Fundamental of Welding Science and Technology
Dr. Pankaj Biswas
Department of Mechanical Engineering
Indian Institute of Technology, Guwahati

Lecture - 11
Physics of Welding - 3

So, our present topics is on Physics of Welding last class I was discussing about welding arc power and how to optimize the arc power, how to optimize the arc length that I have discuss in detail in last class. And at the end I was solve the problem. Today the following topics will be covered here also I discussed initially about the arc power.

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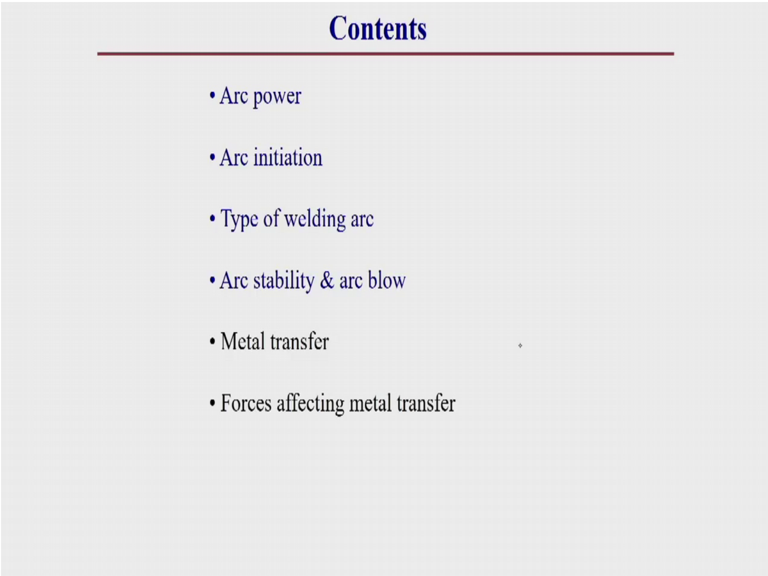

And how to optimize; that means, arc power here also I will discuss about the arc power. And I will solve another problem on arc power first of all after that I will show you how to initiate the arc, then type of different welding arc, what are the different types of arc and at the end of today's lecture I will discuss about arc stability and arc blow.

So, first of all I will solve a problem one arc power; actual how to find out the optimum arc length as well as of optimum power of welding power source; last class we solve a problem on that. Today we will solve similar types of problem, but little bit different; today also we will solve; I will solve a problem on welding power and optimum arc length, but the problem statement is little bit different than previous problem.

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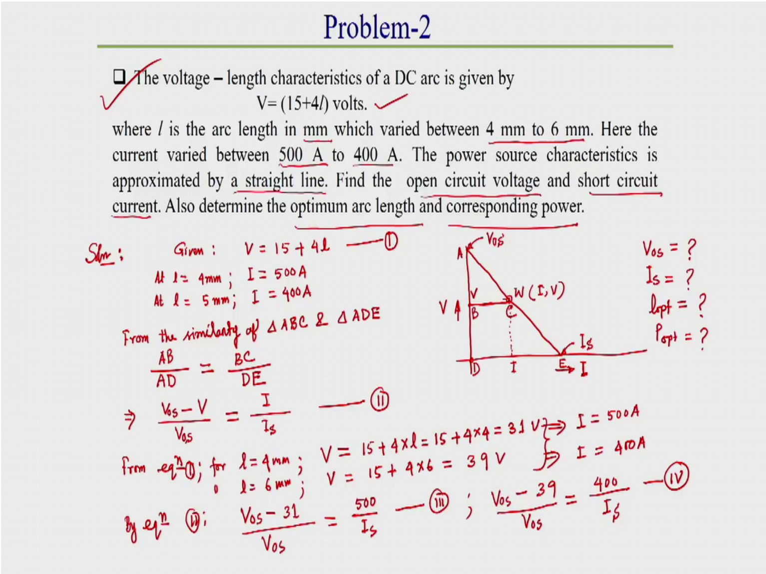

Here the problem statement is look like that is problem 2; the voltage length arc length characteristics of a DC is given by V is equal to this thing where l is arc length which is in millimetre which varied between 4 to 6 mm.

Now, for this following arc length the current varying from 500 to 400 ampere; that means, for 4 millimetre arc length here the current is 500 ampere and for 6 millimetre arc length the current is 400 ampere. Here the power source is a characteristics is approximated by straight line here this is also given. So, here power source characteristics also actually this power source is approximated here by a straight line, but we can solve the problem of curve types of approximation also, but there will be the solution will be little bit difficult; that is why here for our approximation easy to solve here we are approximated that the power source characteristics is a straight line in nature. But we can consider actual curve shape of power source characteristics also there generally what happens? There the problem that mean solution will be little bit difficult.

Then here what are the things you have to find out? Here we have to find out the open circuit voltage and short circuit current; that means, from this problem we can say that for a power source; let us what should be the open circuit voltage and open circuit short circuit current that also we can find out if we know the detail procedure of this thing first; that means, as per our requirement we can give some sort of this thing.

That means, these are the requirement for our case; that means, we want for 4 millimetre arc length we want 500 ampere current and for 6 mm arc length; we want let us 400 ampere current. For this types of a statement if you provide then what should be the actual power source or what should be the design of the power source; that means, what should be the short circuit current, what should be the open circuit voltage of the power source; that we can calculate by this procedure or if a whatever the procedure we learn and so by this procedure we can calculate that things. So, if we give this thing to this supplier; they can provide the thing as per our requirement also.

So, what happens? So, here what are the things we have to find out? Here we have to find out the open circuit voltage and short circuit current; also we have to find out what should be the optimum arc length and what should be the optimum power. These are the things we have to find out I will solve this problem in detail then it will be very clear to you.

So, first of all what are the given parameter? Here what are the different parameter is given that say here the given data is what are the thing given here? Here generally voltage arc length characteristics which is represented as 15 plus 4 l; here l is in millimetre it is given; let this is equation number 1 I am representing. Then another thing what are other things is given? At 4 mm l arc length at l is equal to 4; mm l is equal to 4 mm here I current I is equal to 500 ampere; it is given.

And l at l is equal to 5 mm what are the other thing is given? I is equal to 400 ampere and other things also in this problem statement is given which is general these power source characteristics is approximated as a straight line is nature. Generally power source characteristics we know; it is generally represent voltage versus current region.

So, here this is approximated as a straight line how thus just I am drawing a straight line here; this is their straight line. This is called short circuit current that is that is I am represent this is short circuit current which I have to find out and let this is this is generally called open circuit voltage that is I am representing open circuit voltage.

So, let for a particular voltage with a working point is I am representing in terms of W. So, for a particular voltage V here let us the working point W; the corresponding welding current is we can easily calculate that that procedure I; I already have discussed in details. So, what happens? For a particular, so here generally working point have a I am representing in by the following the point that different point of this characteristic I am representing in the following way; that means, that this is A, this is B, this is point this point is C, this is point is D and this point is E; so, these are the different point which I am representing here.

Now, from here from the similarity of triangle here we can see that AB C and AD E this 2 triangle are similar to each other. So, from the similarity of triangle AB C; so from the similarity of triangle AB C and triangle AD E what we can write? We can write AE by AD is equal to what we can write? BC by DE; that you know; actually that you also know well actually; from the similarity of triangle we can say that height of one triangle ratio of height of one to another triangle and ratio of base to base of one triangle to another triangle; that generally equal to each other from the similarity that we know.

Now from here what is AB? AB means open circuit voltage minus the working voltage and what is AD? AD generally we can represent open circuit voltage then what is BC? BC generally here is working current or welding current and I comma V actually this is W point is represent. So, generally I; so, this is I divided by; that means, working current divided by short circuit current let this is equation number 2.

So, here what should be our output? Here output actual we have to calculate what is open circuit voltage; what is short circuit current, what is l optimum; that means, optimum length or optimum arc length and what is optimum power corresponding; these are the for 4 things you have to find out. So, first of all we have to find out a open circuit voltage and short circuit current.

So, here in this equation 2; now what we can write? So, from equation 1, now from equation 1 first of all we will calculate the different voltage below. From equation 1 what we can calculate? At l is equal to l is equal to 4 from equation 1 for l is equal to 4 millimetre; what is V? V we are getting as 15 plus 4 into l means l means; so it is 15 plus 4 into 4 that is 31 we are getting.

Similarly, for from equation 1; for l is equal to 6 mm; what we are getting? V is equal to we are getting 15 plus 4 into 6; that means, 39; 39 volt ok. Now this we will put this voltage value will put in equation number 2. So, this two; so these voltage this 31; that means, voltage 31; 39 will put in equation. So, by equation 2; what we get? We get V o s minus 31 divided by V o s is equal to what we get?

I means for corresponding to this 31 what is the current value here corresponding thing is this 31 voltage? We got there current value is 500 ampere; that means, and corresponding to this 39 voltage current value is generally 400 ampere that is given actually this two is given. So, generally here what we can write? This 500 divided by I s let this is equation number 3. And another equation what we by equation number 2 what another what we other things we got?.

So, V o s divide minus 39 if the voltage is 39 that open circuit voltage V open circuit voltage minus 39 may be open circuit voltage like for my equation 2 actually what we are getting; 400 divided by I s short circuit let this is equation 4.

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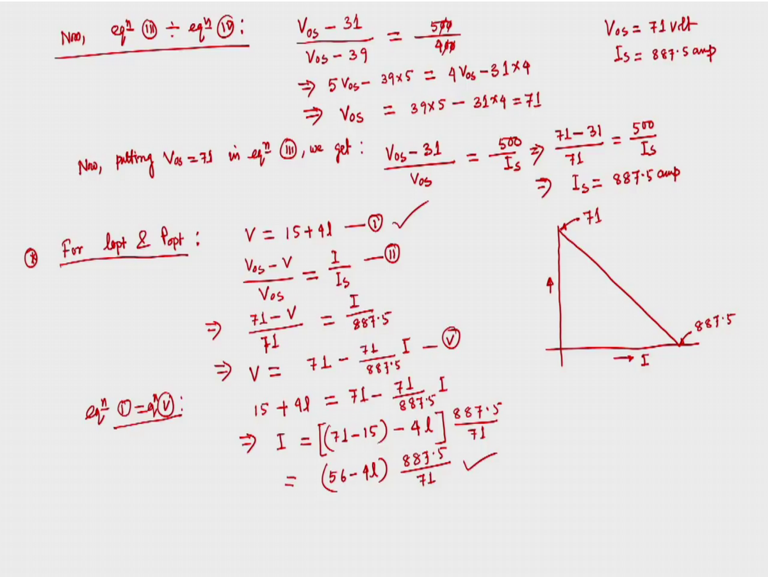

So, now by dividing the equation 3 by 4; so what we can write? Equation number 3 divided by equation number 4; by this what we can get? We can get V o s minus 31 divided by V o s minus 39 is equal to 500 divided by 400.

So, from here we can easily calculate the open circuit voltage. So, just I am cross I am doing the cross multiplication; so, 5 V o s minus 39 into 5 is equal to your 4 into V open circuit voltage minus; 31 into 4. So, from here what is the open circuit voltage we are getting? So, open circuit voltage; that means, this 5 o s minus 4 o s will give you the open circuit voltage which is generally 39 into 5 minus 31 into 4.

This will gives you a value which is equal to 71. So, we got a solution that is there the open circuit voltage is we got one solution that open circuit voltage is 31; 71 volt. So, you already got this open circuit voltage by putting this open circuit voltage in equation 3. So, now, putting this V open circuit is equal to 71 in equation 3 or equation 4 we get; so, V open circuit voltage minus 31 divided by V open circuit; V open circuit divided by 500 divided by I s.

From here generally we can calculate the short circuit current open circuit voltage is 71 minus 31 divided by 71 is equal to 500 divided by I s. So, here we get I s is equal to that directly I am just putting this I s value I s is equal to 887.5; 887.5 ampere. So, we got this open circuit voltage as well as short circuit current; this is actually ampere open circuit voltage and short circuit current we got. Now we have to find out the optimum arc length and optimum power.

So, now what we got? We got the power source characteristic open circuit voltage and short circuit current we got. So, here generally this is short circuit current is 887.5 here generally this open circuit voltage is generally 71 this we already got. Now for optimum arc length and optimum power we have to find out for optimum arc length and optimum power what we have to find out?.

We have to find out the current because we know voltage is equal is a function of l; voltage is a function of generally 15 plus 4 l; this is given this equation is given in equation number 1; which I have already shown in previous slide. And another equation also we got that equation generally; so, here what we have to find out? We have to find out both current and; that means, welding current and welding voltage in terms of l.

So, what we know? We know another equation number 2 is open circuit voltage minus this is generally equation 2. So, by this equation 1 and 2 what we can find out? We can find out this current in terms of l as well as voltage in terms. So voltage already is given in equation which is a function of arc length; now we have to find out the current also is a function of arc length; then only will be able to find out optimum arc length and optimum power.

In this equation in equation 2 what we can get; voltage current relationship in terms of that is from equation 2 actually voltage current relationship. So, here from here what we get? V we can represent as 71 minus by some calculation 71 divided by 887.5 into I.

I think this is correct; so this 71 minus this. So, this is my another equation let us this is equation number 5; now this equation 1 and 5 from by equating; that means, by equating equation 1 and 5 we will get the current is a function of l; then only we can get power is a function of l. So, here we equating equation 1 is equal to equation number 5; by this equation number 1 equal to equation number 5 by these what we get? We will get current is a function of 887.5; from here I we get as now this 71; 71 minus 15; minus 4 l into 887.5 divided by 71 correct.

This is equal to actually your 56 minus 4 l into 887.5 divided by 71 we got; from given data we got that voltage is a function of l and from this 2 equation that equation number 1 and 5, we get welding current is also a function of l. Now, we will go for finding out the; what is the power.

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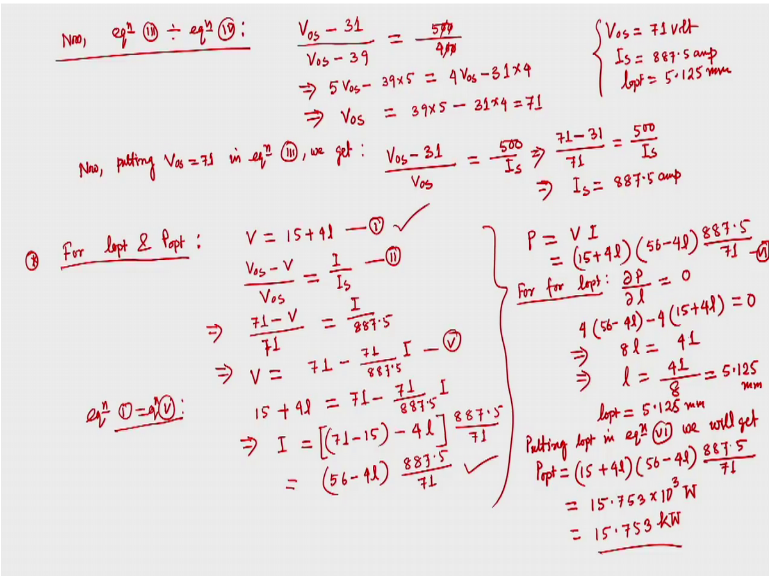

So, here power is equal to V into I; that means, they had the power is also say function of l because we are interested to find out the optimum arc length. So, for optimum arc length generally power should be a function of only l; that is why we are doing voltage is a function of l which is already given. Then we are finding out the current also is a function of l generally that we are finding out there is a 56 minus 4 l into 887.5 divided by 71.

Now, for optimum arc length l optimum what we have to do? We have to do del P by differentiation del P by del l del l and its make equal to 0; if you just do it then we will get optimum arc length. So, here we have to differentiate equation let this is equation number 6. So, we are differentiating equation number 6 with respect to l and make it equal to 0, we will get the optimum arc length.

So, here generally 4 into 56 minus 4 l minus 4 into 15 plus 4 l that will be equal to 0. So, this will gives a value of; that means, here your 8 l equal to 56 minus 4 1; so, here l we will get as 41 divided by 8. So, here optimum arc length is 5.125 millimetre because in our problem itself it is given l is in millimetre that is why everywhere we are considering l.

So, this is actually this is our; so here optimum arc length equal to how much? 5.125 millimetre. Now what will be the optimum power; so we got this 2 and the third solution is l optimum is equal to your 5.125 mm. Now putting this value of optimum arc length in equation number 6; so putting l optimum in equation 6 to you will; we will get optimum power.

So, what will be the optimum power? Optimum power will be your 15 plus 4 l into 56 minus 4 l into 887.5 divided by 71. So, if we put the value of l in this equation that is 5.125, we will get optimum power as 5.753 into 10 to the power 3 this unit will be in watt. So, this is equal to we can write a, this we can tell that optimum power of this arc is 7 point kilowatt also we can write.

So, we got this force; so what happens while once is we know the detail step about how to find out the optimum arc length, how to find out the optimum arc power. Then what happens as per our requirement we can also designs some welding machine as per our requirement. So, from this problem will learn how to find out the open circuit voltage. how to find out the short circuit current, how to find out the optimum arc length.

So, this types of problem if it will come actually so we can easily solve if you know the procedure its basic procedure in detail. So, here basic procedure is a state forward then early here we have to find out the power in terms of length; that means, first of all what is the procedure? Here procedure is first of all voltage which is a function of l that will be generally given in our problem statement. Then we have to find out the current yeah which we should be a function of l; that means, we should find out the current in terms of l.

So, if voltage and current is a function of l; then we can easily find out the power as a function of l because power is equal to voltage into current. So, if we get the power as a function of l, if we just derivative this power with respect to l then we can easily find out the optimum arc length from there. So, if you know the optimum arc length based on this optimum arc length; we can easily find out what will be the optimum welding voltage, what will be the optimum welding current.

So, if we get this optimum welding voltage and optimum welding current then we can easily get the optimum arc power. So, by this generally we can easily calculate all the element required for arc power. Now, we will go another topic how the arc is initiated. So, we got arc power now how this we; we got idea about welding arc in more or less in details, now will say we should know how this arc is initiated.

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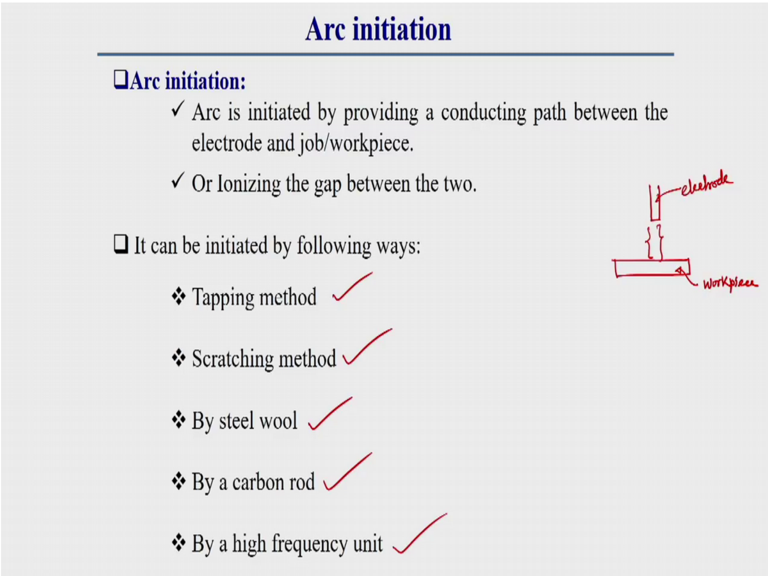

Generally arc is initiated by providing a conducting path between electrode and work piece. So, what happens for initiation of the arc let this is our work piece and this is electrode. So, first of all we have to make a conducting path actually by providing a conducting path that this is our work piece and this is our electrode.

So, here what we have to do? We have to generally make a conducting path between these two; that means, work piece and work piece and electrode; we have to generally providing a conducting path between these two, then we can get a electrical. Or this can be done by ionizing the gap between this two not other way we can say that we have to ionize this gap if we can ionize this gap then we can generate the welding arc.

Then how this welding arc is generated? There is different techniques are there for different types of welding techniques what are the different techniques? One technique can be tapping method, here I am showing around 5 different techniques are there we generally used in welding industry that I am showing; this can be tapping method. This can be a scratching method this can be by steel wool this can be that mean arc can be started by a carbon rod it also can be started by a high frequency unit these are the different technique generally which is used to arc initiate.

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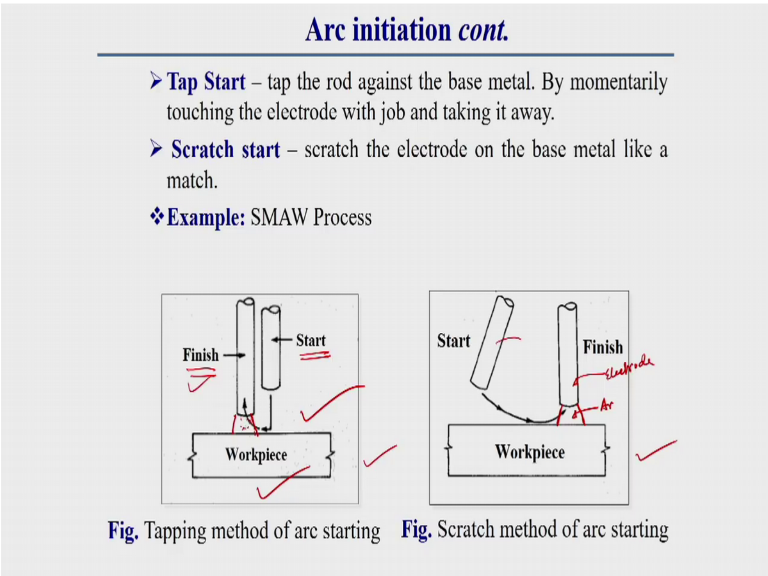

Fig. Tapping method of arc starting Fig. Scratch method of arc starting

Now, one by one I will discuss in detail generally tapping method this is generally tapping method. In this method generally this electrode let this your electrode you see this is generally starting point this is generally finish point I have shown here.

A starting point when a means here generally tap the road against the base material this electrode have to tap with this rod with this work piece and what happens? By momentarily touching the electrode with the job by tapping method and generally it taking it away; that means, in taken position its tapping it away from its initial position; then a arc is started have a arc will start this types of arc will start here it means here we will get a arc.

So, this is called tapping method; that means, tap the rod against the base material then my momentarily here what we do? Here momentarily we have to tell this electrode with this base material or work piece material and after that we have to take it away. So, once we take it away; in this final first finish position we will get a electric arc here this is called general tapping method.

A scratch method or this is called a scratching method by this is scratching method generally how the scratching method is done? Here the scratch the electrode is electrode this electrode is scratched this is a this electrode scratch on the base plate like a mess. So, then what we get? We can get a arc here. So, after scratch at the finish position we will get a arc. So, this is the technique we generally used in manual metal arc welding process; that means, this two technique generally used in manual metal arc welding technique SMAW that is shielded manual metal arc welding process generally it is used.

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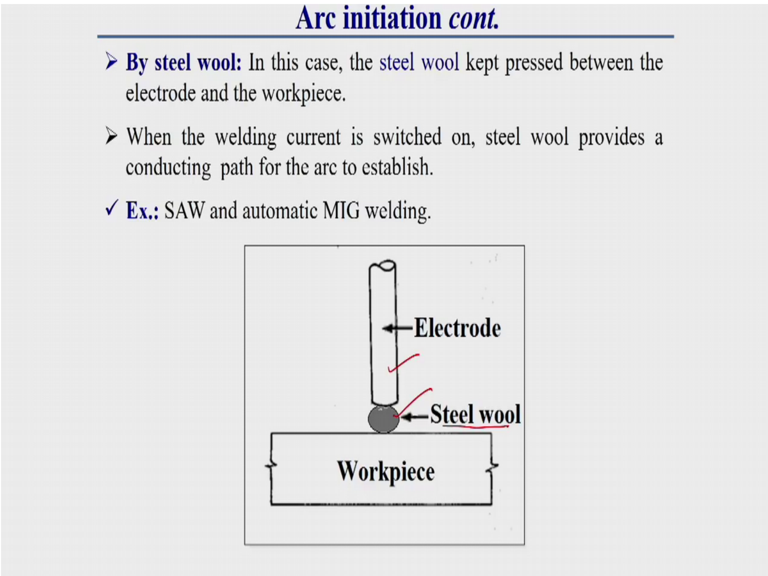

Then other technique like by steel wool in this technique what is done? Here a steel wool kept in between this electrode and work piece. Here you see this is the steel wool we generally kept in between this electrode and work piece; then current is switched on; that means, welding current is switched on.

Once welding current is switched on then this steel wool provides a conducting path for the arc to establish; this is term this is steel wool general once the current is switched on, then this is steel wool means it is a chip of steel from machining you see some set of chip is come out this is steel wool a small chips of a steel. So, this is a conducting material.

So, once it keep in between this na then once we switch on the current then what happens its provide the conducting path. So, here arc provide the its provide the conducting path for arc to establish. This technique is widely used in Submerged Arc Welding techniques as well as in MIG welding technique also. Then MIG means GMAW; Gas Metal Arc Welding on metal in a gas welding technique generally this steel wool techniques is used.

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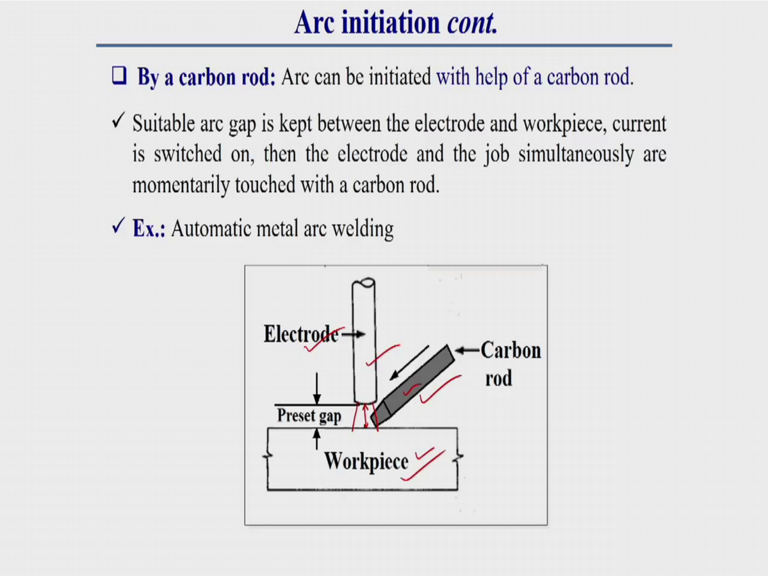

Then another categories is by generally a carbon rod also we can generate the arc; in this technique generally a suitable arc gap is maintained in between electrode and work piece this is the gap. Then the electrode and the job simultaneously momentarily toss with a carbon rod; so, first of all a gap is maintained then the current is 1.

So, once the welding current is 1 after that what we have to do? Then the electrode as well as this work piece are momentarily tossed with this carbon rod. So, once we toss this electrode once we toss this electrode and work piece by this carbon rod, then this carbon rod provide a conducting path. Due to this conducting path generally a arc is established in between this gap.

So, in this way generally the arc can be initiated this is generally we observed this types of arc initiation is done in case of automatic types of metal arc welding techniques, then in some phases some TIG welding techniques also we can see this types of arc initiation techniques.

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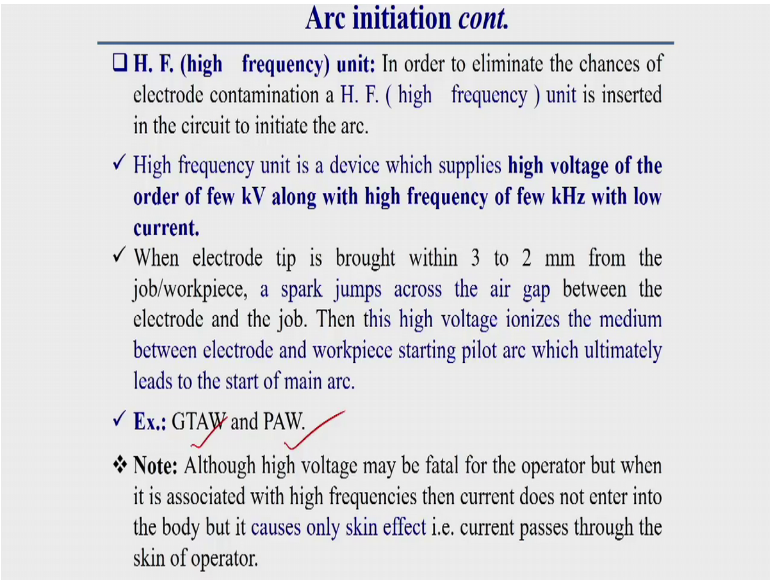

Another categories this is when a very sophisticated technique for arc initiation; here a high frequency unit is used to generate the arc ah. Generally why this high frequency unit is good and it is which is advantages than other technique because generally in this techniques; we can eliminate the electrode contamination with base material.

That means, what happens there is a chance of electrode contamination in case of TIG welding or plasma arc welding techniques. Generally there is a chance of electrode contamination once the arc is initiated by other method like tapping method or sketching method then that time what happens? Due to this short circuiting of the electrode with work piece there is a chance of contamination of this electrode with base material; that means, there is a chances of melting of this electrode and its deposited with welding material. So, so that that will create a defect actually; to eliminate this thing a high frequency unit generally used to initiate the arc.

Generally this high frequency unit is inserted in the circuit to initiate the; this unit generally inserted in the circuit to initiate the arc this high frequency unit is inserted with the circuit to initiate the arc. It generally this high frequency unit is a device which supply very high voltage and low current. Here generally it supplies very high voltage within a range of some kilovolt or very low current it can supply. But this thing sees with this high voltage with a very high frequency also this high voltage with very high frequency this unit supply. So, what is the output of this unit, this high frequency unit device? It supplies very high voltage within a range of some kilovolt with high frequency and with low current very low current.

So, how it is initiated? First of all a gap is maintained in between this work piece and electrode there is maintain a gap this gap is generally within a range of 2 to 3 millimetre. Then what happens? A spark jump across the air gap between the electrode and the job; then this high voltage then the whatever the high voltage of this unit this high voltage generally ionized the medium between electrode and work piece; which generally start initially a pilot arc. Then this pilot arc ultimately leads to a start of main arc.

So, first by jumping of this spark its ionize the medium between electrode and work piece; that gap due to this ionization a pilot arc is initially generated; that pilot arc generally cannot do the welding that pilot arc cannot do the welding. So, it leads to generate the main arc. So, first this a pilot arc is generated by this high frequency unit; then its leads to generate the welding arc which generally do the welding operation.

This types of technique generally used non consumable types of electrode like tungsten; there generally we used this types of a high frequency unit; like in Gas Tungsten Arc Welding, in Plasma Arc Welding techniques. So, I will generally there is used a non consumable types of electrode that is tungsten electrode generally used. So, to eliminate the contamination generally this is used over there.

Here one things we should keep it in mind though high voltage; generally we know that high voltage generally may be fatal for welder. But here as we are using high frequency that is why it is not that much of dangerous then only high voltage unit. So, due to this high frequency unit generally this current cannot pass into the body of the welder. So, here what happens? There can be some is skin effect if there is a contact between this unit with this welder open contact with this welder and the unit then what happens there is a chance of some skin effect.

Because here due to this high frequency generally this current cannot pass into the body; its generally can pass in the surface of the skin of our body. So, it can there can be some skin effect, then also we should careful to once we go for using this types of arc initiation technique. So, we got idea about that different techniques of arc initiation; now we should know what are the different types of arc. We should know the different categories of arc ah; we can categorize the arc in 4 different categories ah.

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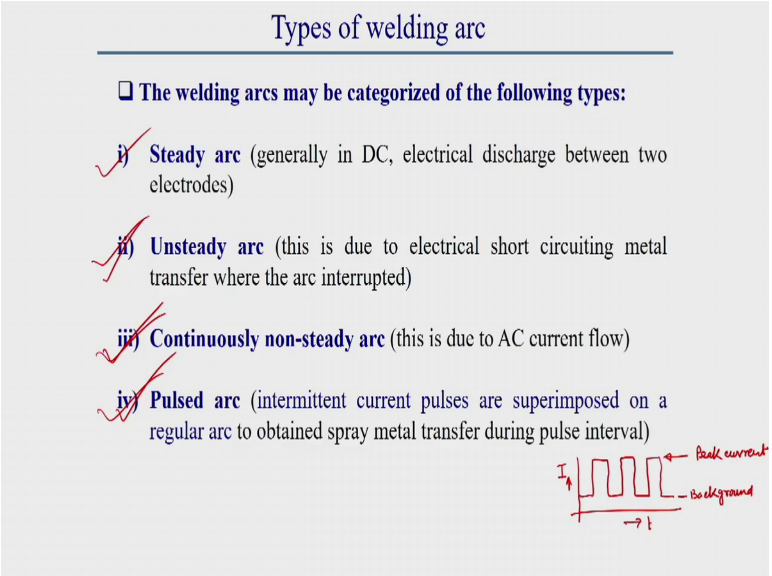

This four different categories of arc are this arc can be study arc that can be unsteady arc, this can be continuously non study arc and this can be pulsed arc. Generally a steady arc we observed in case of DC current where generally direct current power supply is used there we get a steady arc.

On a steady arc generally this is a arc which we observe once there is a metal transfer occur which is short circuit in nature. This metal transfer related thing I will discuss in details in subsequent topics of this physics of welding itself; so, there I will show you what is short circuiting types of metal transfer. In case of short circuiting metal transfer generally; there we observes on a steady types of arc; that means, here the arc is irregular in nature which is on a study with; that means, its bearing with time unsteadily that is why this is call unsteady arc this second category; this is we observe generally in case of short circuiting types of metal transfer.

Short circuiting types of metal transfer means there is a continuously there is a variation of arc gap between electrode and work piece and there is also workers some short circuiting. So, there is the different steps in between arc gap as it is taken place that is why this arc characteristics is unsteady in nature.

This third category is called continuously non study arc; continuously non a steady arc this is observe in case of general alternating current. That means, AC power supply generally this continuously non steady arc we have the because in case of alternating current flow there is a sinusoidal variation of current is there. So, due to this sinusoidal variation of current is a continuous variation of current is there. So, that is why continuous variation with which is varying with time; that means, somewhere we are getting peaks somewhere 0, somewhere negative, somewhere positive. So, there is a continuous variation of arc is also observe in case of AC power supply.

This fourth categories is called pulsed arc; this pulsed arc generally observed in case of pulse characteristic power source. Pulse characteristic power source have already discussed in details; they are generally a background call due to this pulse characteristics means they are generally what we observe. Here generally current generally varying with time this is pulse in nature.

So, due to this variation those this pulse types of characteristic is a is a DC types of power direct current type power source characteristics. Here generally here there is a peak current as well as background current; this is generally called background current this is generally called peak current. So, generally here the current is varying with time and here there is a peak pulse as well as a background pulse. So, here due to this variation of current with time there we observe a arc that arc is called the arc also is varying with different pulse of current. So, that is that types of arc is call pulse arc.

So, these are the general for different types of arc we observe in case of welding techniques. Now will see what are the different mode of; that means, another categories of welding arc also observed; these categories is based on shape of the electrode tip generally these categories is based on the shape of the electrode tip.

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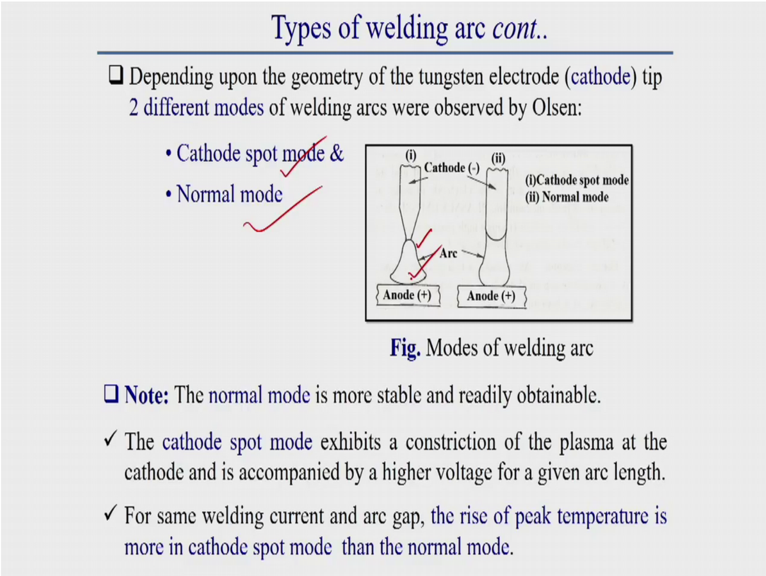

Here generally two different mode of arc we observe in case of tungsten electrode. So, here depending upon the geometry of the tungsten electrode here we observe two different types of mode of arc. What is these two different types of mode of arc? These two different types of mode or one mode of arc is called cathode sport mode arc, another mode of arc is called normal mode arc.

Cathode spot mode arc here the cathode spot mode exhibits a constriction of the plasma at the cathode and this accompanied by a high voltage for a given arc length. Though the normal mode is more stable and readily stable, but for the same arc gap we get higher temperature that serves same arc gap; for same current we get higher temperature rise in case of cathode spot mode than the anode spot mode. Because generally for same arc gap due to this construction of the arc there we get higher voltage due to this higher voltage for same current and same gap itself; we get generally higher temperature in case of cathode spot mode.

Here in case of cathode spot mode in the plasma is constant the electrode tip become sharp due to this sharp and tapering shape of this electrode tip here; due to this magnetic effect; that means, current flow and due to this current flows and its magnetic effect; here the in cathode region generally cathode space region here generally the arc plasma constriction occur arc plasma constriction as well in at the cathode region. Due to this constriction arc is become like this is generally cathode spot mode.

So, what happens? Here cathode spot mode provide higher voltage for same current and same gap itself it provide higher voltage and it provides higher temperature than the normal mode for same current and same arc gap.

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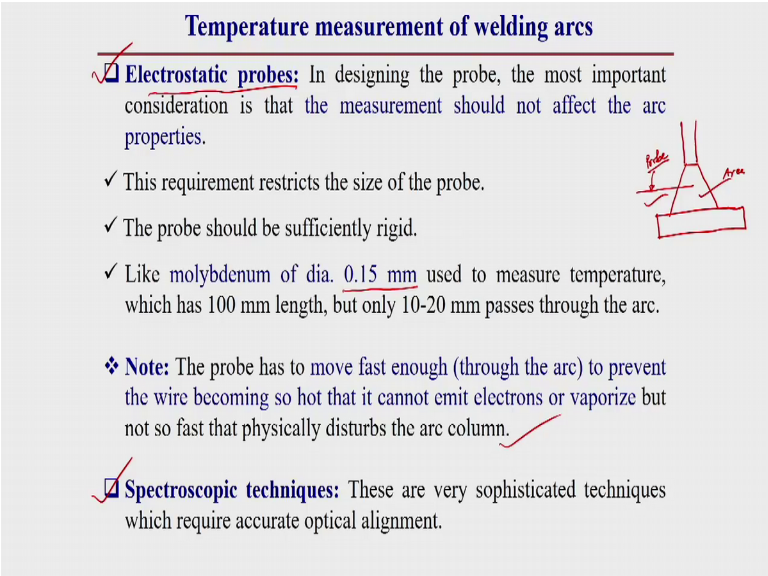

This arc temperature we got; that means, now we got the idea in case of cathode spot mode; we get higher temperature, in case of normal mode generally we get lower temperature. Then how we can measure this temperature in arc? That also we should know.

Generally the temperature of arc we can measure by two different technique one is called electrostatic technique, another one is call spectroscopic techniques. So, one is called electrostatic technique and another one is called a spectroscopic technique. So, electrostatic techniques in this technique there is used a probe that is why this techniques also sometimes called electrostatics probe technique.

In designing the probe the most important consideration is that the measurement should not affect the arc properties. So whatever the probe we are using to measure the arc temperature; that means, let this is let this is the arc. So, in this arc what happens? We are generally measuring the temperature by using a probe this is let us a probe. Now here generally this probe should not disturb this arc it should not disturb; this probe should not disturb the arc always keep this thing is mind.

Further generally consider some design criteria here one things this probe should be sufficiently rigid; then another things this probe should have generally vary a smaller diameter; so, that it should not disturb the arc. Further there we used molybdenum as probe material; these diameter of this probe generally used as 0.15 millimetre which is given here. It has a length is around 100 mm, but only 10 to 15 millimetre of this length pass through the arc; only this though it has a length is around 100 mm, but only 10 to 50 millimetre its passes through the arc.

Now here one things we should keep it in mind the probe has to move fast enough to prevent the wire becoming so hot that it cannot emit electron or vaporize. That means, this probe we should pass through this arc in such a way; so, that this probe should not vaporize or probe should not emit the electron inside the arc. And an another things we should keep it in mind this moment should not so fast, so that it is physically disturb the arc column that also you should keep it in mind. So, there should be a optimum movement of probe inside the arc.

So, so that it should not disturb the arc as well as it should not vaporize or it should not emit the electron; that we should keep it in mind. That techniques then from this probe generally why some data acquisition step we can measure the temperature. Here one things we should keep it in mind here that these temperature of these arc is within a range of around; I have to already told you within a range of 20000 Kelvin, then what a probe of molybdenum whose temperature whose melting point is a within a range of around 2600 degree centigrade. And it’s; the vaporise temperature within a range of 4500 degree within that range actually.

So, what happens then how this probe is measuring the temperature of arc? That also we little bit we should know that is why what we have told you this probe we should passed through the arc so fast so that it should not emit the electron, it should not vaporize this is one things. So, by touching the arc by this probe whatever the sense it is taking; that sense itself it can record the temperature range; record the temperature range by using data acquisition system.

Another technique generally which is used that is called a spectroscopic technique; in this is generally it is a sophisticated techniques; here generally alignment of optical lens is very very important here. So, generally this spectroscopic techniques required a accurate optical alignment. Generally what about the lens and other system is used to measure the temperature here; that is required accurate optical alignment always this is a very sophisticated technique; by this optical system we can also measure the temperature of arc.

So, next class I will start arc stability and arc blow ah; there we will discuss in details what is arc stability, what is arc blow, what are the different effect of this arc stability, what are the effect of arc blow in details in next class.