Welding Processes
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Advances in gas metal and welding – Pulsed GMAW

So we were looking in last class the flux code arc welding so we look at that the various fluxes that we are used in flux code arc welding or in manual metal code arc welding electrode like, so we looked at the rutile based electrodes the basic electrodes also basic electrode and we looked the chemical reaction that actually produces us the shielding gases, so in rutile based electrode with the hydrogen is primarily generated by the martial decompositions reading to the generation of hydrogen into surface of terrarium oxide for example and then cellulosic material carbon monoxide carbon dioxide generation and in basic electrodes disintegration of calcium carbonates leading to generation carbon-dioxide and we look at metal transfer begin here and rutile base electrode because of the influence of titanium oxide and the fluxes on the surface tension.

So the metal transfer only mostly globular and the top right side much finer and then we are very steady state spray transfer achieved in rotated based fluxed containing electrodes, so there an basic electrodes, we do not have the luxury of the transferring the droplet like in a rutile based electrodes in basic electrodes is mostly repulled globular and most our time we have un-burn fluxes forming in the finger at the tip of at the center of the electrodes, so we looked at various modes of metal transfer in a video in while welding and self-shielded flux code arc welding electrodes, self-shielding means again we do not use external shielding gases, shielding gas is a generator while burning the fluxes.

So I showed you coupled of videos where self-shield electrodes basic electrodes which generates carbon-dioxide CO2 while burning and then the metal transfers primarily repulled globular transfer is in not it and then we stop the last class at the slide where I showed you the advancement that are made in GMAW, so we looked at the one slide so we will see in elaborately is this class some of the advancement that are made to make the process much more stable right, so once such advances is the pulse GMAW.

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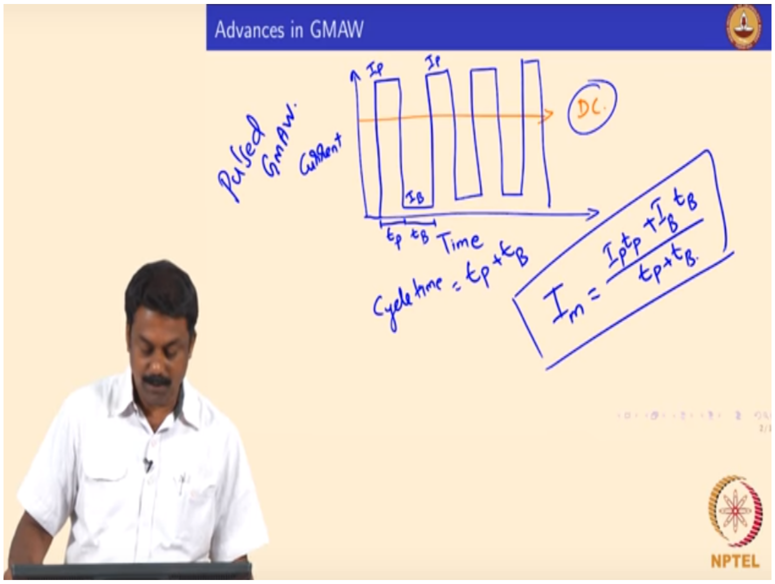

So I already indicate at the use of current pulsing in metal transfer characteristics, so when you looked at the behavior of metal transfer is a function of current the our objective to achieved these stable process characteristically to achieve a drops spray transfer is in not it, so will have to get a spray transfer, so that the productivity increases we transfer the enough volume of liquid metal to the weld but the transfer should be made in such a way that the droplet diameter is equal to the filler diameter, electro diameter or straightly lower than that and then will have continuously transfer the droplets.

So that can achieve just above the spray transition current if you keep the current above spray transition then we can achieved the spray transition in drop by drop mode that is why we called it does not dropped spray transfers, so if you look at the constant current GMAW we will have to increase our current above it is spray transition to achieve this kind of spray which we required stable GMAW the same transfer can also be achieve in servicing a constant current by using in a pulsed current, so in pulse current what we do is so supposed if you look at time versus current, so in a conventional so GMAW in order to touched you the this spay transfer so in a conventional transfer.

So you may have some main current is in not it in a constant current in a conventional GMAW where we have yeah you have the constant DC right, so instead of using in a constant current and we can use a pulsed current in which so you have a current pulsing where your maximum pulsed current much higher than your current needed for the constant current case and then we will bring it back immediately to some value and then maintain at a background level and then again we will do pulsing and then dis-cycle continue further so in this case advantage of using such pulsing is the reached a much higher current than these spay transition current during pulse on so this is known as the pulse current.

So by doing so we can form a droplet and then because of the high current this supplying can create of an Lawrence force in such a way that the droplet can be transferred one drop let per pulse, so during this IPTP at so this is pulsing period TP, so during this TP we increase a current to IP and then one droplet can be retired and immediately the current can be re-decrease to a background level which is IB, so in this case we can maintain the mall arc so arc is very low power and this background current can be sufficient to maintaining a low current arc and then we give a sometime interval TB background current and then immediately we can rise the current to again the IP to detached the another droplet.

So now advantage of doing this is if you take an average the currents over a one cycle, one cycle is one cycle time, what is one cycle times in this case is TP plus TB is in not it if you take the average current over this one cycle it will be much lower than the current what you used in a constant current is in not it right so if you look at the average current how do you calculate the average cycled supposed if you want to calculate their mean IP times TP plus IB times TB divided by TP plus TB exactly so if you calculate the average I mean will you much lower than what you use constant current case that means that the amount of heat or the energy you generate it will be lower than when you use a constant current but by lowing lower current you can steal achieve us a spay transfer.

So you can achieved at stable pay transfer by supplying an average current much lower than, so when you use the constant current throughout the welding process, so your heat input or arc energy decreases significantly without compromising your productivity and the process stability, so such kind of way form are very widely use to achieve us pray transfer on GMAW process and by doing so you also reduce the, the amount of heat you put in the material while welding so the other advantage over here is, so you minimize the damage you do in to the best material because you reduce in heat import are or can significantly without compromising the transfer characteristics what you achieve otherwise use a constant current right and the by (())(08:54) controlling the process characteristics we can achieve a one drop per pulse.

So by (())(09:04) selecting in the frequency of the pulsing we can also determine how many droplet is already detached per second is in not it is supposed if you have achieved applying a 50 herds of pulse so number of pulse is 50 per second, so you gets 50 droplet per second however at this this pulsing cycle right you can increase the pulsing number of frequency you can increase subsequently but that is depending on the power source characteristic, so by using an modern rectifier inverter best power sources using a microprocessor control and we can achieve such a way from very easily it is clear so we will see in this class.

So how do we choose this pulsing parameters so what is so special about it we videos obviously so look at when we are doing the pulsing or we transfer takes place and then some calculations to identify this IPTP for a given material and then we will move on to the next advancement in GM measurement it is good any question so far then we will go to the next slide then it will be clear even more.

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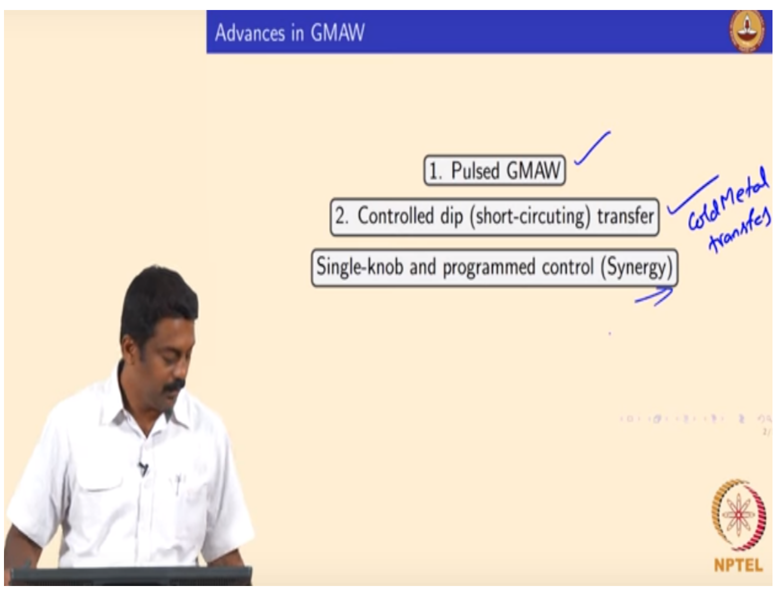

So the three in fact two advancement I want to cover here which is very widely use now a days in a industries the pulsed GMAW the second is the controlled dip transfer so the control dips transfer it is now known in various names so most commonly use control dip transfer is cold metal transfer so cold transfer welding which is another variant of the control dip short circuiting transfer where the play on with the wave form because when you do that short circuiting transfer there are some inherent problems the moment you are short circuiting so what are problems for examples when you have short circuiting even text place inherently your role takes becomes zero.

So then your current is passed in a system which is voltage is zero so that means that you create an thousand amount of laws and forces plus joule heating of their electrode so then you have uncontrolled current passing through when this short circuiting happens the droplet develops enormous amount of Lorentz force as well as the magnetic field which may cause the droplet re-explode and that can cause serious turbulence in the well pooled and the explode in the droplets and the well pooled and causes serious pattern so than your well qualities decrease significantly because you creates us pattern as well as the explosion lead to well pooled turbulence and then well stability decreases.

So in order to achieve a stable transfer to during this short circuiting events people thought it and then they modified the wave forms in such a way that when the short circuiting happens we can minimize the current by detecting the voltages and then we can manipulate the wire moment back and forth and such a way that we can achieve drop transferring extremely low heat input by the manipulating the wave forms in fact we can droplets transfer droplets at the melting temperature of the droplets, by controlling with the transfer, so that is why this two are very widely use.

Now a days and GMAW gas made of welding the pulse GMAW and then the controlled dip transfer which is known in various brand names one of the brand name is cold metal transfer, so we look at this two and then this two the process is possible by the advancement in the power source okay and the this one such advancement which is widely used for achieving the pulsing and the controlled dip or short circuiting transfer E is synergy power sources, so we look at the what is synergy means and how this synergy power sources is widely use to achieve this advancement in GMAW good.

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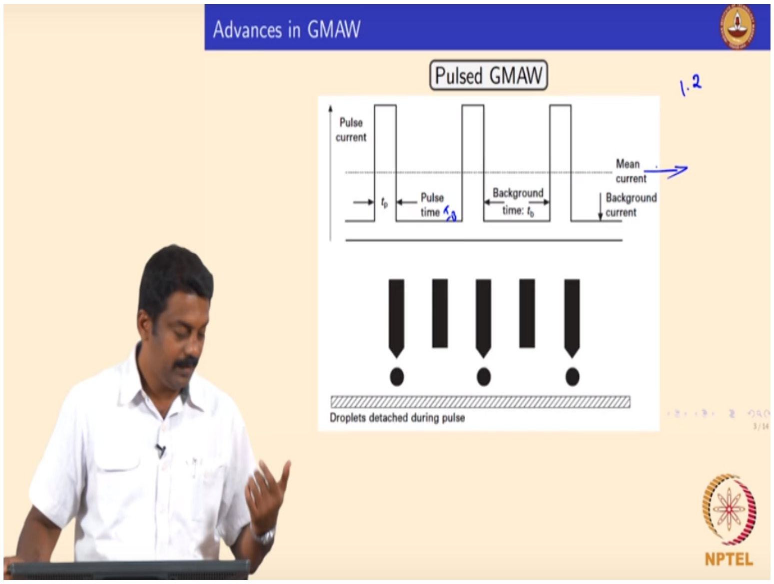

So we will move on the first pulse GMAW, so it is explained the in the first live so what you trying to do is instead of using a constant current, so we do on a pulsing current and during this pulsing period we makes that one droplet detached from the electrode by subjecting a much higher pick current and thin we maintain a back ground current during this process and in this case we made an and very small arc make sure that arc is there otherwise we will have to apply and I frequency ignition so during his period so we maintain an IB in such a way that an arc stable and then subsequently we can do another and another pulsing and then achieve subsequent droplet transfer.

So by doing so the total average mean decreases significantly for example 1.2 mm carbon steel so if you achieve an drops pray transfer is above said towards amperes, you could achieved by pulsing in as flowed as 70 amperes this similar transfer characteristics okay, so the I mean can is low as 70 amperes you can choose by playing around the IP the pick current and the back ground current and then pick time and the back ground time we could achieve absolutely similar characteristic at as low as 70 amperes, so that is advantageous so because we are also not consuming energy and also characteristic are much-much nicer then when you use a constant current and you also much and very stable process at a very low heat input right, so we will see the video of this process and then we will go to the physics of it right good,

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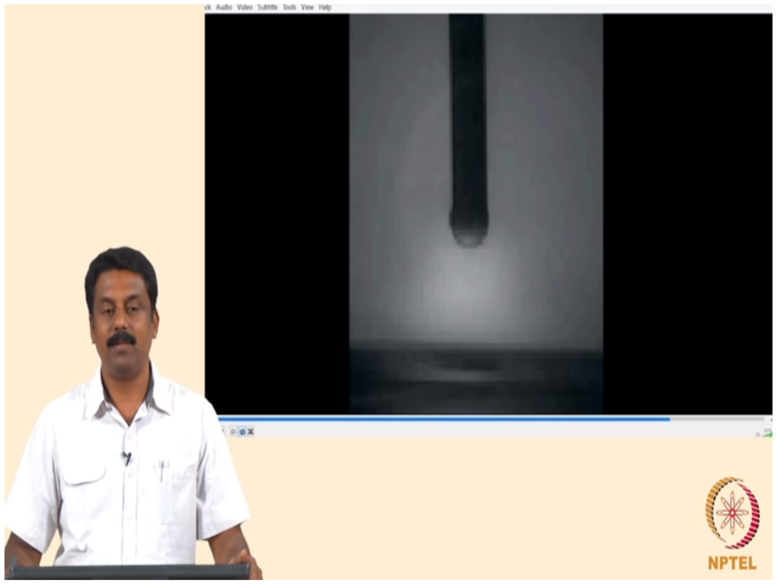

So we will have to achieve a dross plate transfer, so the characteristic of dross plate transfer is the droplets we attached with the diameters similar to the filler and this it has to be continuous you see that, so the arc is there is back ground arc and we are transferring the droplet one per pulse, so the pulse is given arc glows and that you form a droplet and then the droplet is form and they it is detached because already pulse current it is clear and the subsequently even the pulse is stopped and then you maintain an arc and this cycle can be continuously applied to get the droplet attached continuously.

So the number of droplet detached is determine by the pulsing frequency if you give 50 pulses obviously if you detached 50 droplets per second, so we will have to (())(16:36) is choose the IP TP and it is similarly background current and which will be characteristics of the melting wire composing as well as the shielding gas which you use because that will determine the amount of heat that is transfer to be crippled to melt is in not it melting rate determine again the heat in the electrode the heat supplied from the arc to the electrode and then if it is anode, so we have the two other parameters right what are the parameters common guys melting rates the work functions.

So the amount of energy gained is in not it right and then that would determine whether it is positive or negative in the arrow and then we will have a latent heat contribution and then latent heat of contribution it is clear, so once you known the melting rates which extremely important in this case because we allow to the arc an constant is in not it the length over here from here to here it is constant that means that, so we will have to calculate even melting rate in such a way that we can also feed the wire in dissimilar way, so then how do we calculate the melting rate here.

So we will have to first calculate the I mean based on the formula the average formula and the moment we I mean then we can also calculate from the same equations alpha I mean plus beta L I means square divided by pie R square it is clear right, but now how do we choose IP and TP we cannot choose a randomly right, so there must be some relationship for a given material we will have to identify how do we arrive at the pulsing parameter though we can do that, so we can also get the pulsing parameter predictor for a given material of diameter, so we will quickly go on.

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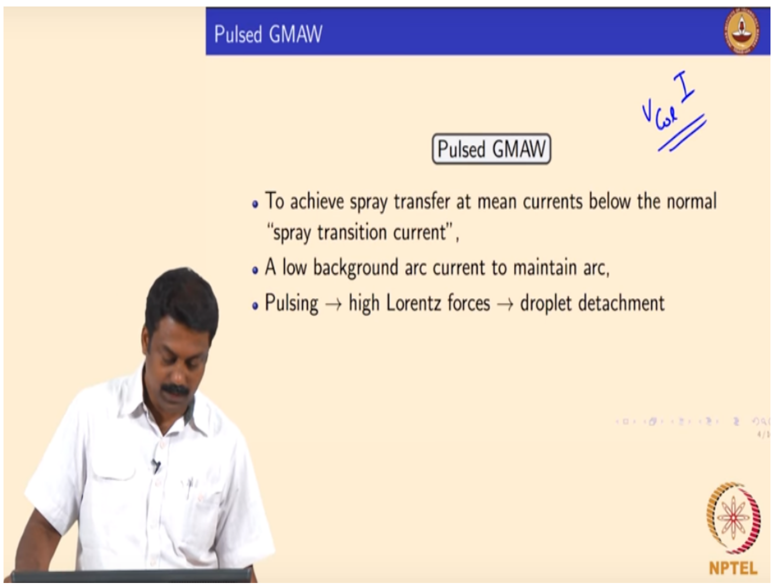

So this is clear right so we transfer a Doppler to per pulse right it is clear the objective of this pulse GMAW to achieve a spray transfer at mean currents much lower than the spray transfer current otherwise we use it for the constant current GMAW we met in a small background current to have an arc otherwise we will have to apply high voltage arrive frequent ignition during that period and that may cause instability and during pulsing we increase a current a much higher than your spray transfer current, so that we melt the tape and then transfer it apply by the increase Lorentz force yes clear good.

So this process is known to get very stable transfer then the constant current GMAW, so because of the increase pulsing current and we definitely detached the droplet because of the increasing current generator because when he increases the arc and G also in peace is in not it because if we look at the V column I obviously I increasers significantly so in that case the amount of heat is transferred from the arc to the electrode the pulse increase significantly so immediately we fall the droplet in the moment droplets is form the Lorenz force pulled the droplet down it is clear.

And then do not you keep it at that current level for long time if you keep it at the long time obviously what happens suggesting spray would happens is in not it because it is much higher than this spray transition right, so if you keep the pulsing duration long enough then you will start detaching depleting getting spray more because the current is much higher than the spray transition alright it is clear, so (())(21:03) playing around with the pulsing current IP and that back ground current we can achieved extremely stable process achieved metal transfer characteristic which is very needed for stable GMAW process it is clear.

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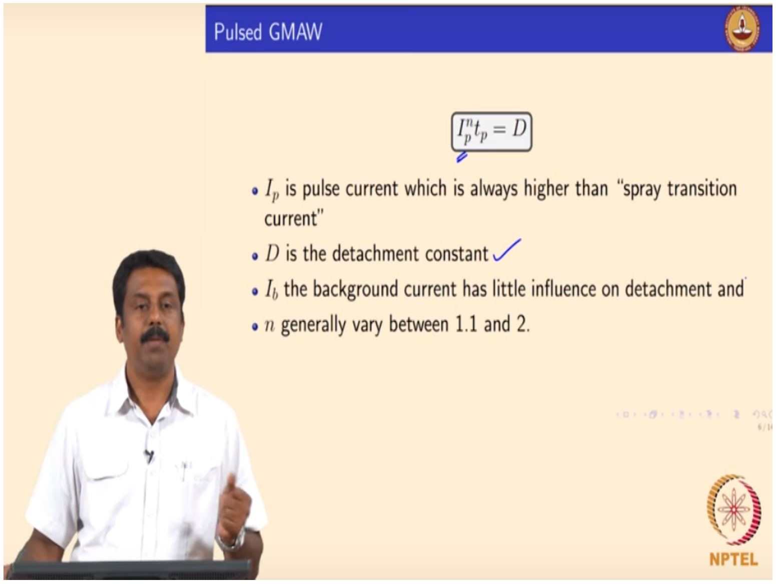

So this video already seen so we have an transfer carried out in a pulses GMAW process, so there are some relationships we can use generally for given material the IP TP is a constant, so that is function of material composition and the diameter, and we will come back to that so that you are calculating the pulsing parameters, so the IP is a pulsing current which is always higher than the spray transition current much higher than spray transition current and D id the detachment constant.

So and then IB is a background current and has little influence on detachment because detachment already happen before the uncertain of IB it is clear and then the relationship N generally vary between 1.1 and 2 in post of the material we can make as that a constant and D is function of material composition and the diameter it is clear.

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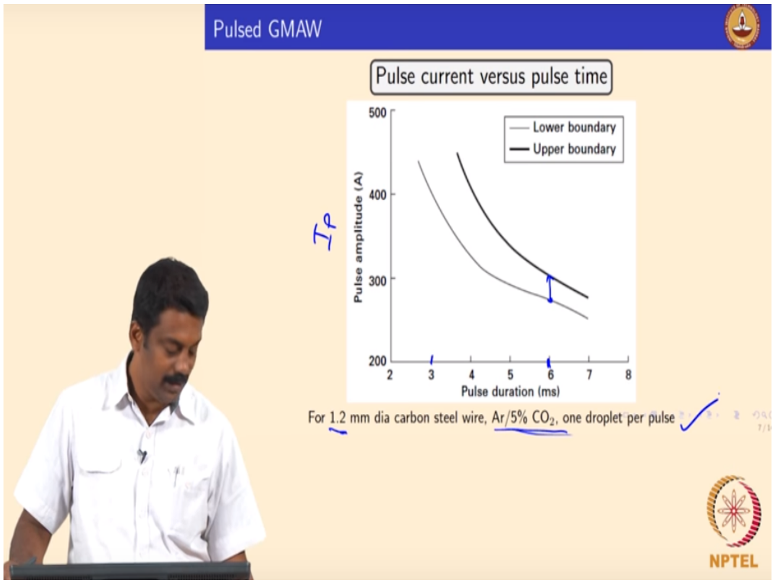

And then we can established for a given material as such a pause as window, so we pause as map we can generate for a given material where pulse amplitude this is IP and then pulse duration which TP plus TB alright, so we can get the pulse duration as function of pulse amplitude and which would give us a stable one transfer per pulse that is a criteria, if you look at the video we will have to make sure that one droplet would come per pulse during our this cycle period and if for example at higher pulse duration period it has to be in this range so if it is lower than that the current right the current is very low.

So you may have the detachment happen with the much larger Doppler diameter because gravity should do the job because the lower current must as to be created only gravity has detached the droplets if the current is much higher along a duration you may drop you may get more droplets per pulse because you are keeping it for every current for longer times that means that you get more droplets for pulse similarly at a shorter durations you need to have a longer current to achieve on droplet and if it is lower than you may not get the conditions stable transfer right you may again get higher than this spray transition.

So we can achieve as such an process map which is extremely important for a material so for example this graph is generated for 1.2 mm dia-carbon steel wire with argons plus 5 percent CO2 and then that is the condition that one droplets per pulse and these information they are there in the power source now a days okay, so without the information we cannot achieve we cannot arrive at the pulsing parameters right so the advancement powers what we talk about in micro-processor controlled the power sources and these are the information we generate by carrying the fundamental experiment applied to the power source system and the power source can choose supposed it is wants to use.

And mean current of example of 200 than it has to calculate a bottle IB and TP IB and TB, for a given IM so the it get one droplet totals immediately you all will do the calculations and then identify what will be the water filtrate to maintain the constant arc, so all the calculation it has to do and then give the pulse parameters and the wire filtrate to welled and achieve the stable transfer it is clear so who does not the calculation takes place so what are the parameters we need.

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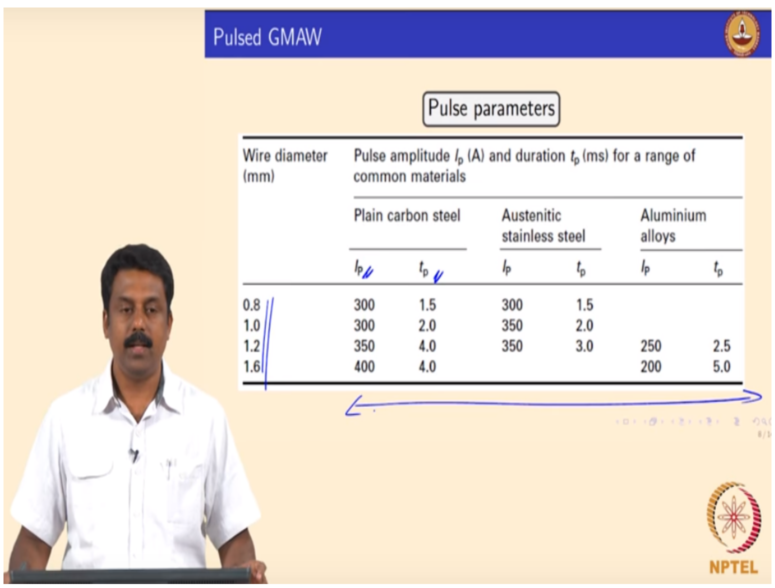

So we will first we need to identify such a maps for example we need to identify so what is will be the pulsing current and then TB pulse duration and then we can identify for a given material wire diameters, so various composition we will get this parameter, so IP TP and then the comes only changed and identify which current will give you a stable a once pulse transfer for a given pulse so this information is already be we can generate readily and then we goes power source and then we can do some calculations.

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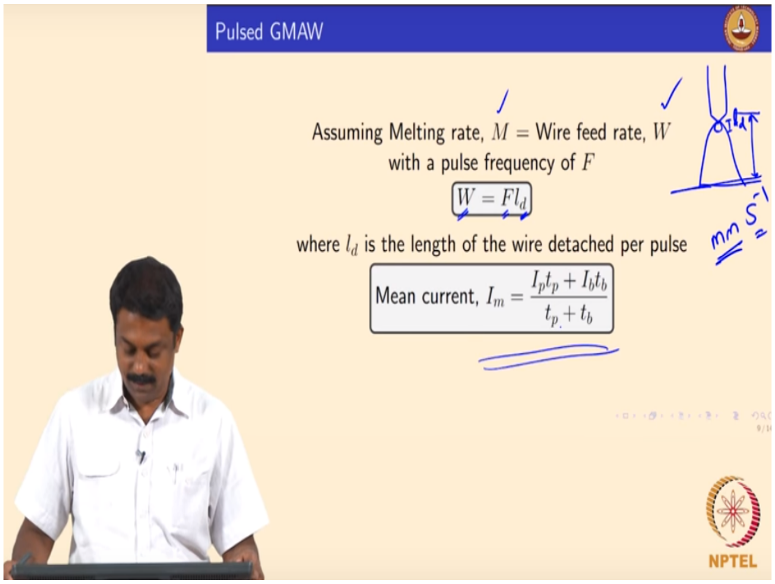

So this are all very simple physics right, so supposed if you want to maintained the constant arc length so this is my arc length, so this would be constant that means that the melting rate should be equal to fire filtrate so you supply what he melts, so then the arc length becomes constant right and supposed if you are transferring at one pulse the length LD of the material so then basically the wire feed rate is equal to the frequency of pulsing times the length of wire is transfer we melt is in it, what is F, F is a frequency right.

So that is nothing but the unit is mm per second is in not it basically how much mm you transfer in a second that is wire feed rate is in not it what is per second here is a frequency right, so frequency is number of pulses per second because you transfer one droplet per pulse so this is a relationship we have right and then we have I mean relationship what is I mean, the main current which is IP TP IB TB by IP plus TP and simple average is in it, so when you have an pulsing current right now this two we have.

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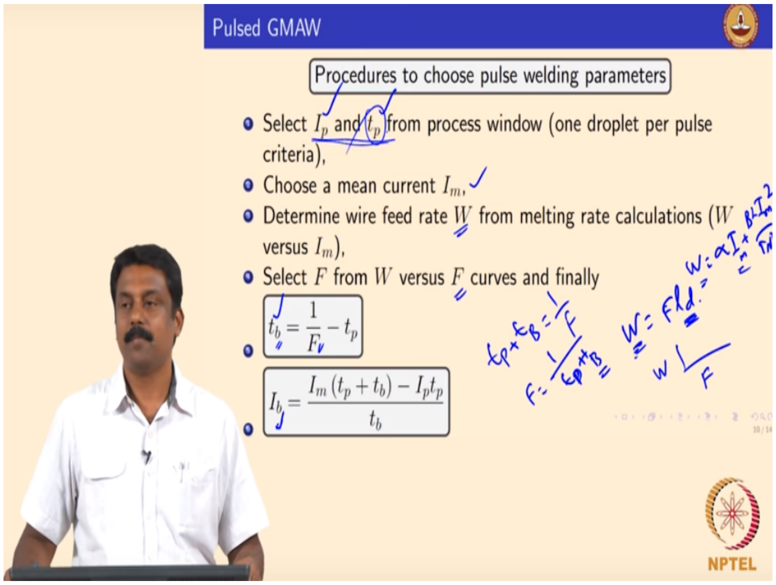

And then we can select the pulsing parameters these two, how do we do that so first we need to get IP and TP from the relationship the process window the condition is need one droplet per pulse, so that is the criteria and then we choose a mean current I mean, so any I mean current we can calculate the wire feed rate is in it, how do we calculate the wire feed rate alpha I plus beta L M square but pi R square is in not it because I mean E is this relationship but we can calculate the wire feed rate alright, so one we know wire feed rates it can also calculate from the wire feed rate the frequency F, because what is relation between F and frequency is in not it and the Doppler diameter it is follower diameter we cannot sure is in not it or we can also established the relationship between the wire feed rate versus frequency or we can choose.

So what will be WF relationship, so we can choose F from the W once you know F, we can calculate what is a background time we need because we know IP and TP we know TP already is in not it, so we can TB so which is nothing but, so TP plus TB is equal to one by F is it not, that is the frequency, so F is equal to, so one by TP plus TB, so from that we know TB we need to know TB because background we do not know so F we know from W, W we know from IM, so IM we know from the relationship one droplet at per pulse so once you know the TB all the unknowns are now known except the background current, the back ground current can be solve from the equation.

So we know IP and then we know TP we know TB only unknown is IB, IP calculate from the average equation right, so this all calculations are done in power source now a days, so this call calculations done in power source now a days, so when you want to established own pulsing parameters we got to do the all this calculations by our self so that is what when you are now buying a power source the company they also sell the welding parameters and you have to pay for that, so suppose if you want to weld (())(31:28) 625 where in pulse GMAW and you can allow to contact the power source manufacturer and they will give you simple program and program you need to load into the power source the program contains all the calculations.

And then you know you can identify the what diameter, the wire diameter is very critical because that determines DL, so a given LD you will have to identify W, W again is determine by the compositions, because compositions can times even H, CP right, latent heat of melting is there and when CP is there that will use to calculate the melting rate, so melting rate then want you know melting rates so need to keep the constant arc length so the wire feed rate is identify and then for a given composition the data base also contain, so what will be the relationship between IP and TP because map I showed you the graph.

So once you have the IP and TP is known W is known F is known and then TB is also known once you get IP TP TB, it was called IB and then you get all the parameters or pulsing, so once you know the calculation then the power source can feed all the parameter and wire feed rate to achieve the Doppler transfer in spray mode at a constant arc length, it is clear, so this is how we established the welding procedure specifications, so the money goes by a power sources the data base for this if some company suppose if you are approaches or we need to developed welding procedure parameter we will have to do all this exercise if I want to weld say a gas component in GMAW in a pulse mode.

Then we will have to established because this material may not be used or may not be developed the welding procedure and we will have to developed the welding procedure by following such principles to identify the stable metal transfer alright, so that is the technology of meld what we called it yes any question so far how do you arrive at the parameter with a simple logic what we follow to identify the pulsing parameters for GMAW yes it is clear good.