Welding Processes
Professor Murugaiyan Amirthalingam
Department of Metallurgical and Materials Engineering
Indian Institute of Technology, Madras
Modes of droplet transfer Part 03

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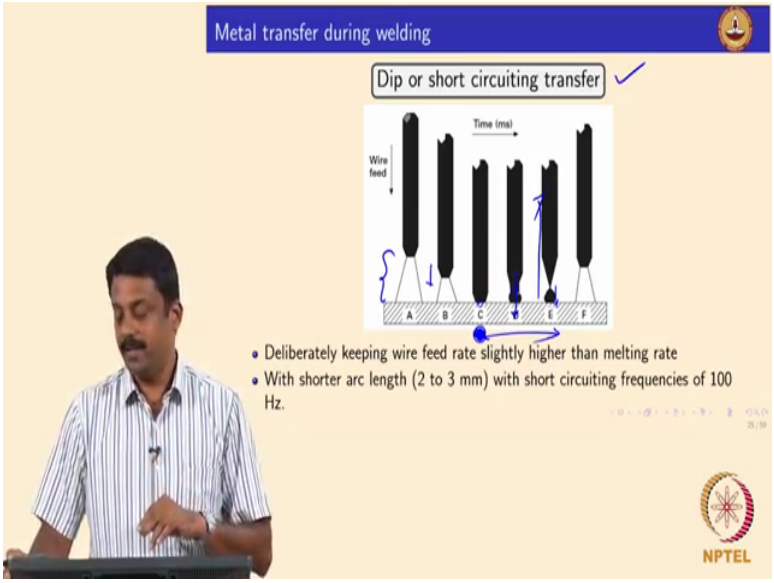

So other mode of transfer, so far we looked at free flight transfers and we can also achieve the stable transfer by dip, what do you mean by dip? So we can also touch the droplet once it formed onto the pool and one pull it back so the you also change the force balances, you can overcome the surface tension because the liquid pool surface tension would make sure that the droplet is detached. So that kind of transfer is known as dip transfer or short circuiting transfer.

So this is a part of non-free flight transfer, in free flight transfer droplets are transported from the tip by free flight. So you can also achieve the transfer by short circuiting there are lot of advantages having short circuiting transfer. Some of the major advantages you seen is controlling the heat input, so we can also carefully manipulating by carefully manipulating the event of short circuiting we can switch off the arc momentarily so that when the droplet is transferred it is transferred by surface tension of the liquid, no other factor by doing so we can reduce the super heating of the web pool.

So the one example schematic I show you here from (())(1:49) John Norrish book. So basically what we do is, so wire is continuously fed if the melting rate is equal to the wire feed rate, what happen to the arc length if a melting rate is equal to the wire feed rate? Arc

length becomes constant, but you can also carefully manipulate the feeding rate such a way that it slowly bring the wire towards the work piece or weld pool.

So increase the speed of wire feeding such a way that slowly you can bring the work piece or the filler to the work piece and establish a short circuiting, is it clear? And once the short circuiting happens and you also increase the current and then what happens so once you have short circuiting happens you can also transfer the droplet to the work piece, so you form a droplet and then once you are dipping it you melt the droplet and then subsequently you can pull the wire back, so whatever is molten is detached by the surface tension of the weld pool, is it clear?

In this process the advantage is here during these three steps arc is not there. So when the moment the short circuiting happens arc is gone and then you can dip the filler, either filler can melt before short circuiting or during short circuiting it can melt and then you can transfer the droplet by retracting the wire back and during this process by carefully manipulating the current voltage waveform we can transfer the droplet without any explosion, that is very critical because if you keep on passing the same amount of current and you form a neck then you increase the Lorentz force so high and you will have explosion.

So your power source should be capable of turning the current OFF the moment short circuiting happens. So by deliberately keeping the wire fed slightly higher than the melting rate we can establish short circuiting, the moment short circuiting is established we will have to identify that moment and then switch OFF the current or reduce the current and then the molten droplet at the tip can be transferred to the work piece by surface tension of the liquid pool, is it clear?

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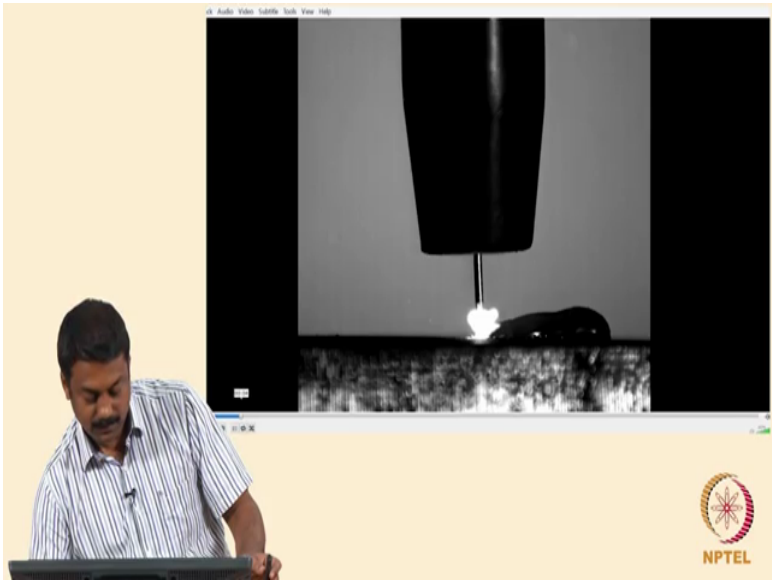

I will show you video, it will be very clear. So this is transfer, so what is happening here? So you have an arc so transfer happens by short circuiting and during the short circuiting event there is no arc, do you see that so you establish a arc with the arc length and then you switch OFF the arc the moment the short circuiting happens and then you transfer the droplet by the surface tension of the liquid pool, is it clear?

The explosion is the arc so we have this is a cycle, first is arc struck so this is the first event that video is recorded, so now a pulse okay the droplet is molten, the tip formed the droplet and then you are also pushing the wire because your feed rate is higher than the melting rate and then the moment the short circuiting event happens the power source switch OFF the current, so then we can the power source can measure the short circuiting event by measuring

the voltage, the moment the voltage becomes extremely small that means that short circuiting has happened.

And then the current is switched OFF, arc is completely gone. So now the wire can be retracted back and during this process the surface tension of the pool pulls the droplet with its surface. So it goes back droplet is transferred, do you see that? And then the moment a critical length is achieved arc struck ignited by the high frequency ignition and this process continuous, so you keep on doing it.

So to achieve such a kind of complex metal transfer the power source characteristics is extremely important because power source should also calculate how much it melts, melting rate should be calculated accordingly wire feed rate also be controlled so that you can establish the short circuiting at a given defined interval. The moment short circuiting is established again power source should measure the voltage of the system and the moment the voltage becomes extremely small currents will be switched OFF and then droplet can be detached by retracting the wire back.

So what happens if you keep on passing the current, so then you will have an explosion. If the current is passed continuously so in this case suppose current the equal amount of current is passed like an arc in current and you have a very small area neck forming when you are retracting or when you are doing a short circuiting and you have a enormous amount of Lorentz force concentrating on a very tiny neck.

So if Lorentz force is concentrating on tiny neck obviously it will cause an explosion because if you keep the current constant the amount of Lorentz force is confined to a very tiny area and the moment you confined the Lorentz force you have an explosion because the all the fundamental the electrons are concentrating now on a very small neck, so that is the reason so when you want to establish a short circuiting transfer you need to make sure that the current is switched OFF look at the cross section area it is decreasing extremely small, do you see that?

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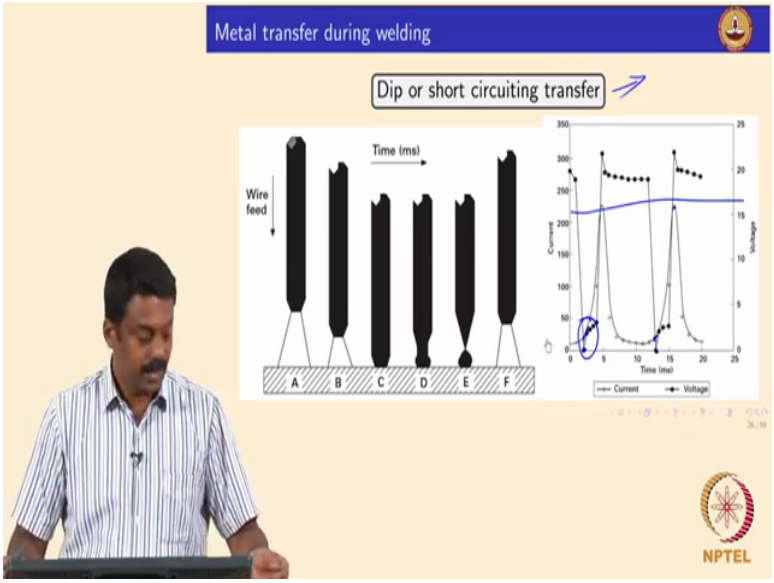

So that is the reason so if you want to achieve a proper short circuiting event we will have to make sure that so when so this is the current and voltage the moment the current is the short circuiting happened you will have to make sure that your current is also low and then you can have a pulse to form arc and the droplet at the tip and then you bring it down, so this is the arcing voltage and arcing current and then the moments also getting establish voltage becomes zero so the current become minimum and then you continuously again this is arcing voltage and during this process you give a pulse current pulse to melt the droplet and then bring it down, the moment the voltage becomes zero short circuiting minimize the arc, is it clear? So this is how the controlled dip short circuiting transfer is established.

So this technology is very widely used nowadays in advance GMAW process in various names one of them is coal metal transfer. So one of the technology advantage of here is so the heat input can be reduced significantly because when the droplet is transferred technically you transfer it at the melting rate or melting point of the droplet and arc is not continuously ON, even the pulsing transfer droplet is transferred in much higher temperature when you are doing a free flight transfer, droplet temperature reaches to the arc temperature or it is super-heated not arc temperature it is super-heated.

So the droplet which transferred in it has a super liquid in free flight transfer, whereas in the short circuiting transfer the droplet is transferred they also switch OFF the current. So when the droplet is transferred you transfer it close to the melting point of the droplet. So you are dipping it so the droplet temperature, melting temperature becomes more or less the same. So

that is why this process is also known as coal metal transfer because the droplet temperature is much much lower than in a conventional droplet temperature, is it clear?

So this is known as controlled dip short circuiting transfer, we will see in subsequently in advance GMAW process when we look at end of this unit, what are the complex waveforms we use to achieve this transfer? But the basic is this, what is the basic? The moment short circuiting happens voltage becomes zero and the power source identifies that moment, switches OFF the current and subsequently the wire is detracted.

So the forward and reverse motion of the wire is controlled by controlling the feeding rate and how does this feeding rate controlled? By calculating the melting rate, so melting rate has to be calculated for a given (())(12:42) wire for a given composition then we can calculate the melting rate, once you know the melting rate and we know for a given arc length when does short circuiting is established, is it clear?

These are all possible because of the microprocessor control power sources the power source has a computer inside, a brand inside. So all the programs are already preloaded by establishing the entire process, so if you give that is why we use in advance power sources synergy, so it is all synergically controlled, the power source because for a given composition filler diameter the program is already there, so what will be the feed rate, so what would be the current it has to use for a pulsing for a given pulsing, how much it is going to melt?

And if it is melting, how much feed rate it has to maintain so that it can establish short circuiting and for a given time interval, we will see in some calculation when you are looking at in a pulse GMAW how short circuiting at (())(13:56) short circuiting can be established? Okay, it is clear, right? Short circuiting transfers how you do it? The trick is here this is the trickiest part controlling current and voltage, the voltage is controlled by itself because of this short circuiting, the moment short circuiting happens current should be minimized to avoid explosion, is it clear?

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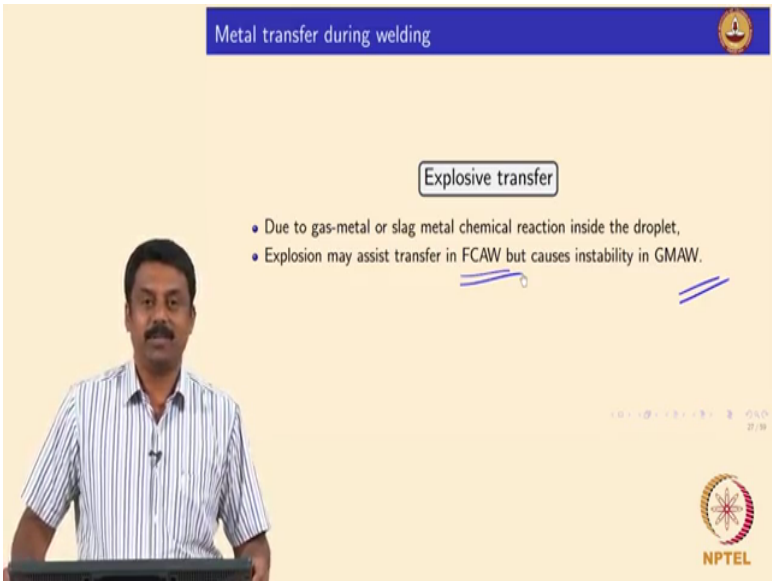

Okay, we will move on. So the some of the cases if you increase the current tremendously high and if you also have a shielding gas generated especially you know in self-shielded electrodes and you may also have an explosive transfer, in most of the cases it happens in self-shielded electrodes or in flux code arc welding electrodes, where you have a very high current and if you are using it and you have a gas which is actually generated by the flux and the gas pressure is contained so you increase the plasma jet pressure and the Lorentz force and you may expect an explosion of the droplet.

In most of the cases it is extremely unwanted mode of transfer in any case because you can never weld by explosive transfer. In most of the cases it is used for spraying or coating and if you want to deposit FCAW wire on to the substrate and you can use that because anyway you do not care about where exactly droplet is going, so you can do an explosive transfer by using high current, in case of productivity.

But in GMAW it causes instability because when you are doing welding you do not expect a droplet to explode and then go everywhere, you want a droplet to go to the weld pool the cavity, if you are using it in using the FCAW or any other electrode for deposit to make a layer the coating then you can you can use explosive transfer, is it clear? Unfortunately I do not have any video for this because we never managed to get there we need very high current for explosive transfer, good.

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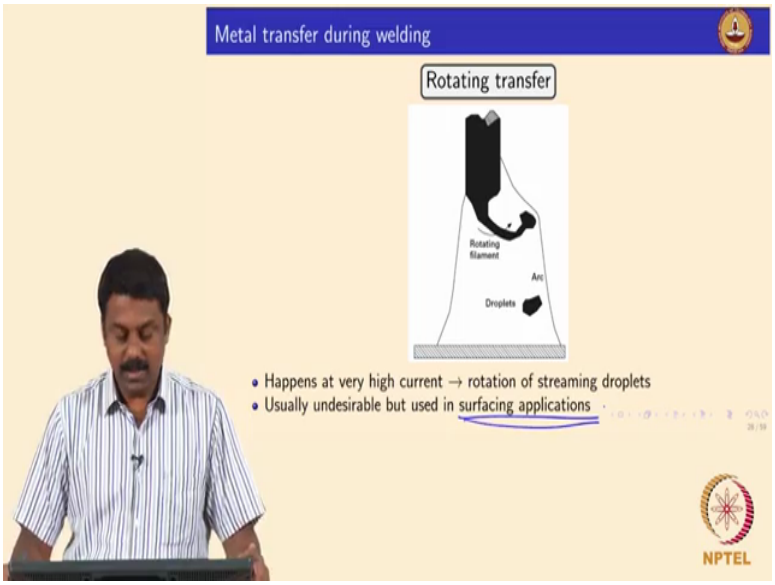

So if we increase sometimes current jetting spray becomes rotating transfer because again the reasons I told you the same the jetting if you start making a jet and you have a Lorentz force continuously forming and then certain magnetic forces start rotating or changing the path of the spray and you will have rotating (())(16:51) transfer it goes everywhere and then you end up transferring the droplets at various places.

So again this is also sometimes used for surfacing using in FCAW or in GMAW surfacing, so again so for welding applications it is not (())(17:13), is it clear? Good.

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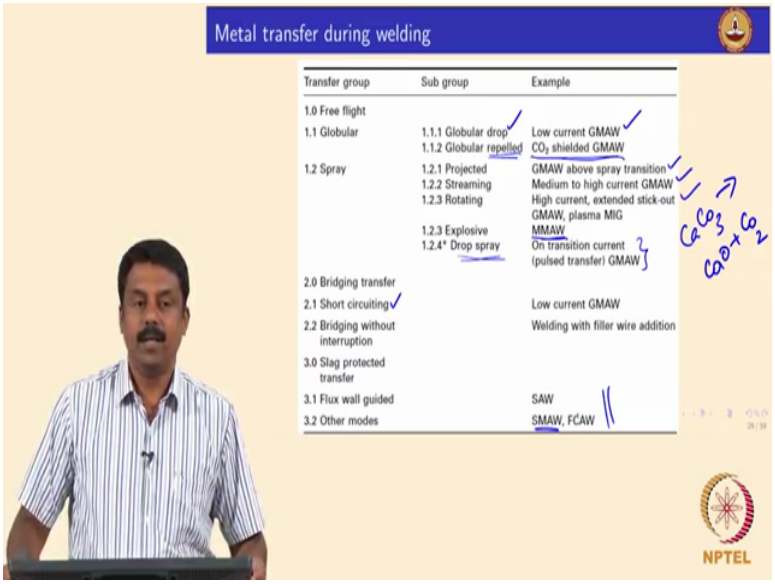

So what are the most commonly observed transfer mechanism or transfer mode in various applications? So as I said for low current GMAW globular and in CO 2 cases CO 2 shielded GMAW you see globular and repelled globular and because of the instable instability associated with the CO 2. So the GMAW above spray transition it is the drop spray or projected spray which are same and then once you increase the high current then it becomes streaming and rotating and explosive transfer and explosive transfer is very commonly observed in self-shielding, what is self-shielding? We do not give any extra shielding gas shielding gas is generated by the electrode itself.

For example we will go next slides so this is MMAW manual metal arc welding electrode and you have a flux on top of it, and these burns generates carbon di oxide. So when you have calcium carbonate it burns it becomes. So we generate shielding gas by burning flux, so this is used for the manual metal arc welding or shielded metal arc welding and because of the CO 2 generation and plus high current what you use to melt such a large diameter and you sometimes get an explosive transfer.

So drop spray again just above or in and around this spray transition which is the most advisable and the transfer mode, drop spray or the projected spray in various transfers you would see. So you can also achieve the short circuiting transfer by carefully playing around GMAW the parameters like wire feed rate, voltage, current can achieve this transfer. And the other modes you will see when we are looking at the mechanisms of SMAW and FCAW.