Welding Processes
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Modes of droplet transfer Part 01

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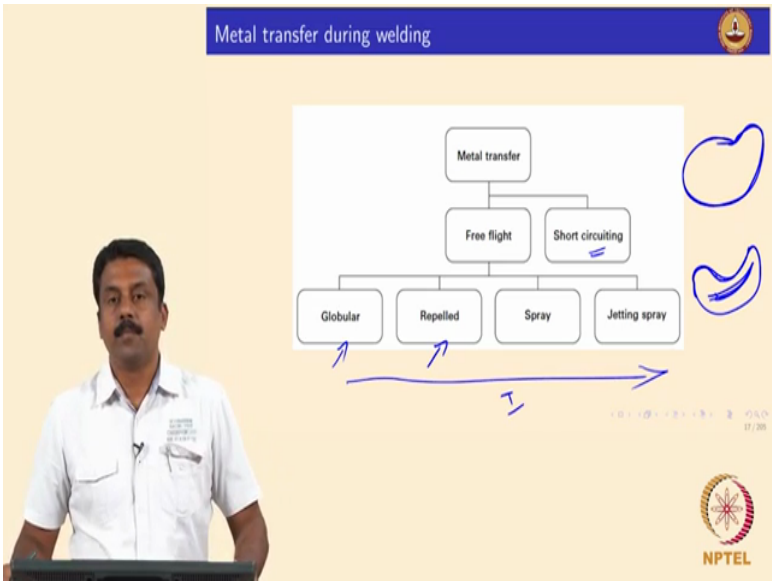

So based on the force balance you may have the droplet transferred in various modes. In most of the cases the diameter of the droplet and the frequency of droplet transfer will determined by which force is rate controlling? If gravity is rate controlling, droplet will be transferred with high mass like a globes the volume will be higher, if Lorentz force is rate controlling it can transfer very small diameter (())(0:47) droplet at much higher frequencies, why? Because melting rates, okay.

So for example (your) melting for a given current for I is fixed we melt and if you are changing the current obviously you also change the melting rate, so you will have to transfer more. So melting rate is also increasing, you are creating more volume of liquid metal then that has to be transferred. So you transfer it into a very small diameter droplets at much faster rate, it becomes spray, so that is why we call it spray transfer when increasing current.

So the transfer mechanism would change from globular to repelled globular, so what is repelled globular we will see in subsequent slides, so then the mass is keeps on increasing and if the current is increased in this way so you have globular and in this case repelled globular mode the globe is there but it is the current is not sufficient to pull the droplet. So you also generate local magnetic force inside the droplet because current is increasing, so the globes becomes like a shoe of a buffoon in the circuit.

Okay, so how does how many of you have seen circus? In a real circus? So the buffoon is there, he always wears a typical shoe so that the shape of the droplet when the current increased slightly but it is not sufficient to reach the critical Lorentz force to droplet transfer then he also generated locally slightly increased magnetic force that would change the shape of the droplet from globular to repelled globular.

Okay, sometimes you can also observe in the video so you see that droplet the transfer in some cases it becomes like this you see that, yeah see this when exactly yeah just before this frame yeah see this it is globular not really globular, globular means it will have circle see the droplet shape. So in this case the current is there but is not sufficient to pull the droplet something in this case and because of the increasing current compared to the initial globular transfer you may also change the shape of the globes into such a shape.

And then if increase the current further the globular transfer becomes spray transfer when the Lorentz force supersedes the gravitational forces and if you keep on increasing it then you would also start melting more the current is very high it will start making a jetting spray the spray velocity will be much higher. So these 4 modes are commonly observed during GMAW welding which is known as free flight, why it is called free flight? Because the droplets are transferred from the tip to the work piece there is no contact between the consumable and the weld pool.

In some cases you also make a contact and then transfer droplet by short circuit ad that is a specification. So these are the common modes of the metal transfer observed in GMAW.

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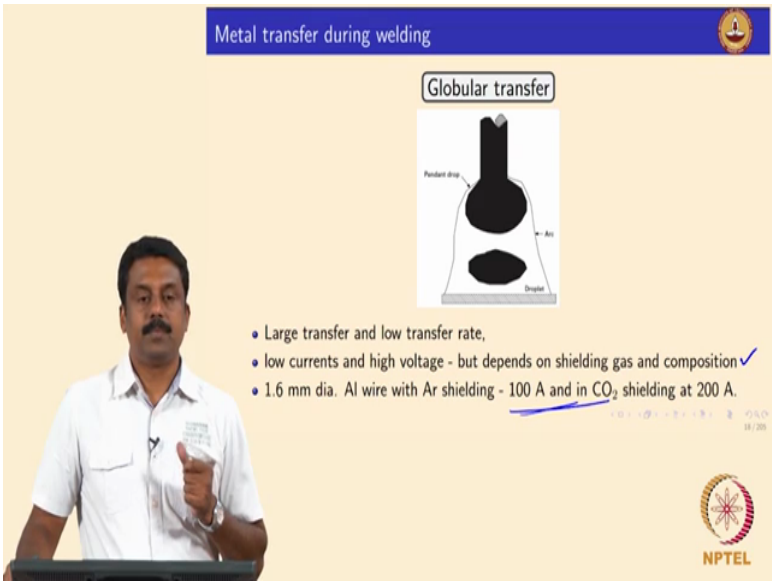

The first mode is globular transfer, so globular transfer we observed at very low current, so the per transfer you transfer more volume of metal the droplet diameter will be very high, it happens in very low currents. So if the plasma jet velocity is quite low, current is low the obviously transfer would only be assisted by the gravity. So most of the commonly observed transfer happens at very low current so generally for 1.2 mm low carbon steel wire if you are welding it on 50, 60 amperes and 70 amperes the transfer will be most likely globular transfer, okay is it clear?

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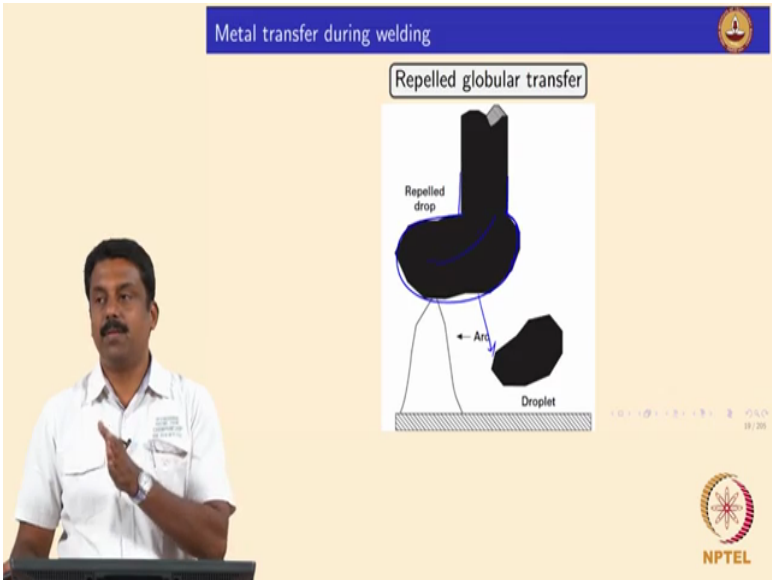

And if increase the current slightly further it becomes repelled, okay so repelled acts on the globular shape changes to repelled globular because of the increasing current so there will be

some Lorentz force generated and that would change the magnetic field inside the droplet and it would change the shape of the droplet into a shoe of a buffoon or a joker and then the droplet after at any critical mass the gravity would pull it down, the video I showed you right, it is what happen.

So the current is now we are increasing from say globular transfer to repelled transfer and if we increase the current further you would see a change in the transfer mode.

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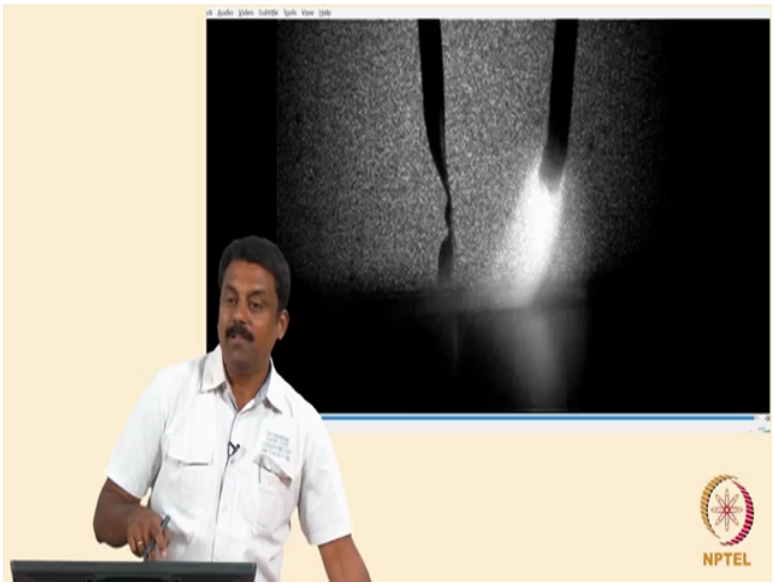

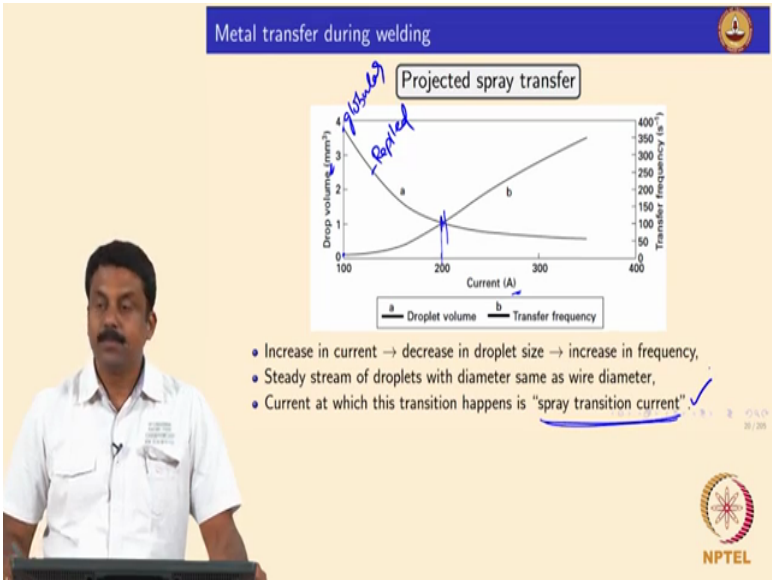

For example this graph I showed you drop volume is function of current, at lower current the frequency will be very low and diameter will be very high that is globular transfer and if you increase the current droplet diameter decreases, repelled and frequency also increases after a

critical current the globular transfer becomes spray transfer and that current is known as spray transfer current or spray transition current.

So it is very critical parameter in GMAW welding because if you want to maximize the productivity and you achieve a good aesthetic, a good control stable transfer characteristics then you need to operate your welding current and just above spray transition so you also melt more and you also have a very stable transfer, you transfer more, the diameter when it becomes more or less equal to the filler diameter so that is a thumb rule.

So when the droplet diameter becomes equal to the filler diameter you can achieve a very stable transfer in spray mode. So the current at which the droplet kinetics change from globular to spray is known as spray transition current. So that is where you change the droplet diameter to smaller with very high transfer frequency it means that you transfer more volume of molten metal with smaller diameter and which is very beneficial because then your process characteristics for example the your feed rate or the welding rate it increases because you melt more so you can transfer more volume of metal to the work piece and if you are transferring the smaller droplet you also reduce the spatter formation if you are transferring it to large droplet there is a possibility of droplet exploding that will cause spatter, but if you are transferring in a smaller diameter we ensure that droplet reaches the work piece into one intact.

So again the video you see that I showed you the high speed video, so you see that in this case you also see the droplets are spraying, it is exploding and causing a spatter, whereas in the spray transfer we do not see that phenomena happens, you see that you see now something is escaping. In all the cases (())(10:20) is happening you see this again droplet is flying away, whereas in spray transfer you see another spatter is going these are the spatters, you are wasting the droplet, the moulted volume what is going.

So in order to achieve the stable process conditions we need to reach such a state where your droplet diameter in this case is smaller than your filler wire diameter in spray transition. So the ideal situation is you need to operate just above spray transition current where your droplet diameter remain as equal to the filler wire or smaller than filler wire, is it clear? So that is the current you know it is spray transition current.

So ideally so (())(11:10) for that current the spray transition current and in GMAW it is always addressable to operate your welding just above spray transition maybe a 5 amperes above spray transition to ensure the stable metal transfer.

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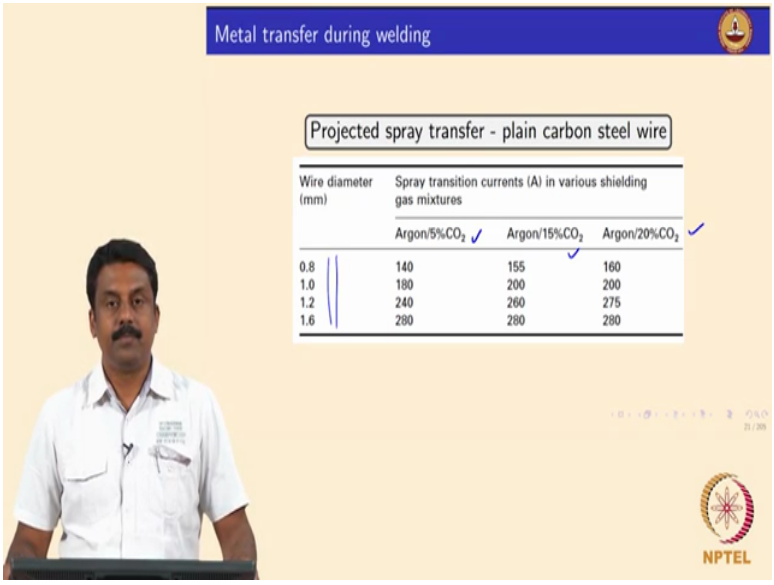

So I just listed some of the parameters argon 5 percent CO 2, argon 15 percent CO 2, 20 percent CO2 for varying filler meter diameter, so what is spray transition current? So if you increase the diameter obviously the spray transition current also increases, is it clear? So we can identify and then we choose the current based on the mode of transfer.

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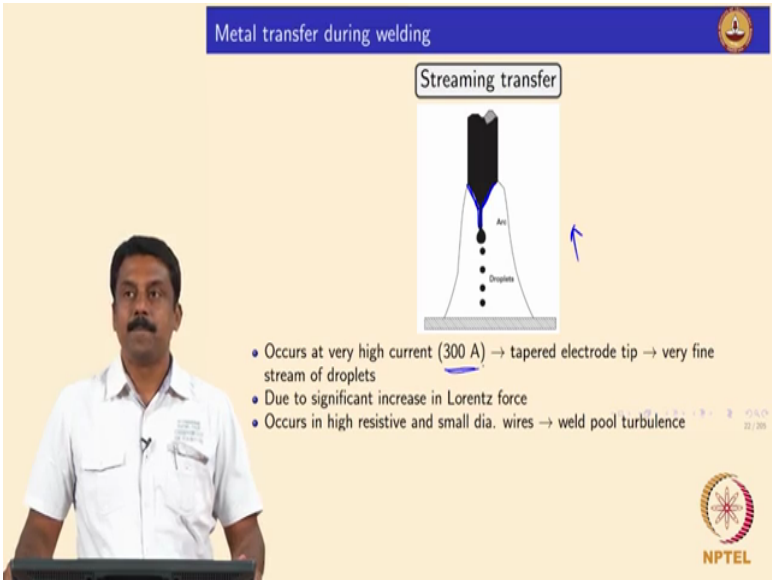

Okay, so we will look at the last transfer so this is streaming transfer, it happens in very high current, then you already form a neck when the current is increased the Lorentz force is so high, we may end up transferring droplet with much smaller diameter and you may also see unbolted regions because the kinetics are so fast and you start forming a neck and transfer the droplet into much much smaller diameter and this is not an ideal case then there will be an instable neck formation which mainly to say some instability in the transfer.

So it happens in very high spray transition and this is not addressable except if you are doing it for a coating, where you need to melt really really more it does not matter I do not care whether spatter forms are not ultimately even spatter forms it will go and stick somewhere else. For welding it is bad, if you are doing for cladding then it is very useful because you need to melt as much as possible to deposit. So we will wind up this.