Manufacturing Processes – Casting and Joining
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Lecture – 19
Shielded metal arc welding, MIG & TIG Welding

Hello and welcome back to the course on Manufacturing Processes - Casting and Joining. let me remind you that in our last lecture session we were discussing the arc welding and its characteristics.

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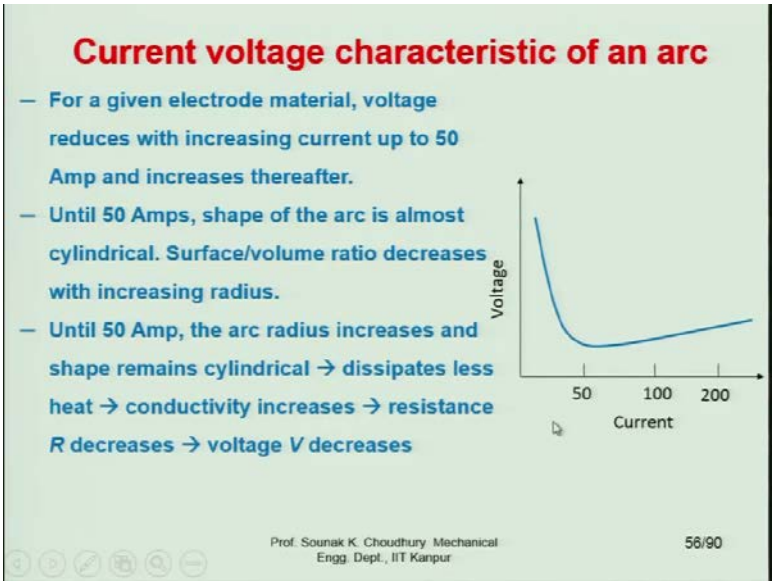

We said that the voltage and the current relationship, if you see the slide, when the current is increasing from the beginning to the up to 50 amperes, the voltage drops. This is because the arc radius increases, the shape remains cylindrical. So, up to this it dissipates less heat. The conductivity increases. Once the conductivity increases meaning the resistance R decreases and the voltage decreases.

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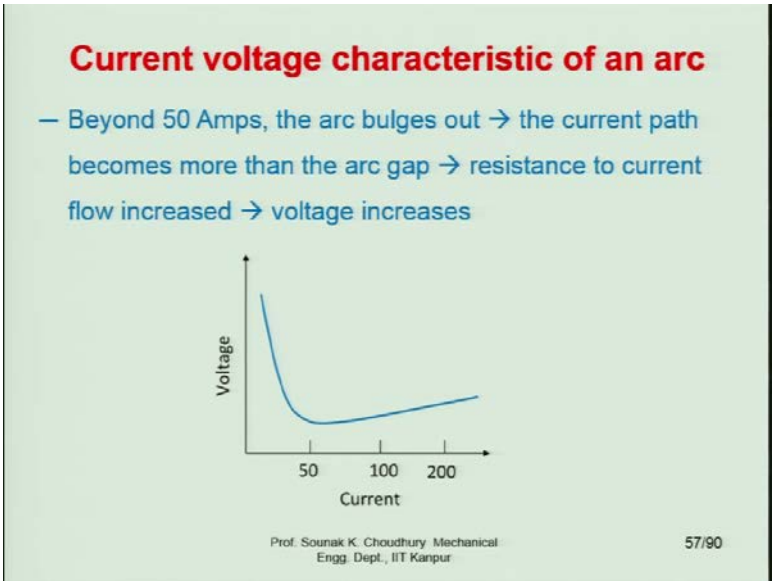

After it crosses 50 amperes, it increases. The voltage increases because the arc bulges out after this because the current is too high. The current path becomes more than the arc gap. By arc gap what we mean is the distance between the electrodes, that is the electrode and the work piece which is to be welded.

The current path becomes more than the arc gap, the resistance to current flow increases, and the voltage increases. This is what happens as the current goes beyond 50 amperes. Here it is the ampere along the X axis and this is the voltage along the Y axis.

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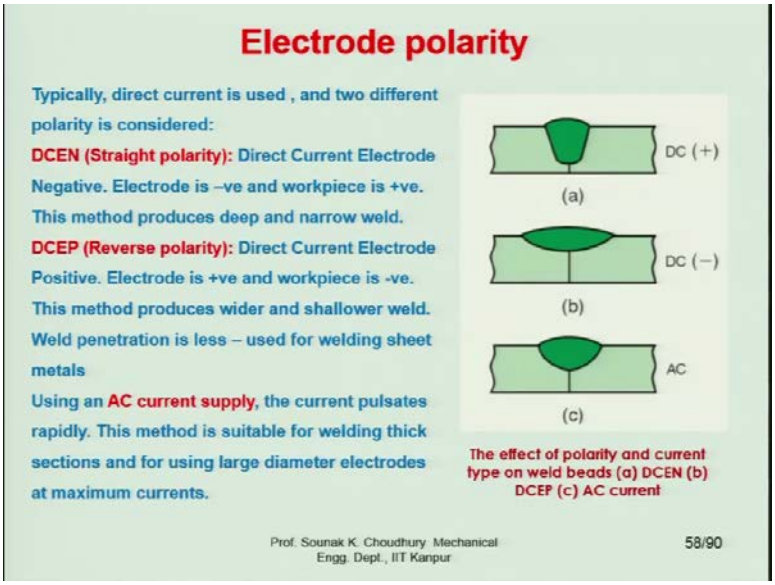

Now the polarity; we said that there are two types of polarity that can be used in the arc welding. One which is straight polarity that is direct current, electrode is negative; electrode is something in the arc welding that the operator is holding above the material to be welded. In this straight polarity, direct current is used and the electrode is negative and the work piece is positive.

Electrode or that rod is negative and the workpiece is positive in the straight polarity. This method produces deep and narrow weld; this is normally used for the deep and the narrow weld like this and there is another way of doing that; this is called the reverse polarity; this is also direct current and electrode is positive in that case and the workpiece is made negative.

This method produces wider and shallower weld as you can see here, this is less than in the first case, but it is wider than in the case of the straight polarity, when the electrode is negative and the workpiece is positive. In the reverse polarity, once again, electrode is positive and the workpiece is made negative.

In Fig. (b) that is the reverse polarity this is used for the welding of the sheet metals because the sheet metals are very thin and there you do not need a deeper weld. Therefore, this is suitable for the sheet metal welding. Using an AC current supply the current pulsates rapidly if in these two cases we said that we use the direct current, where the AC current supply is used the current pulsates rapidly.

This method is suitable for welding thick sections and for using large diameter electrodes at maximum currents. This is an exceptional case. In case of AC current, the polarity is immaterial because we are having the current pulsating.

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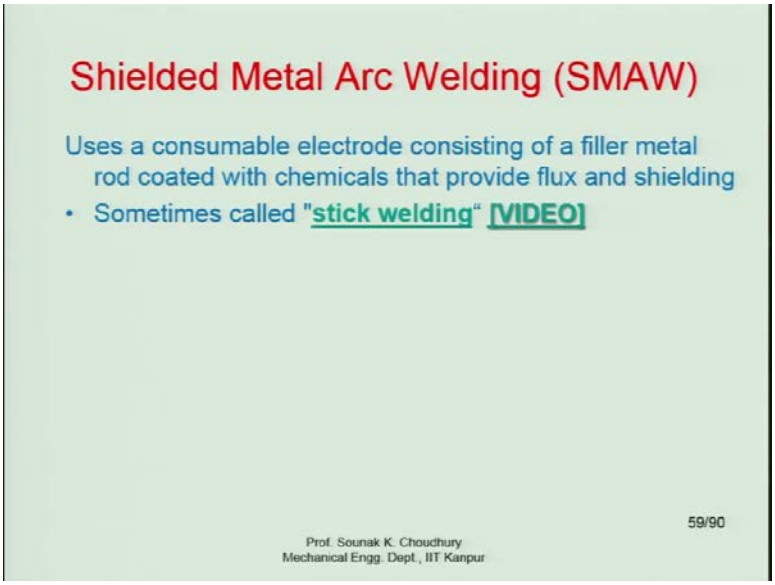

Next, we will discuss the Shielded Metal Arc Welding in brief, it is SMAW in short. This uses a consumable electrode; this is also a type of the arc welding, but this is shielded when the parts to be welded, they will be shielded by some kind of a slag or the shielding gas.

This process uses a consumable electrode consisting of a filler metal rod coated with the chemicals that provide flux and shielding. Sometimes this is called the stick welding. Stick welding meaning that electrode which operator is holding that has a coating and when that coating melts at higher temperature when the short circuit happens. Then at that temperature it melts and it produces gas which shields and provides alloying material as well.

It can provide the alloying material to the molten metal in the weld pool. These are the two purposes why these coated electrodes are used. There is a small video I would like to show you on the stick welding. This is also called the stick welding because of the stick that the operator is holding.

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What is stick welding? Stick welding is an electric arc welding process that uses rod shaped metal electrodes that are covered with a flux material.

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The American welding society calls this process shielded metal arc welding or SMAW.

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You may also.hear this process called manual metal arc welding or MMA welding some people refer to this process.

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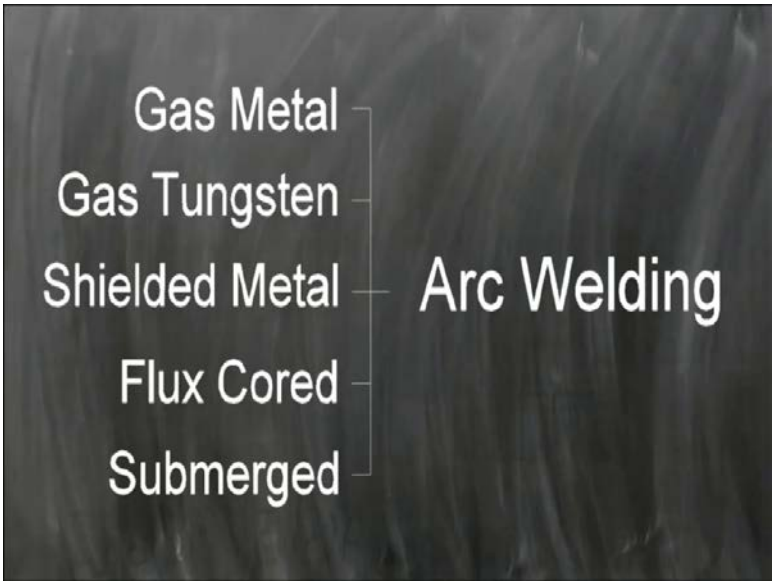

Simply as arc welding, but shielded metal arc welding or stick welding is just one of many types of arc welding.

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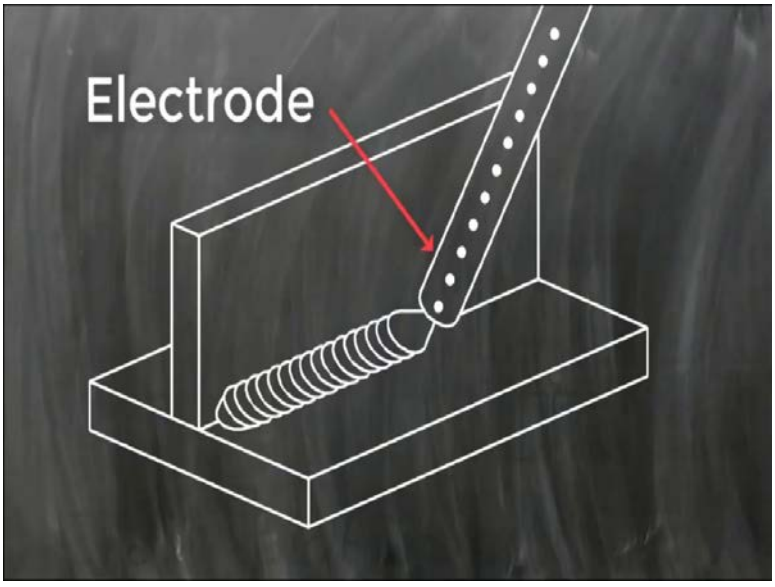

In stick welding an electric current flows through a metal electrode or stick.

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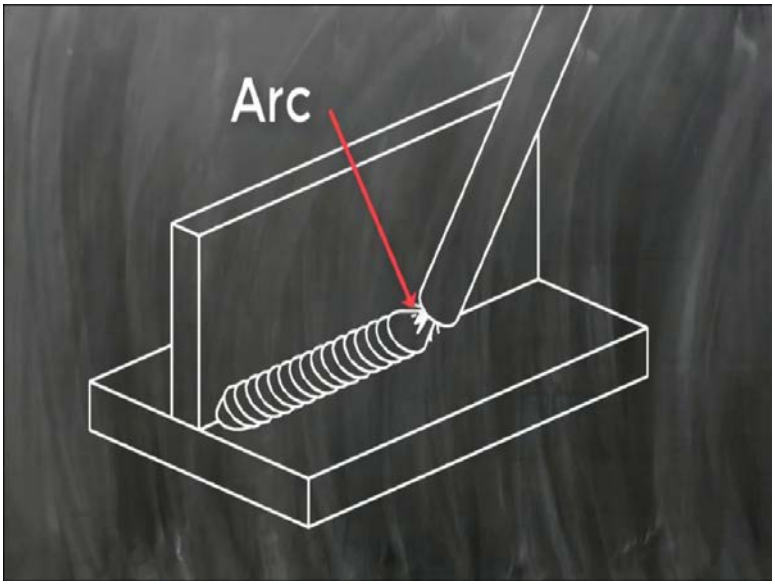

An arc forms between the end of this electrode and the workpiece. The art melts both the metal in the rod and the metal in the pieces to be joined.

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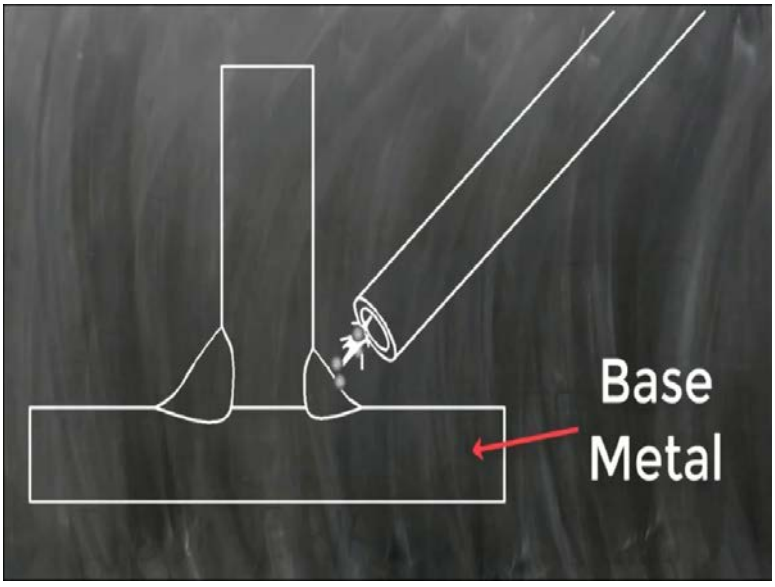

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The metal from the electrode is ejected into a molten weld pool and mixes or coalesces with the workpiece. The metal in the workpiece is called the base metal and the metal added to the joint from the electrode is called filler metal.

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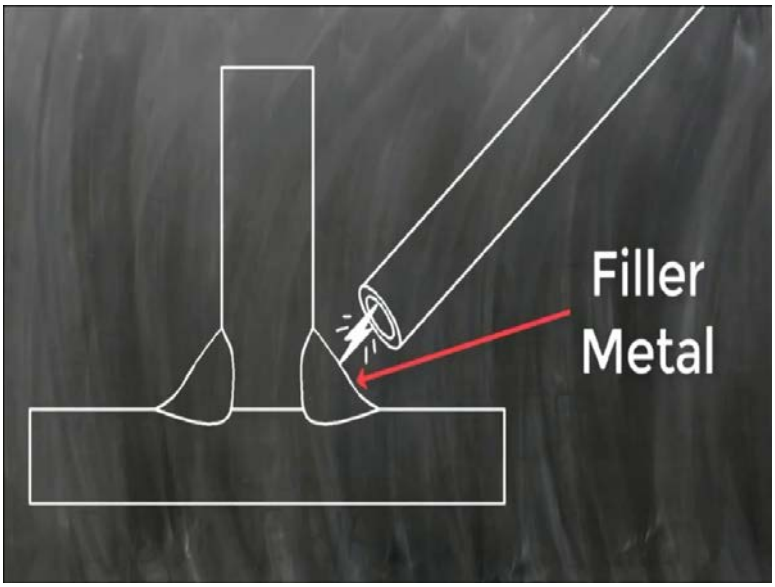

Stick welding always adds filler metal to the joint.

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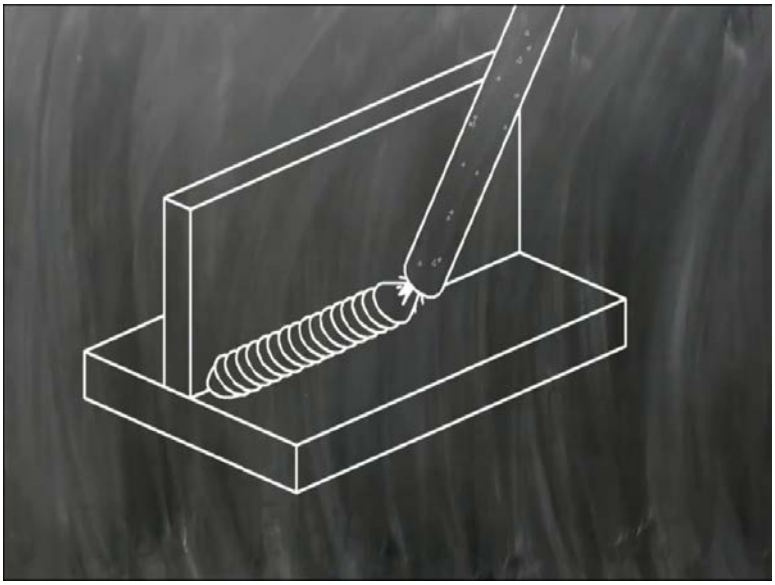

Because the electrode is constantly melting away and becoming part of the welded structure.

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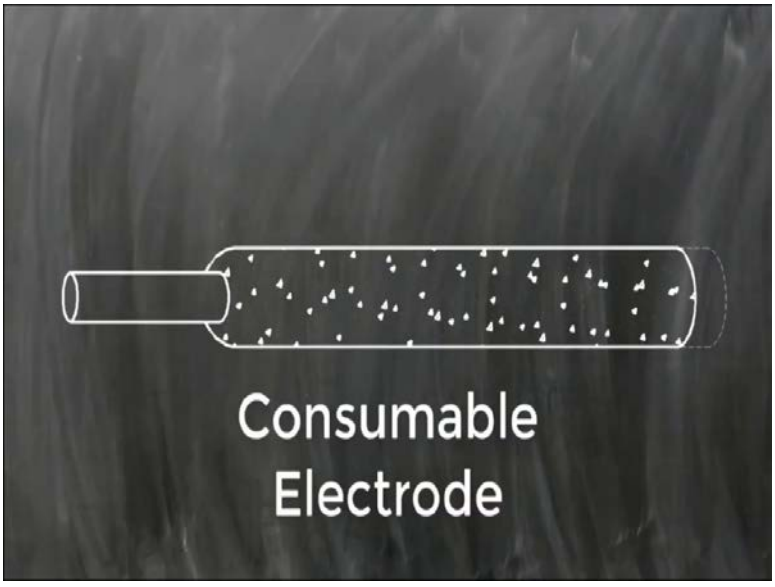

Stick welding is known as a consumable electrode process.

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As the electrode is heated by the arc some of the covering on the electrode releases protective gases that shield.

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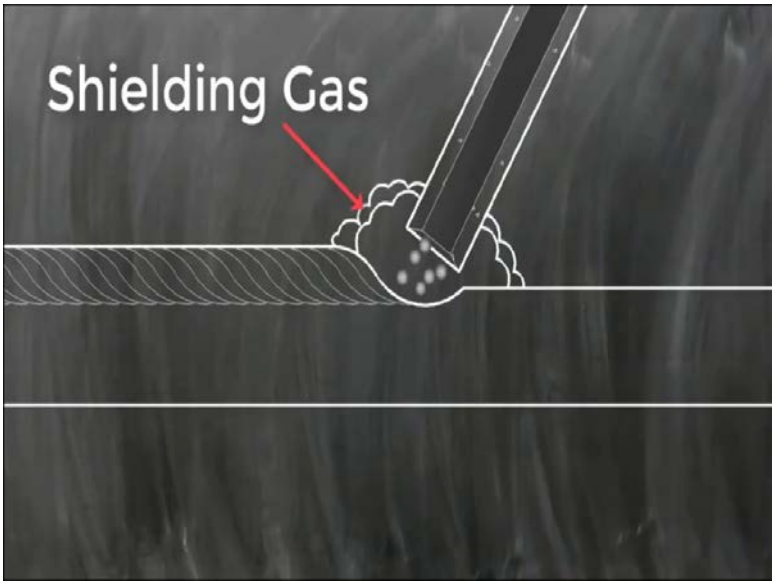

The weld and help stabilize the arc the remaining covering melts and covers the molten weld pool with a protective slag layer.

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This slag layer protects and helps shape the weld as it solidifies.

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But it must be removed when the weld is cool since the gases generated by the flux covering are able to completely protect the molten weld.

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There is no need for other shielding equipment such as high pressure gas cylinders regulators or hoses.

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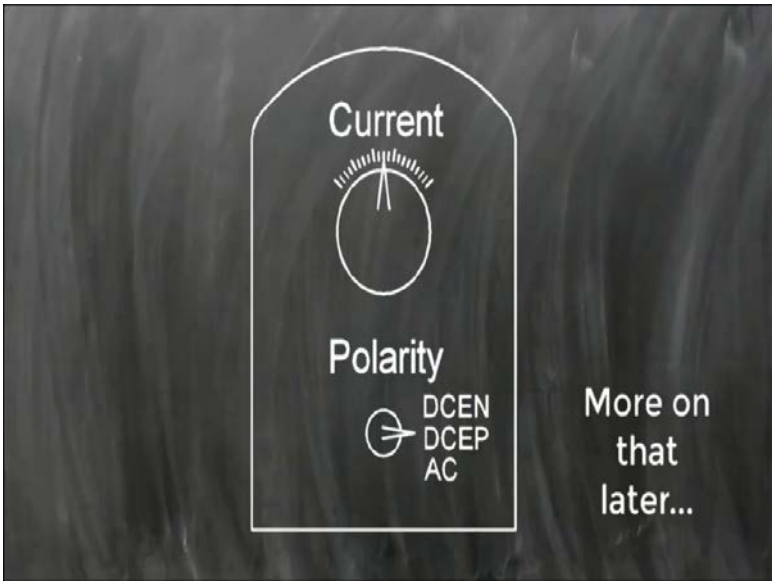

Compared to other welding processes stick welding equipment is often very simple. Sometimes the only controls on the machine are current and polarity.

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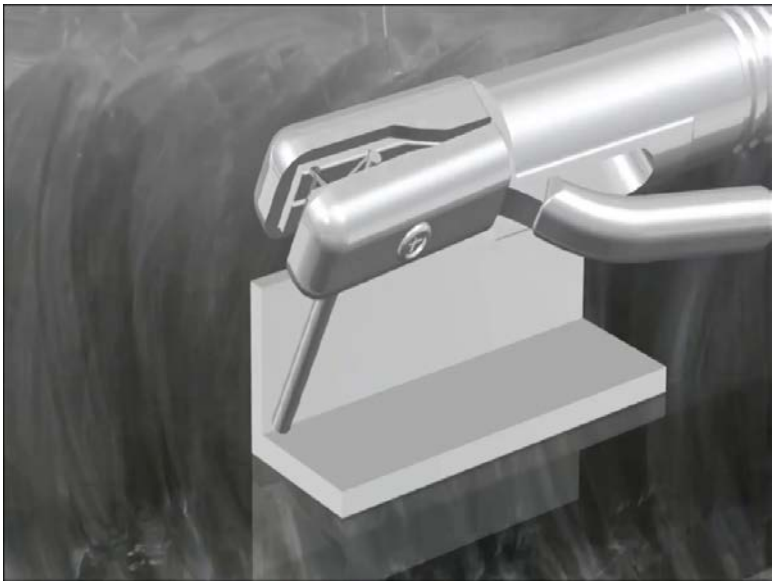

Many important welding variables come from how the person doing the welding positions and moves the electrode, for this reason the quality of welds produced by this process depends greatly on operator skill.

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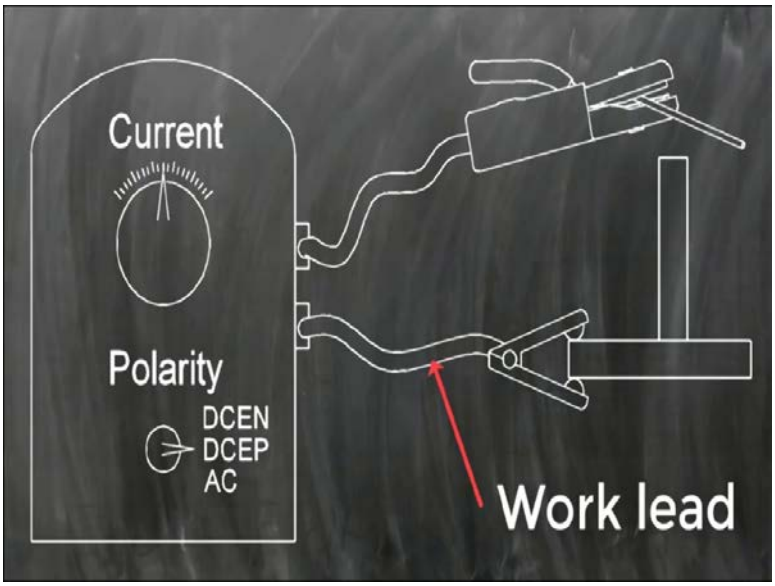

In stick welding two insulated wires are connected to the welding machine, one lead goes to a clamp which is connected to the work this is called the work lead.

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The other wire goes to an electrode holder; the uncovered wire grip into the electrode is placed into the electrode holder.

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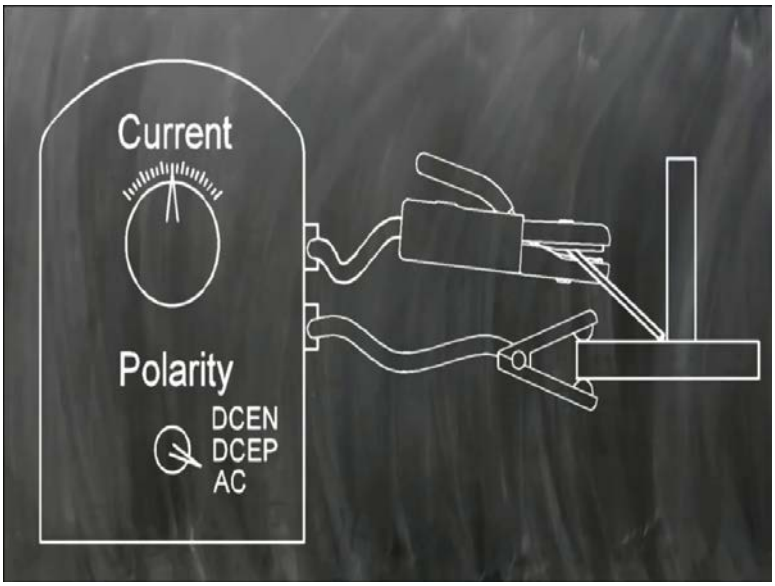

The polarity of the welding setup refers to how the electricity flows from the machine to the workpiece and back the current will either be AC or DC.

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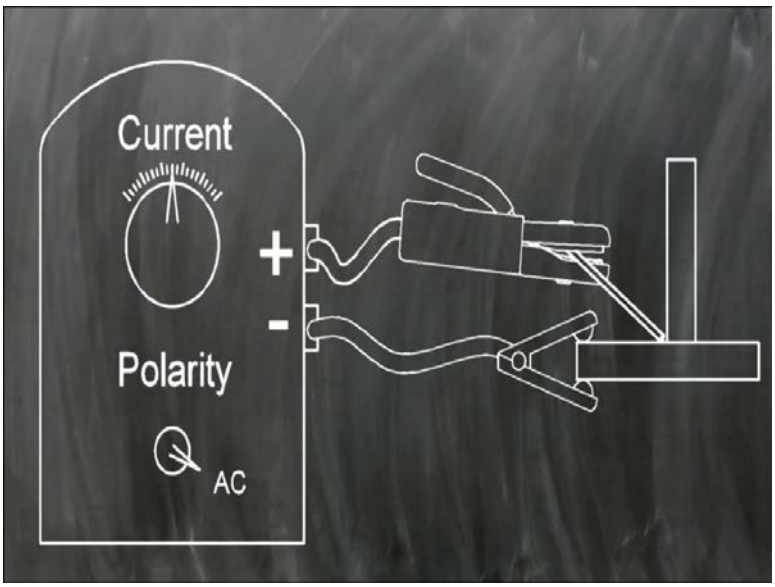

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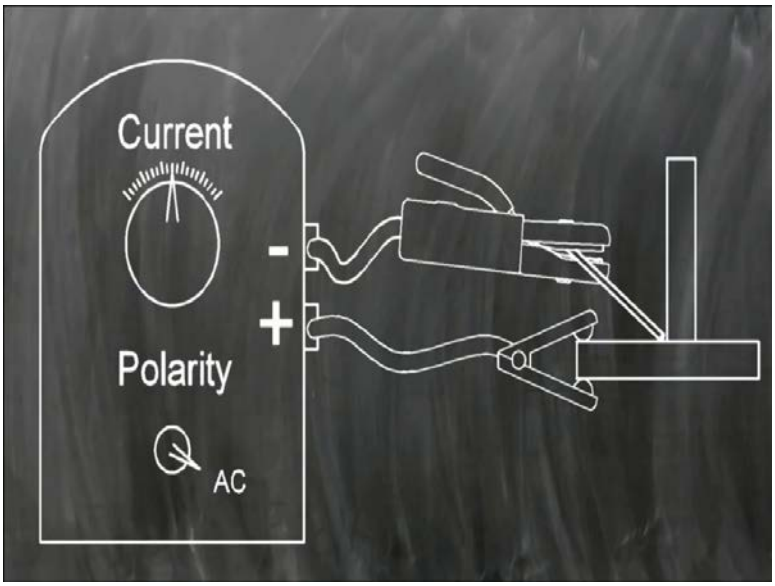

In AC or Alternating Current the direction of the flow of the electricity changes directions many times every second. Direct Current or DC is like the flow of electricity from a car battery.

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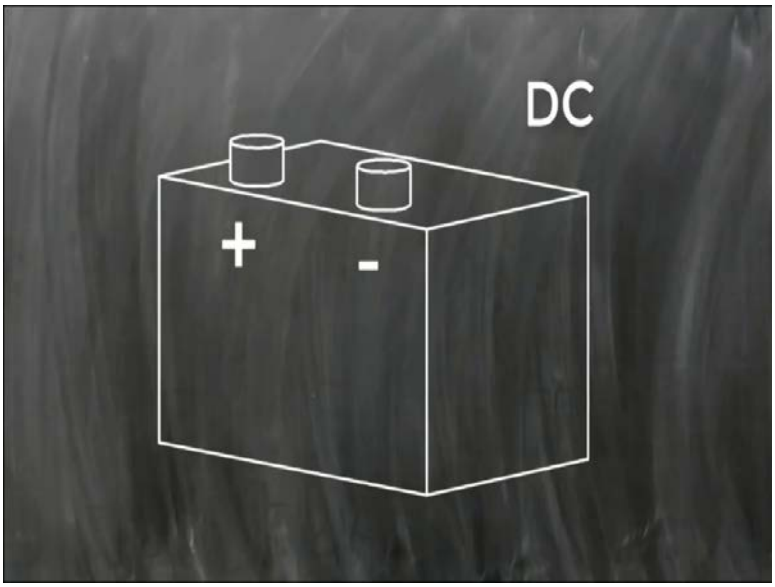

One lead is always positive and the other is always negative. DC can be set up two ways in stick welding.

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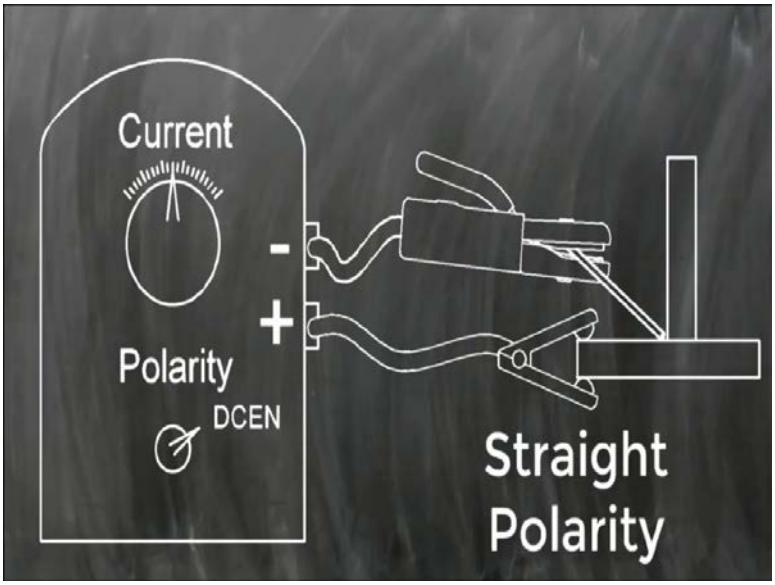

One way to connect DC is DCEN or DC Electrode Negative which is often called straight polarity. In DCEN the electrode is connected to the negative terminal and the work is connected to the positive the other way to connect DC is DCEP, which is DC Electrode Positive often called reverse polarity.

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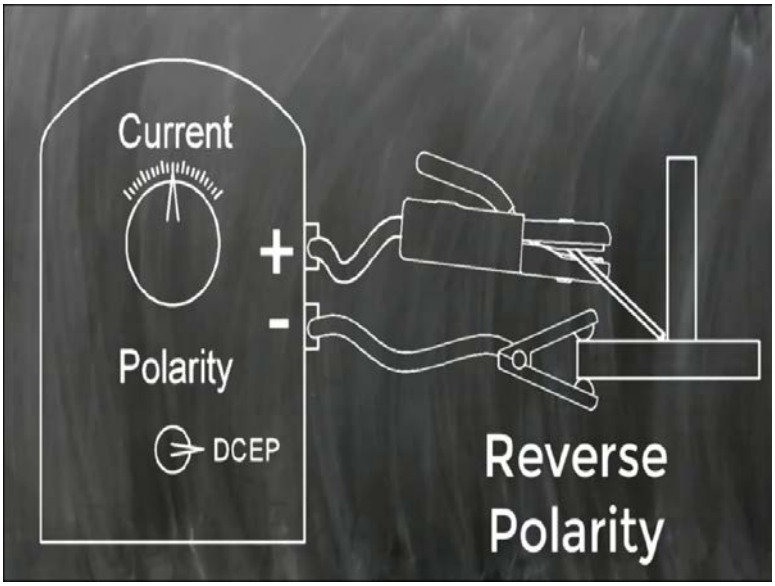

Many stick welding electrodes operate on DCEP, but some designed to work with DCEN or AC.

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Welding Position[a]	Type of Current[b]
,OH,H	dcep
,OH,H	ac or dcep
,OH,H	ac or dcen
,OH,H	ac, dcep or dcen
,OH,H,	ac, dcep or dcen
illets	ac or dcen
	ac, dcep or dcen

check the manufacturers recommendations for the proper settings.

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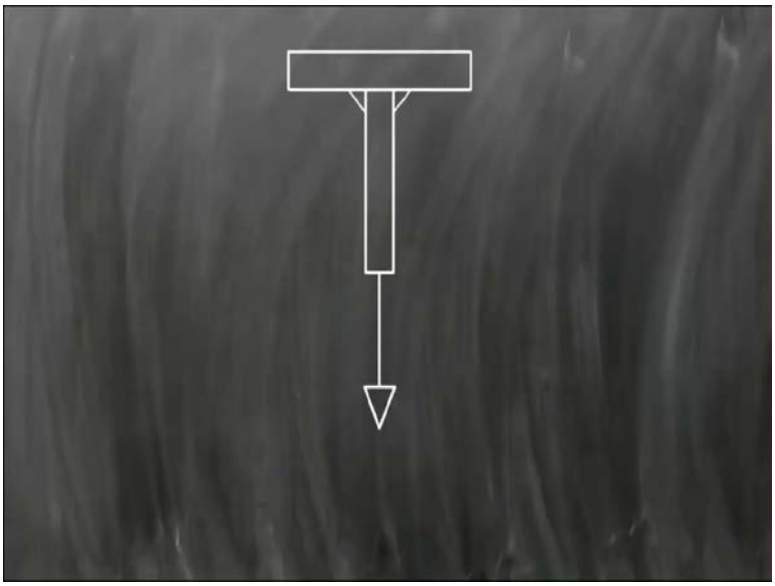

Stick electrodes are made with a variety of metal alloy compositions and flux chemistries, you want to make sure the electrode you plan to use will be strong enough.

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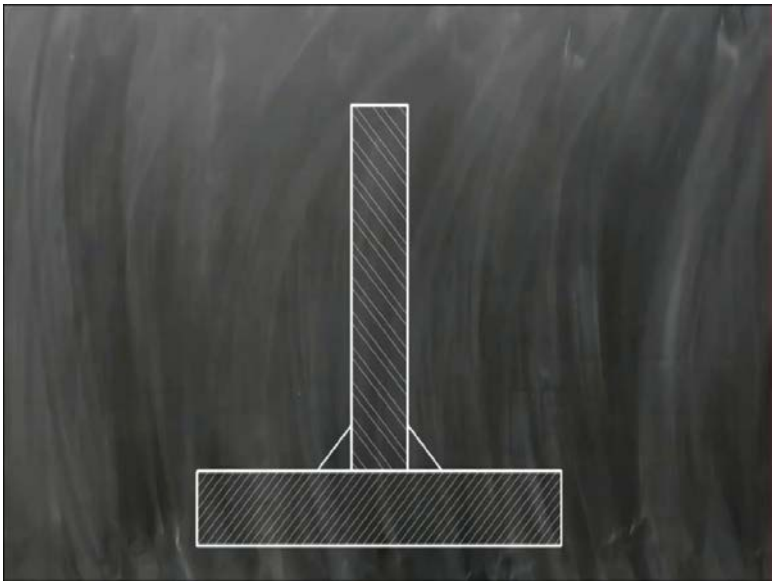

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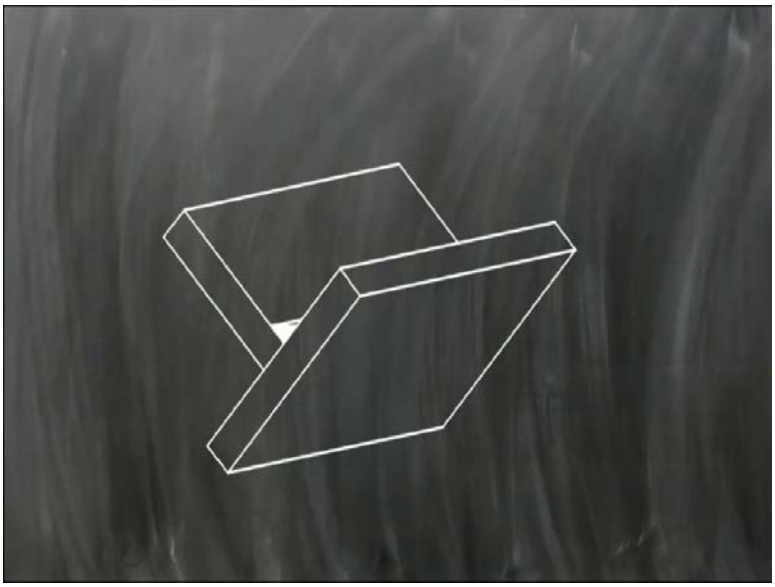

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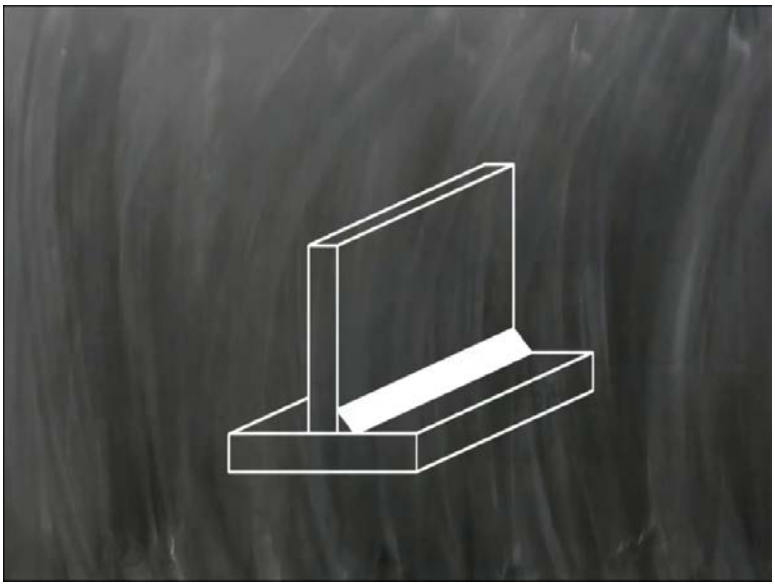

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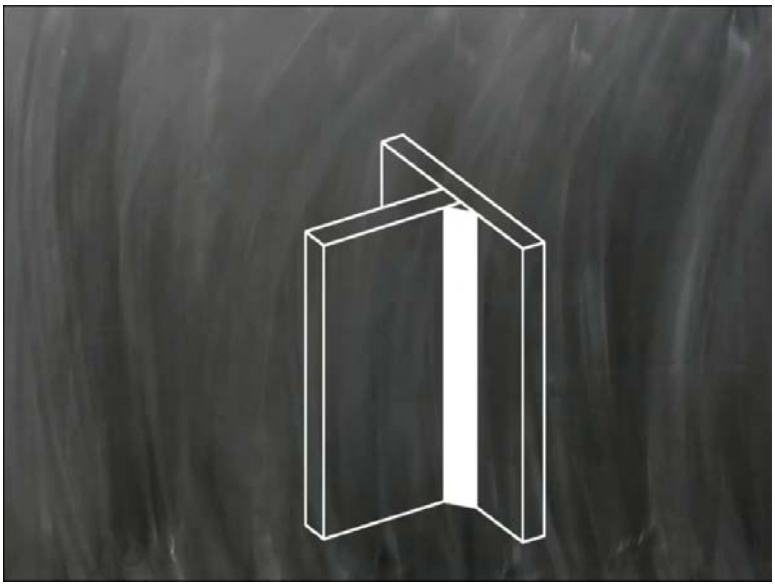

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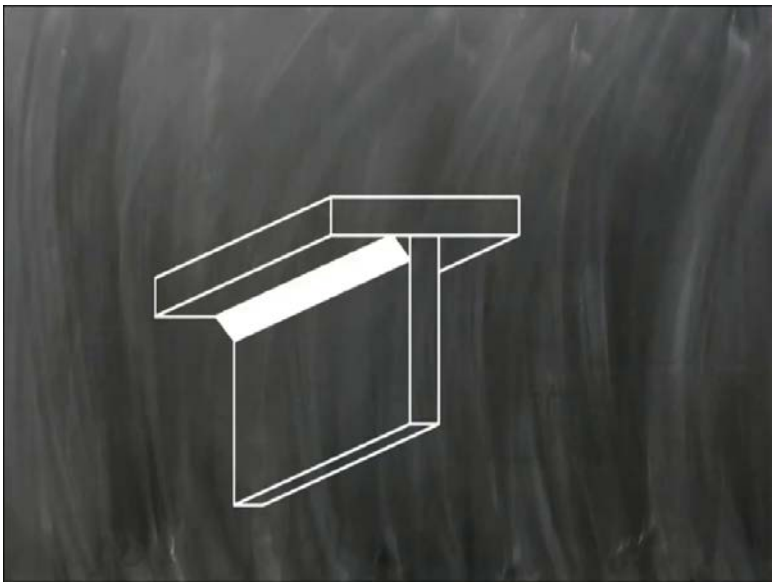

And that it is compatible with the base metal and the position of the joint you want to weld.

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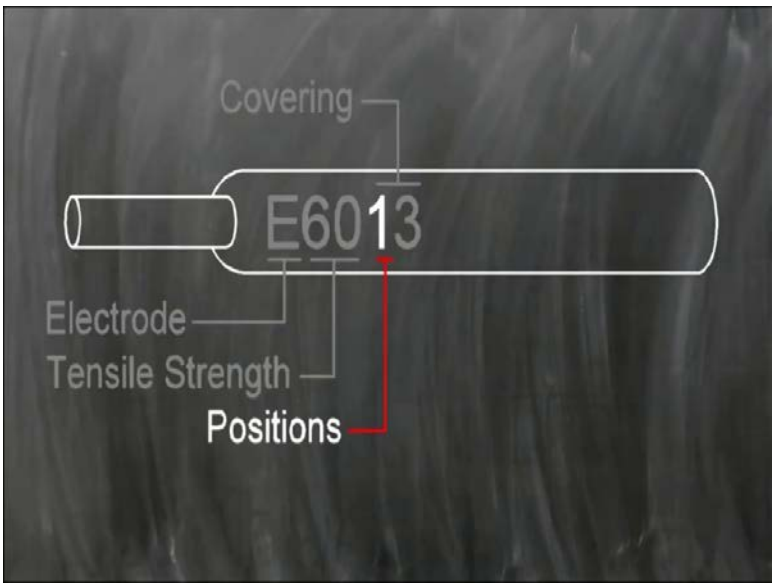

Often electrodes have the American welding society classification code printed on them. This code will identify tensile strength the flux covering type the appropriate welding positions. And sometimes other important information.

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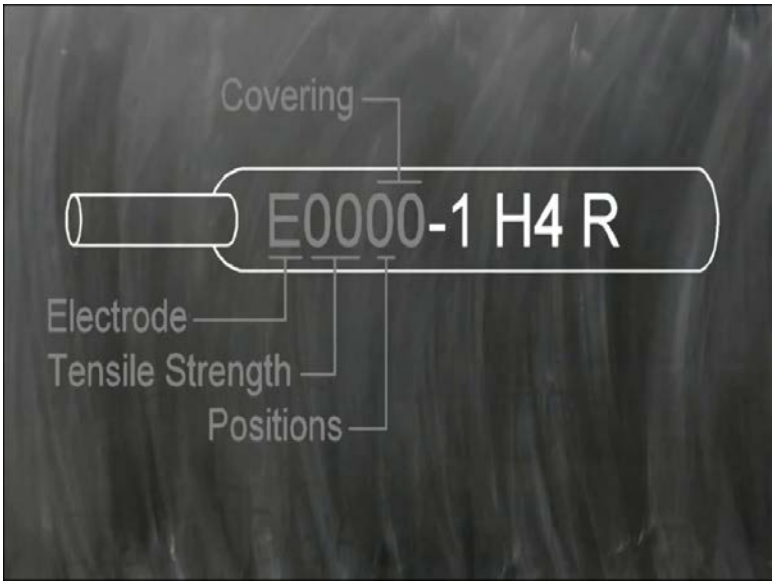

In summary stick welding is an electric arc welding process it uses a consumable electrode rod that is covered with a flux material, when heated the flux releases shielding gases that protect the weld, a layer of slag covers the weld while it solidifies and is removed when the metal cools. Stick electrodes are not all the same and must be chosen for this specific job they need to do.

So, probably it will give you a very clear idea about what the arc welding and particularly the stick arc welding is. That video clarifies also the polarity - the DC polarity and DC current and the AC current when the straight polarity and the reverse polarity in the DC current and, when the AC current is passed - all those concepts have been clarified.

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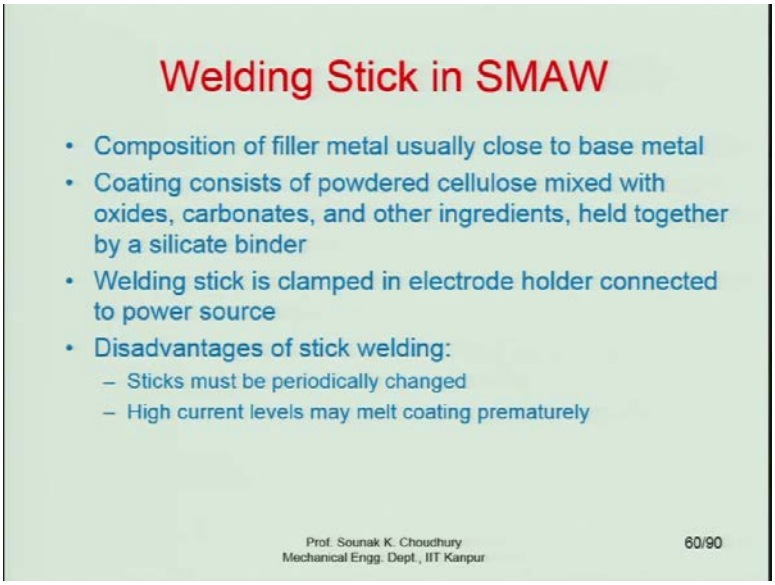

You will see what is that welding stick. Although in that video also it has been shown that on the stick, on the welding rod, there will be different kind of nomenclatures and the nomenclature meansthe composition of the filler metal, usually close to the base metal.

Because this metal is shielded. It will also add the alloying material to the base metal. Therefore, it's composition is very close to that of the base metal. Coating consists of powdered cellulose mixed with the oxides carbonates and other ingredients held together by a silicate binder. So, this is what the composition of the coating is.

Welding stick is clamped in electrode holder that you have seen in that video, connected to the power source. The disadvantage is that it will be consumed and time to time you have to change the stick. You have to stop the process that I also mentioned in my last lecture session. That is you have to stop the welding process and then change the stick and continue again.

High current levels may melt coating prematurely. Since the current is very high in that gap, so prematurely it can be melted and it will be wasted and it will not be properly welded because it is premature melting.

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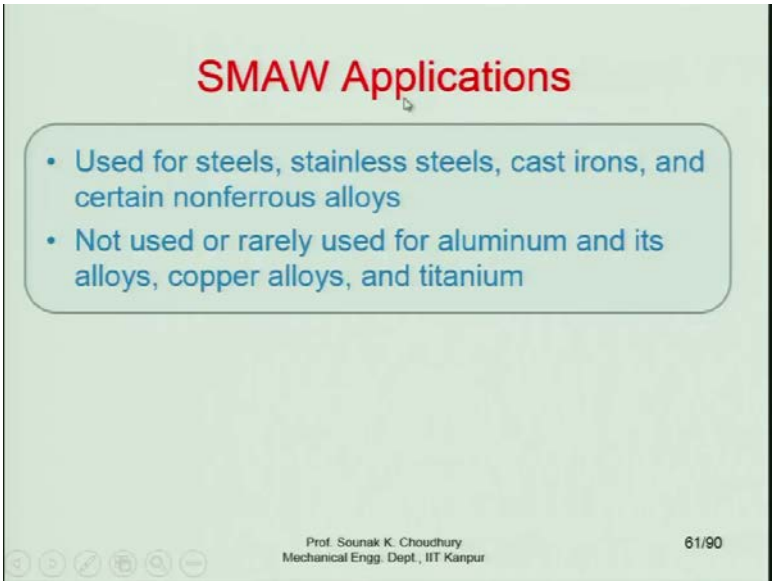

Applications: these processes are used very widely for stainless steels, cast irons and certain non-ferrous alloys as well. Not used or rarely used for aluminium and its alloys copper alloys and titanium because the heat input is very high. Therefore, these materials are not used for the welding with the stick metal arc welding.

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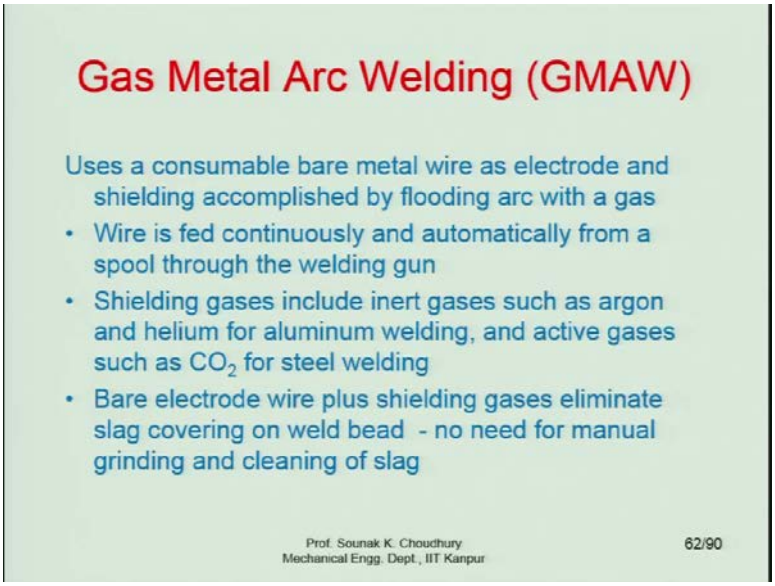

Another process is the gas metal arc welding that is comparable to the shielded metal arc welding or the stick welding. Here it uses a consumable bare metal wire. There it was a rod with the coating material and here the bare metal wire which may be in a spool and fed to the zone continuously. So, you do not have to really stop the process and change the electrode like it was in case of the shielded metal arc welding.

This wire is the electrode and shielding is accomplished by flooding arc with a gas. In of shielded metal arc welding, the shielding gas was evolved, it evolved because of the burning of the coating. Coating contained the composition that evolved the shielded gas and covered the entire zone.

Particularly the arc is Covered. Now wire is fed continuously and automatically from a spool through the welding gun. It will come continuously as I said in that case you do not have to stop the process to change it. Shielding gases include inert gases such as argon and helium particularly for such metals like aluminium welding. By the way, aluminium welding is not done in case of the shielded metal arc welding.

In this case, in the gas metal arc welding the shielding gas is supplied separately and the wire is used as an electrode; here the aluminium welding is possible. Here from outside the inert gas like argon or helium is supplied for the aluminium. And such active gases as carbon dioxide is used for the steel welding.

The bare electrode wire plus shielding gases eliminate slag covering on the weld bead. This is an advantage because when it is covered with the slag, it will stick to the weld pool. So, when the weld pool will be solidified then you have to use the grinding process to remove that slag from the top of the solidified metal.

That is eliminated because there is no slag here because the bare metal electrode has no coating. That is another advantage. No need for manual grinding and cleaning of the slag.

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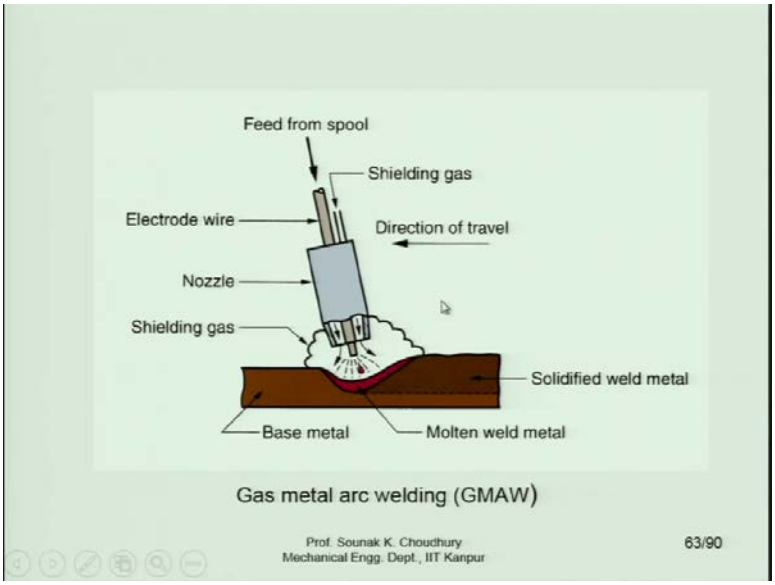

Here is the diagram. This is the schematic diagram of the gas metal arc welding here; you can see the wire from the pool. This is the electrode wire which is wrapped up in the spool.

From the spool the wire is fed continuously and it is working as an electrode. The entire nozzle with the shielding gas passing through, will be moving along the path where the electrode with welding required and this is the base metal where the welding is required.

And this is solidified weld metal. The weld metal will be the material from the wire. This wire will be exhausted, but since it will be wrapped up in a spool, it will be continuously fed and it will be deposited on this and after solidification, this will be the solid weld metal.

Around that arc there will be shielding gas which as I said for aluminium it is the inert gas, for steel it is the carbon dioxide, and so on. It will protect the weld pool from the outside contamination and from being oxidized.

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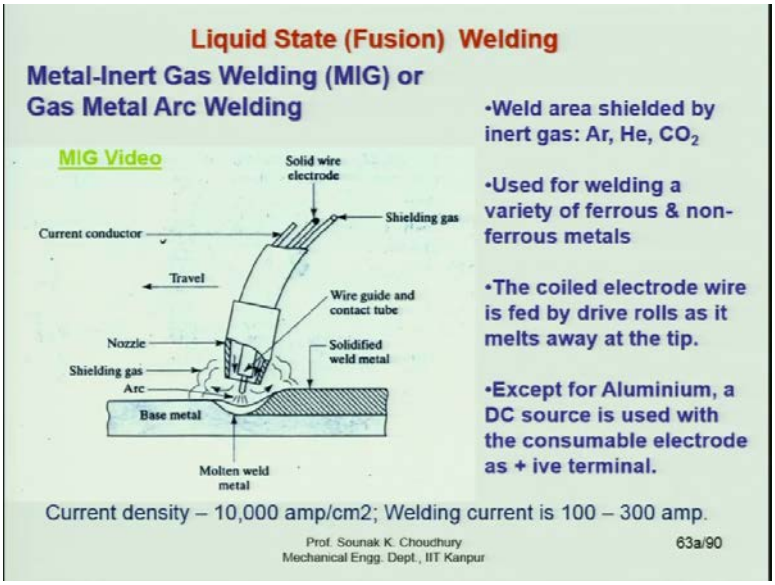

Liquid-state welding: fusion welding we are continuing. This is another welding process which is called the metal inert gas welding and this is very popularly used in industry. It is called the MIG welding or this is also called the gas metal arc welding.

The gas metal arc welding is what we started discussing with and we said that schematically it is like this. More details I will show you in a small video. Before I go to that, I will just describe some of the characteristic features of the MIG welding. As I said that MIG welding is the same as the gas metal arc welding.

The weld area shielded by inert gas like argon or helium for aluminium, carbon dioxide for the steel used for welding a variety of ferrous and non-ferrous metals. The coiled electrode wire is fed by drive rolls as it melts away at the tip. As it is melting away, it will be fed with the help of the drive roll from the spool. Except for aluminium a DC source is used with the consumable electrode as positive terminal.

Normally this wire is made as a positive and the workpiece is made as a negative terminal. The current density is very high which is 10000 amperes per centimetre square and the welding current also is very high it is up to about 300 amperes. 300 ampere current is very very high current as you know that. Even up to 1 ampere current may kill a person. I will show you a small video which will again clarify the working principle of the MIG or the Metal Inert Gas welding.

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What is MIG welding? MIG stands for metal inert gas welding.

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The American welding society calls this process Gas Metal Arc Welding or GMAW.

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You might also hear it called wire welding, a MIG welding a thin wire acts as the electrode.

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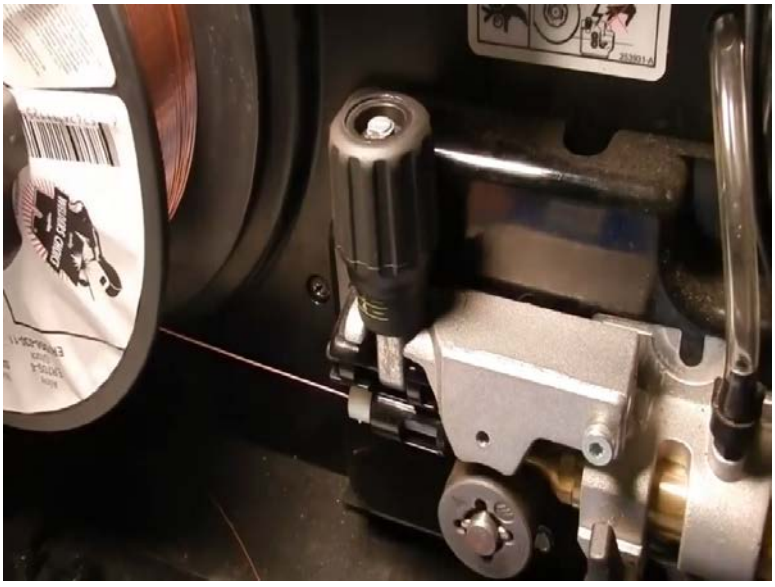

This wire is fed from a spool melted on a gun or inside the welding machine through a flexible tube.

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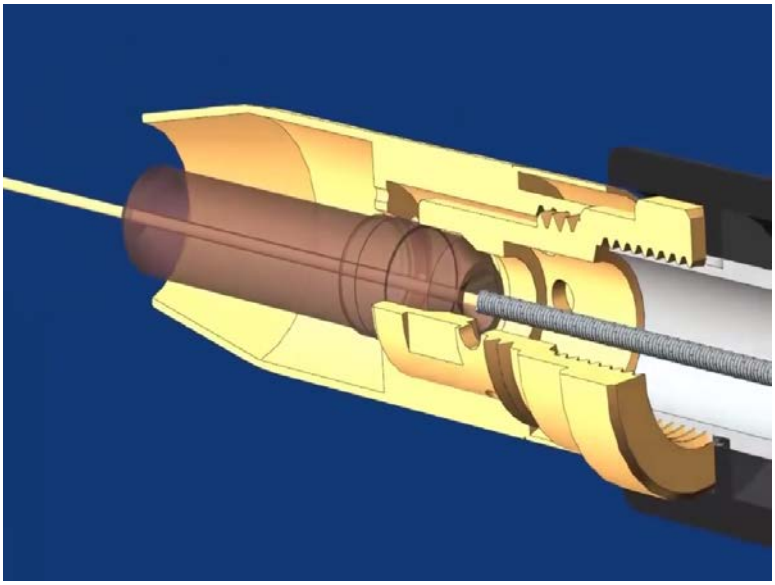

And out of the nozzle on the welding gun or torch the wire is fed continuously when the trigger on the welding gun is pulled.

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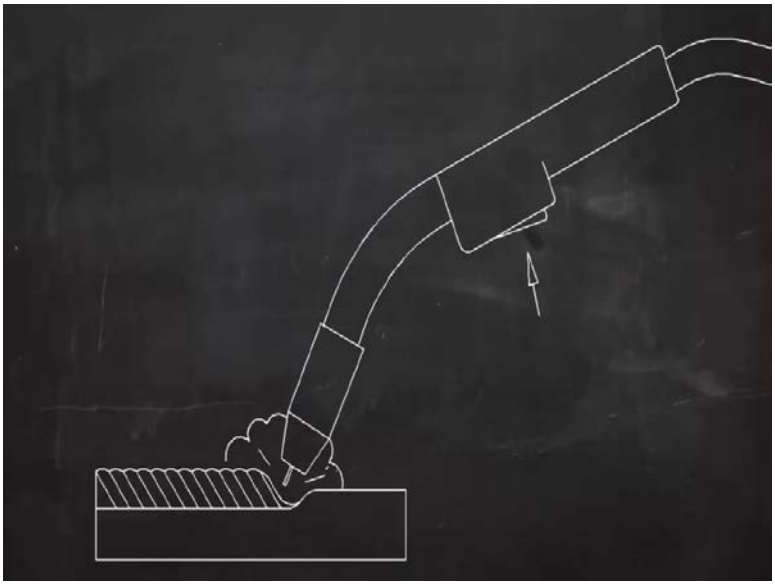

When this trigger is pulled it also switches on welding current and a shielding gas.

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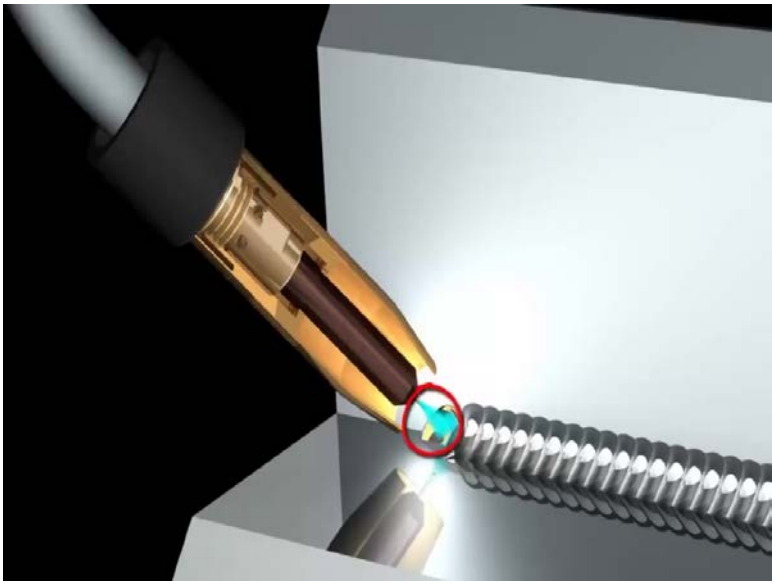

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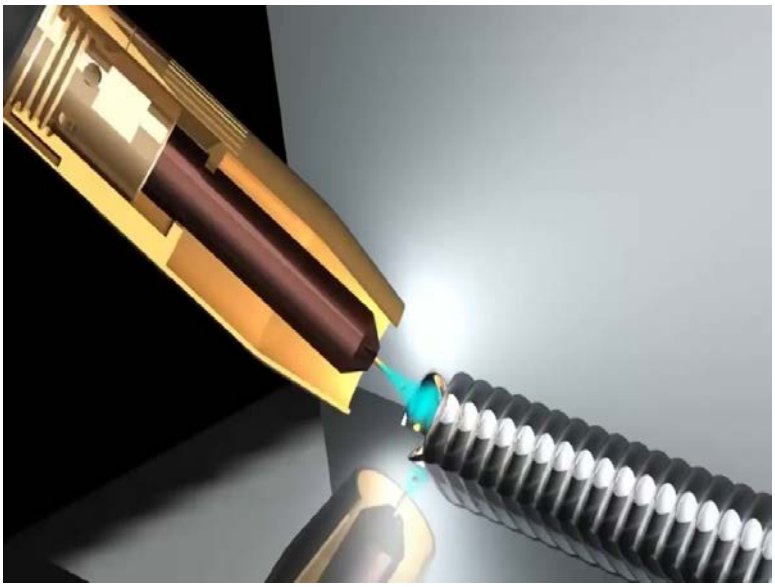

And like to arc forms between this wire electrode in the workpiece and heats both metals above their melting point.

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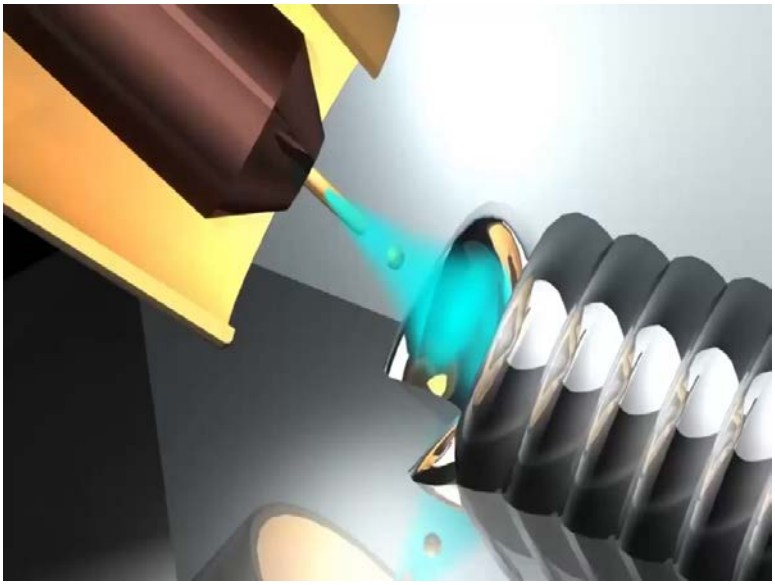

These metals mix together or colourless and solidify to join the workpieces into a single piece.

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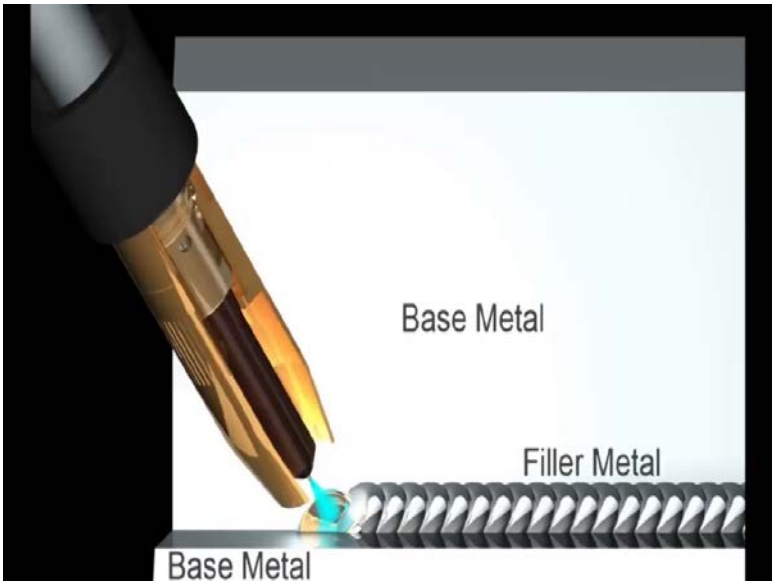

The metal in these parts to be joined is called the base metal and the metal that comes from the melting wire electrode is called filler metal. MIG welding always adds filler metal to the joint.

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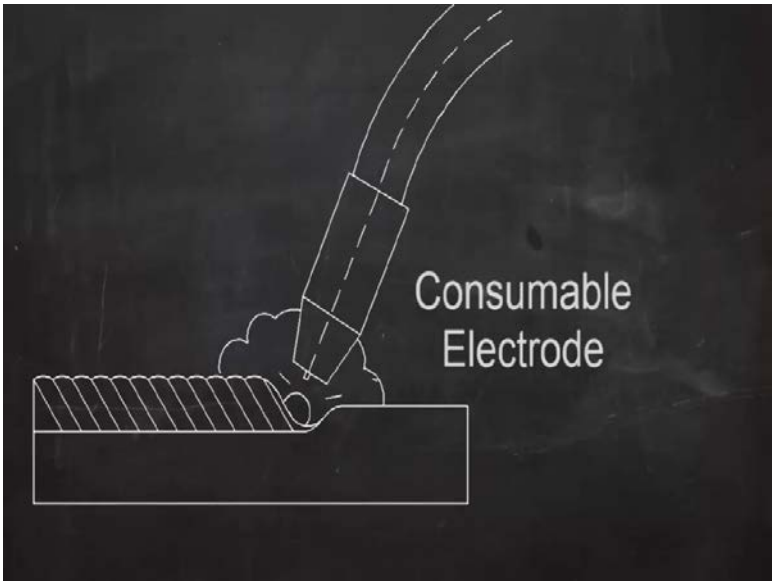

Because the wire electrode melt as its being used MIG is called a consumable electrode process.

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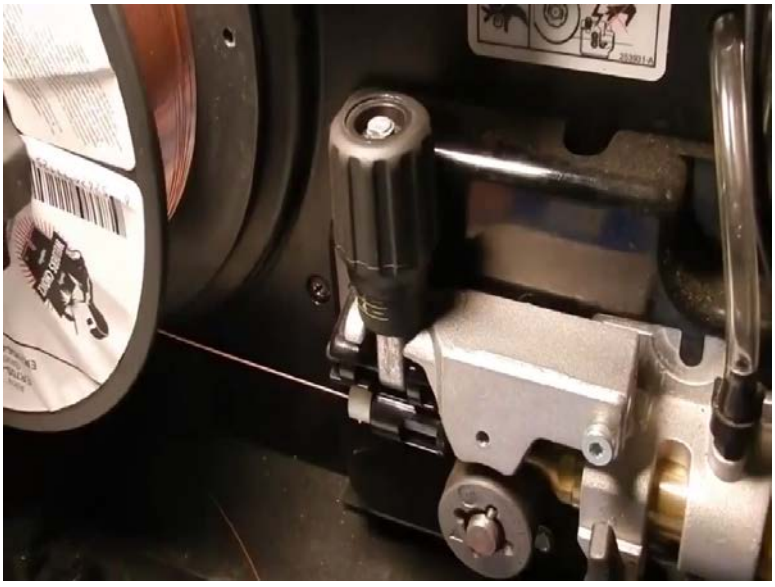

Here is the MIG wire going through the wire feeder into a flexible tube or conduit liner.

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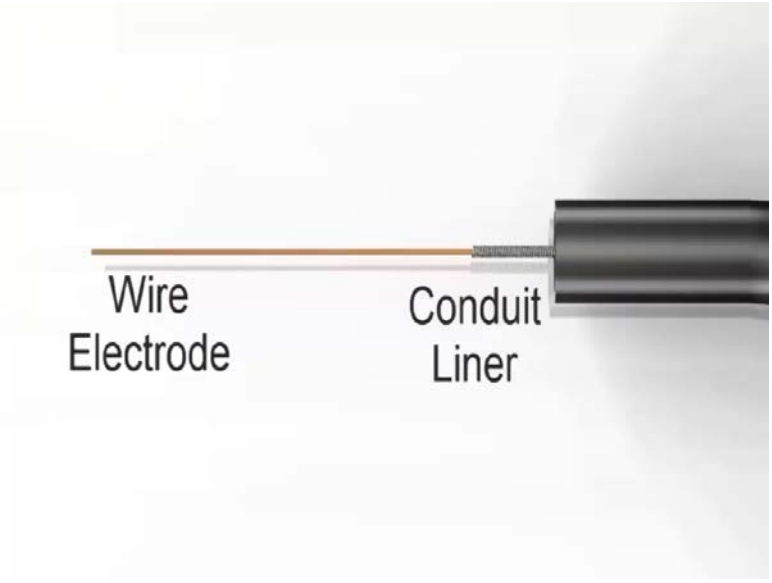

The liner goes through the hose or welding lead all the way to the torch nozzle.

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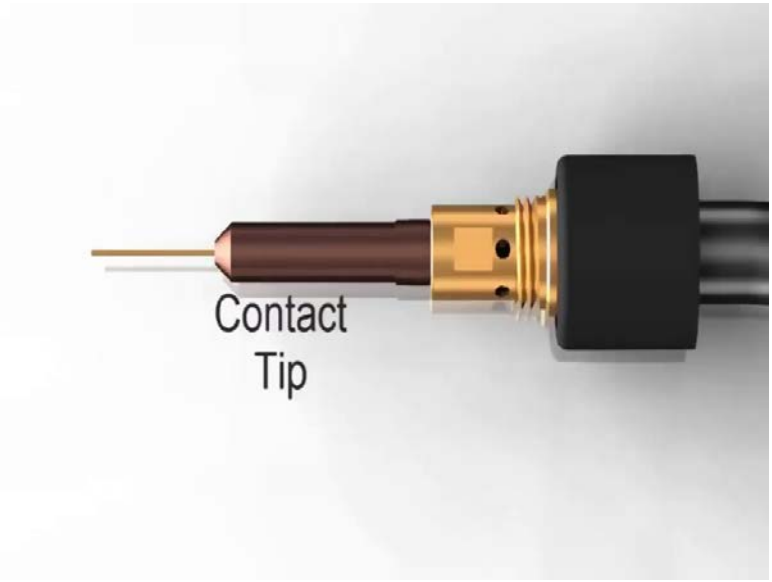

At the nozzle the wire is fed through a contact tip and comes out at the point of the weld.

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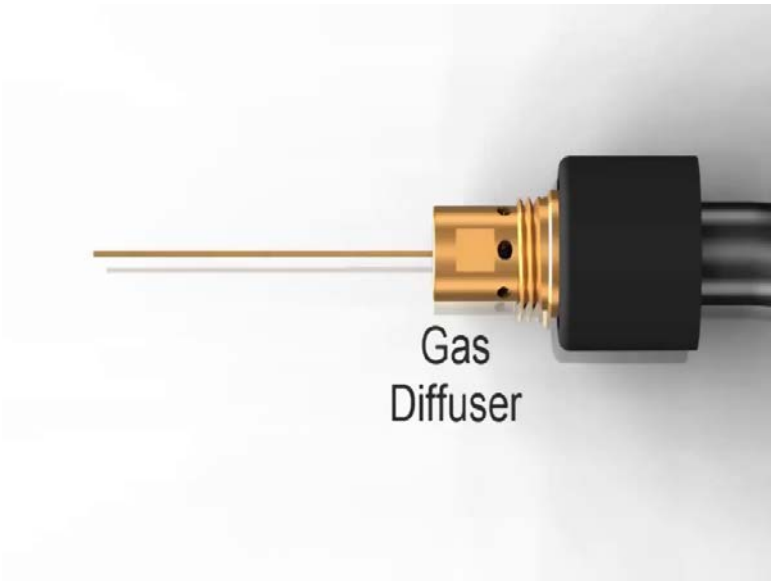

Shielding gas is also fed through the welding lead it goes through a gas diffuser and flows out of the nozzle.

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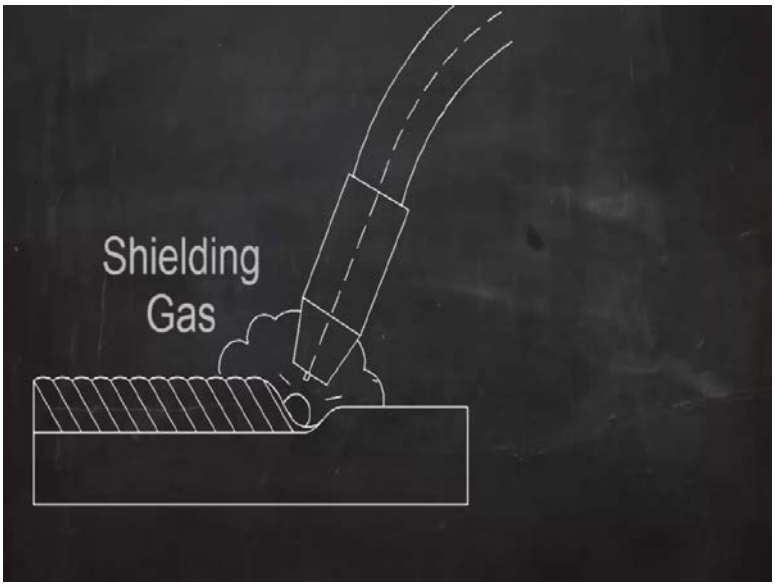

This shielding gas which is often a mix of argon and CO2 protects the molten metal from reacting with oxygen, water vapour and other things in the atmosphere.

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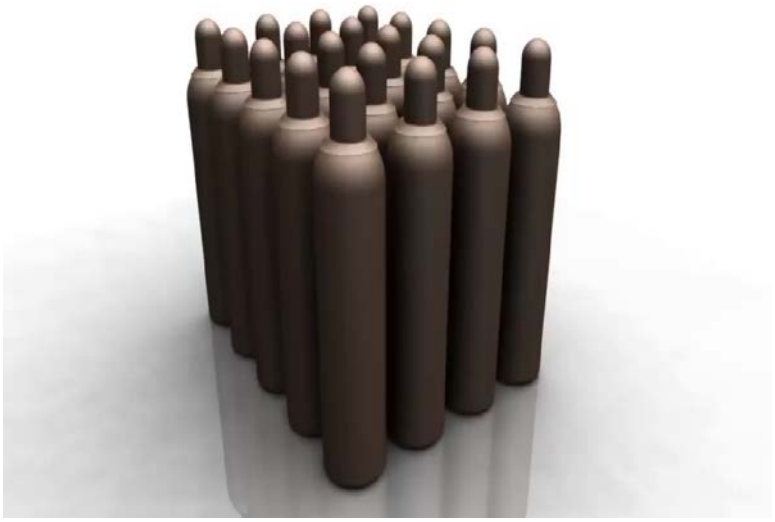

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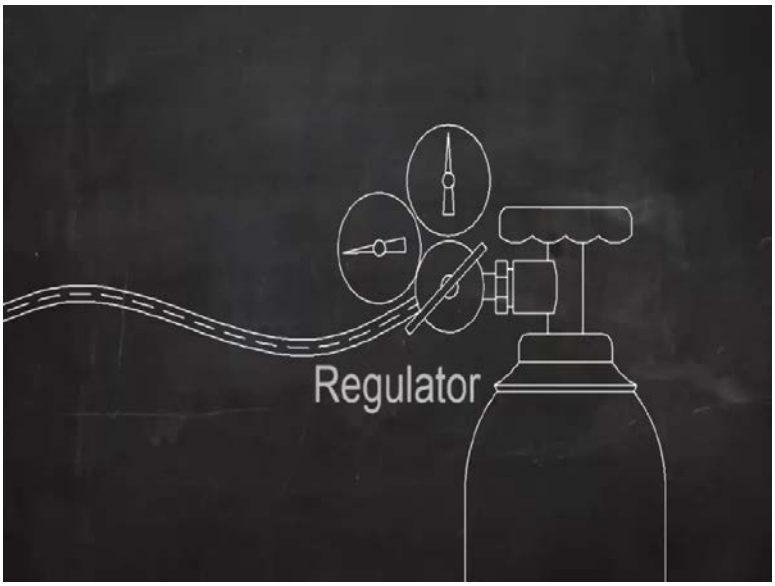

The shielding gas is stored in high pressure cylinders like these the pressure is reduced to a usable level by a device called regulator.

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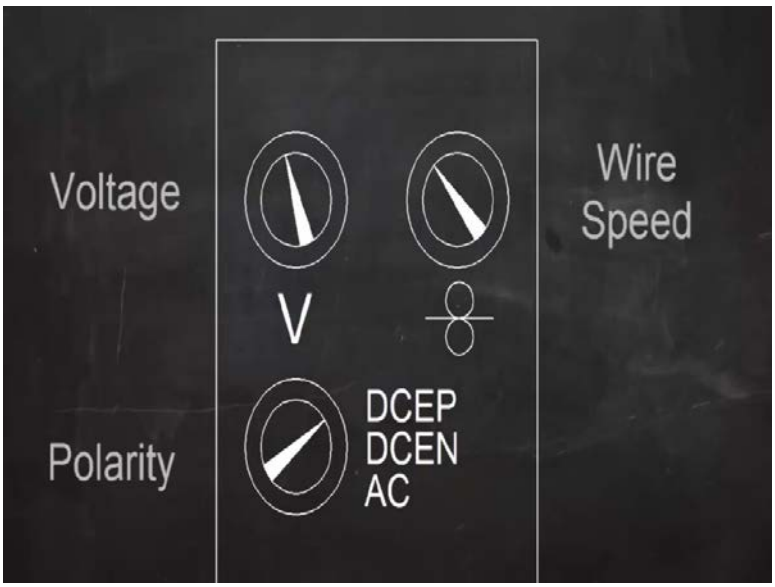

And MIG welding all the machine controls are set on the machine itself, the most important of these are polarity wire speed and voltage the trigger on the gun is just an on off switch.

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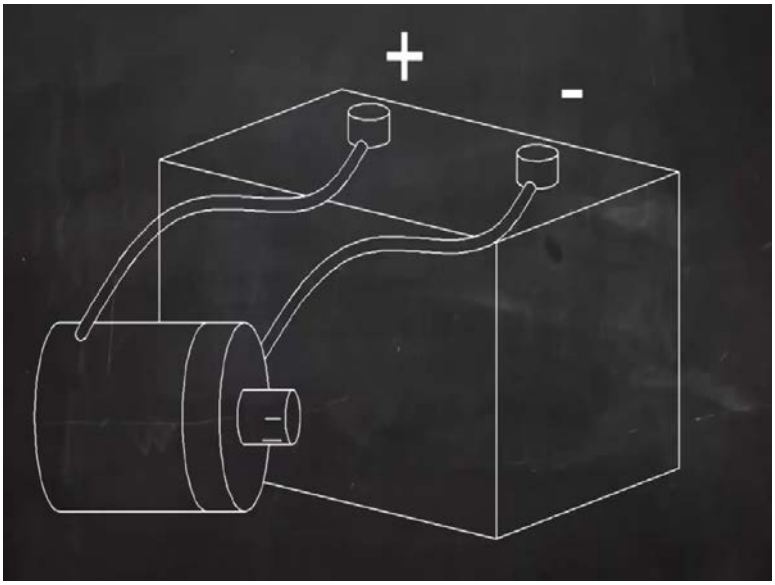

For most MIG welding the current is direct current or DC; DC is like the current flowing from a car battery one wire is always the negative and one is always positive.

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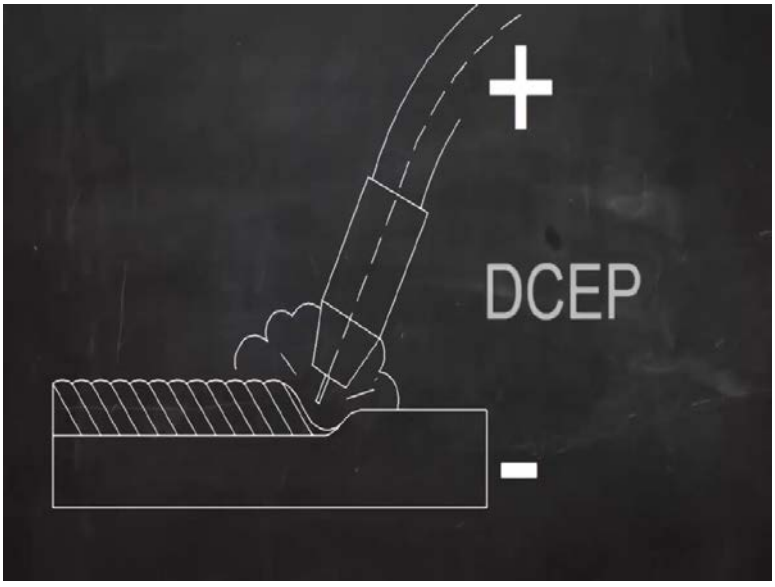

In DC MIG welding the electrode is usually positive and the workpiece is negative. The term DCEP is used indicating that the current is direct current and the electrode is positive.

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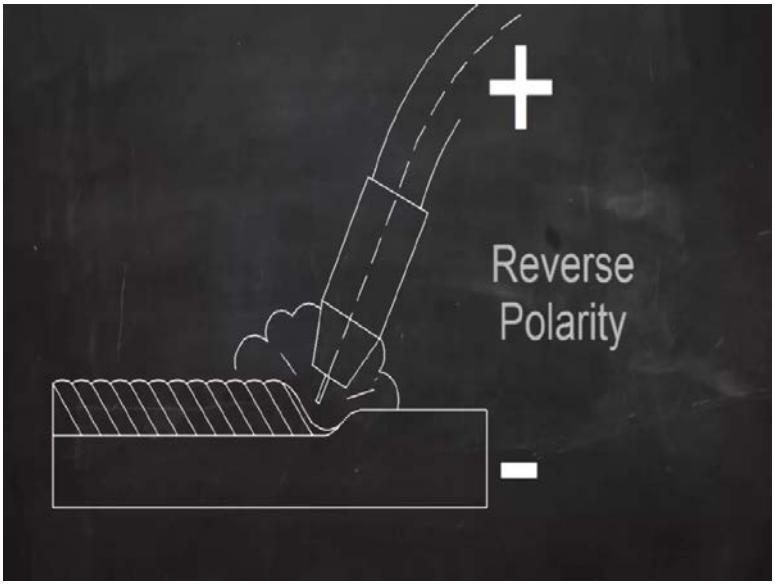

This is also called reverse polarity, but DCEP is a more descriptive term and an electric circuit the current flows in a loop.

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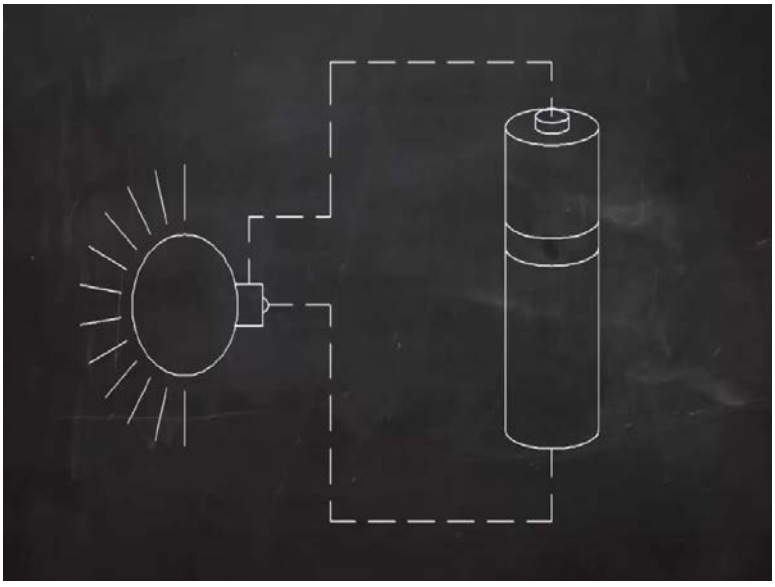

In MIG welding the current has to flow in a complete circle from the machine to the torch into the work and back to the machine.

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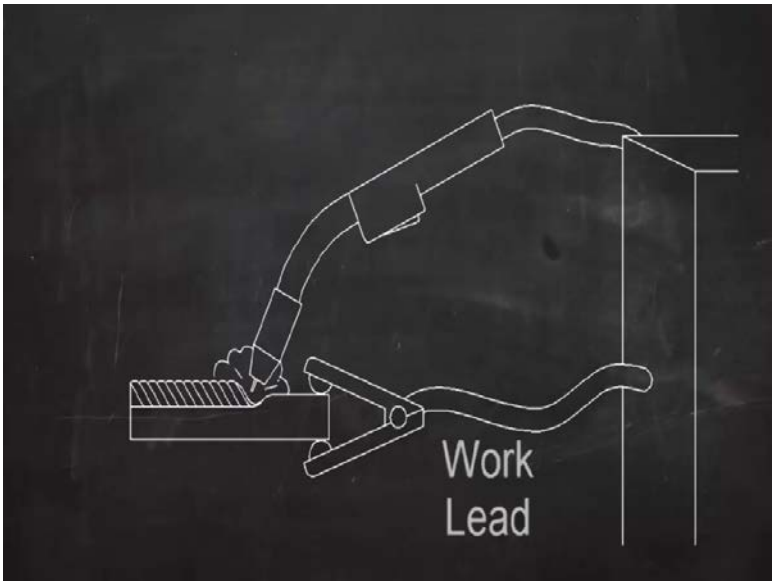

The work lead is clamped to the work to complete the circuit from the workpiece back to the machine.

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So, in summary MIG welding is an electric arc welding process.

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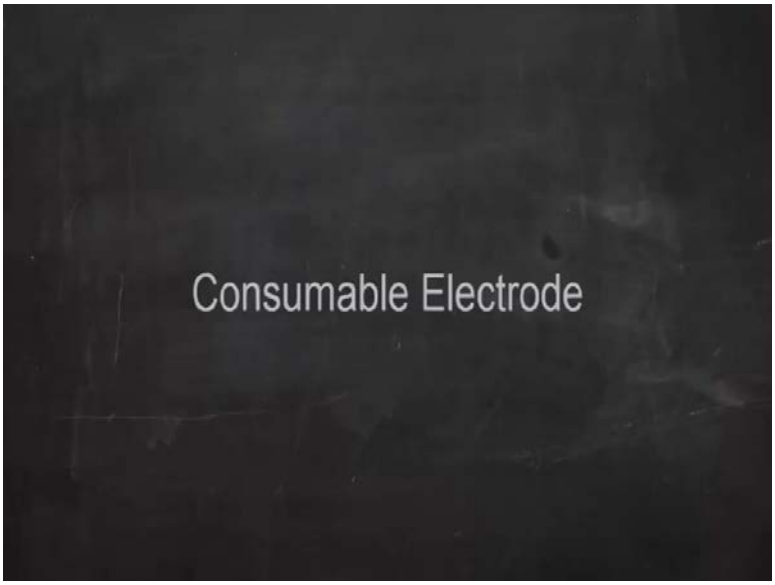

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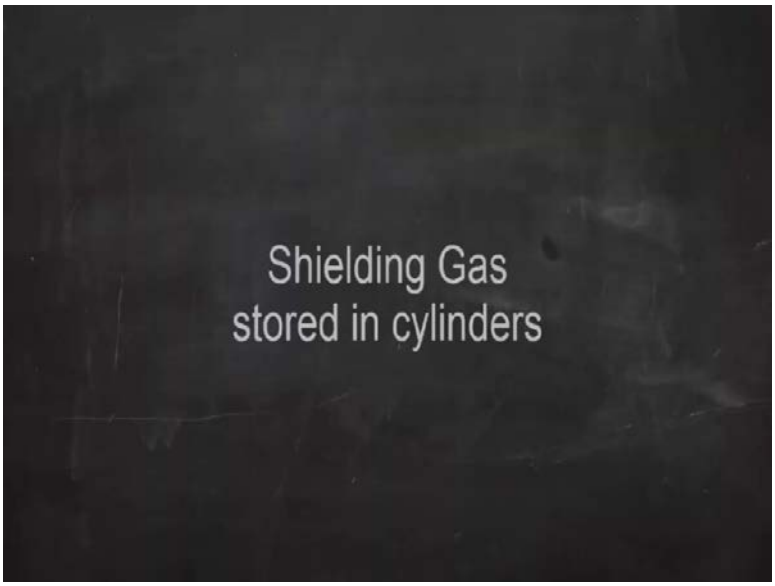

It uses a consumable wire electrode. Filler metal is added automatically and the shielding gas comes from a high pressure cylinder.. So, you have seen that video and I hope this gives you a clearer picture of the MIG welding. There are MIG welding machines.

They are quite elaborate and in that MIG welding machine that you have seen in this video, all the arrangements are be there, that is, the spool with the wire, the shielding gas cylinder separately coming to the zone, the travelling nozzle and so on.

And you have seen that there are regulators for the gas and the knobs for selecting the voltage and the current. It also indicates at a certain time what is the voltage and what is the current. The current density is very high and the current is about 100 to 300 amperes. Whereas, the current density is about 10000 amperes per centimetre square, so this is very high.

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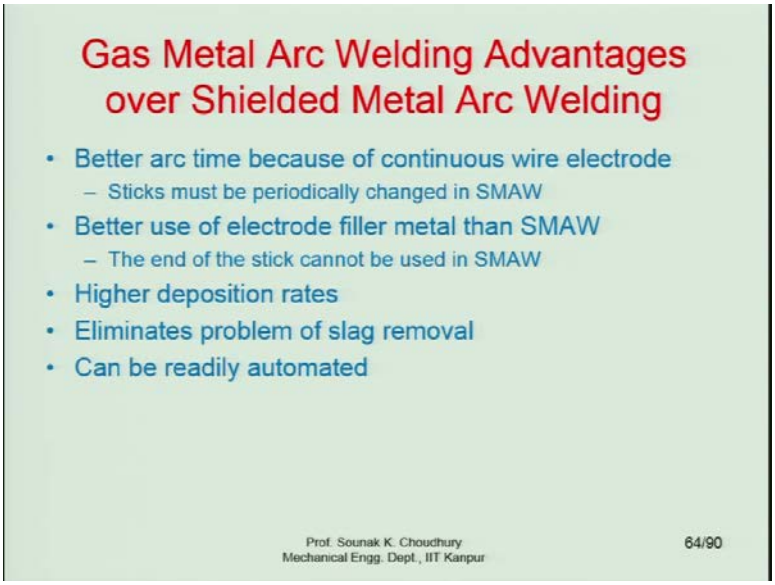

Gas metal arc welding advantages over the shielded metal arc welding: some of them I told you already, better arc time because of continuous wire electrode. The sticks in the case of the shielded metal arc welding must be periodically changed.

You have to stop the process to change the electrode. Better use of electrode filler metal than in case of the shielded metal arc welding. Here it is the wire and it is being fed from a spool continuously, so it will be better used because in case of the shielded metal arc welding what happens is a particular length of this cannot be used since it is very close to the holder.

But in this case the entire wire is being used. The end of the stick cannot be used here. Higher deposition rates in case of the gas metal arc welding. Eliminates problem of the slag removal - this has been already said that there is no slag, so there is no question of removing that slag layer by manual grinding or other processes, can be readily automated.

Many labs of many institutes now have the MIG welding machine since they have become not very expensive because they are produced in a mass production and they are quite automatic machines.

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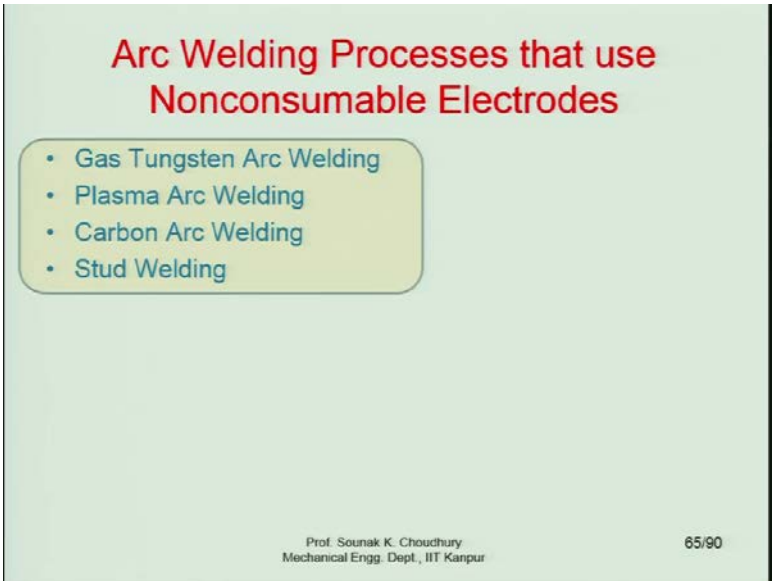

Arc welding processes that use non consumable electrodes: Gas tungsten arc welding, plasma arc welding, carbon arc welding and the stud welding. These are the different arc welding processes which use non consumable electrode.

So far what we have seen is the consumable electrode with the shielded metal gas; shielded metal arc welding or the gas metal arc welding, in both cases the electrode is consumable. But these 4 cases of the arc welding processes use the non consumable electrodes.

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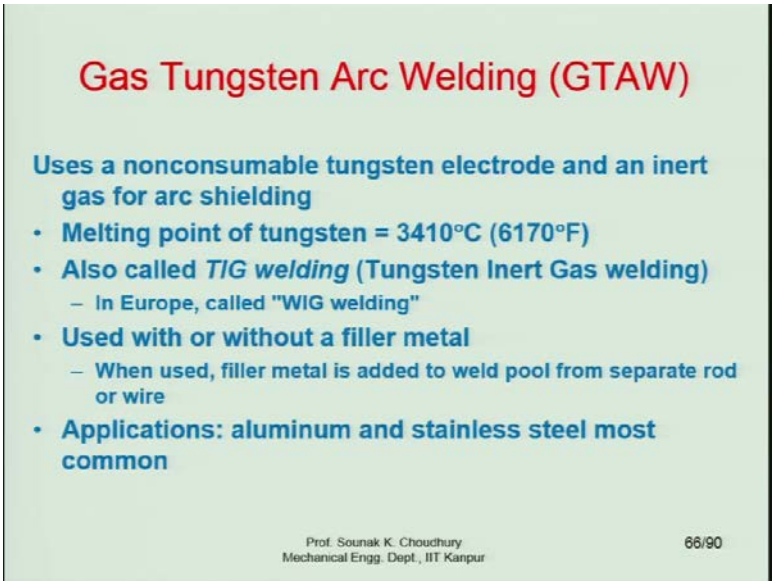

Let us see what is that gas tungsten arc welding. It uses a non consumable tungsten electrode and an inert gas for arc shielding.

Instead of the wire here there is a tungsten wire, tungsten rod and that tungsten rod is not consumable, that is not being worn out and the same tungsten rod can be used for many times for the welding process. Melting point of tungsten is very high, it is about 3410 degrees centigrade.

Also called the TIG welding like we have seen the MIG welding. These two processes have become very popular and those automatic machines are being installed in many places in many Institutes. You must have had one in your Institute, this is called the TIG welding. TIG welding is Tungsten Inert Gas welding. The electrode is tungsten wire or tungsten rod and the shielding gas is passed separately.

TIG welding or tungsten inert gas welding in Europe it is called WIG welding because W stands for tungstenor wolfram. If you see the tungsten in Mendeleev's periodic table, you will see that that is W; Wolfram is the name of the tungsten. I mean the tungsten is also called wolfram.

From that W is coming and they call it WIG welding instead of tungsten inert gas TIG welding in Europe. Used with or without a filler metal, separately a filler metal may or may not be used that depends on the kind of the metal that is being welded.

When filler metal is added to weld pool from separate rod or wire that is understood like in all cases of filler metal. And it is applied widely for aluminium and stainless steel.These are the most common materials that are used for the TIG welding.

We have discussed MIG and TIG welding which are very important and the modern welding processes. In MIG it is the consumable in TIG it is non consumable electrode used. The rest of the material I will discuss in our next lecture session.

Thank you for your attention.