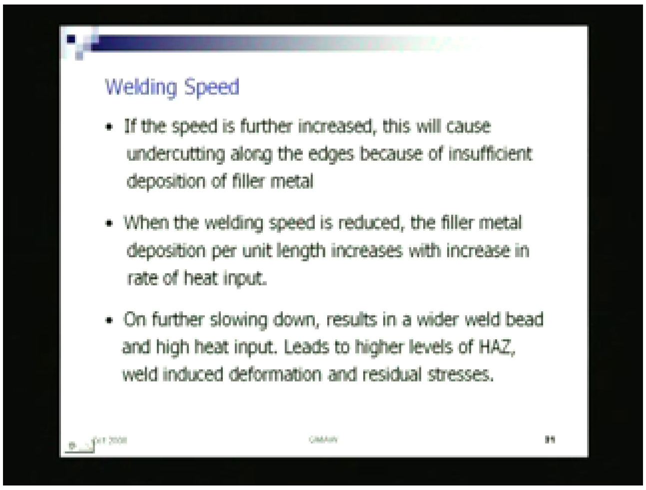

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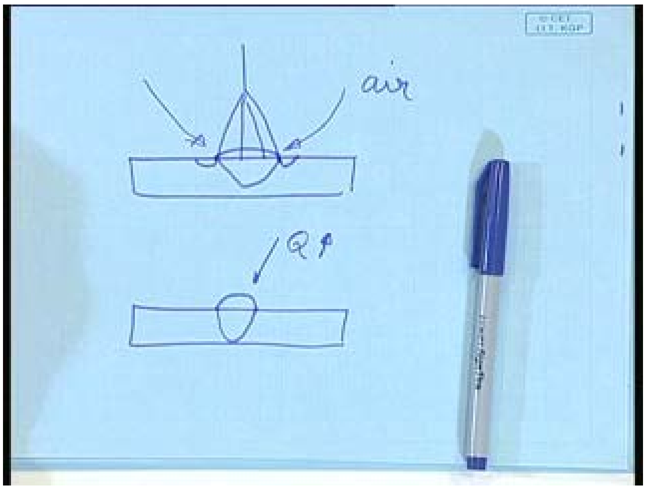

Welding speed, obviously the speed is further increased. This will cause undercutting along the edges. We have talked about the undercutting. That means, that the edges of the weld bead that there will be an insufficient deposition of filler metal. So, there will be insufficient deposition of the filler metal in the edges. That is called that means; it may lead to a defect called under cutting, whereas if you reduce the welding speed, then the filler metal deposition per unit length increases obviously with increasing rate of heat input.

So, what will happen that means, you may end up over welding a place, you may end up in a situation of over welding. Extra metal has got, additional metal has got deposited. It gives rise to more heat input. Heat input increases. So, more deformations additional heat affected zones. So, further if you slow down, if you still becomes slower, then that it results in a wider weld bead and high heat input. Then, it will also become wider heat input, also will increase the crown. Will increase means, the reinforcement will increase. It will lead to higher levels of heat affected zone, higher levels of weld induced deformation, and stresses, which means neither a very high speed is good nor a low speed is good. Again the same thing, somewhere in between you will have to look into.

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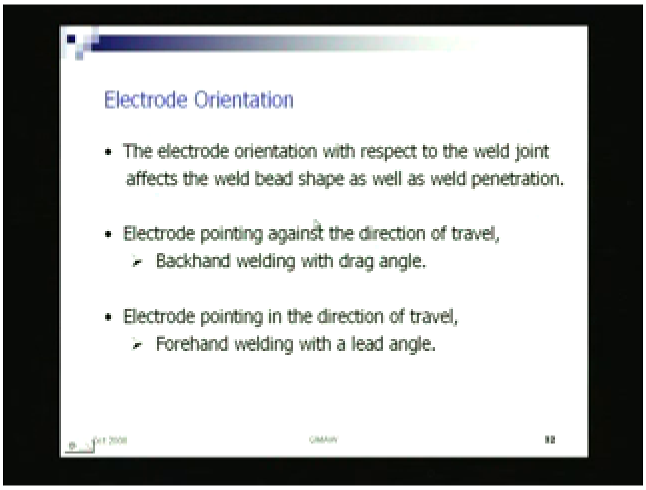

Electrode orientation as I was saying, the electrode orientation with respect to the weld joint, that also affects the shape of the weld bead. That also affects electrode pointing against the direction of travel is backhand welding. It is referred to as backhand welding. With drag angle electrode pointing in the direction is called forehand welding with a lead angle.

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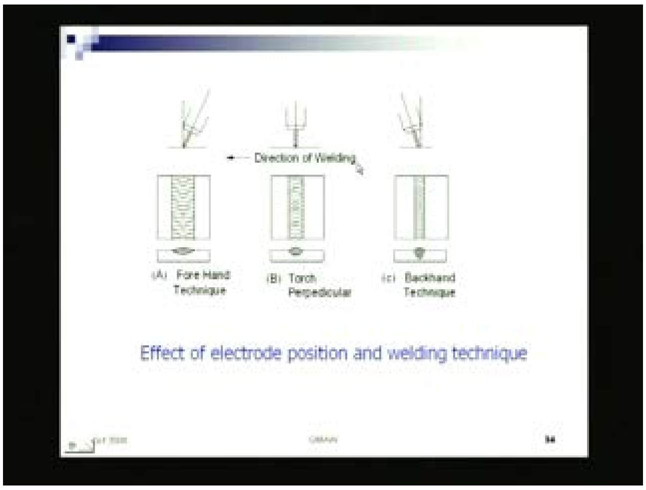

This is my direction of welding. In this case, it is remaining perpendicular to the plate. Here the direction is this, but as if I am holding the electrode like this, and moving in fashion, that is forehand technique. Whereas, I can hold the electrode like this, and do it this way as if I am dragging it. So, that is the backhand technique. There is a drag angle. So, what we see what the effects we see, that means, electrode pointing against the direction of travel.

If the direction of travel is this, and it is against, then it is a backhand with a drag angle. If it is in the direction of travel, I am pushing it there. Well, I am pushing it and here, I am dragging it. So, if I am pushing it, that is, a forehand with a lead angle.

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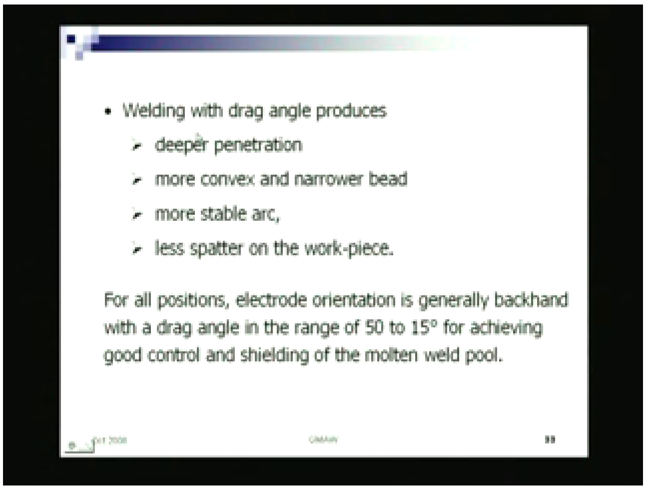

So, what do you see? Welding with drag angle produces deeper penetration, more convex and narrower bead, more stable arc less spatter. That means with drag angle, this is with drag angle. Then, I get a deeper penetration, narrower bead. Just the opposite in the forehand I get a wider bead less penetration. So, you can see keeping all other welding parameters constant. That means, heat input I am not changing, the voltage current speed I am keeping constant. Only the orientation I am changing and thereby, the fusion zone is getting changed.

So, what you see that electrode orientation is generally backhand with a drag angle because this is a preferable weld geometry, is a preferable fusion zone geometry. So, that is what it is kept in the range of 5 to 15 degree, not 50. It is 5 to 15 degrees. It is wrongly written here in the range of 5 to 15 degrees for achieving good control, and shielding of molten metal. So, this is what the thing is.

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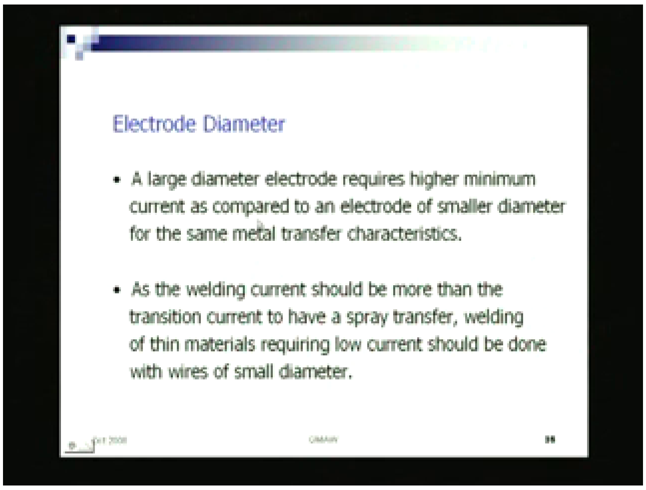

In electro diameter, obviously electrode diameter is higher. The diameter you need more current, then more deposition rates. So, a large diameter electrode requires higher minimum current, a high level of minimum current, whatever current that will be higher obviously, because as the diameter is more compared to an electrode of smaller diameter for the same metal transfer characteristics.

So, as the wielding current should be more than the transition current to have a spray transfer, welding of thin materials requiring low current should be done with wires of small diameter because for transition current, you need always higher. So, if I use a higher diameter electrode, still further higher current will go and so, thinner material will get cut through. So, a thinner material to be welded with a thinner wire and obviously, thereby I can use lesser level of current, and still I achieve spray transfer if necessary.

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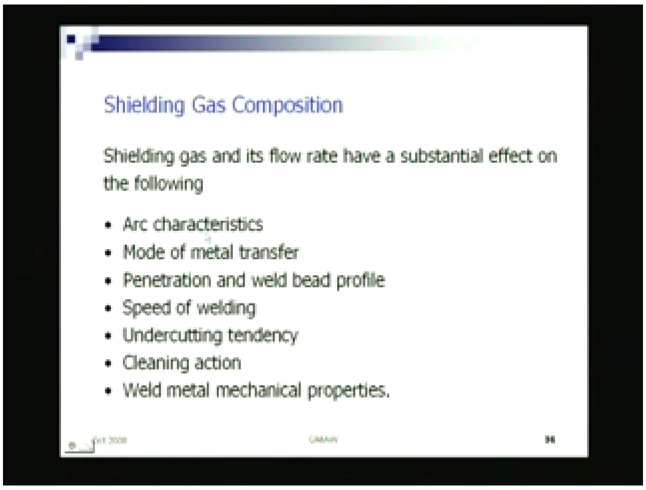

Shielding gas composition, it has a substantial effect on this following arc characteristic, mode of metal transfer, penetration and weld bead profile, speed of welding, cleaning action, mechanical properties, all these even the gas composition it matters.

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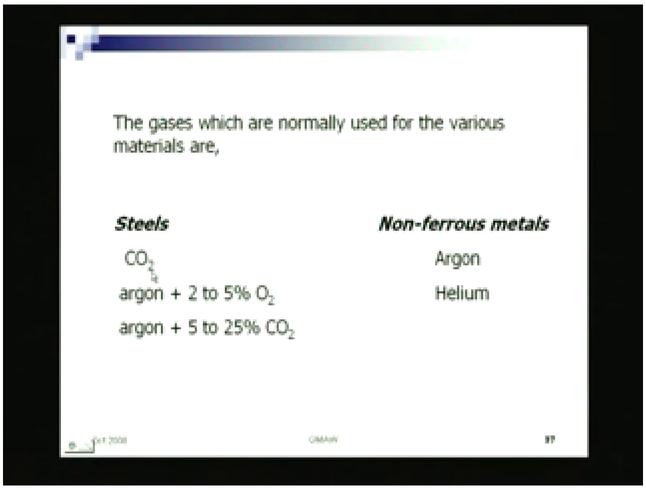

Preferably used gases are like, this in steel, you have CO2. This gives you most widely used, this gives a globular mode transfer. If you want spray mode, then use argon instead of pure argon. It is mixed with oxygen or CO2. This is a non-ferrous materials means alluminium or other.

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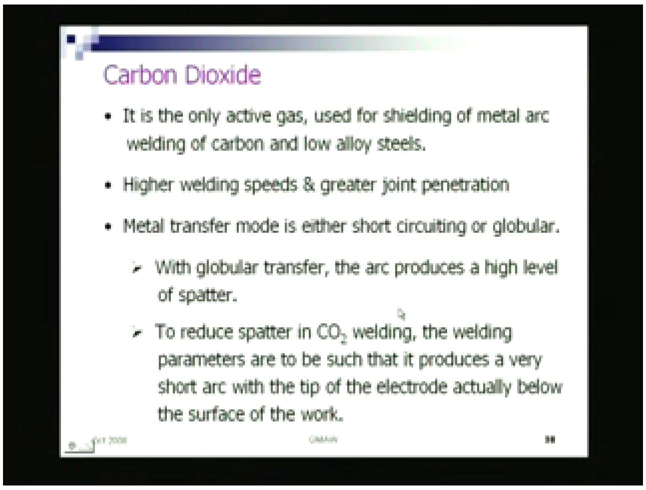

So, here we will take quick look. Carbon dioxide is the only active gas, used for shielding of metal arc welding gas metal arc. It produces globular transfer, produces a high level of spatter. So, there are techniques that it produce a very, I mean welding parameters should be such that you have a short arc.

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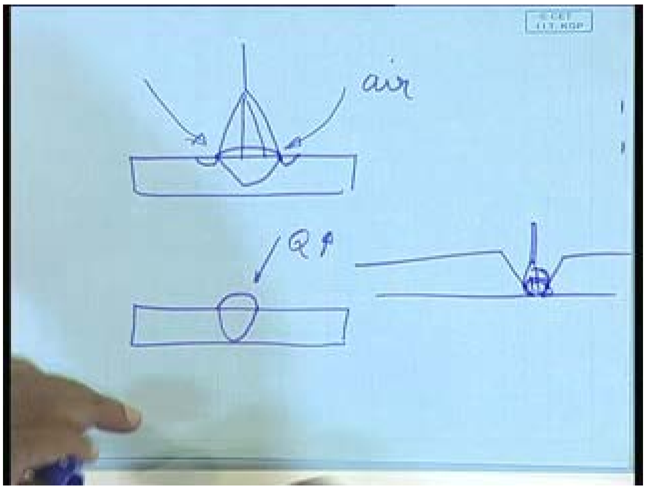

Why? Because such that a drop falling from a height and drop falling from lower height, that makes a difference. Spatter is less. So, thereby with the tip of the electrode, actually below the surface of work means, say this is my steel plate. The weld groove is like this. So, suppose this is being welded. Now, electrode tip comes here, it is going inside below the surface of the work because my metal deposition is taking place here. So, I keep such a smaller calculated, I mean very small possible arc length, such that to reduce spatter.

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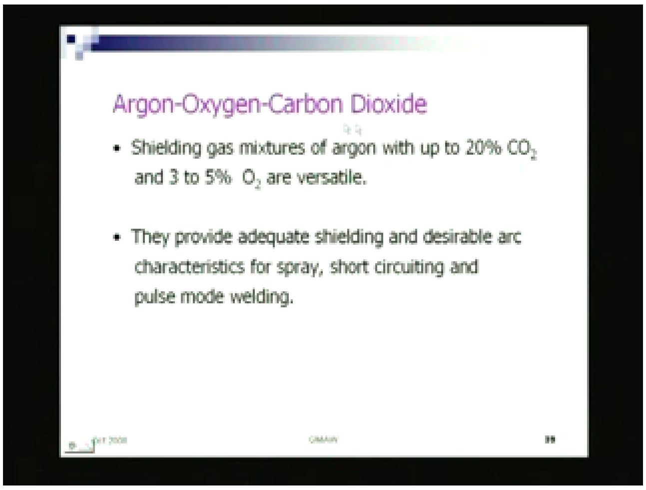

Well, that mixture of argon, oxygen, carbon dioxide, these provides adequate shielding and desirable arc characteristic for spray transfer, short circuiting as well as pulse mode. So, if I want to go for spray, short circuiting, pulse mode, it is preferable to use argon, oxygen, carbon dioxide mixture.

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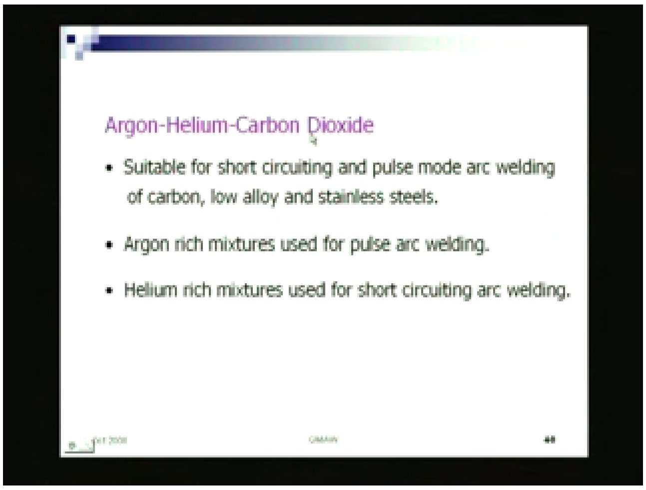

If it is argon, helium, carbon dioxide, well this is good for welding of low alloy and stainless steels, low alloy steels otherwise, and stainless steels. Argon rich mixtures used for pulsed arc welding, helium rich mixture for short circuiting arc welding.

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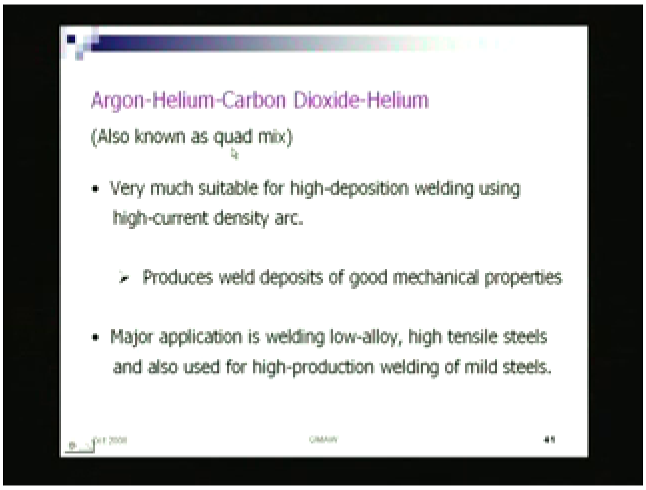

There is something called Argon-Helium-Carbon dioxide-Helium, it is a quad mix. That means argon and helium is mixed, carbon dioxide and helium is mixed, either both are mixed. So, it is very much suitable for high-deposition welding using high-current density arc for high deposition. What happens is with helium, the heat quantum increases because it has a higher, what we call that ionization potential. So, it contributes to heat additionally.

So, we can go for a higher deposition welding. Higher deposition means, what high rate of melting. So, it produces weld deposits with good mechanical properties. Major application area is in the welding of lower alloy and high tensile steels. Whenever there is a low alloy high tensile steels, argon-helium-carbon dioxide-helium, this quad mix is more suitable, but obviously everything cost money because cheapest is this gradually we are becoming expensive. Carbon dioxide is cheapest, argon is more expensive here, helium is still further expensive and so on so forth.

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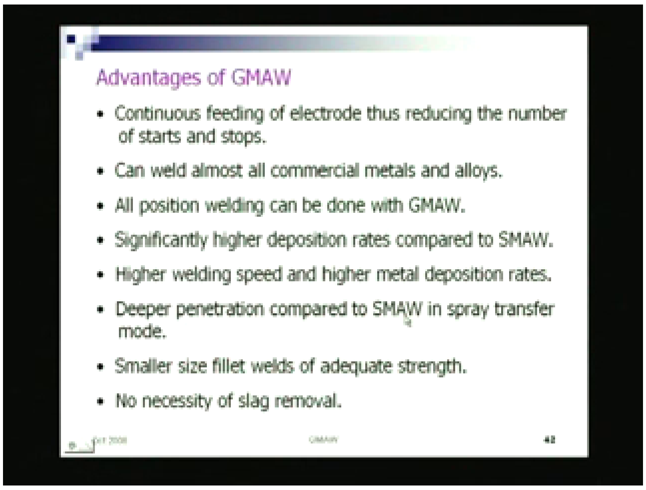

Well, so these are the advantages of GMAW. Primarily advantage is we reduce the number of starts and stops. As I mentioned in the first class, it can weld almost all commercial metals and alloys. All position welding can be done. GMAW has significantly higher deposition rates compared to SMAW manual metal arc welding or shielded metal arc welding, higher welding speed and higher metal deposition rates, deeper penetration compared to shielded metal arc welding in spray transfer mode, smaller size of fillet welds of adequate strengths.

Smaller size means, what means as much as required, you can control, fine control because you are using thinner electrodes. 1.8 millimetre, 1.2 millimetre dia. The electrode or in which, whereas in manual welding the stick 3 millimetre dia. So, control is here more precise control and finally, no necessity of slag removal.

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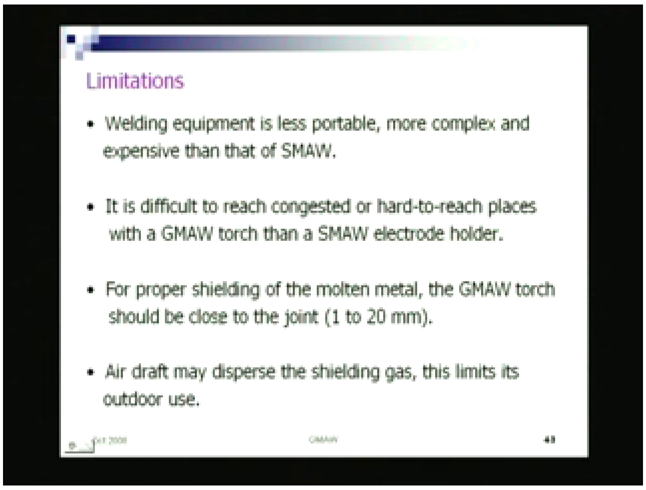

These are some of the limitations. One of the main limitation is external welding becomes difficult outside welding because of outdoor use, because of dispersion. The wind may disturb. Well, so that is all with gas metal arc welding. Next, we will look into possibly gas tungsten arc welding.