**Manufacturing Process - I**
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**Module - 3**
**Lecture - 5**
# Arc Welding Power Source Part – 2

Welcome students. This is the second lecture on arc welding power sources. In the last lecture, I have covered the various power sources, which are used for welding purpose and the classification of the welding power sources. And the basic characteristics of the welding power sources which are used in selection of the arc welding power sources. These characteristics where the open circuit voltage power factor static characteristics of the power source, duty cycle class of insulation which has been used in making the power source.

So, out of these characteristics the first three characteristics like open circuit voltage power factor and static characteristics of the power source I have already covered in the previous lecture. And in the static characteristics we have three types of the characteristics of the power sources; the constant current power source, constant voltage power source and rising characteristic power source. So, the constant characteristic power sources I have already covered in earlier lecture, and I had just started the constant voltage power source in the previous lecture, so that the constant voltage power source remaining part of that portion we shall start now.

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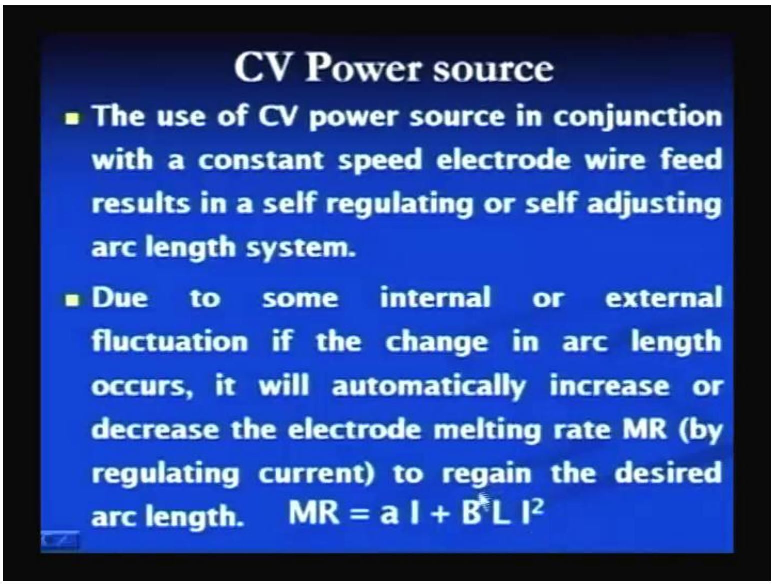


The constant voltage power sources are mainly used in arc welding of arc welding process which are semiautomatic in nature and used competitively thin or small electrodes. Use of constant voltage power source in conjunction with the constant speed electrode wire feed system results in self regulating arc. Self regulating arc automatically adjust the arc length when there is a fluctuation in the arc length due to any reason. So, that benefit is obtained when constant voltage power source is used with the constant electrode wire feed system.

Due to the internal or external changes the fluctuation in arc length occurs during the welding, and these are automatically taken care of by regulating the melting rate by change of the current. So, the current magnitude is changed to regulate the melting rate which in turn helps to maintain the constant arc length, and this melting rate is significantly governed by the welding current. And this melting rate is given by this equation; the MR melting rate is equal to a into I plus B L I square where a and B are constants, and I is the welding current, and L is the electrode extension. A is a constant which is determined by the ionization potential of the metal, or it in turn we can say that it depends on the kind of metal which is being used as a electrode. The B is a constant which includes the effect related to the electrical resistivity.

So, the first factor a I is related to the contribution of the heat generated at anode side or cathode side, and B L I square is the another factor that represents to the contribution of electrical resistance heating on the melting rate. So, the melting rate equation includes the effect of both melting rate caused by the anode or cathode reaction, or the second factor B L I square represents to the melting rate which is determined by the electrical resistance heating effect. Here from this it is clear that second factor the melting rate is largely affected by the current, because here we have the melting rate is equal to B L I square. Well, the melting rate is not that much effected by the anode or cathode reaction because here it is a into I. So, if we increase the current, the increase in melting rate will be more if the electrode here is of the small diameter. In that case your second factor B L I square will have more effect on the melting rate compared to the case when large diameter electrodes are used.

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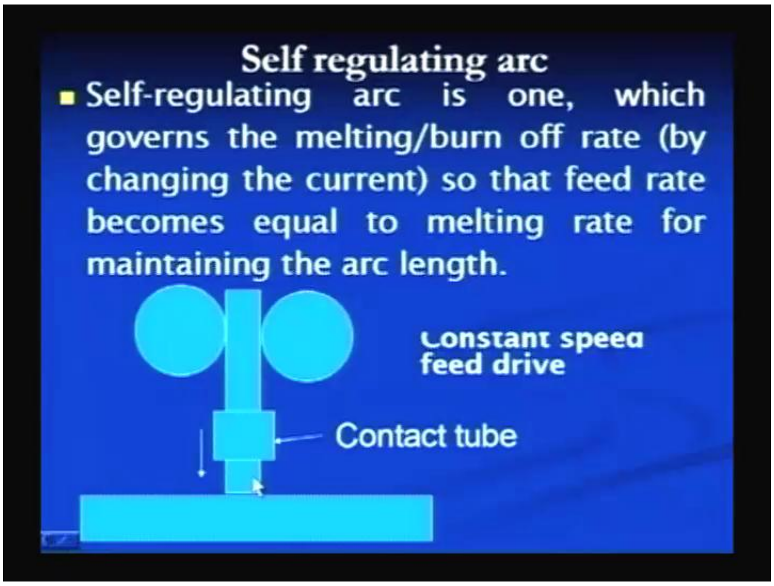


We will see the self regulating arc in detail which is obtained in the constant voltage power sources. The self regulating arc is one which governs the melting rate oblique burn off rate by changing the current, so that the feed rate becomes equal to the melting rate for maintaining the arc length. So, this is the condition which is required for maintaining the arc length that feed rate must be equal to the melting rate. And if due to any reason there is change in feed rate, then melting rate should be regulated accordingly by change of the welding current.

And here that we can see the constant speed feed system is used to feed the electrode, and it passes through the contact tube. And these are the rollers which are used to move the electrode forward, and if there is any fluctuation in gap between the work piece and the electrode that is arc gap, then the current is adjusted automatically in case of the constant voltage power sources to change the melting rate and so as to maintain the arc gap or arc length.

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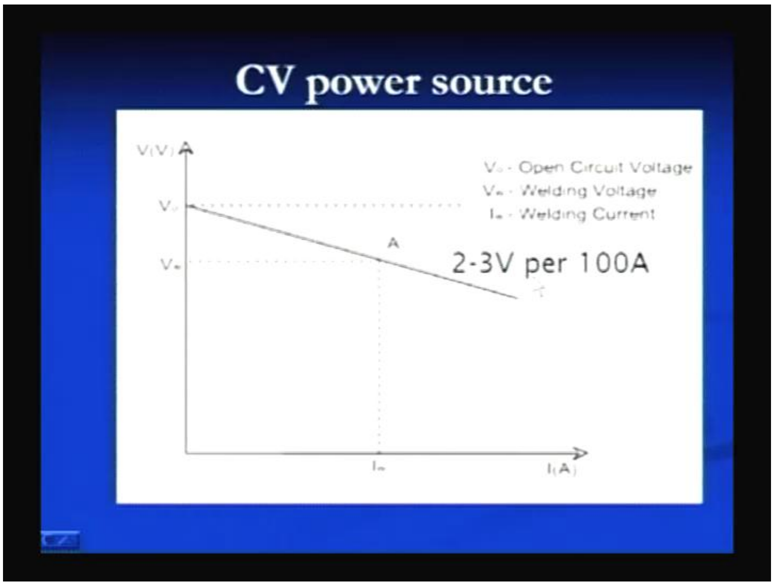


The constant voltage power source there are many other important factors like the voltage current relationship which is known as VI characteristic of the power source. The VI characteristic of the power source in constant voltage power sources show slightly negative slope and this is because of internal resistance and inductance effects within the power sources. And this sloping down is generally found equal to the 2 to 3 volts per 100 ampere of the current. So, minor fluctuation in the arc length or arc voltage leads to a significant change in the welding current in the constant voltage power sources which in turn produces the great change in the melting rate which helps to maintain the arc length if the constant speed wire feed system is used.

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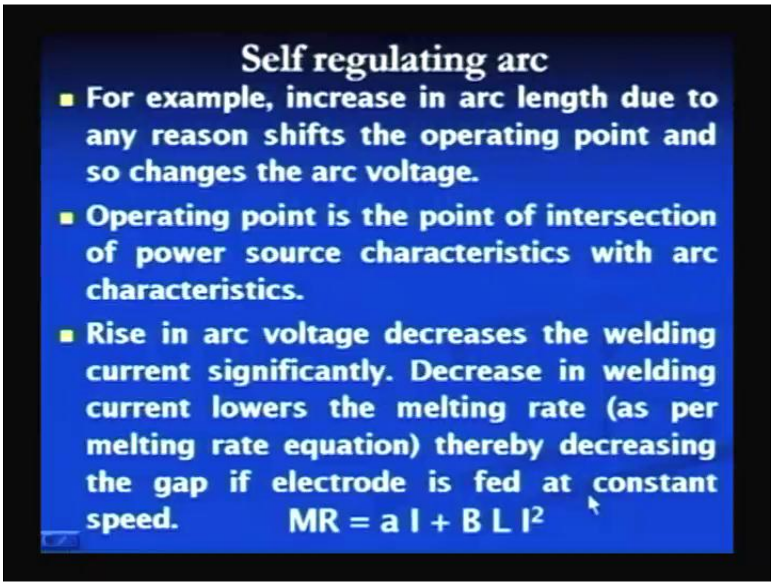


For example, increase in arc length due to any reason shifts the operating point so as to change the arc voltage, means if there is any change in arc length it shifts the operating point and accordingly change in arc voltage is noticed. Operating point is the point of intersection of the power source characteristic with the arc characteristic. That we will see in the next slide how the operating point is obtained and how it is shifted with a change in arc length.

The rise in arc voltage decreases the welding current significantly, and the decrease in welding current lowers the melting rate as per the melting rate equation we have seen in the previous slide. And thereby decreasing the arc gap if the electrode is fed at a constant speed, and the melting rate is governed by this equation; this is what I have already explained in the previous slide.

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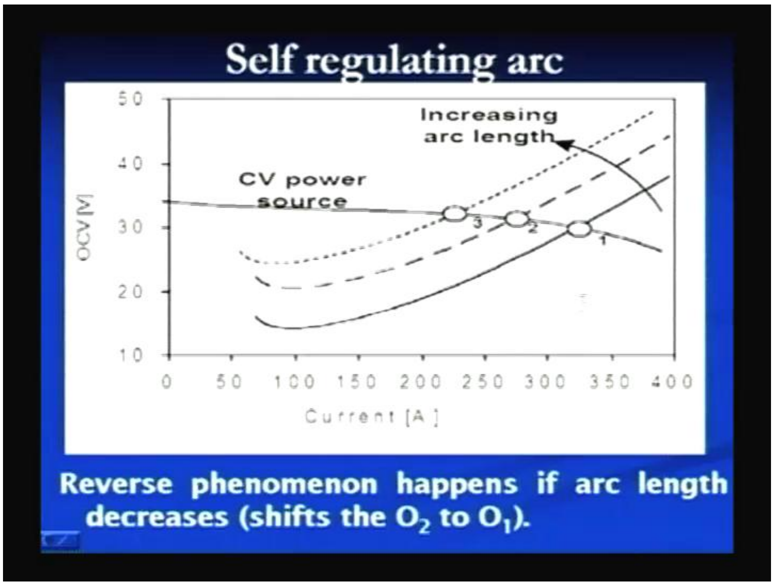


Now we will see that how the change in operating point with the change in arc length can be used to explain how the arc length is maintained. You see with the increase in arc length, operating point shifts from 0.1 to 2 and then 2 to 3. These lines indicates the arc characteristic, and this solid line indicates the power source characteristic, and intersection of the power source characteristic and the arc characteristic results in an operating point.

If there is increase in arc length due to any reason, then the operating point will be shifted from 0.1 to 0.2, and then when there will be change in operating point from point one to point two, it will decrease the welding current significantly, say, from here 340 to somewhere here 260. So, this significant reduction in the welding current will decrease the melting rate, and if the electrode is being fed at constant speed then it will result in the reduction in the arc gap or arc length.

So, after sometime equilibrium will be maintained which will be corresponding to the arc length which is required, and the reverse phenomena happens if the arc length decreases. We can see here if the arc length decreases, then there will be change in shift from operating point two to operating point one. Reduction in arc length or arc gap will lead to the increase in welding current from somewhere 260 to 70 to 340. So, this significant increase in welding current will automatically increase the melting rate, and for a given feed rate increased melting rate gives the increased arc gap. And after sometime again an equilibrium is established which leads to the constant arc length.

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The constant arc length is maintained by using the two different types of the drives which are used in the semiautomatic welding processes. And these two drives are of the two types; in one case it is of the constant speed wire feed system, and another is the variable speed wire feed system.

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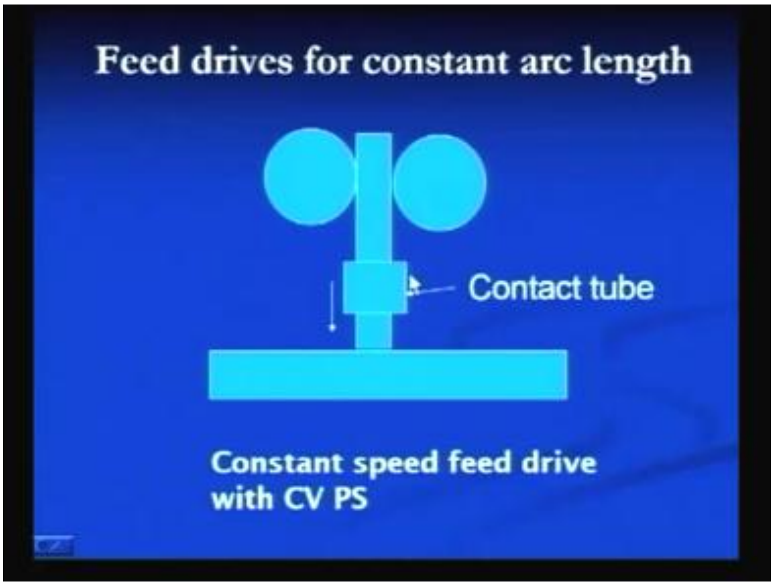

So, first of all we will see the constant speed of feed drive system. In the constant speed of feed drive system, constant voltage power source is used, and this kind of arrangement is mainly used when small diameter electrodes are used. And if the diameter of the electrode is too much, then we do not get the significant change in the melting rate with the change of current. So, in that case it becomes difficult to maintain the arc length just by changing the welding current

So, in case when the electrode is of the smaller diameter, the combination of the constant voltage power source and constant speed feed system results in the constant arc length by producing the self regulating arc; this is what I have already explained in the previous slides. The next one is the variable speed feed drive system that we will see now.

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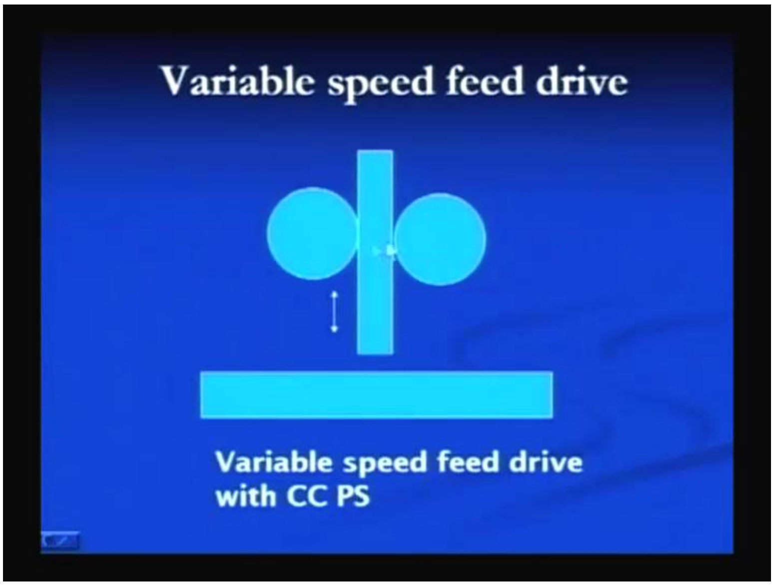


Variable speed feed drive system in which the speed is regulated as per needs to maintain the arc length. For a given current setting we will be getting the constant melting rate, and if there is any fluctuation in the arc gap that will affect the arc voltage and the change in arc voltage is sensed by some electrical equipment. And that variation in arc voltage is used as an input to regulate the current which is being used to run the variable speed feed drive system.

So, when there is a reduction in the arc length then the optimum one. Then this reduction in the arc length will lead to the reduction in arc voltage; reduced arc voltage will help to reduce the speed of the feed drive system. Reduced speed of the feed drive system will reduce the speed by which electrode will be fed in the forward direction and thereby increasing the arc length. So, the change in the feed rate of the electrode is basically used to maintain the arc length whenever there is fluctuation in arc length. The change in speed is obtained by using the variably speed feed drive system.

So, this kind of system for maintaining the arc length is particularly used when the electrical resistivity of the electrode material is less and the diameter of the electrode is significant. Under these conditions the change in melting rate is not significant when the current is changed. So, under these conditions to maintain the arc length, variable speed feed drive systems are used rather than constant speed feed drive system in association with the constant voltage power sources. These variably speed feed drive systems are used with the constant current type of the power sources.

Rising characteristic power source, this is the third type of the power source. We have seen that there are three types of the static characteristics of the power sources. One is constant current; the second one is the constant voltage, and third one rising characteristic. The constant voltage power sources are not actually able to supply the constant voltage, because there is slight negative slope, which is caused by the internal resistance and inductance effect in the welding power sources. But if exactly constant voltage is required for automatic welding purposes, then rising characteristic power sources are used.

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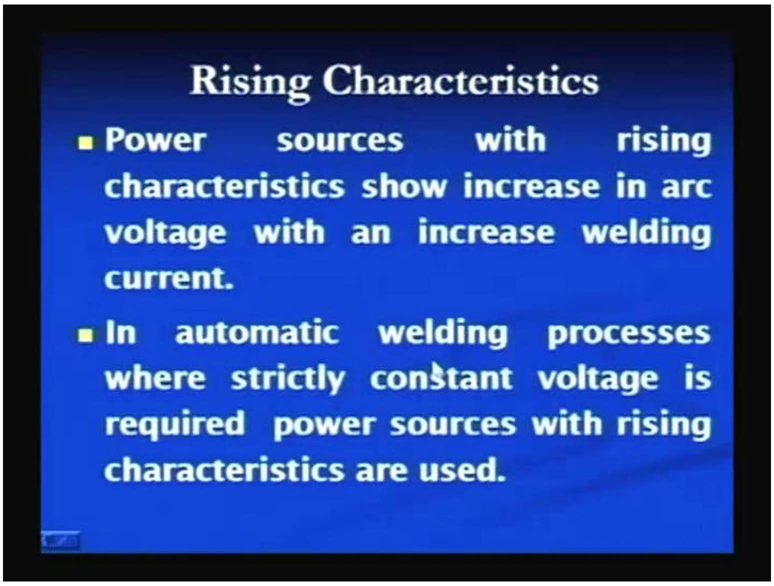

The power sources with the rising characteristics show increase in arc voltage with an increase in welding current. And in automatic welding processes where exactly constant voltage is required the power source with the rising characteristics are used, because not exactly constant voltage is supplied by the constant voltage power sources, but the voltage slightly decreases with the increase in current. But here in this case slight increase in arc voltage is noticed with the increase in welding current that can be seen from the diagram next slide.

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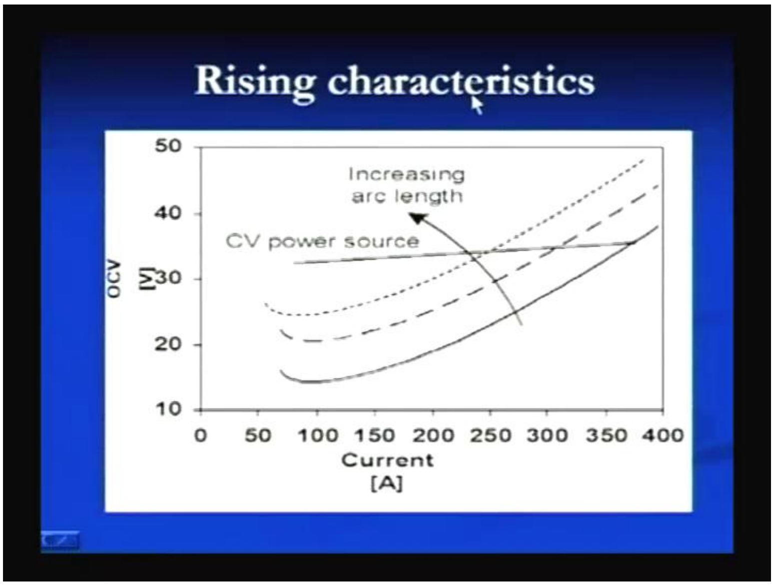


So, here as earlier I have told you these are the three different arc characteristics corresponding to the different arc lengths. Here increasing arc length, and so for a smallest arc length this is the arc characteristic for the middle arc length and the larger arc length. And this is the power source characteristics VI characteristic of the power source. So, intersection of the arc characteristic and the power source characteristic leads to the operating point. So, this is one operating point; this is another operating point, third operating point.

We can see here there is no major change in the arc voltage or the open circuit voltage which is available to the power source with the change in current. Here we can see with the change in operating point from this point to this point, there is no major change in the arc voltage even when there is reduction in the arc length or increase in arc length. So, for the automatic welding processes where the process will be performing without interference of the human being, there it is required to have the constant arc voltage and under those conditions the rising characteristic power sources are found more useful compared to the constant voltage power sources.

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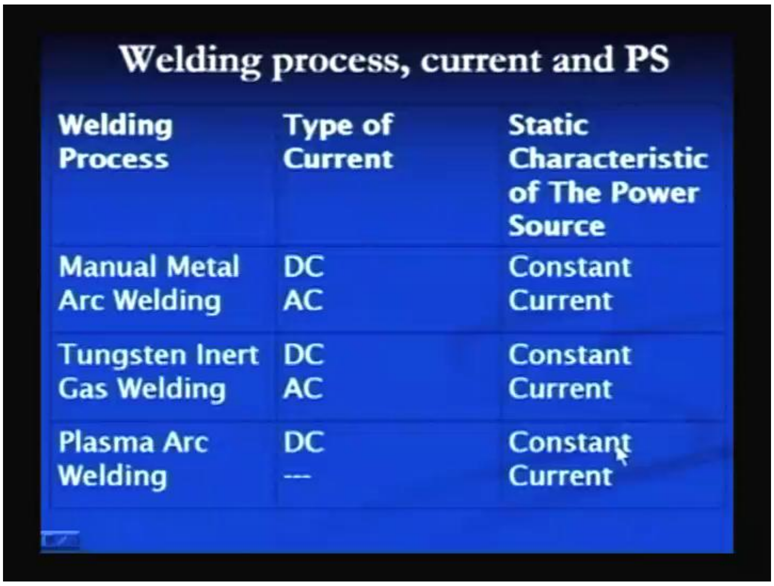


Now we will see the relationship which is generally found or generally used for the different welding process, what type of current is to be used and what type of power source should have a static characteristic; that relationship we will see here. For the different welding processes, we need the different types of the current and the power sources with the different static characteristics. Like manual metal arc welding processes can use AC or DC but with the constant current type of the power source.

And the tungsten inert gas welding process can use AC or DC with the constant current power source. Here the DC is normally used for producing the high quality welds of the ferrous metals. And while AC is preferred for welding of the aluminum to get the advantage of the cleaning action, both these processes are controlled manually. So, there are significant chances that arc length will fluctuate, and under the fluctuating arc length conditions it is desired to use constant current power sources, because those arcs will be able to supply the heat consistently and uniformly to produce uniform and sound well joint.

And the plasma arc welding also DC current is used from the constant current power source. So, other welding process with their current and the static characteristic of the power sources we will see in the next slide.

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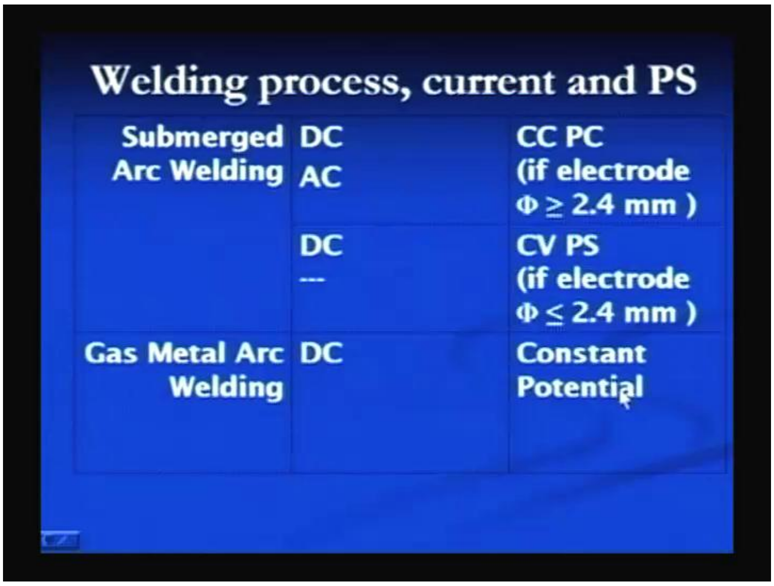


The submerged arc welding process can use AC or DC. It is common to use DC with the DCEP and AC can also be used but the DC direct current is commonly used in submerged arc welding, and the constant voltage power source or constant current power sources both can be used. But if the electrode diameter is greater than 2.4 mm; means for the large diameter electrodes, the constant current power sources is preferred for the submerged arc welding with AC or DC. But for the small diameter electrodes diameter less than 2.4 mm, normally constant voltage power sources are used with the DCEP DC electrode positive.

Because this type of the current and the constant voltage power source has to obtain the self regulating arc which helps to maintain the arc length uniform during the welding. In the gas metal arc welding process also direct current is normally used with the constant voltage power sources; constant current power sources can also be used with the large diameter electrodes.

Dynamic characteristic of the power source we have seen that in the static characteristic power source represents the VI characteristic. VI means volt ampere relationship of the power source when pure resistive load is applied across the terminals of the power source. Well, the dynamic characteristic of the power source represents to the way by which power source responds under the actual dynamic fluctuating conditions of the arc.

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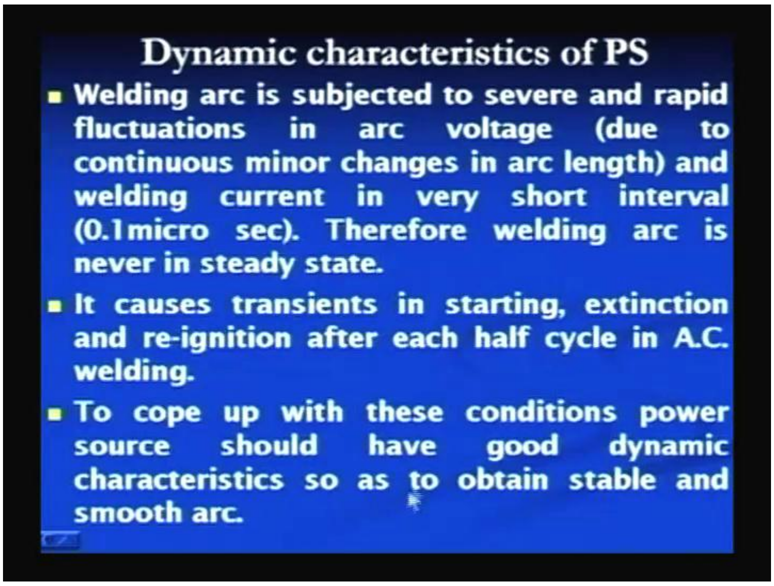


And a power source should have a good dynamic characteristic to produce very smooth stable arc which can produce sound by joint, because the welding arc is subjected to the severe rapid fluctuation in arc voltage due to the continuous minor changes in arc length. And the welding current in very short period is during the welding there is always fluctuation in the arc length; even it may be very small, and that fluctuation in arc length leads to significant changes in the arc voltage and the arc current. And therefore, welding arc is never in steady state.

It may look like the welding arc is smooth and burning smoothly producing heat in a very regular way but actually it is not so, because there is always significant fluctuations in the arc length which will be causing to the change in the welding current and the voltage. And this fluctuation may be in very short interval of the period like 0.1 microns of the second. And these fluctuations cause transients in starting stage extinction and the reignition after each half cycle in the AC welding.

So, which these fluctuations in the current and the voltage can also be noticed when the arc is just ignited or it is extinguished or it is a reignited during the AC welding. And to cope with these conditions, power source must be capable to supply the current and voltage which is required to obtain smooth and stable arc. You see the conditions are constantly changing during the welding, and your power source must be able to supply the current and voltage, which is required as per the changing conditions. And if the power source is having good dynamic characteristic it will be able to supply the desired current and voltage under the changing conditions and during the welding.

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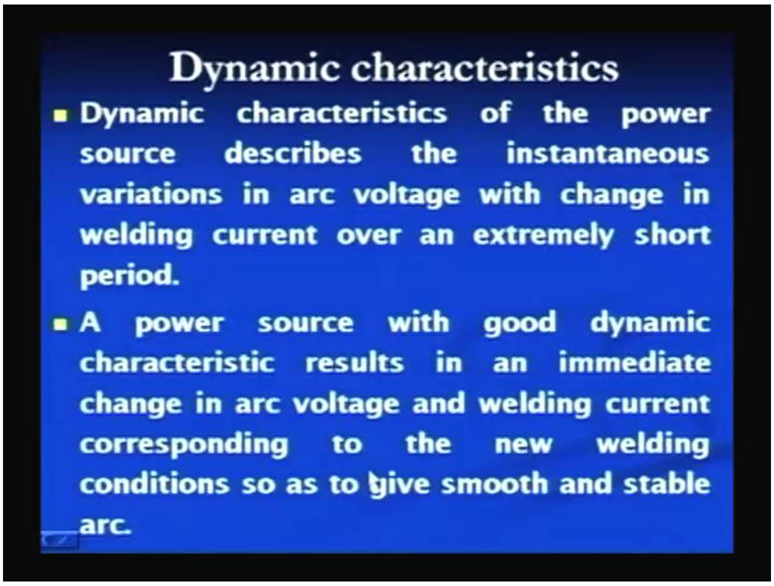


Dynamic characteristic of the power source describes the instantaneous variation in the arc voltage with the change in the welding current over extremely short period. We can see that the dynamic characteristic of the power source can be plotted which will indicate that how rapidly the current is changed or voltage exchanged by the power source with the small change in the arc length, and how much time it takes to respond during the welding under the changing conditions.

So, dynamic characteristic of the power source describes the instantaneous variation in the arc voltage with the change in welding current over extremely short period of time. Power source with the good dynamic characteristic results in immediate change in the arc voltage and the welding current corresponding to the new welding conditions so as to give smooth and stable arc.

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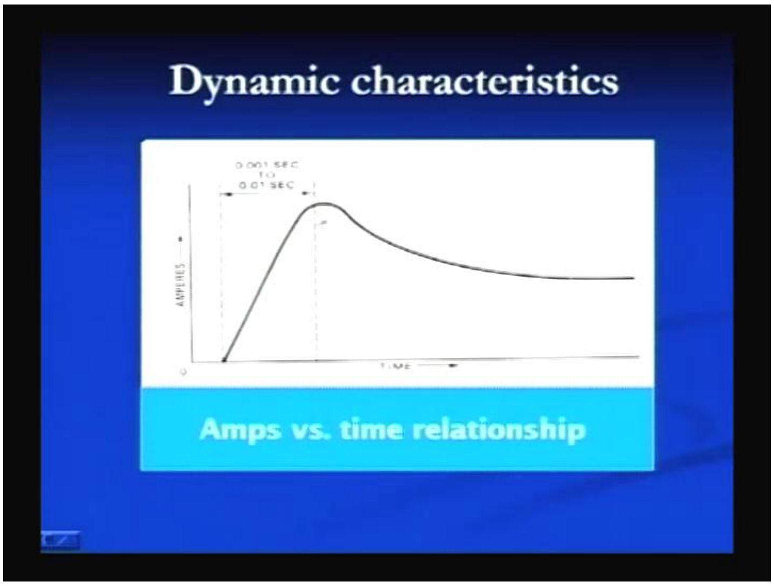


You can see here that how rapidly the current changes and how much time it takes to the current under the time relationship here it is. And this slope indicates that how rapidly the power source is able to respond under the changed conditions. So, here this slope indicates to a great extent the dynamic characteristic of the power source as far as current is concerned. And this time requirement from very low level to high level may vary from 0.001 second to 0.01 seconds which will decide that how good dynamic characteristic of the power source is and how rapidly it responds to the changed welding conditions.

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We can see here the time in the micro seconds and here the change in the welding current, and then the sharp rise in the welding current and then fall in the welding current. And these points represents that the melting is starting, melting is continuing, then here current reaches to the peak value, then detachment of the drop and then the current comes down. So, it represents that how rapidly the current varies as per the needs during the welding, and here x axis represents the time and here y axis represents the variation in the current or current magnitude.

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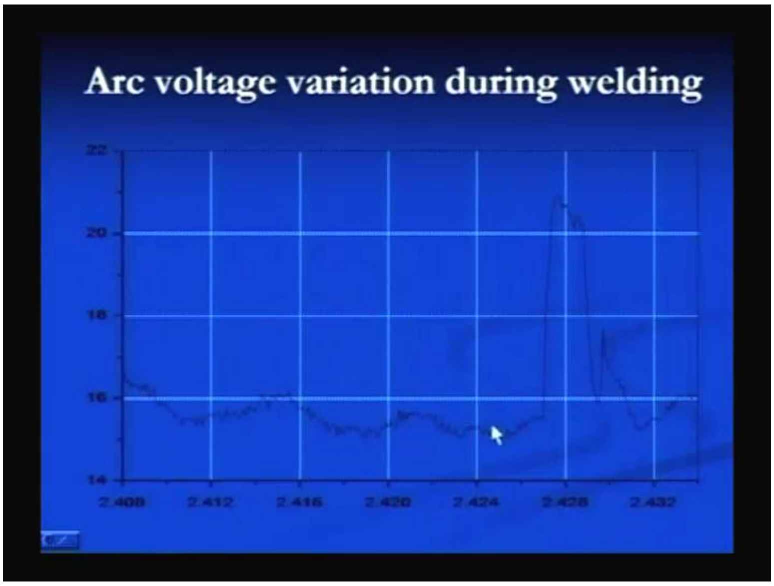


Now we can see the arc voltage versus the time relationship during the welding, and here the fluctuation in the arc voltage over very small period of time can be seen here. And here it suddenly shoots up from somewhere 16 volts to 21 volts and then it comes down, and here time is in the x axis and y axis represents the arc voltage. So, we have seen that if the power source is having good dynamic characteristic it will show a rapid change to the arc voltage or to the welding current over a very small period of time.

High frequency unit is a device which is normally used in the welding systems which are used for the tungsten inert gas welding process, plasma arc welding process in which direct touch method is not used for igniting the arc. So, high frequency unit helps in starting the arc by superimposing the high voltage at high frequency. So, the details of the high frequency unit we will see now which is a frequently used in the power sources which are used in welding by the tungsten inert gas process or plasma arc welding process.

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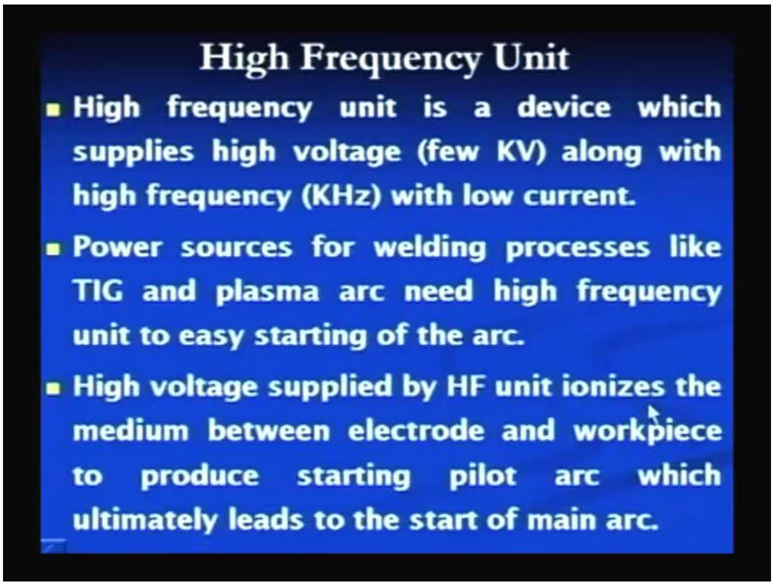


The high frequency unit is a device which supplies the high voltage along with the high frequency and low current. So, the pulse of the high frequency and high voltage a current is supplied to the power source which is delivering the power to the arc for reigniting the arc, and the power source for welding processes like the TIG and plasma arc need high frequency unit to for easy starting of the arc. And the high voltage supplied by the HF unit ionizes the arc gap between the electrode and the work piece, and the ionized gas column which is produced between the two is used to initiate the arc by the high potential difference established by the high voltage pulse which is supplied in the HF unit or high frequency unit.

So, we can say that high voltage supplied by the HF unit ionizes the medium between the electrode and work piece to produce the starting pilot arc which ultimately leads to maintain to start the main arc. So, here mainly the pilot arc is started by the HF unit which helps to ignite the main arc, and this pilot arc is generated by the ionization of the arc gap. And that ionization takes place due to the field emission which is generated by the high potential difference established between the work piece and the electrode.

So, the ionized gas column helps to start the pilot arc which ultimately leads to start the main arc. And once the main arc is started, the HF unit is removed from the power circuit, or the HF unit is mainly used to supply the high frequency high voltage current only to start the pilot arc. And once it is started, the HF unit is stop or it is disconnected from the power circuit.

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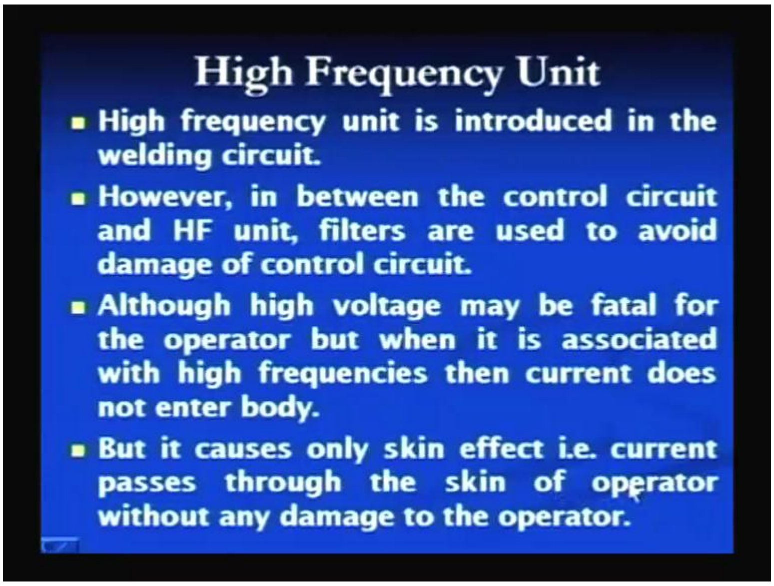


The HF unit is introduced in the welding circuit two plates role so as to supply the desired high voltage and high frequency current to ignite the pilot arc. And it is introduced in such a way that filters are there between the HF unit and the control circuit, because if the filters are not there between the high frequency unit and the control circuits. Then the HF unit can damage to the control circuits, and that is why normally filters are introduced between the control circuits and HF unit to supply the pulses of the high voltage and high frequency current to start the pilot arcs which helps to initiate the main arc.

Although, high voltage may be fatal for the operators, but when it is associated with the high frequencies then it does not enter in the body. And normally the arc voltage is kept in between the 80 to 100 in the manual metal arc welding or sealed metal arc welding. And the open circuit voltage can be in range of 30 to 80 in general, higher the voltage open circuit voltage is at greater will be the chances of the electric shock to the operator. And HF unit, however, is able to supply the voltage of 2000 to 5000 units and that high voltage can be damaging to the operator. But that high voltage is not supplied at the low frequencies, though the high voltage is supplied at very high frequencies

And because of the association of the high voltage with the high frequency, it does not damage to the operator even when operator comes in contact of this high voltage high frequency current pulses. And because of the skin effect the voltage may be very high, but when it is associated with the high frequency it results in only skin effect; means the current mainly passes through the skin of the human being. It does not pass through the body of the operator, and that is why operator does not feel any kind of damage or electric shock.

So, the high frequency unit supplies the high voltage mainly to initiate the arc, and its association with the high frequency helps to avoid any kind of damage to the operator which can be related to the shock. So, the shock related damages are not there to the operator because of high frequency which offers the benefit of the skin effect.

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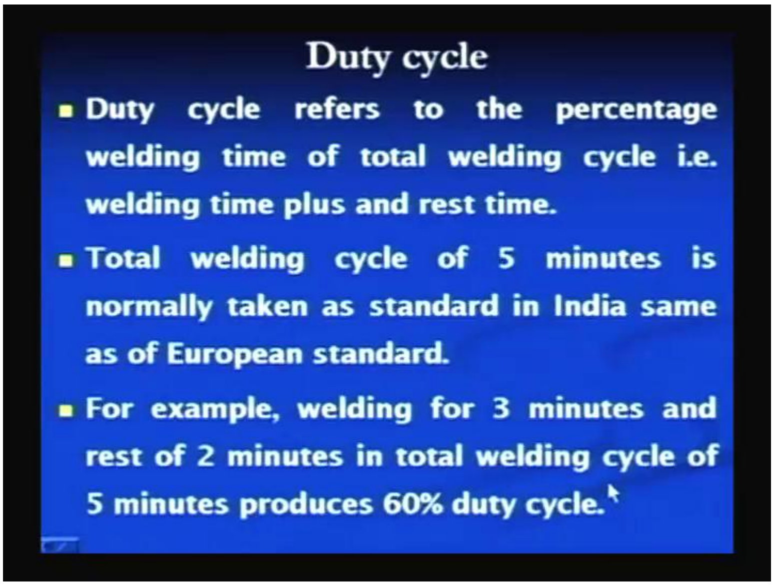


Duty cycle is another important parameter of the welding power sources, because the duty cycle is frequently referred wherever selection of the welding current is made. All the welding power sources are specified in association with the duty cycle; like 100 percent duty cycle this power source will be able to deliver 200 ampere current 500 ampere current or 100 ampere current depending upon the capability of the power source.

So, the duty cycle is always associated with the welding current, and lower the duty cycle higher the welding current is possible which can be drawn from the power source.

So, what is that philosophy behind the duty cycle, and why it is related with the welding current which can be drawn from the power source; that we will see in detail one by one along with the one simple numerical and its solution also. Duty cycle refers to the percentage of the welding time of the total weld cycle time; that is the welding time plus the rest time. Here during the welding when current flows and arc is generated, arc is used to melt the metal and to produce the joint.

So, the time when there is flow of current and arc is generated and produced heat is used for the welding purpose is termed as welding time; means when whenever there is arc that period will be considered as the welding time, and after welding for few minutes it will be stopped for some time. So, the time when there is no flow of current, no arc will be considered as a rest time. And the combination of the two welding time plus the rest time is referred as a total weld cycle time.

So, the percentage of the welding time of the total weld cycled time is referred as duty cycle. And it is expressed as a percentage; like in a 10 minutes total weld cycle time, if the welding time is 2 minute, then the duty cycle will be 20 percent, or if the welding time is 10 minutes in the 10 minutes total weld cycle time, the duty cycle will be 100 percent. So, the total weld cycle time is actually different, and this standard time value is different in the different countries like the total weld cycle of the 5 minutes is normally taken as the standard in India.

And similar is also used as European standard; means the total weld cycle time of the 5 minute is considered as a standard in India and the same; the total weld cycle of the 5 minutes is also considered as per the European standard, while as per the American standard the total weld cycle of the ten minutes is considered as the standard. So, that accordingly changes the duty cycle percentage. So, in India we normally express the total weld cycle time of the 5 minute, and based on that duty cycles are calculated. For example, the welding for 3 minutes and the rest of the 2 minutes in the total weld cycle of the 5 minutes results in the 60 percent duty cycle.

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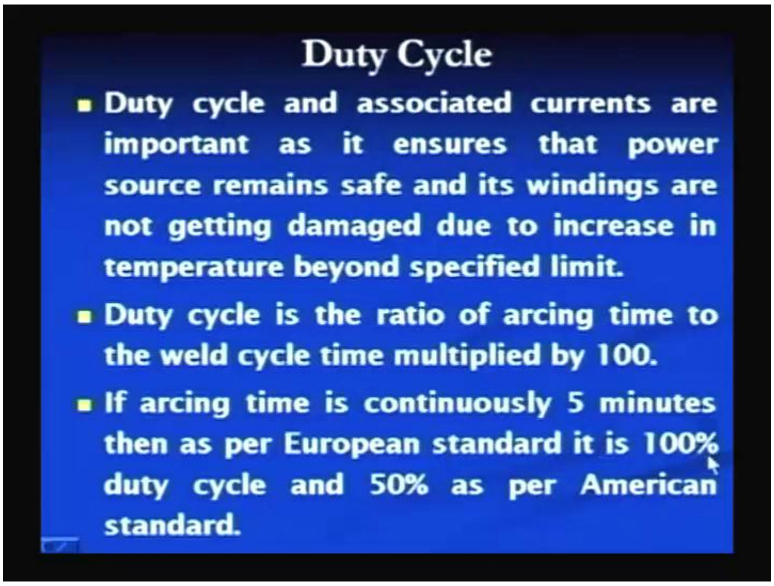


The duty cycle and the associated currents are important as it ensures that power remains within the safe limit, and its winding are not getting damaged due to the increase in temperature beyond the specified limit, because the arc welding processes are known as the low voltage and high current processes. When high current is drawn from the power source due to the electrical resistance heating it coils and cables start getting heated. And the increase in temperature of the coils and cables can lead to the damage of the coils and the cables, and that is why the welding current or the drawing of the heavy current from the power source should be stopped after sometime, so that the temperature of the coils and the cables can be maintained within the limits.

Otherwise, excessive rise in temperature due to the continuous drawing of the heavy current from the power source can damage to the coils, cables and to the power source as a whole. And that is why how much current we are drawing that determines up to what extent there will be electrical resistance heating. If the current being drawn is high then the coils and the cables will be heated rapidly to the allowable temperature limits, and we may have to stop the welding earlier.

So, to maintain the temperature of windings and cables, it is necessary that the temperature and the welding time the duty cycle and the currents are seen together, so that whenever high current is drawn from the power source that current is drawn only for the limited period of time; means the welding time should be determined on the basis of the current which is to be drawn. And that is why the duty cycle and the welding currents are very closely associated with each other; if the welding current is determined by considering the duty cycle properly, then it will ensure that the power source remains safe. And its windings are not damage due to the overheating or excessive rise in temperature beyond the specified limits.

This is another way to see the duty cycle it is the ratio of the arcing time to the weld cycle time multiplied by 100. If the arcing time is continuously 5 minutes and then as per the European standard, it is considered as the 100 percent duty cycle and 50 percent duty cycle as per the American standard. Because total weld cycle time as per the European standard is 5 minute and as per the American standard it is 10 minute. So, the arcing for 5 minutes as per European standard results in 100 percent duty cycle, while as per the American standard it results in 50 percent duty cycle.

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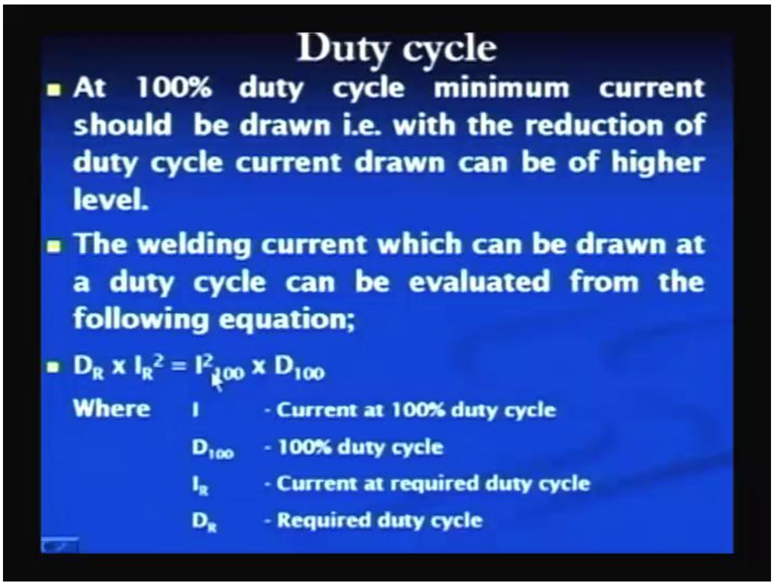


Here we will see that the if the current is drawn continuously for a period more than either 5 minute or 10 minutes, then we say that the duty cycle is 100 percent. And at 100 percent duty cycle we do not stop the welding operation, and the current is drawn continuously. So, to avoid the excessive heating and to maintain the temperature of the coils and cables within the safe limit, it is necessary that at 100 percent duty cycle minimum current is drawn from the power source.

Otherwise, continuous drawing of the heavy current from the power source can damage to the coils and cables. And that is why with the reduction of the duty cycle current higher level of the current can be drawn from the power source. So, lower the duty cycle higher the current which can be drawn from the power source, higher the duty cycle lower current should be drawn from the power source. The welding current which can be drawn at a duty cycle can be evaluated from the following equation.

One equation is used to determine that how much current can be drawn safely from the power source if we know the current which can be drawn at a given duty cycle. So, that equation is like this DR into IR square equal to I square at 100 into D at 100, where actually here it is I 100; I is the current which can be drawn at 100 percent duty cycle. D 100 is the 100 percent duty cycle; IR is the current at the required duty cycle, and DR is the required duty cycle. So, here this is the current I square at 100 duty cycle, and this is the 100 percent duty cycle.

So, here the product of the current and the duty cycle at 100 percent duty cycle and the product of the current square and the duty cycle. These four values are used to determine the current which can be drawn from the power source at a given duty cycle if we know the current which can be drawn from power source at 100 percent duty cycle, or if we know the current which can be drawn at a given duty cycle. Then current which can be drawn at 100 percent duty cycle can also be determined. So, this will be more clear from numerical problem which is there in next slide.

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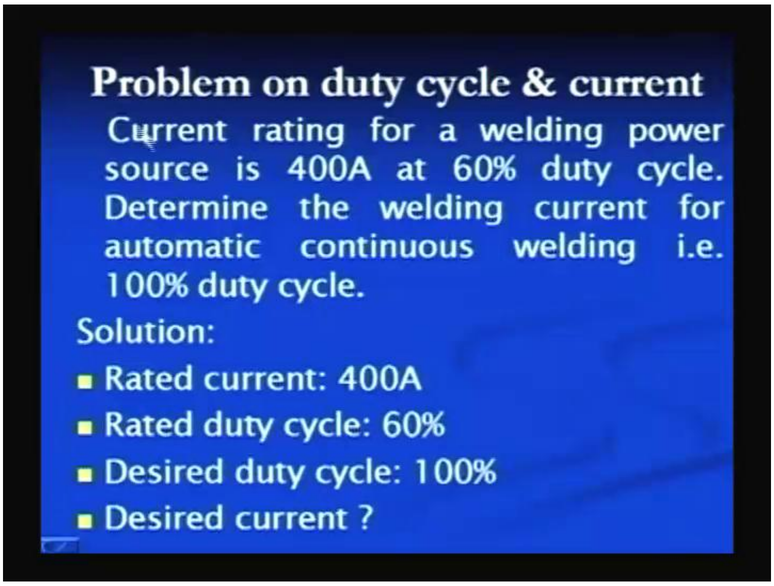


Like the current rating for a welding power source is 400 at 60 percent duty cycle; means from the power source we can draw 400 ampere current at 60 percent duty cycle. Then determine the welding current for automatic continuous welding conditions. Whenever we get the term automatic welding means it represents to the continuous welding or 100 percent duty cycle. So, to determine the welding current at 100 percent duty cycle, we are having these values that the rated current is 400 ampere at the rated duty cycle 60 percent.

And the desired duty cycle the current at which the desired duty cycle the current which is to be determined at 100 percent duty cycle is to be determined. So, the desired duty cycle is given 100 percent, and the desired current is to be determined or to be evaluated; that is what determines the welding current for 100 percent duty cycle of an automatic continuous welding.

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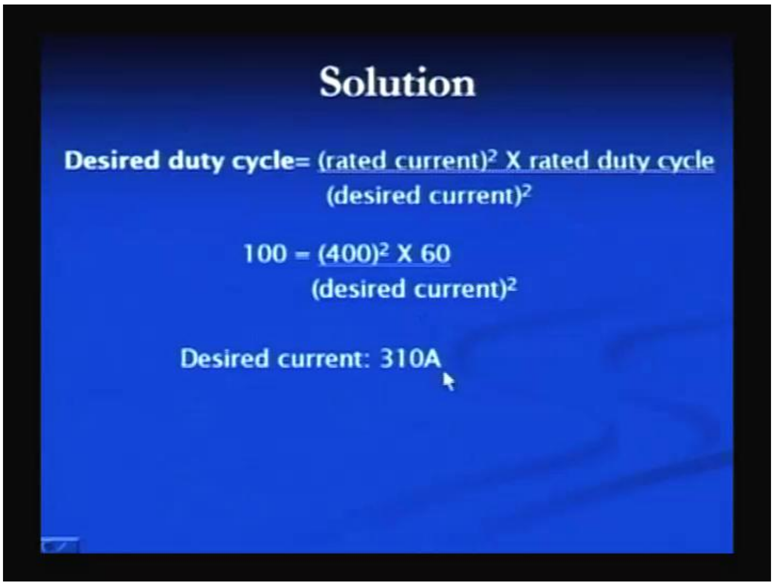


So, here the same equation can be written also like this; the rated current whole square into the rated duty cycle divided by desired current whole square. So, here desired duty cycle is 100 and the rated current is 400. So, 400 whole square into the rated duty cycle is 60 divided by desired current. So, on solving we get another 300 ampere current. So, it is also clear that if we need current at higher duty cycle, the current value will be reduced. And in other way also we can see that at 100 percent duty cycle we can draw 310 ampere current. Then at the lower 60 percent duty cycle, we will be able to draw the higher level of the current.

So, higher the duty cycle lower the current which can be drawn, or lower the duty cycle higher the current which can be drawn safely from the power source without damaging its coils and the cables due to the excessive heating. The heating will damage to the coils or not, it will depend upon the kind of material, which is being used. The material disabled to withstand at a higher temperature, then the transformer coils and the cables will not be damaged easily. And if the material is of the lower electrical resistivity of the larger diameter, then also damages will be less on the power source due to the electrical resistance heating or the rise in temperature caused by the electrical resistance heating.

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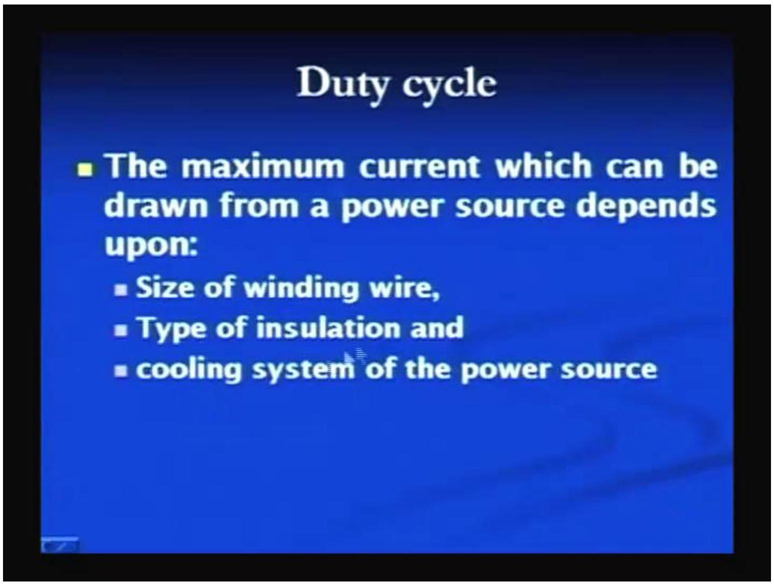


We have seen that the duty cycle is significantly governed by the welding current. So, the ability of the power source to supply the high current is determined by the number of factors; maximum current which can be drawn from the power source depends on the size of the wire which is being used for winding purpose. Larger the diameter of the electrode, greater will be possible to draw the higher current because of the lower electrical resistance heating effect.

And type of insulation, better the quality of the insulation higher will be the current which can be drawn from the power source without damaging due to the electrical resistance heating. And cooling system of the power source, if the forced cooling is being used then it will allow you to draw the higher level of the current. And alternately, we can say that the large diameter of wires better quality insulation and the good cooling system allows the higher duty cycle even at a higher level of the current.

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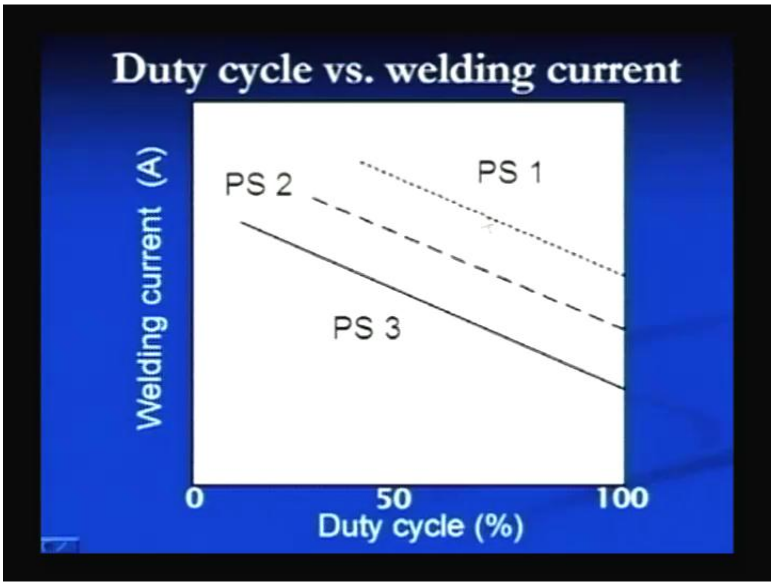


We can see here for three different power sources, power source 1, 2, 3, the ability to supply the current decreases with the increase in duty cycle, but if the insulation quality is good, the diameters are more under the cooling system is good. Then it will allow you to draw the higher level of current even at the higher duty cycle. So, in general for a given duty cycle the power source may show the higher it may allow to draw the higher level of welding current or the lower level of welding current depending upon the things which have been used in construction of the welding power source. In general, the welding current which can be drawn from the power source decreases with the increase in duty cycle.

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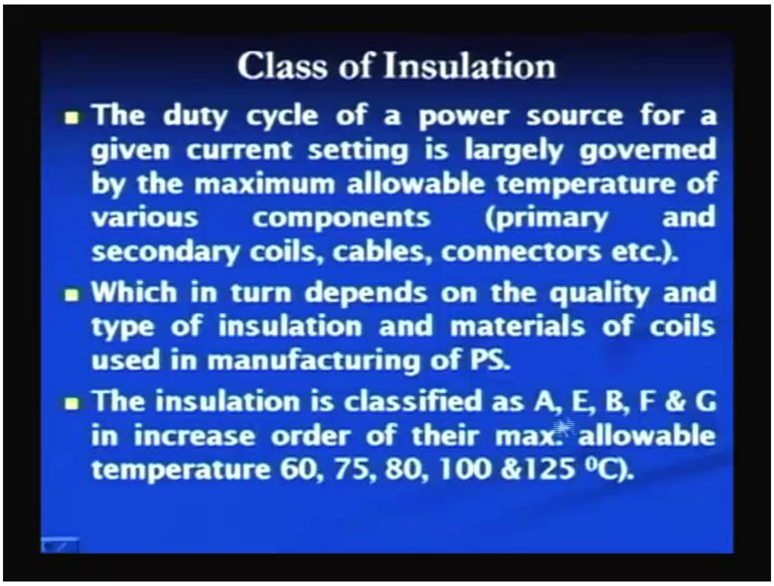


The class of insulation determines to a great extent the ability to withstand at high temperature of the cable and the coils which has been used in the power sources. The duty cycle of the power source for a given current setting is determined by the maximum allowable temperature of the various components which are there as primary or secondary coils, cables and connectors. The higher the ability of temperature to which these can withstand greater the duty cycle which will be possible, which in turn and the ability to withstand at a higher temperature depends on the quality.

And the type of insulation material which has been used for making the coils and cables of the power source, and the insulation which is used; insulation is one important aspect in the welding power sources, and the better the quality of the insulation which is used in power source greater will be the ability to withstand at a higher temperature by the cables and the coils. And these insulations are classified as A, E, B, F, G in the increasing order of their maximum allowable temperature which can be there for A class insulation it is 60 degree; for E class it is 75; for B class it is 80, F class it is 100, and for G class it is 125 degree centigrade. So, depending up on the class of the insulation it will allow to withstand at higher temperatures or at lower temperatures.

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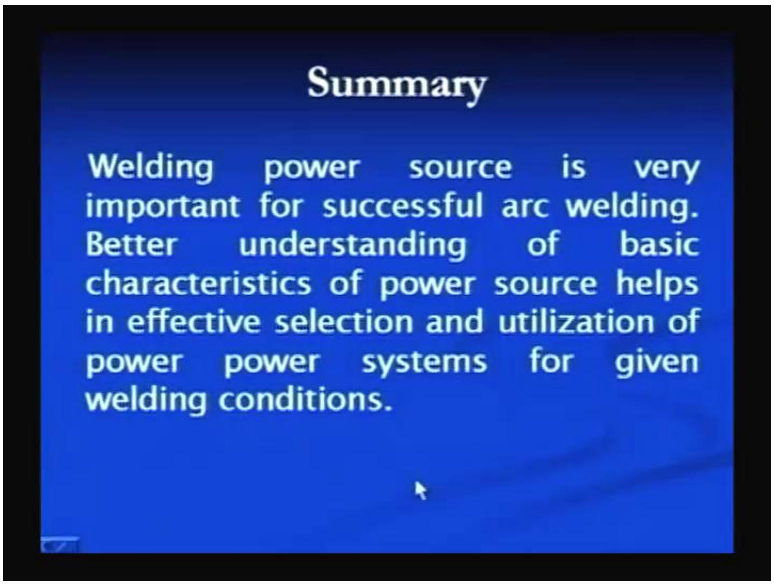


So, in this lecture you have seen that the constant voltage power sources, the rising characteristic power source, the duty cycle and the insulation, these four basic characteristics of the power source. So, this was the second and last chapter of the arc welding power sources.

Thank you.