Manufacturing Processes - I
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Module - 3
Lecture - 4
Arc Welding Power Source Part – 1

Good morning students. Today, I will be talking about the arc welding power sources where we will see the different types of the power sources, which are used in arc welding processes and it is their basic characteristics, the applications and in-depth understanding on the basic characteristics of the power source will also be developed, which we will use in effective use and selection of the welding power, sources for the different welding processes. Each welding, arc welding process needs a controllable delivery of the current for producing this stable arc, so that proper fusion of the base metal can take place and the sound weld joint can be made.

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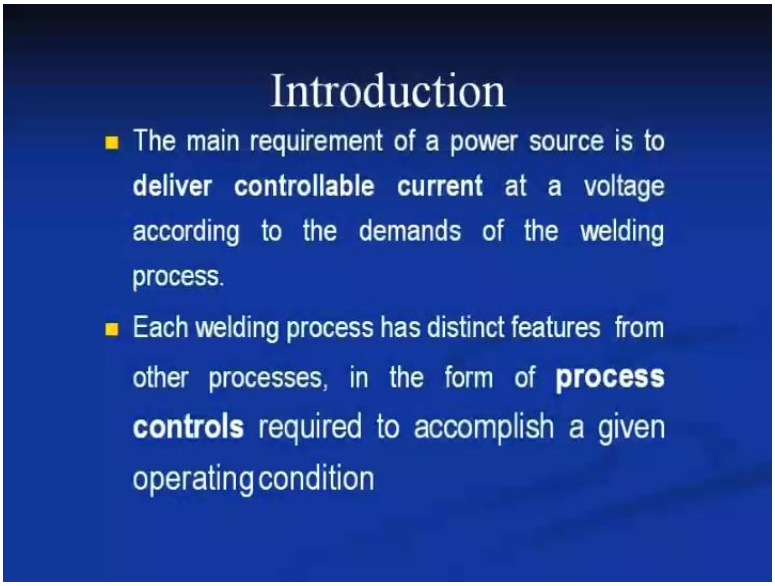

So, you know, that the main requirement of power source to deliver the controllable current at a voltage according to the demand of the power source. Each welding process had its own specific features as far as the power requirement is concerned and that is why, the different types of the power sources are recommended for the different arc welding processes.

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The arc welding processes power sources, which are, which contribute significantly in producing successful weld joints. The common arc welding power sources or the welding transformers, which deliver the alternating current, that is, AC; welding rectifiers, they supply DC; and the welding generators, they supply AC as well as DC.

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The applications of the power source are very wide and these are used ranging from the fabrication shops to the faraway sites where there is no regular power supply.

The welding transformers, rectifiers, DC generators are generally used in fabrication shops. And engine coupled AC generators as well as DC generators are used at the site

where line supply is not available. Normally, rectifiers and transformers are preferred because of the low noise, higher efficiency and lower maintenance as compared to the generators.

To select the power source it is important, that we understand the kind of welding process on which power source is to be used and what kind of the consumable is to be used during the welding. And that is why, the selection of the power source is mainly governed by the welding process and the consumable to be used.

And when arc welding power source is selected, we use the proper open circuit voltage by setting the OCV, which can range from 70 to 90 volt in case of the welding transformers. While in case of rectifiers, it is generally lower and it is normally used in the range of 50 to 80 volt.

The welding voltage is found to be lower than the open circuit voltage. The welding voltage is one, which is found between the electro tape and the base metal being welded while the open circuit voltage is the one, which is found between the terminals of the power source when there is no flow of the current.

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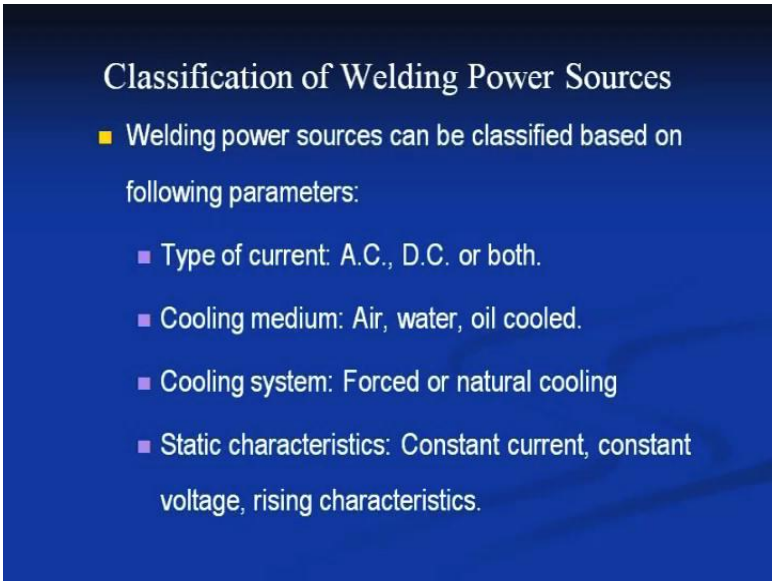

The welding power sources can be classified based on the number of factors such as the type of current. The welding transformer can be of the AC type, DC type or it can deliver both, AC as well as DC.

The welding transformers can also be classified based on the cooling medium being used. These can be air cooled, water cooled or oil cooled transformers. The cooling system can also be of the naturally cooled or the forced cool, cooling system can be used in these transformers or in the power sources.

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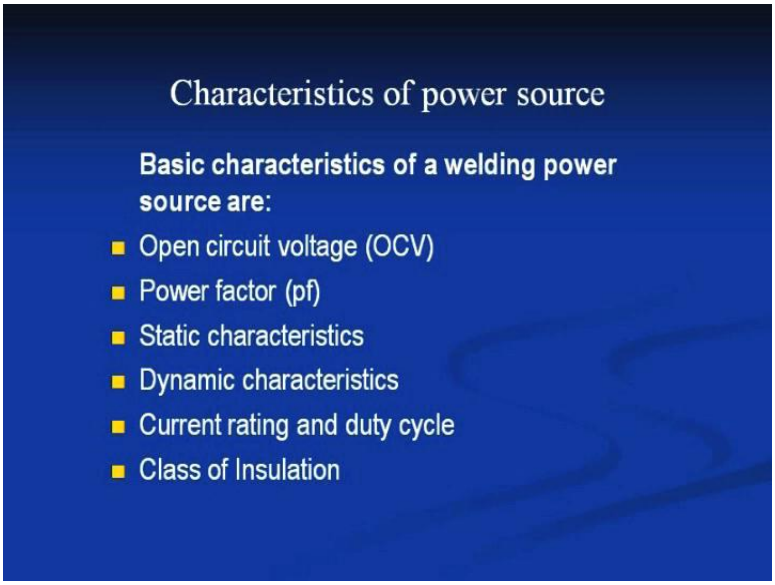

There are many characteristics of the power sources, which are important for the success of the power source and help in selection of the power source for a particular welding process. The basic characteristics of the power source include the OCV, open circuit voltage, which can be set in a given power source. The power factor, which is offered by a power source, it is always desired to have the higher power factor, so that the energy can be utilized efficiently.

The static characteristics of the power source and the dynamic characteristics of the power source, which indicate the way by which the arc current and arc voltage will be varying during the arc welding process. The current rating and the duty cycle, which indicates how long the arc welding power source can be used at a given current rating. And the class of insulation of a power source largely governs the duty cycle of the power source and the rating of the current, which can be drawn from the power source at a given duty cycle.

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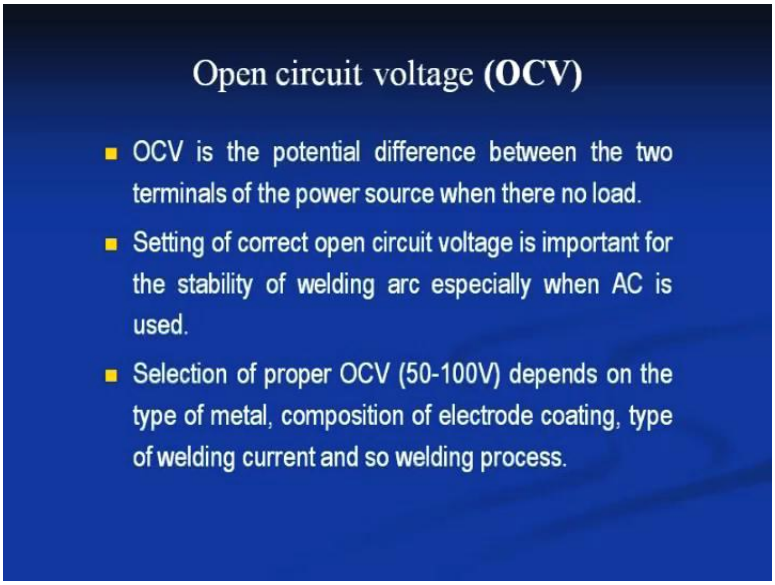

And the open circuit voltage, as I have said, indicates the potential difference between the terminals of the power source when there is no load. And the setting of the correct open circuit voltage is very important for stability of the arc. If the low open circuit voltage is set, then the optimum value, then the arc gets, stabilized, destabilized very frequently and leads to development of the poor weld bead. And therefore, proper setting of the open circuit voltage is important. Normally, the AC power sources need the higher open circuit voltage as compared to the power sources, which supply the DC current.

The selection of the proper OCV in range of 50 to 100 volts depends upon the type of the metal being welded, the composition of the electrode coating, the type of welding current and the welding power source. Like the metals, which offer the low ionization potential, they can be set, means, the power source can use, can be set at the lower open circuit voltage.

And the composition of the electrode coating, similarly, also affects the optimum open circuit voltage setting. The electrode coating having the low ionization potential elements can be set with the lower open circuit voltage. And similarly, the DC currents need the lower open circuit voltage than the AC current. And as far as welding process is concerned, GTA process needs the lower open circuit voltage as compared to the SMAW welding process.

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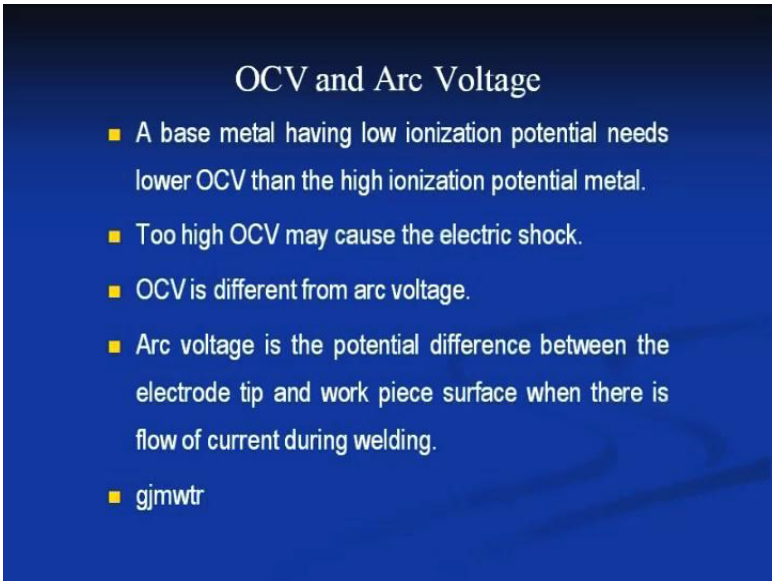

The base metal having the low ionization potential elements, likewise needs the lower open circuit voltage than the high potential metals. But the two high open circuit voltage increases the danger of the electric shock. That is why, normally the open circuit voltage is set below 100 volts.

Arc voltage is found to be the different from the open circuit voltage and generally, the arc voltage is lower than the open circuit voltage. And arc voltage is the potential difference between the electrode tip and the work piece surface when there is flow of current during the arc welding. And the arc voltage is generally found 5 to 10 volts less than the open circuit voltage.

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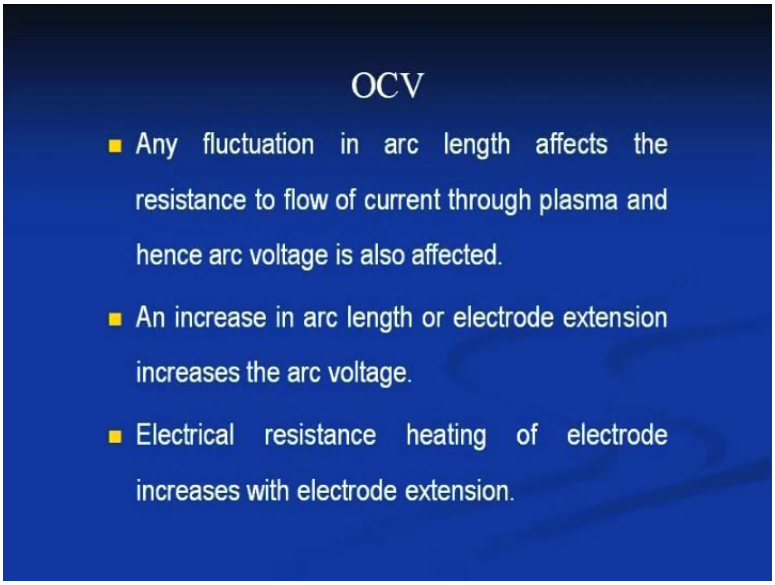

The open circuit voltage especially affects the stability of the arc. Any fluctuation in arc length affects the resistance to the flow of current through the plasma and hence, the arc voltage. So, during the arc welding, whenever due to any reason, if there is a fluctuation in arc length, that affects the resistance to the flow of current through the plasma zone and which in turn affects the arc voltage. And therefore, an increase in arc length, in general, increases in the arc voltage and that the, similarly an increase in electrode extension also increases the arc voltage.

An increase in electrical resistance heating also takes place with the increase in electrode extension because increase in electrode extension increases the resistance to the flow of current and therefore, the electrical resistance heating of the electrode beyond the contact tube or the electrode holder increases with the increase in electrode extension.

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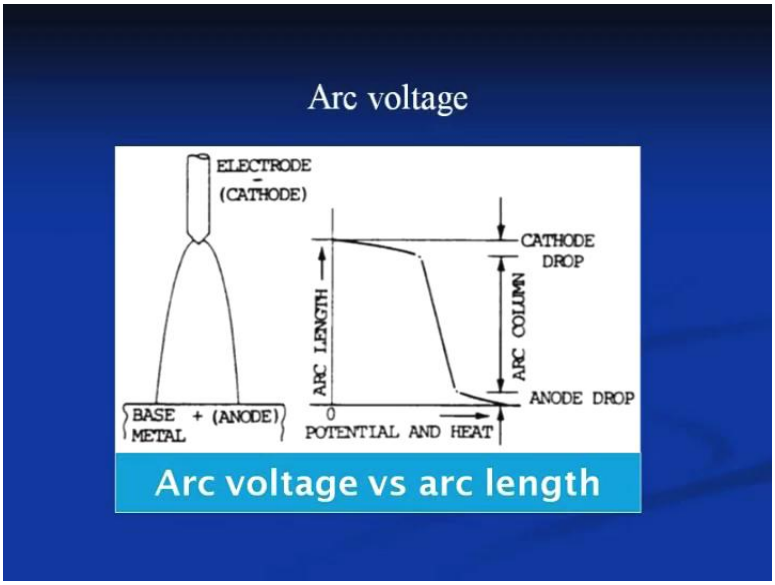

As we can see in this diagram, the arc voltage is the voltage between the electrode tip and the base metal where the entire zone between the electrode tip and the base metal can be divided into the three areas where near the electrode tip we have the cathode drop zone where potential drop takes place very rapidly in very, in a row zone.

And similarly, near the anode also the very sharp potential drop takes place near the anode surface while it is the drop is uniform and slope between, in the arc column zone. So, the entire the gap between the electrode tip and the base metal can be divided into the three zones. One anode drop, the second is the arc column and the third is the cathode drop. The sharp drop in the arc in the potential, sharp potential drop near the cathode and near the anode is mainly attributed to the cooling effect by the electrode and the work piece surfaces.

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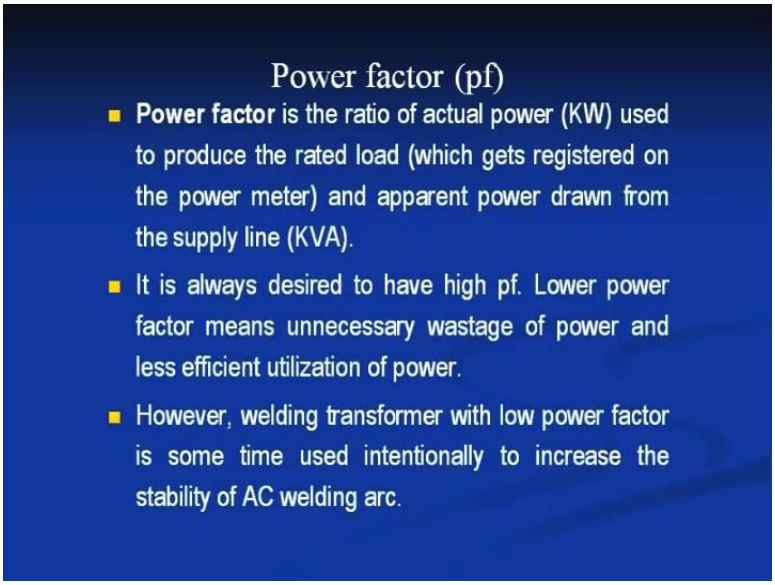

The power factor is another important characteristic of the power source, which shows the ratio of the actual power used to produce the rated load and the apparent power drawn from the power supply line. It is always desired to have the higher power factor of the power source because it indicates, that how effectively power is being used for the given purpose. However, welding transformers with the low power factors are intentionally used it in order to increase the stability of the arc. That is why, sometimes we intentionally use the arc welding power transformers with the low power factor.

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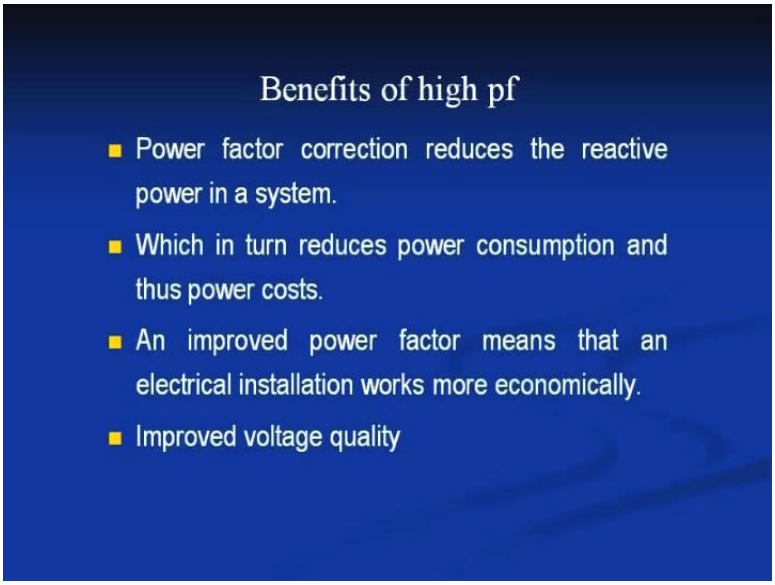

The higher power factor indicates the effectiveness of the energy utilization and therefore, when the power source having the higher power factor, it reduces the reactive power in the system, which reduce, which in turn, reduces the power consumption and therefore, power cost. And improved power factor means, an electrical installation works more economically. And high power factor also leads to the improved voltage quality, fewer voltage drops.

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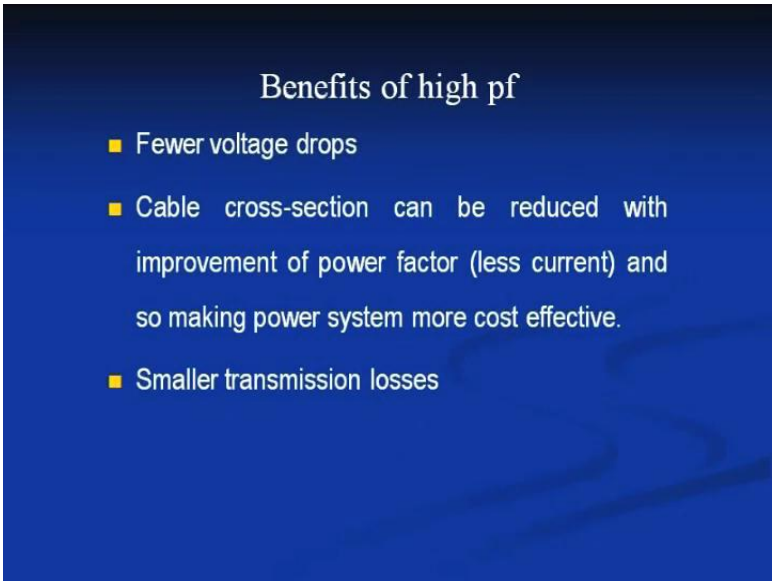

And the cable cross-section, which is required for delivering the power is also reduced with the improvement of the power factor and so, making, which in turn makes the power system more cost effective. And high power factor also reduces the transmission losses.

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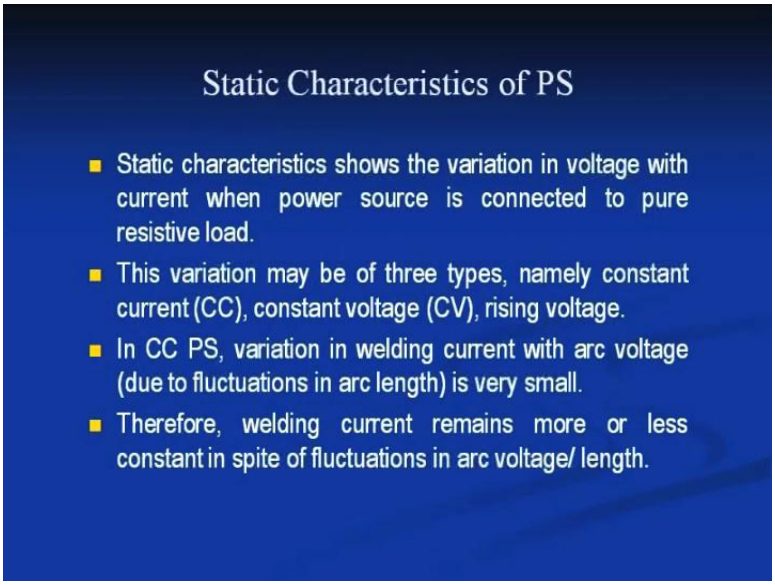

Another, third important characteristic of the power source is their static characteristic. Static characteristic of the power source shows the variation in the voltage with the current when the power source is connected to the pure resistive load. And this variation may be of the three types, namely the constant current, constant voltage and rising characteristic power source.

In the constant current power source, variation in welding current is with the arc voltage is very small because arc voltage frequently fluctuates during the welding due to variation in arc length. And when constant current power source is used these minor fluctuations in the arc length and so, the arc voltage does not affect the welding current significantly. And that is why, the power source is able to produce the uniform heat and which helps to produce the sound weld bead uniformly. And therefore, welding current in constant current power sources welding current largely remains constant in spite of the fluctuation in the arc length and arc voltage.

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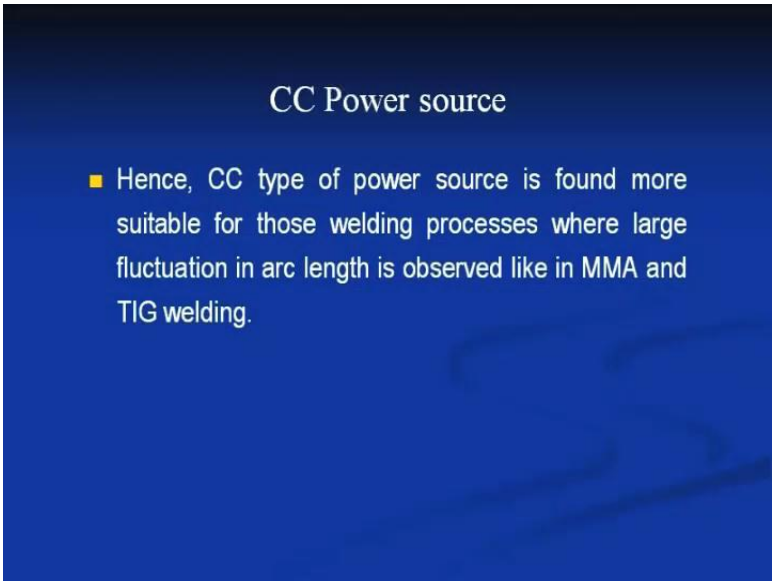

And hence, the constant current type of the power source is found more suitable for those welding processes where large fluctuation in arc length is observed like in MMAW and the GTA welding. In MMAW and GTA welding, mainly manual control is used to manipulate the arc where there is lot of possibility for fluctuation in arc length and this fluctuation in arc length will be affecting to the arc voltage. But in case of the constant current power sources, the arc current and welding current does not change appreciably and that is why, the smooth weld bead is produced due to the constancy of the arc current.

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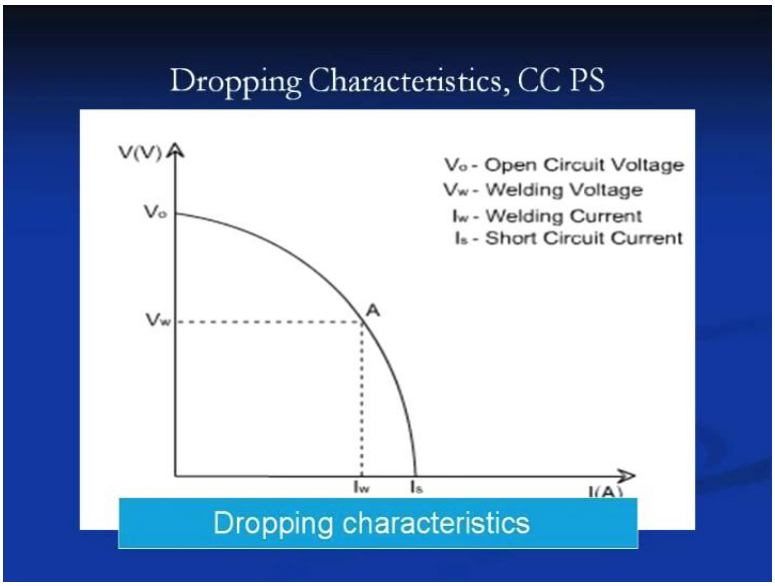

As we can see, the typical constant current power source characteristic in this diagram. Here, with the increase in the arc voltage, y-axis shows the arc voltage and x-axis shows the welding current and this line is showing the dropping characteristic of the constant current type of the power source. So, here we can see, if voltage is increased the current decreases, but not appreciably.

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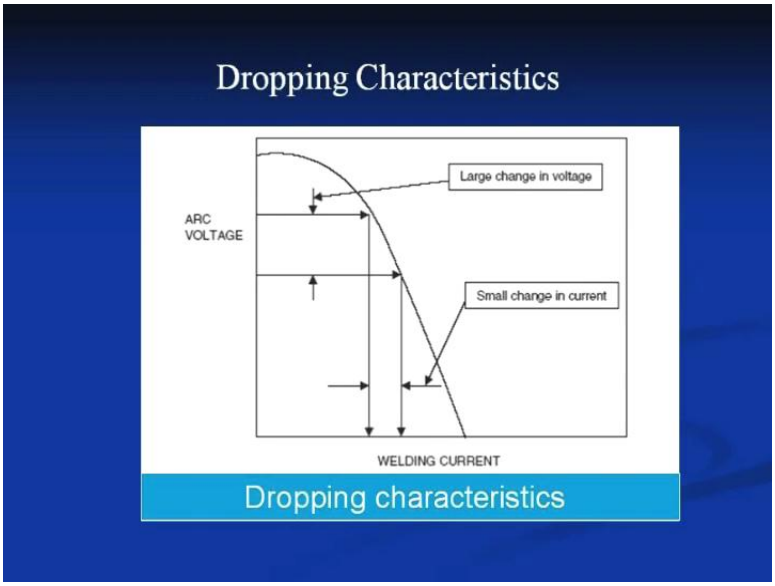

As we can see in this diagram, showing the static characteristic of the power source of the constant current type of the power source, if due to the increase in arc length, if the arc voltage increases with by this much magnitude, the change in the welding current is comparatively small. And that is why, what we say, that even large change in the arc length, it is the small change in large change in the arc voltage, but the variation in the welding current is small.

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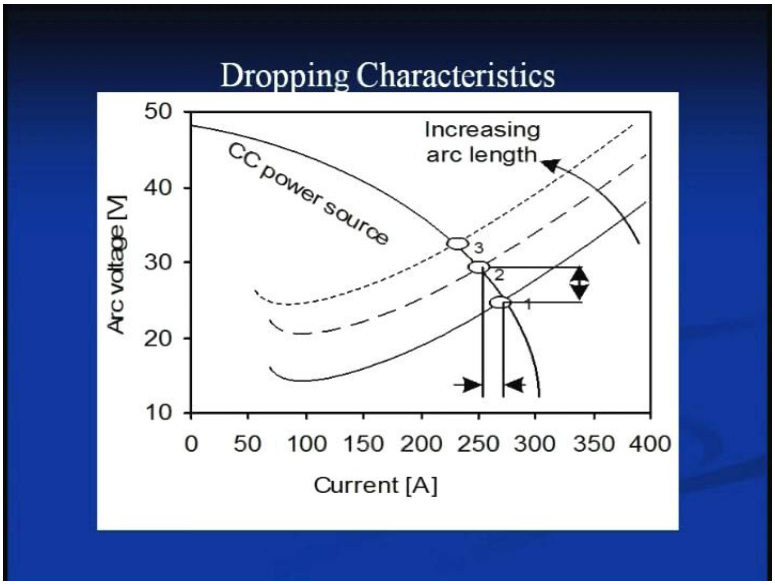

This, we can see with the help of this diagram where the constant current characteristic of the power source and its interaction with the arc characteristic, and the intersection of the constant static characteristics of the constant current power source and the arc characteristics of the power source is called operating point.

So, for the different arc lengths we have the three different arc characteristic considering that the small arc length is used. So, for the same constant current power source we have an intersection, that is, the operating point one indicating, indicating the particular value of the welding current for the arc voltage. With the change in the arc length, if the arc length is increased, then operating point shifts from 0.1 to 2 and the shift leads to the increase in arc voltage and with a small change in the welding current. So, this is small change in the welding current, does not affect much the arc heat, which is being generated during the welding and that is why, it helps to produce by smooth arc, smooth weld bead and the sound weld joint.

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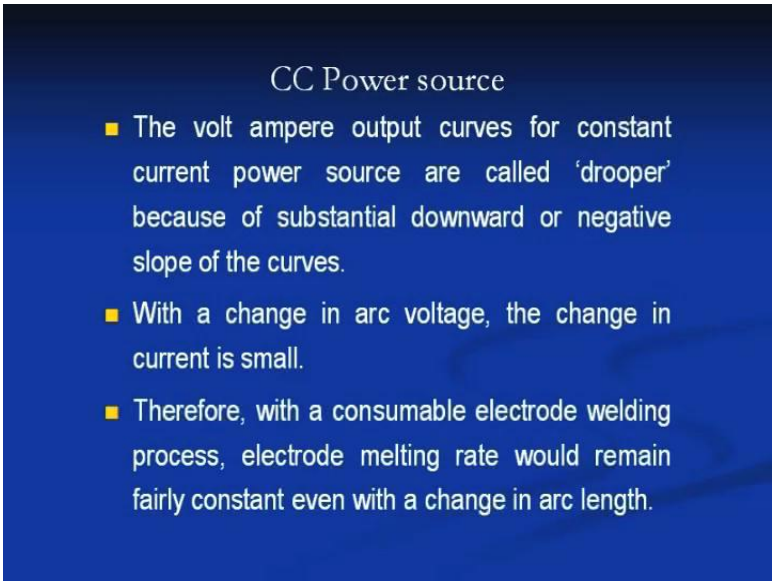

And the arc volt ampere output curve for constant current power source is called the dropper characteristic because with the increase in arc voltage your current drops and it has the negative slope. So, because of substantial downward or negative slope of the curve it is called the dropping characteristic. With a change in arc voltage the change in welding current is small with the constant current power sources. And therefore, with the consumable electrodes, electrode welding processes, electrode melting rate would remain fairly constant even with the change in arc length and which in turn, helps to produce the sound well joint.

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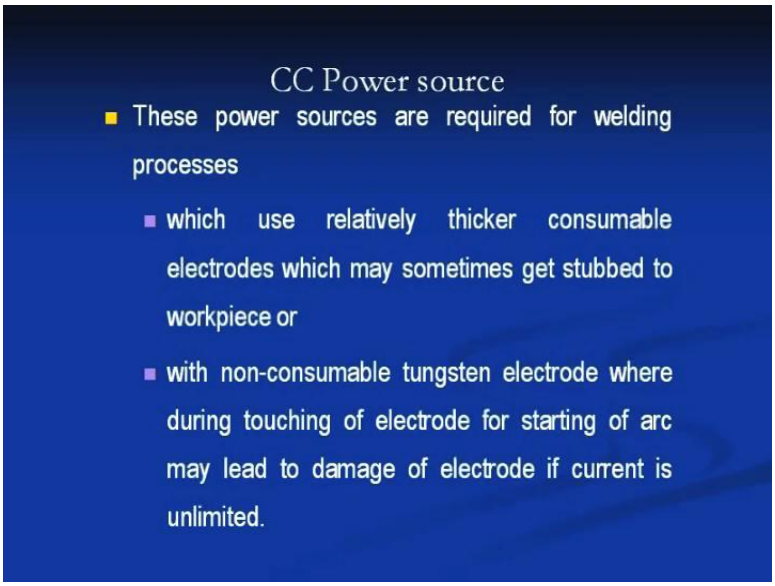

And these, welding, these power sources are required for those welding processes where there is possibility of significant change in arc length. And also, use the thicker consumable electrodes, which may sometimes get a stub to the work piece. And these welding power sources also used with the non-consumable GTA arc welding processes, so that during the touching of the electrode for starting the arc will not damage the power source because of unlimited delivery of the current. So, the constant current power sources are mainly used for the processes where consumable electrodes are used and the GTA arc welding process.

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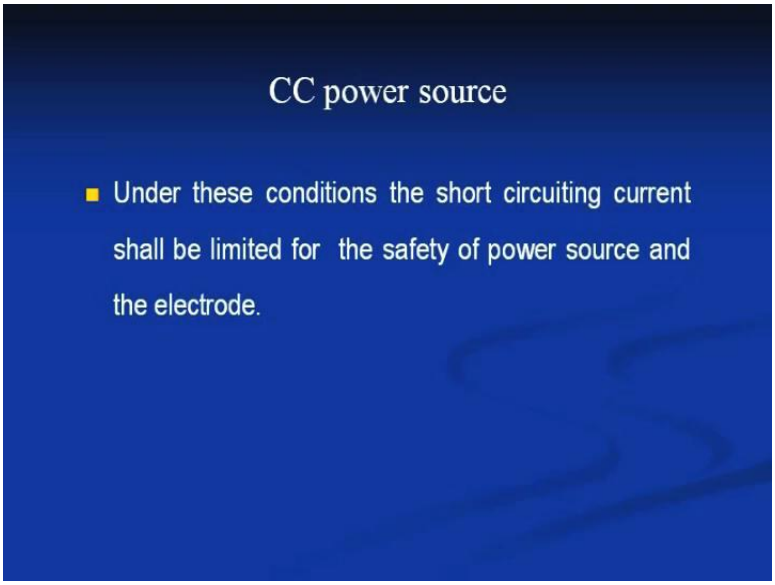

In the GTA arc welding process, where electrode touches to start the arc, it can damage the power source if the unlimited current is used. But with the use of the constant current power source, since the short circuit current is very limited and that is why, it does not adversely affect the power source. Under these conditions the short circuit current is limited in case of constant current power sources, which in turn provides the desired safety to the power source.

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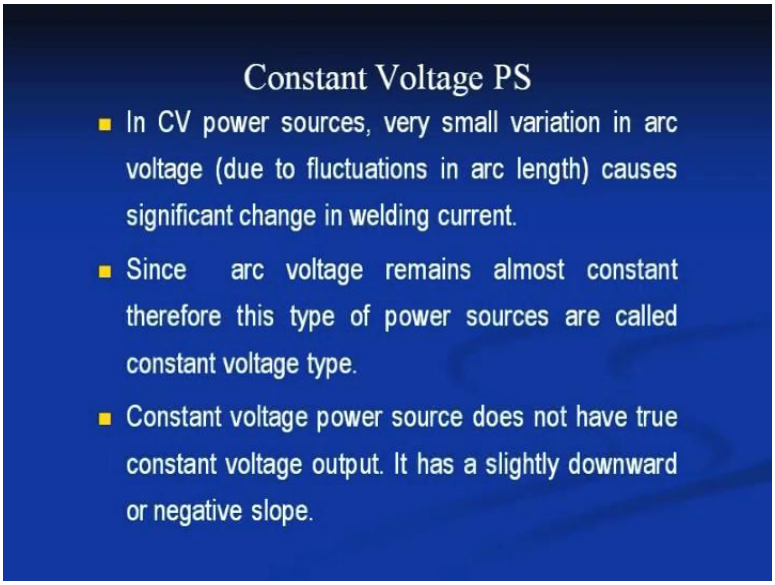

Another type of the power source having the constant voltage characteristic. In these power sources, very small variation in arc voltage takes place due to the change in the welding current, means, even the small change in arc voltage leads to the significant change in the welding current.

Since the arc voltage are almost remains constant and therefore, this type of the power sources are called the constant voltage type of the power sources. Constant voltage power source does not have the true constant voltage, but it has slightly downward or the negative slope.

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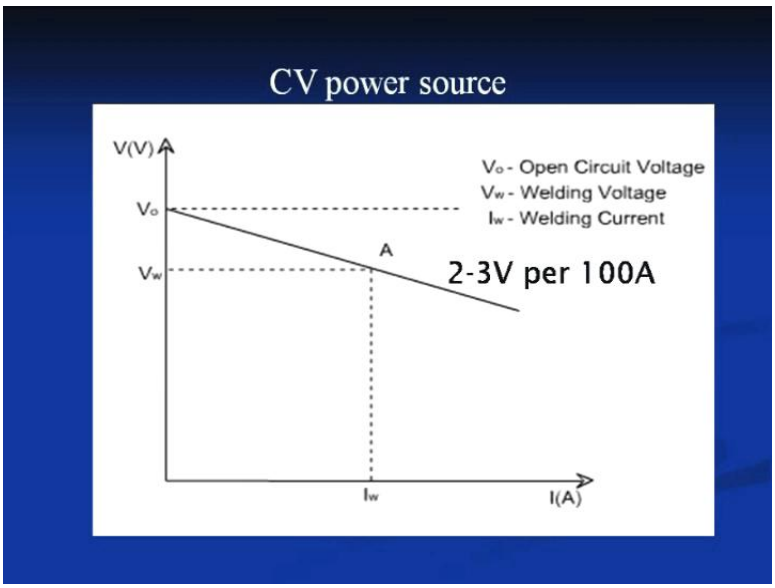

As can be seen in this diagram, here the y-axis showing the voltage and the x-axis is showing the current and this line is showing the constant voltage power source characteristic where a drop of 2 to 3 volt per thousand per hundred ampere can be seen.

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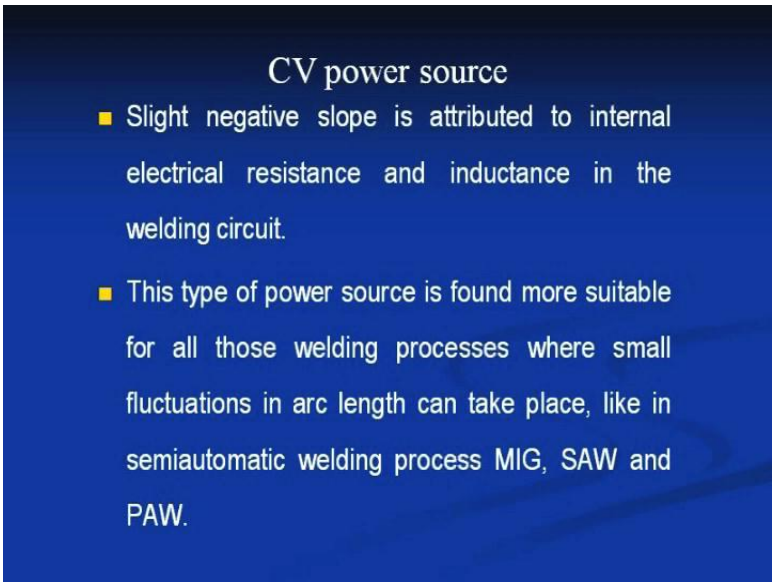

This slight negative slope is mainly attributed to the internal electrical resistance and inductance in the welding circuit. This type of the power sources are found to be more suitable for the cases where the fluctuation in arc length is very limited. And small diameter electrodes are used like in semi automatic welding processes, like GMA, SMA, SAW and plasma arc welding. And therefore, this type of welding power sources are used mainly in semi automatic welding process.

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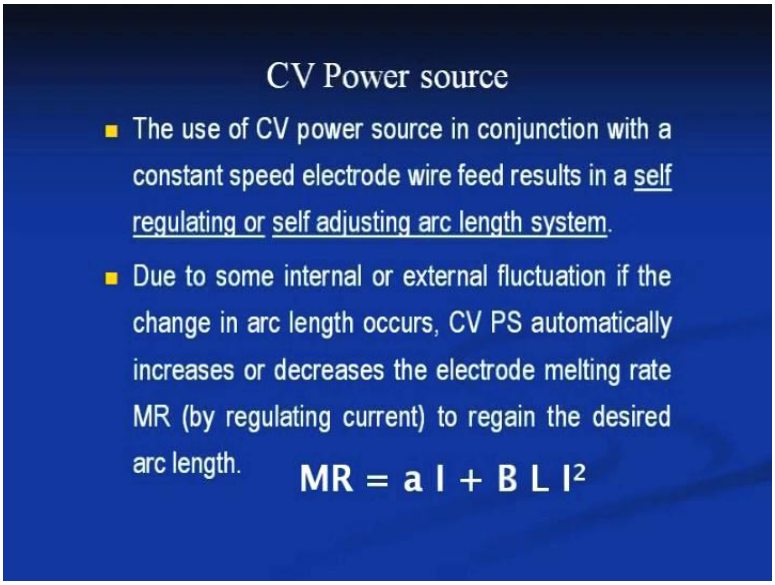

The use of the constant voltage power source in conjunction with the constant speed electrode, wire feed system results in self-regulating arc or self-adjusting arc length system. Due to some internal fluctuation or internal fluctuations, if the change in arc length takes place, constant voltage power source automatically increases or decreases the electrode melting rate and which in turn, helps to regain the arc length.

And the melting rate of the electrode can be expressed by an equation a I plus B L I square where a and B are the coefficients considering the ionization potential, the type of the metal and the flux coating, etcetera. And I is the welding current being used and L is the electrode extension through which current passes for stabilizing the arc.

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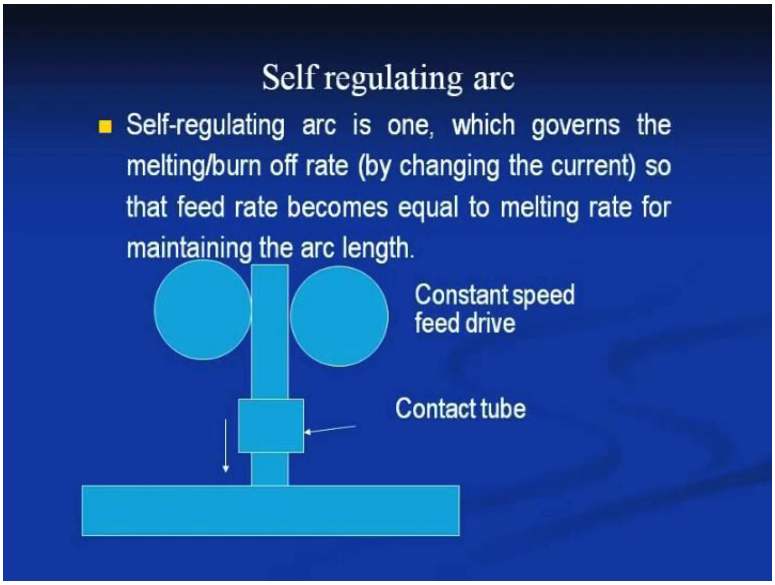

Now, here the self regulating arc is one, which governs the melting or burn off rate by changing the current, so that the feed rate becomes equal to the melting rate for maintaining the arc length. If we see here, the constant speed drive system is used where electrode is passing through the contact tube. And in case of constant speed feed drive, the wire is fed at the constant speed and the melting rate is governed by the current magnitude.

Due to any reason if the fluctuation in arc length takes place, so increase for a given speed, increase in the arc length increases the current and which in turn, increases, which in turn decreases the welding current and thus decreases the melting rate. And so, under the constant feed conditions the gap decreases in order to maintain the arc length.

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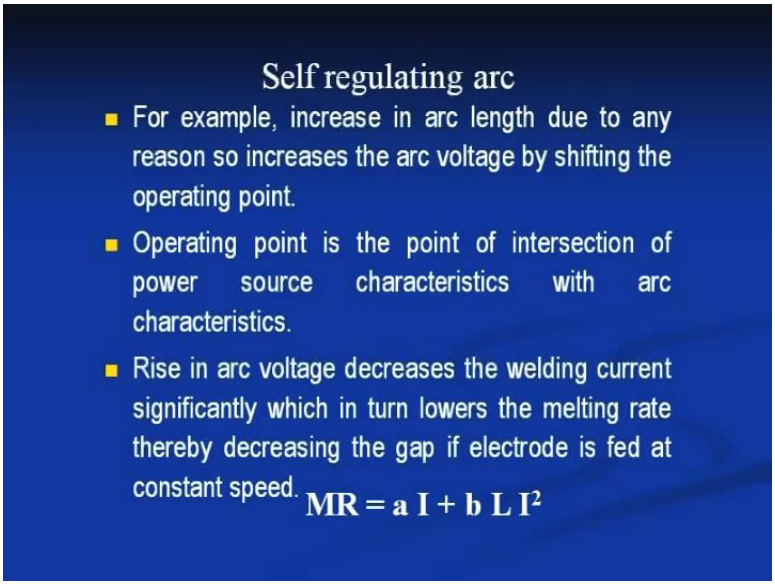

So, self regulating arc, for example, increase in arc length, due to any reason, increases the arc voltage while shifting the operating point from one position to another. And this operating point, as I have said, the point of intersection of the power source characteristic with the arc characteristic. Rise in arc voltage decreases the welding current significantly, which in turn lowers the melting rate and thereby, decreasing the gap if the electrode is fed at the constant speed.

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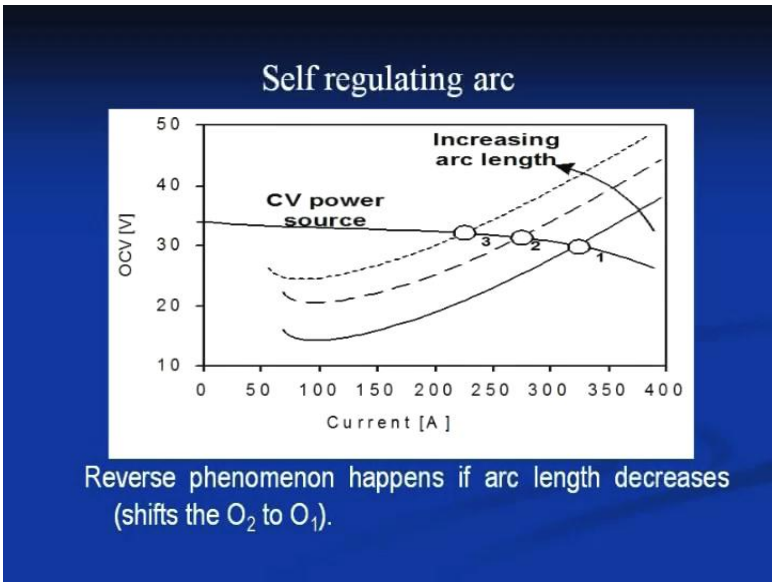

You can see, that how the self-regulating arc is developed here. This line indicates the constant current, constant voltage power source characteristic.

And initially intersection of power source characteristic with the arc characteristic, which is indicated by these three lines of the different arc length is shown by the number 1, 2 and 3, indicating the operating points. When the arc length is small here, operating point is 1 and say, system runs for this welding current and for this arc voltage. And with the increase in arc length, the operating point shifts from 1 to 2. And this increase in arc length shifts the operating from operating point, from point 1 to 2, which in turn decreases the current significantly with a small change in the arc length, arc length and so, a small change in the arc voltage.

So, thus arc, the voltage remains largely constant while the significant decrease in the current takes place, which in turn reduces the melting rate under constant feed conditions. The reduction in the melting rate decreases the gap and thus helps to maintain the arc length.

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Various types of feed drive systems are used for maintaining the arc length in the semi automated arc welding processes.

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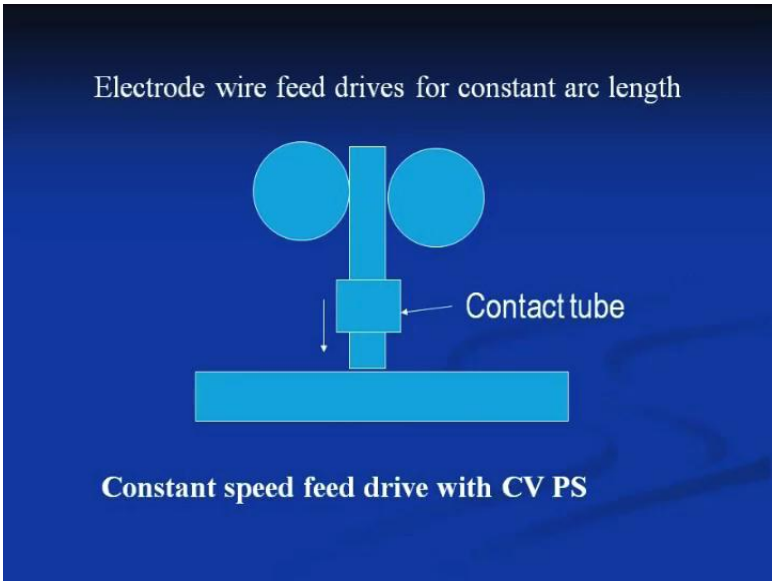

For example, in the electrode feed wire drives for the constant arc length, which offers the constant speed. In this case, the combination of the constant speed feed drive with a constant voltage power source.

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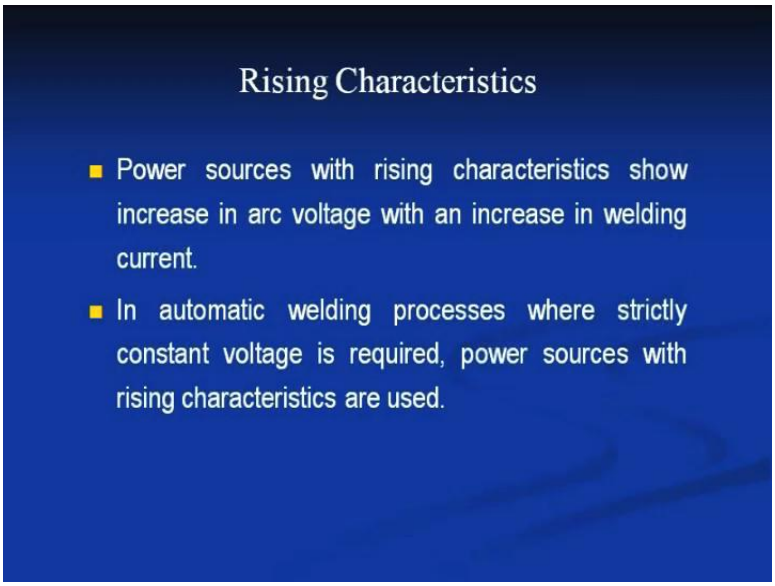

The third type of the static characteristic power sources are the rising characteristic power source where increase in current increases the arc voltage. This type of the power sources are mainly used in automatic welding processes where largely constant voltage is required for the success of the process.

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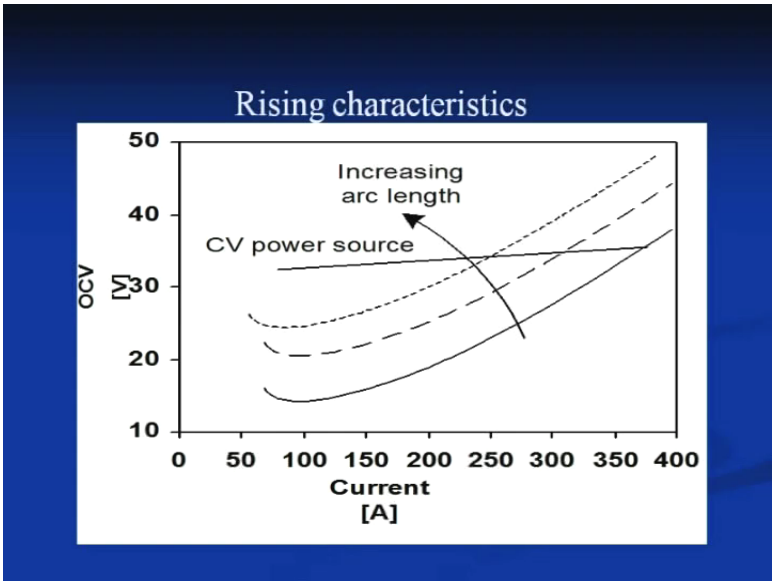

In this diagram, we can see the constant, the rising characteristic power source where slight positive slope of the constant rising characteristic power source can be seen. And you can see here, I mean, the arc welding current is increased, there is little bit increase in the voltage.

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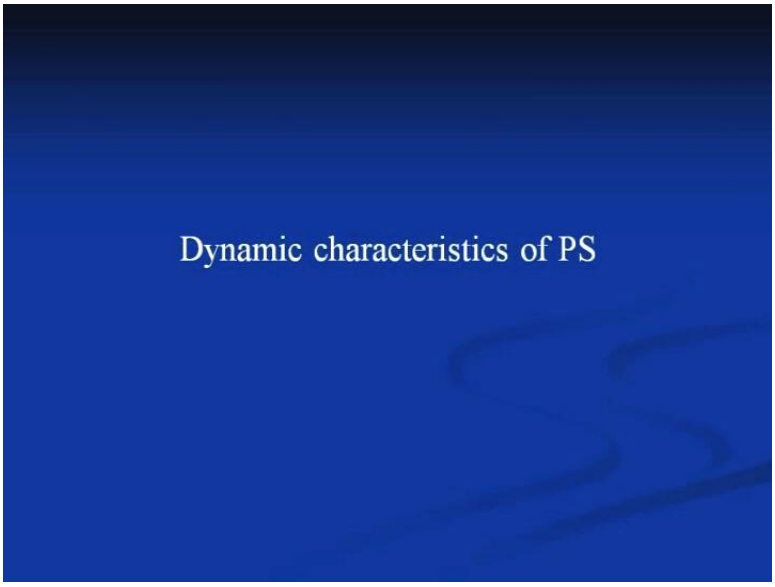

The dynamic characteristic of the power source, very important for success and a smooth welding, using the power source having the good dynamic characteristic.

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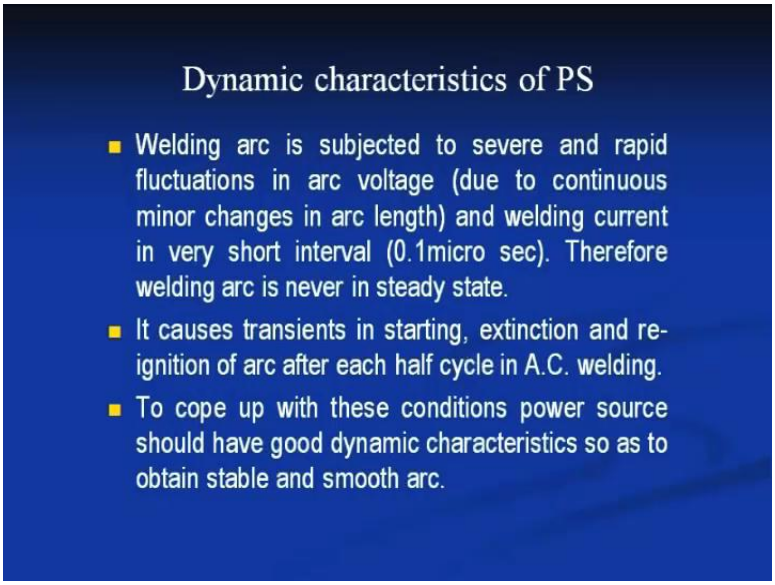

When, because during the arc welding, arc is subjected to the severe transients, transients and fluctuation in arc voltage due to continuous minor changes in the arc length. And the welding current in very short time fluctuates very rapidly. Therefore, welding arc is never in steady state.

It causes the transients in starting, extinction and the re-ignition of, of the arc after each half cycle in AC welding. To cope with the situations and the fluctuations in the welding arc where even a small change in the fluctuation in arc length can lead to the change in the welding current and it is necessary, that power system response very rapidly to the changing conditions during the welding. To cope with these conditions power source should have the good dynamic characteristic, so as to obtain a stable and a smooth arc.

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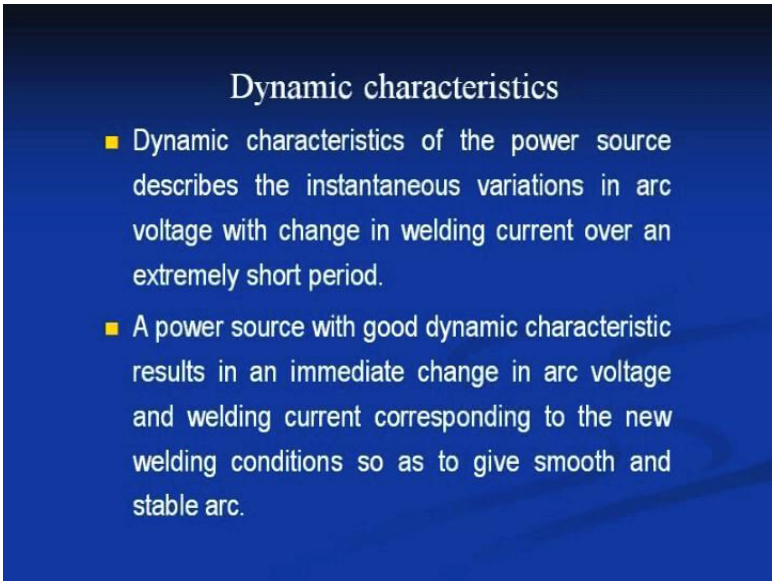

Dynamic characteristic of the power source describes the instantaneous variation in the arc voltage with the change in the welding current over an extremely short period of, of the time. A power source with the good dynamic characteristic results in an immediate change in the arc voltage and the welding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

Can be seen, that how rapidly the change in current takes place with the, in the time and if the welding power source responds very quickly to the fluctuations, which are taking place in very short time. The power source consider, is considered to have a good dynamic characteristic.

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The duty cycle of the power source is another important feature, which is considered in setting the proper welding current.

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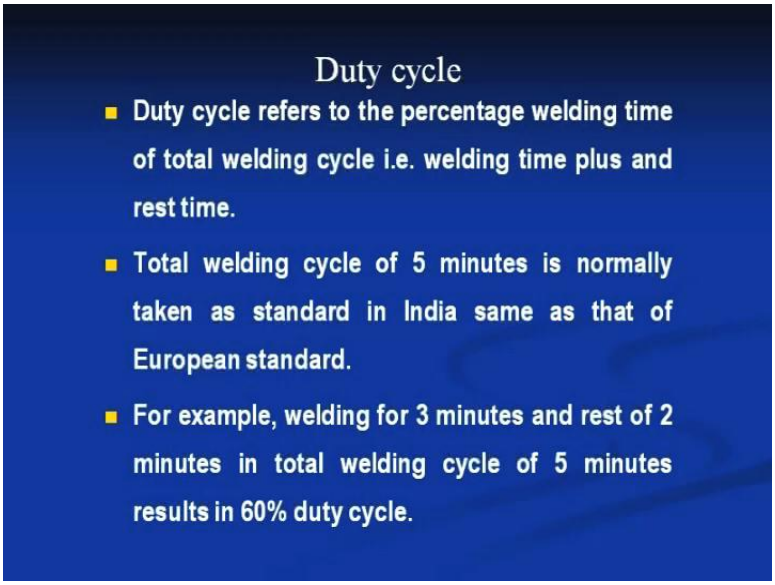

Duty cycle refers to the percentage of the welding time of the total welding cycle, that is, the welding time plus the rest time. The total welding cycle of the 5 minutes is normally taken as a standard in India, same as that of the European standard. For example, welding for 3 minutes and rest of 2 minutes in total welding cycle of 5 minutes, results in 60 percent duty cycle.

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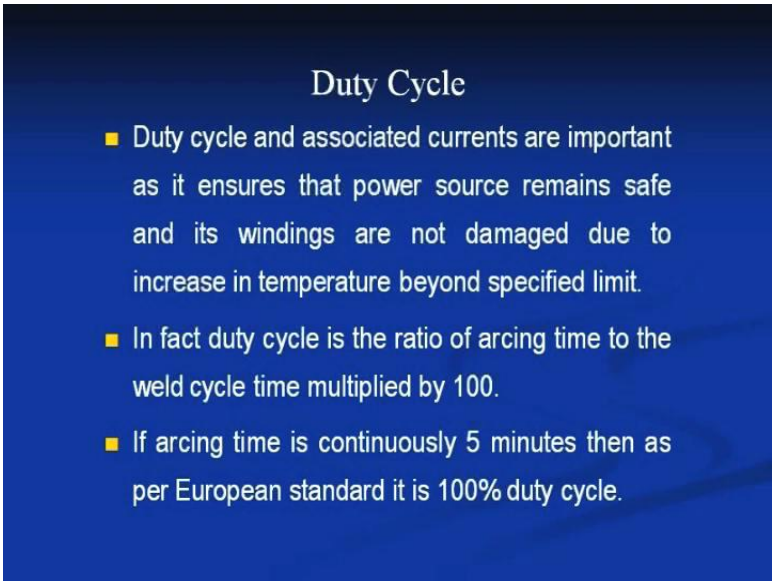

The duty cycle and associated currents are important to ensure the safety of the power sources and to ensure, that its windings are not got damaged due to increase in temperature of the windings and the installation of the power sources. In fact, duty cycle is the ratio of the arcing current to the weld cycle time multiplied by 100. If the arcing time is continuously 5 minutes, then as per the European standard it is considered as a 100 percent duty cycle.

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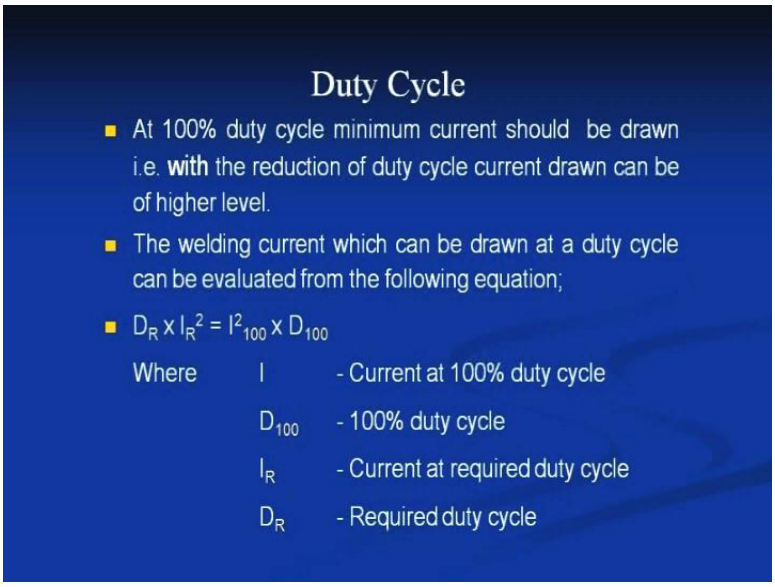

At the 100 percent duty cycle minimum current should be drawn, so that the excessive heating of the windings and the installations can be avoided in order to avoid any kind of

the damage to the power source. So, with the reduction of the duty cycle, current drawn can be higher, of the higher level. Means, if we draw the welding current for a shorter duration, then the higher magnitude of the welding current can be drawn.

The welding current, which can be drawn at a duty cycle can be evaluated using the following equation where D R multiplied by I R square is equal to I square 100 multiplied by D 100, where I indicates the current, I indicates the current at 100 percent duty cycle.

D 100 indicates the 100 percent duty cycle.

I R indicates the current at the required duty cycle.

And the D R shows the required the duty cycle.

So, if the three values are known, third can be, fourth can be obtained and calculated.

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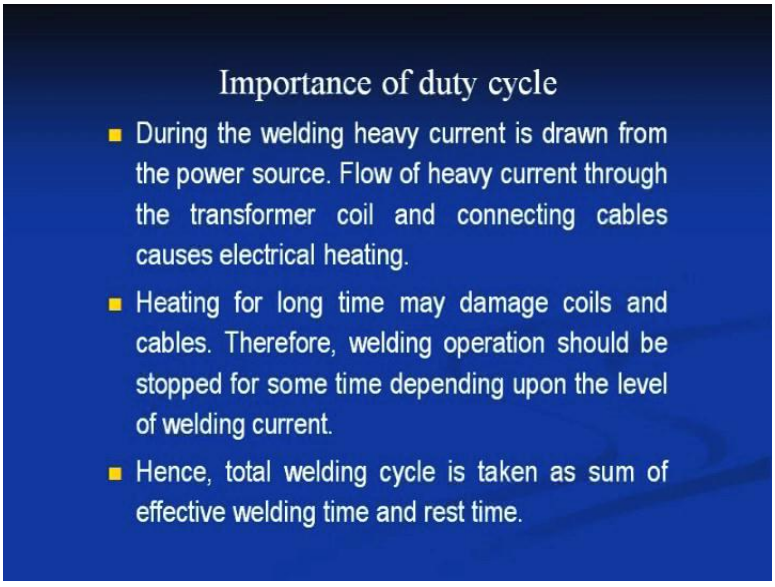

The during the welding current, when heavy current is drawn from the power source, the flow of current through the transformer coils and the connecting cables causes the electrical heating due to the electrical resistance heating. And heating of the coils and the cables for long can damage the insulation and therefore, welding operations should be stopped for sometime depending upon the level of the current being drawn.

And hence, the total welding cycle time is taken as the sum of the effective welding time and the rest time.

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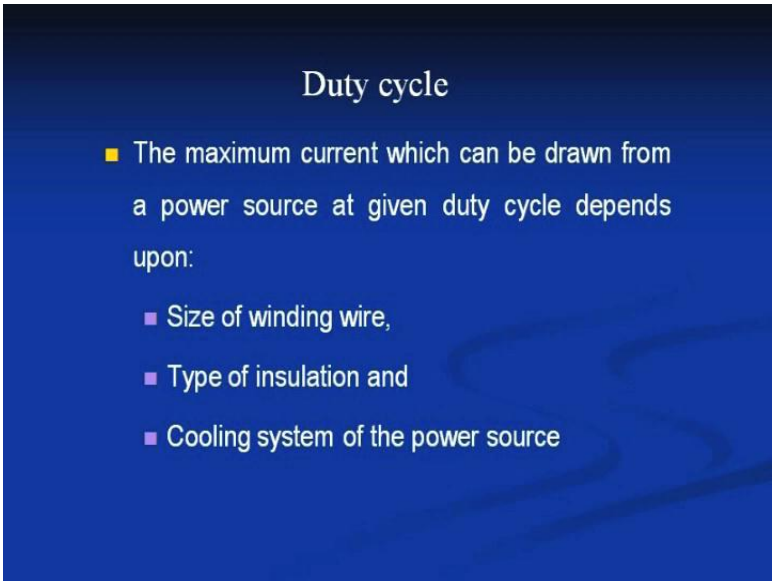

And the maximum current, which can be drawn at a particular duty cycle from a power source depends upon the size of the wires, which have been used in the winding. Larger is the size, greater will be the ability of the wire to withstand and lower will be the resistance hitting.

And the type of insulation, higher quality, better quality insulations will be able to withstand up to the higher temperature and thus increase the ability to withstand even when the higher current is drawn at a particular duty cycle. And the cooling system of the power source, which is in place. In more effective cooling systems allow the withdrawing of the greater welding current at a given duty cycle.

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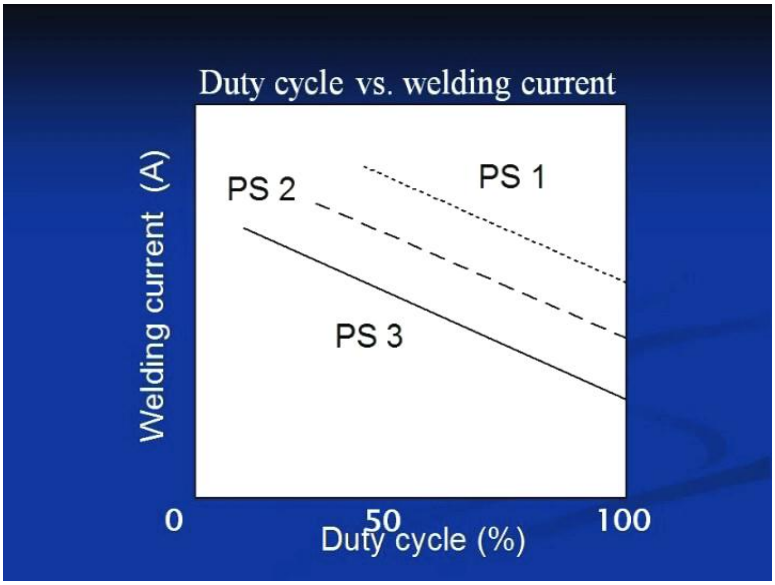

As can be seen, the welding current for the different power sources as a function of the duty cycle. Lower is the duty cycle, higher current can be drawn from the power source and with the increase in the duty cycle and decreases. At 100 percent duty cycle we can draw the minimum level of current, which will allow this running of the system continuously and without any kind of damage to the coils and the cables.

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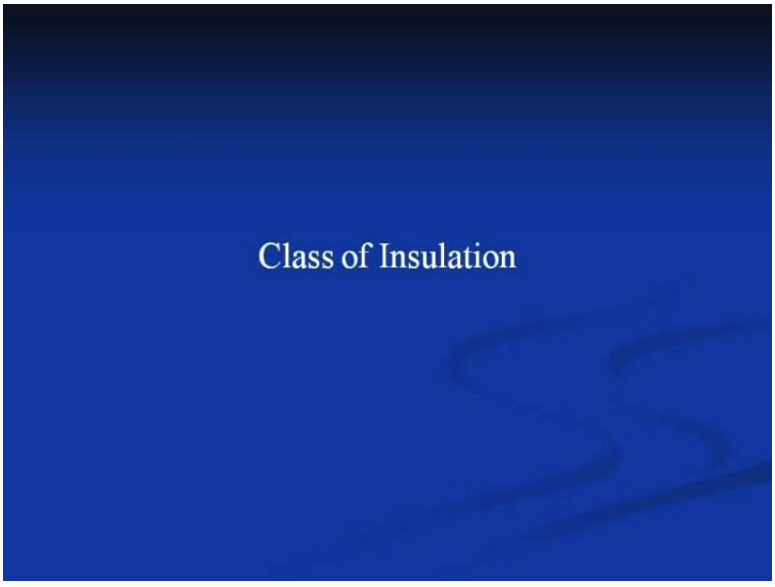

The class of the insulation is the sixth and last important characteristic of the power source.

The duty cycle of any power source is governed by the class of the insulation or the type of insulation, which has been used.

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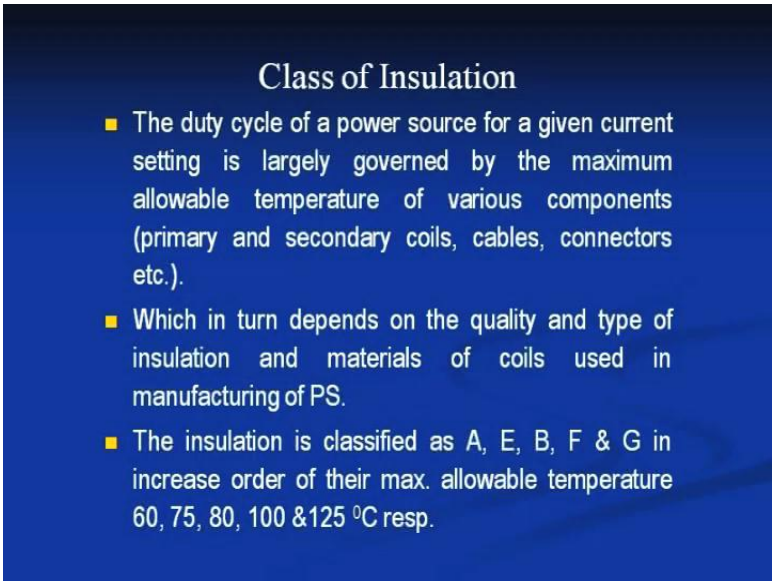

The duty cycle of power source for a given current setting is largely governed by the maximum allowable temperature of the various components such as primary and secondary coils, cables and the connectors, which in turn depends on the quality and the type of insulation and the materials of the coils used in manufacturing of the power source. Insulation can be called as A, E, B, F and G in the increasing order of their maximum allowable temperature such as 60, 75, 80, 100 and 125, respectively. So, in this presentation students you have seen the various important characteristics of the power source and which can significantly affect the selection of the power source for successful welding.

Thank you for you kind attention.