Advanced Manufacturing Processes
Prof. Dr. Apurbba Kumar Sharma
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

Module - 4
Advanced Welding Processes
Lecture - 1
Submerged Arc Welding (SAW)

Welcome to this new module on advanced welding processes, under the course advanced manufacturing processes. In the previous modules, we have discussed about advanced casting processes in the module 1, then the advanced machining processes. In this module module 4, we will be discussing about some of the advanced welding processes, the conventional welding processes, like arc welding and gas welding, serve variety of purposes. Yet there are requirements, when we need to apply newer welding processes to cater to some specific requirements as mentioned below. These are joining of thick plates, structures and large joints.

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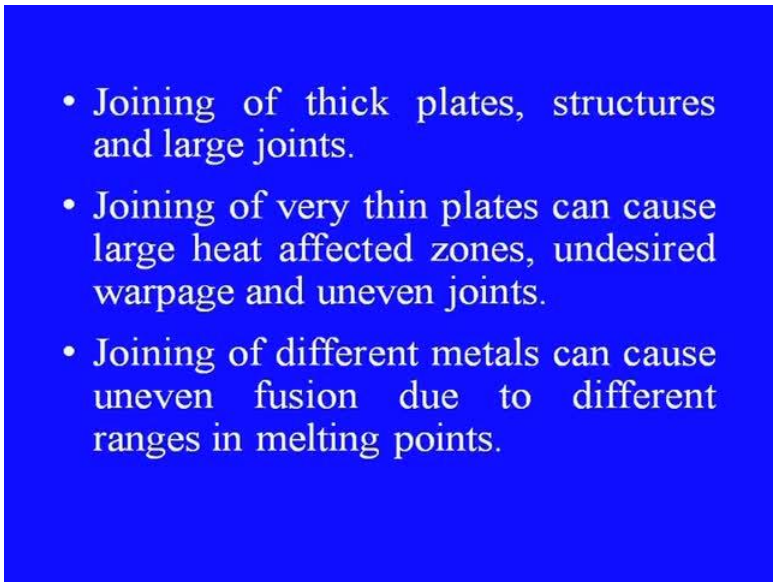

Then joining of very thin plates can cause large heat affected zones, and undesired warpage and uneven joints. This eventually may spoil the work pieces completely. Then joining of different metals can cause uneven fusion due to different ranges in melting points. Requirements of good finish low heat affected zones and high quality weld

demand, use of advanced or non conventional welding methods. In order to cater to these requirements, the following newer welding processes have come into existence.

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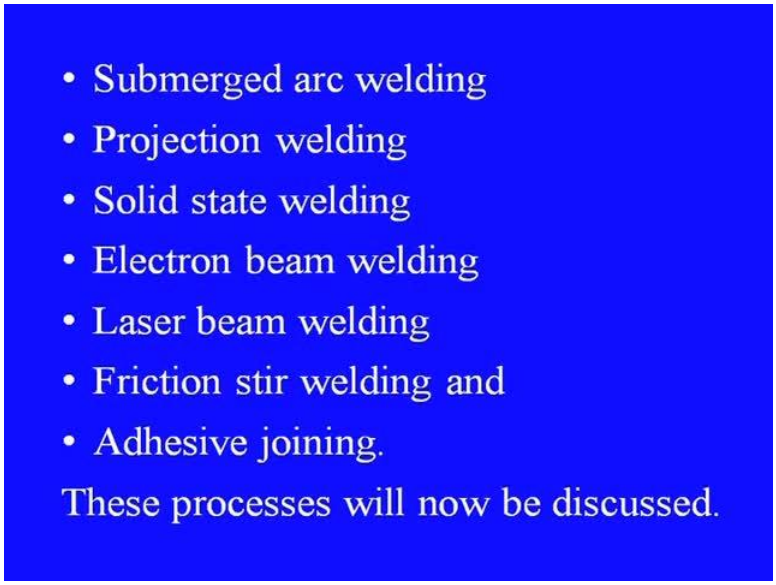

Number one, submerged arc welding, two projection welding, three solid state welding, four electron beam welding, five laser beam welding, six friction stir welding, seven adhesive joining and eight microwave joining. This processes will now be discussed one by one, let us first discuss submerged arc welding.

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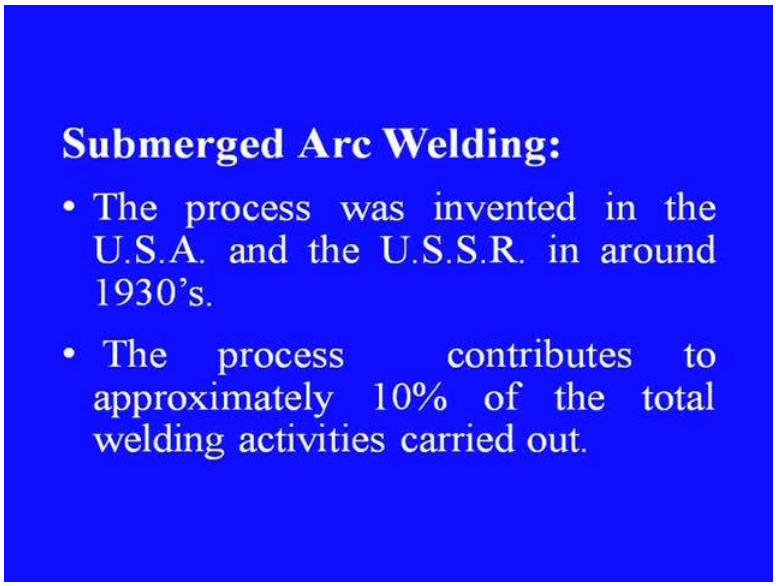

This process was invented in the United states of America and first of all Soviet Union in around 1930s. The process contributes to approximately 10 percent of the total welding activities, being carried out worldwide. In this process, the arc is submerged under a blanket of flux. Hence, it is not visible from outside, the schematic is shown in the screen.

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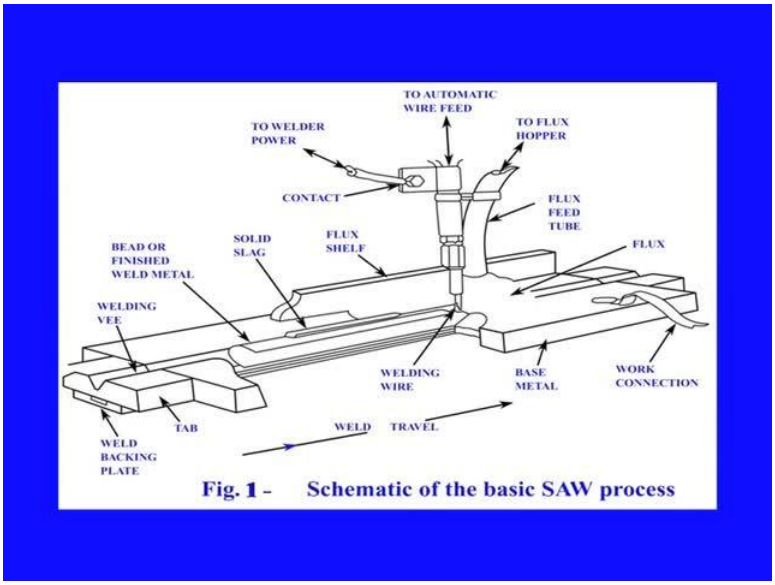

So, this is the common submerged arc welding process, in which this is the flaws, what we were talking about and the arc will be in between this, beneath this, which will be not visible otherwise. And this is this is the welding wire through which, the arc will be produced and this wire will get melted and deposited here. Therefore, this this end, this will be automatic feed for feed for the wire through this end, the wire will be fed into the position of the arc. This this will be the power supply to this to this and to this electrode.

The other the other point of the power will be connected to the work through this. Thus this will be moving during the welding process. So, here in this particular case it is being shown, it is moving from this to this. Therefore, the welding will be carried out or the fusion of the material will take place on the part of this travel of this electric wire. This welding wire and this flux will cover this arc at this point of welding. These are other arrangements for holding the work piece as well as for the movement of the movement of the welding torques, we can say.

Now, let us talk about the principles of operation of this submerged arc welding process. In this process, the end of the continuous bare wire electrode is inserted into a mould of flux, that covers the area or joint to be welded and arc is initiated using some of the common arc starting methods.

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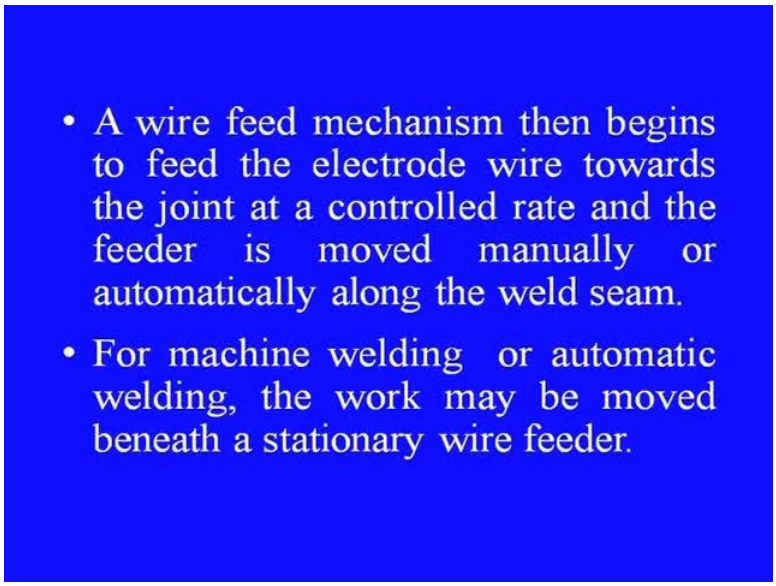

A wire feed mechanism then begins to feed the electrode wire towards the joint at a controlled rate and the feeder is moved manually or automatically along the weld seam. This is what we have just seen in the figure and we have already discussed. For machine welding or automatic welding the work may be moved beneath a stationary wire feeder. Additional flux is continually fed in front of and around a electrode andit is continuously disturbed, distributed over the joint through the hopper. Heat evolved by the electric arc progressively melts some of the flux, the end of the wire and adjacent edges of the base metal, which creates a pool of molten metal beneath a layer of liquid slag.

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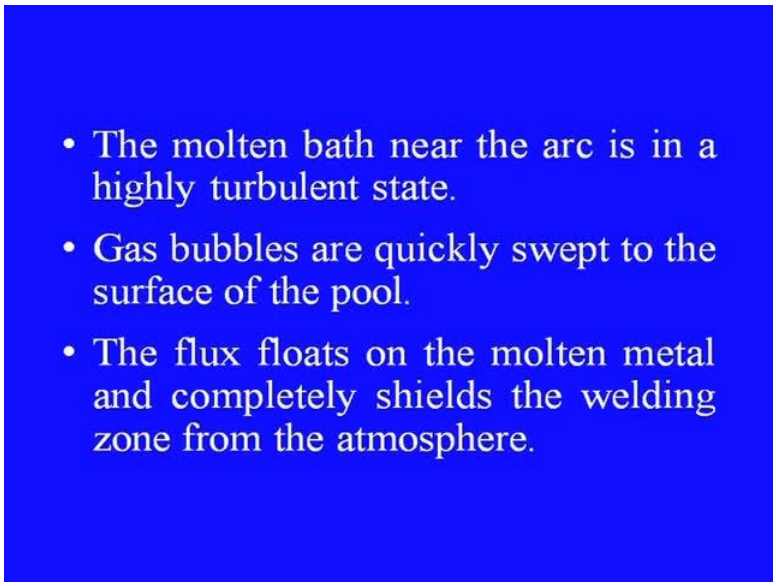

The molten bath near the arc is in a highly turbulent state. Gas bubbles are quickly swept to the surface of the pool. The flux floats on the molten metal and completely shields the welding zone from the atmosphere. The flux blanket on that top surface of the weld pool prevents atmospheric gases from containing the weld metal. It dissolves impurities in the base metal and electrode and floats them to the surface. The flux can also add or remove certain allowing elements to or from the weld metal.

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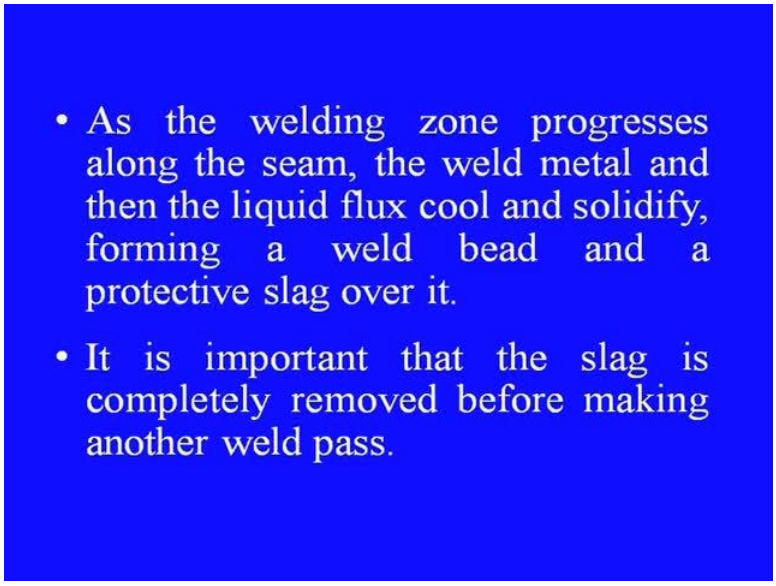

As the welding zone progresses along the seam the weld metal and then the liquid flux cool and solidify forming a weld bead and a protective slag over it. However, it is important that the slag is completely removed before making another weld pass. Now, let us see the factors, which determine the usage of submerged arc welding these factors include.

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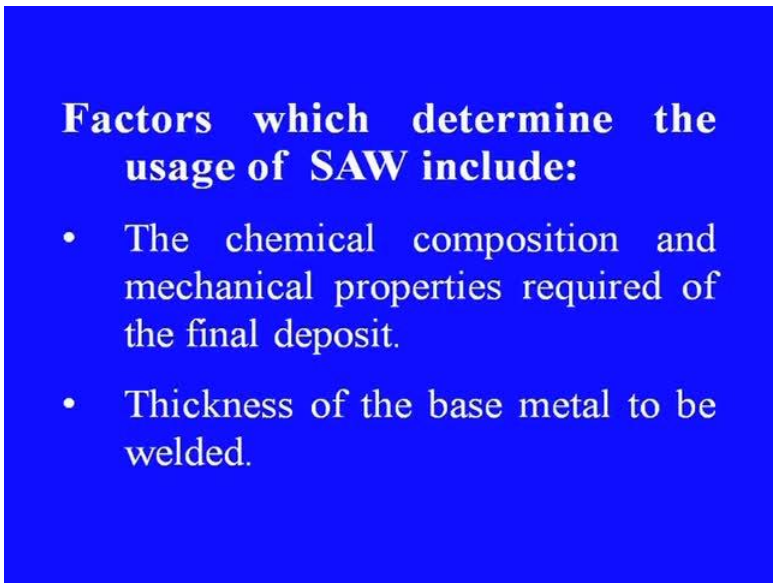

Number one, the chemical composition and mechanical properties required of the final deposit. Number two thickness of the base metal to be welded.

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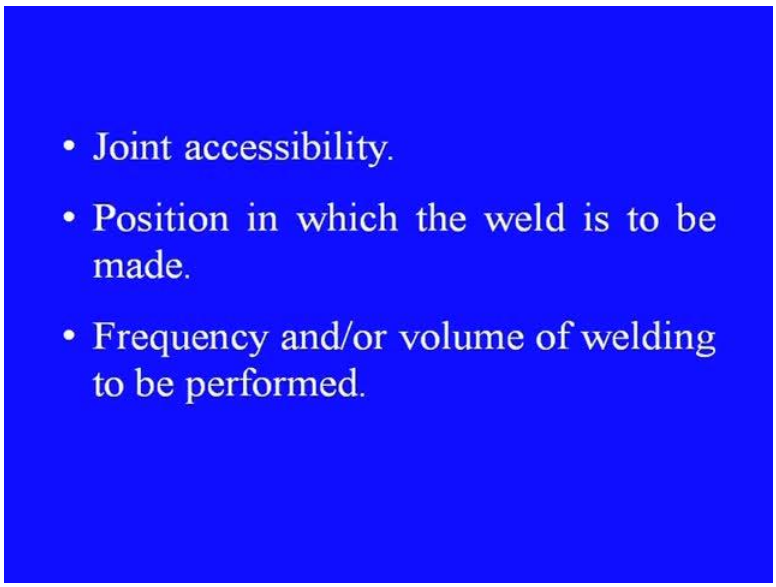

Number three, joint accessibility. Number four, position in which the weld is to be made. Number five, frequency and or volume of welding to be performed. Now, let us look at the characteristics of submerged arc welding process. This process is known for higher metal deposition rate. Higher welding speed, the process has higher process efficiency, lower nitrogen and hydrogen content in the weld metal. Cleaner weld metal, the process has better control over the chemical composition and better control over on the mechanical and metallurgical properties.

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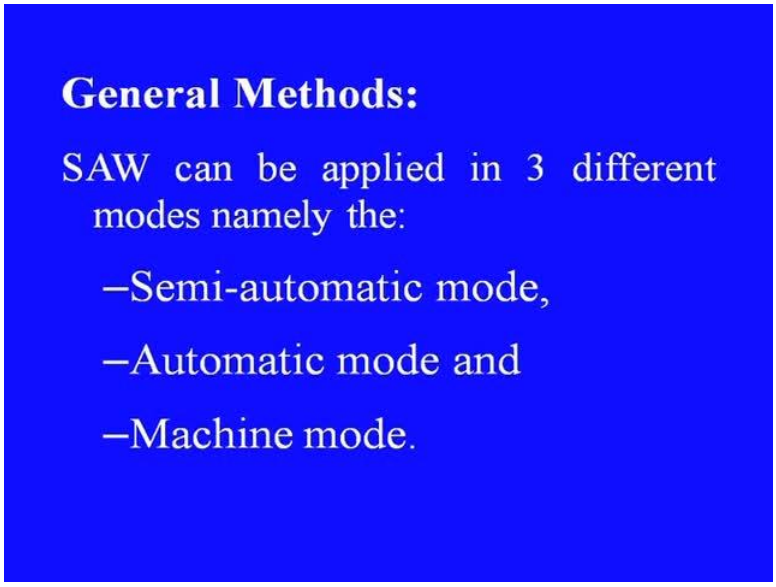

Now, let us talk about the general methods of submerged arc welding process. The process can be carried out in three different modes, namely the semi automatic mode, automatic mode and machine mode. Each method requires that the work piece be positioned such that the flux and the molten wire pool will remain in place. Until there solidified many fixers and positioning equipment can be used for typical requirements like this. Now, let us talk about the semi automatic welding mode.

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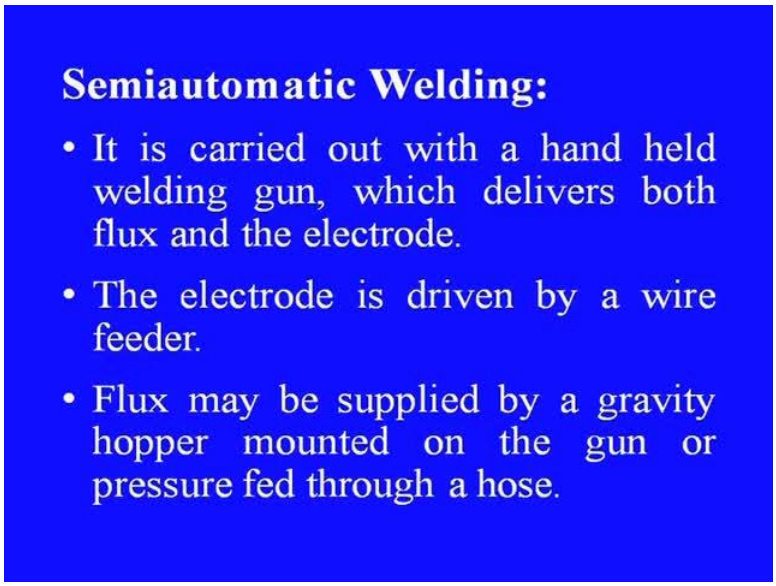

It is carried out with a hand held welding gun, which delivers both flux and the electrode. The electrode is driven by a wire feeder. The flux may be supplied by gravity hopper mounted on the gun or pressure fed through a hose. This method features manual guidance using relatively small diameter electrodes and moderate travel speeds. The travel may be manual or driven by a small gun, which is mounted with a driving motor. Now, let us see the automatic welding process.

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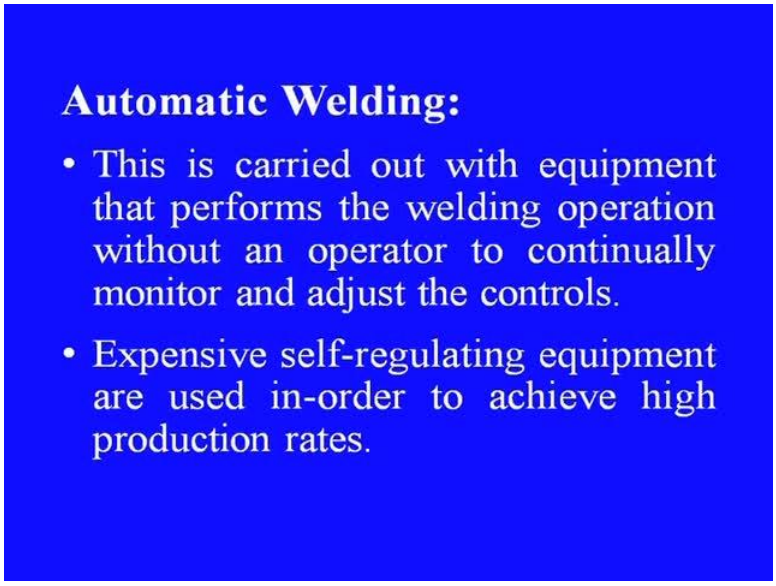

This this is process is carried out with equipment that performs the welding operation without an operator to continually monitor and adjust the controls. Expensive self regulating equipment are used in order to achieve high production rates, in this welding method. Then finally, to the machine welding matter this employs an equipment, which perform the complete welding operations.

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It only needs monitoring for positioning the work, start and stop welding, adjust the controls and speeds of each weld. Submerged arc welding requires, some edge preparations and provisions for backup strips, for effective welds to take place. The details of these are indicated in the next figure and the process parameters are indicated in the next table.

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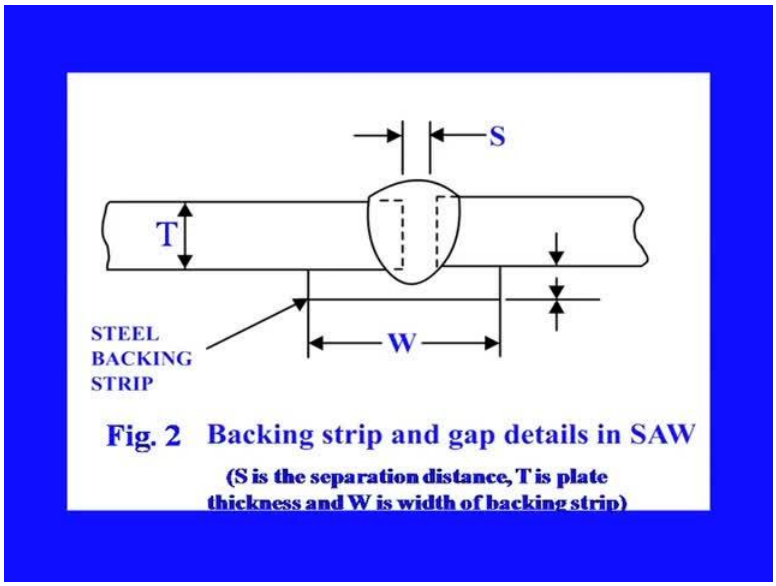

Fig. 2 Backing strip and gap details in SAW

(S is the separation distance, T is plate thickness and W is width of backing strip)

So, this is a basic configuration used in submerged arc welding process as shown in this screen. So, these are the two base materials, so they are positioned like this, were in this portion the welding is to be carried out and the thickness of this base materials is T and W is the width of the backing strip. Just now, we were talking about one backing strip is required for effective welding in this process and this is what is the width of this backing strip. This we can easily understanding form this configuration that this width must be greater than the joint width. This S is the separation between these two base metals. So, this table shows the parameters used in submerged ach welding process.

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Table-1 Process parameters in SAW

Plate Thickness T	Root Opening S	Current	DCEP Voltage	Travel Speed	Electrode diameter	Electrode consumption	t, min	W, min
mm	mm	A	V	mm/s	mm	Kg/m	mm	mm
3.6	1.6	650	28	20	3.2	0.11	3.2	15.0
4.8	1.6	850	32	15	4.8	0.19	4.8	19
6.4	3.2	900	33	11	4.8	0.25	6.4	25.4
9.5	3.2	950	33	10	5.6	0.36	6.4	25.4
12.7	4.8	1100	34	8	5.6	0.69	9.5	25.4

So, this talks about the thinness of the plate. Then what should be route happening, the current required then DCEP, which is called direct current electrode positive voltage. Then the travel speed, then electrode diameter, electrode consumption, then the thickness and the width. So, here different parameters say for example, for plate thickness of 3.6 millimeter route happening generally is taken to be 1.6 mm. current applied is 650 amperes this a v voltage is 28 volts. Then travel speed is set at 20 millimeter per second. Then electro diameter used is generally 3.2 millimeter, whereas, the electrode consumption rate is 0.11 k g per meter.

Then the time for this welding to be carried out is 3.2 minute and width is 15 millimeter. Similarly, for other plate thicknesses like 4.8, 6.4, 9.5, 12.7 seven etcetera are given in this particular table and this can be calculated or can from experimental data, this can be arrived at. Now, let us talk about one of the most important components in this system that is flux.

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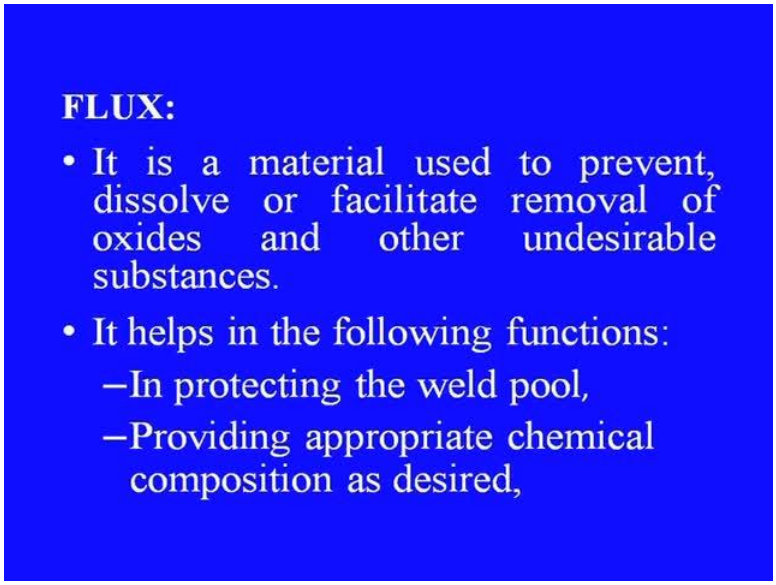

Flux is a material used to prevent, dissolve or facilitate removal of oxides and other undesirable substance. It helps in the following functions; number one, it protects the weld pool from the oxidizing agents or the oxidizing environment. It provides appropriate chemical composition as desired. Then it helps in improving the properties by allowing materials appropriately, that means we can add few materials in terms of flux also or the through or the use of flux also. It helps in deoxidizing the weld metal, it

helps in improving weld bid safe parameters, also helps improving the efficiency of metal deposition and stabilizing the arc. Let us talk about another important component in this system that is power sources.

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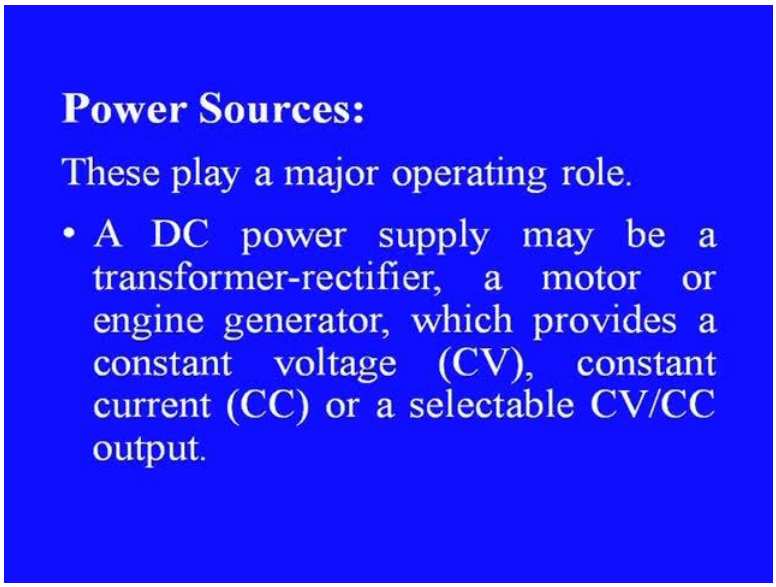

These power sources play a major operating role in this submerged arc welding process. Generally a DC power supply may be a transformer rectifier a motor or engine generator, which provides a constant voltage, constant current or a selectable constant voltage constant current output. AC power supply are generally transformer types and may provide either a constant current output or a constant voltage square wave output. Since, submerged are arc welding process is generally a high current, with a high duty cycle. Therefore, a power supply capable of providing high amperes at 100 percent duty cycle is recommended.

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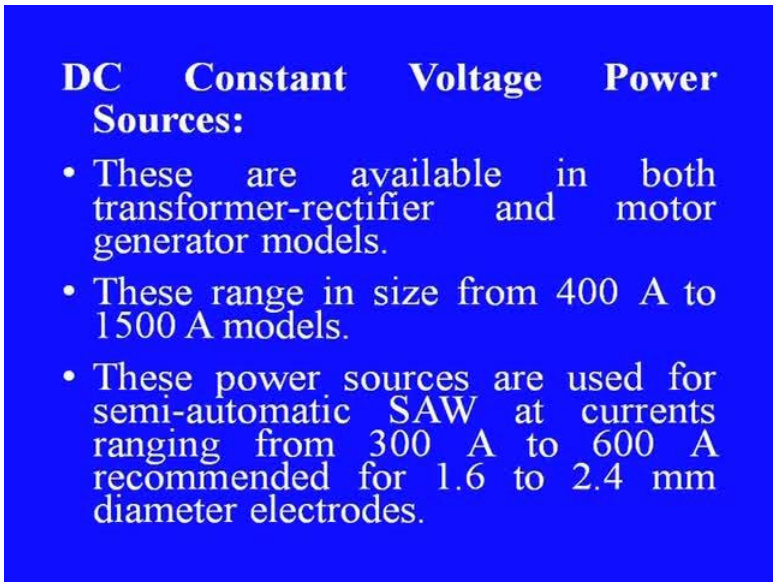

DC constant voltage power sources, these power sources are available in both 400 hundred ampere to 1500 ampere models. These power sources are used for semi automatic submerged arc welding, at currents ranging from 300 ampere to 600 ampere, recommended for 1.6 to 2.4 millimeter diameter electrodes. As we have already discussed size of the electrodes, that is diameter of the electrode is also one of the important parameters to be considered.

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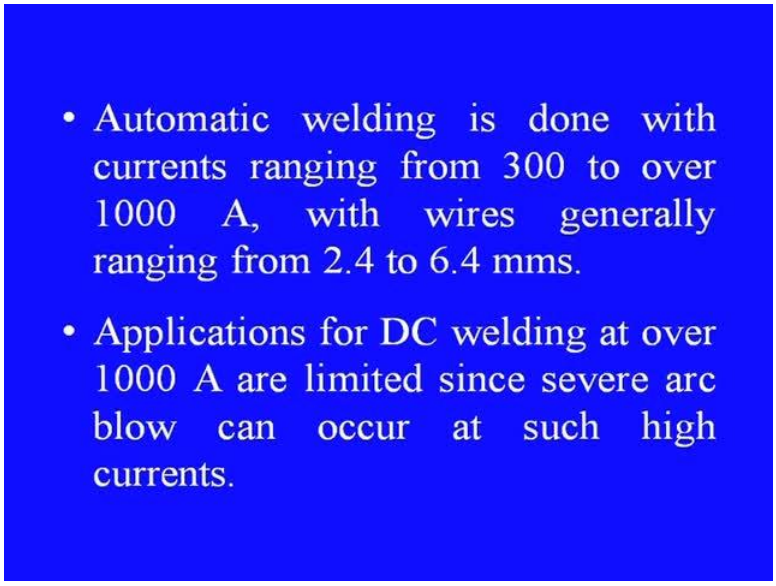

The automatic welding is done with currents ranging from 300 to over 1000 amperes, with wires generally ranging from 2.4 to 6.4 millimeters. Applications for DC welding at over 1000 ampere are limited, since severe arc blow can occur at such high currents. New generation power supplies provide more stable arc and can be maintained at lower current densities. A constant voltage power supply is self regulating, so that it can be used with a constant speed wire feeder.

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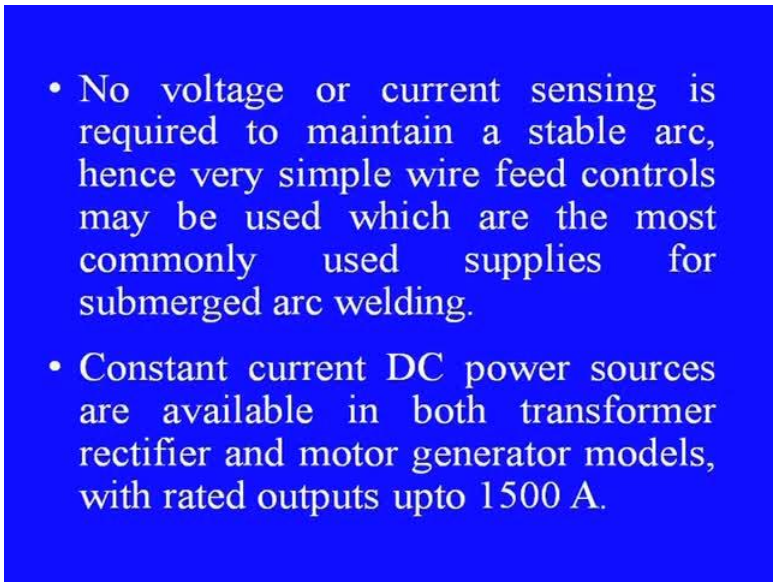

No voltage or current sensing is required to maintain a stable arc. Hence, very simple wire feed controls may be used, which are the most commonly used supplies for submerged arc welding. Constant current DC power sources are available in both transformer rectifier and motor generator models, with rated outputs up to 1500 ampere. Now, let us see the alternating current power sources. Transformers are the most commonly used power sources in a AC welding.

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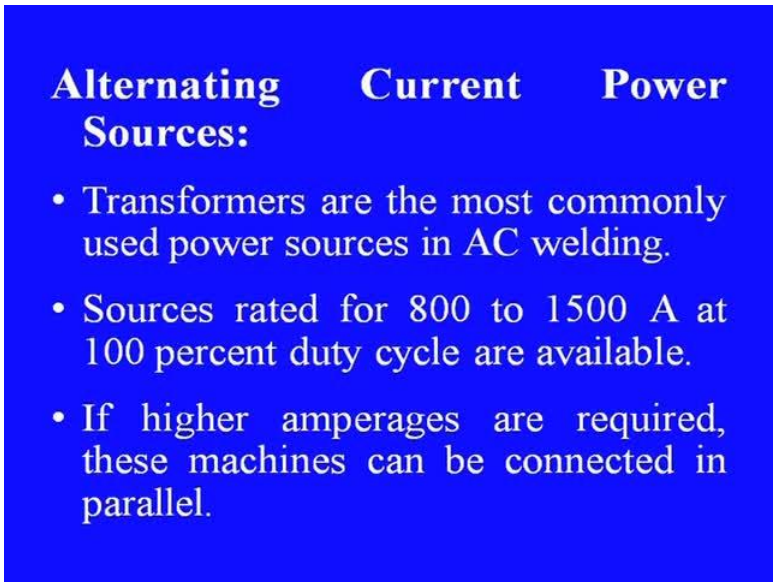

Sources rated for 800 to 1500 ampere at 100 percent duty cycle are generally available. If higher amperages are required, these machines can be connected in parallel also. Conventional AC power sources are the constant current type sources. The most common uses of an AC power for submerged arc welding, are high current applications, multi ware applications, narrow gap welding and applications were arc blow is a problem. As we have already discussed, in DC power sources there may be severe problems of arc flow, which should which should be avoided at any cost. Now, let us see another important component in this system that is controls.

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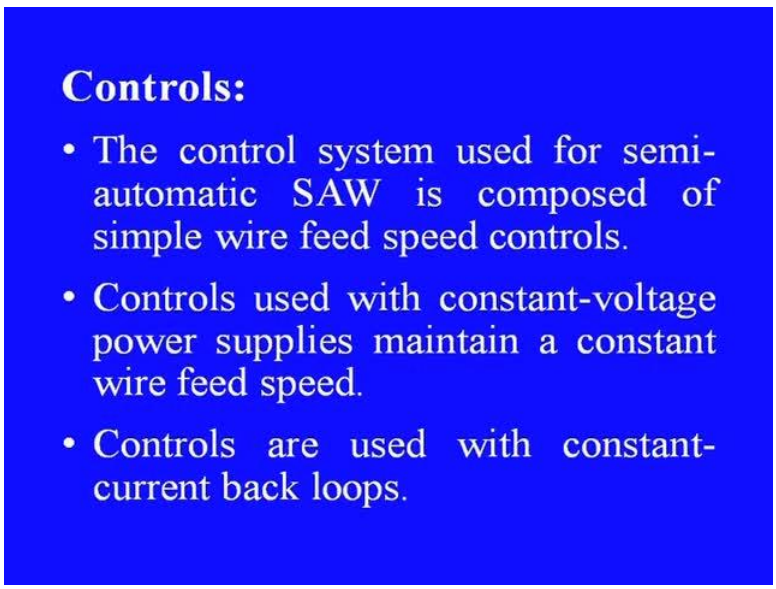

The control system used for semi automatic submerged arc welding process,. is composed of simple wire feed speed controls. Controls used with constant voltage power supplies maintain a constant wire speed feed. Controls are used with constant current back loop, these controls are interfaced with the power supply were feed motor, in order to maintain the welding voltage and wire speed at preset values. The greater advantage of digital controls is their precise control of the welding process.

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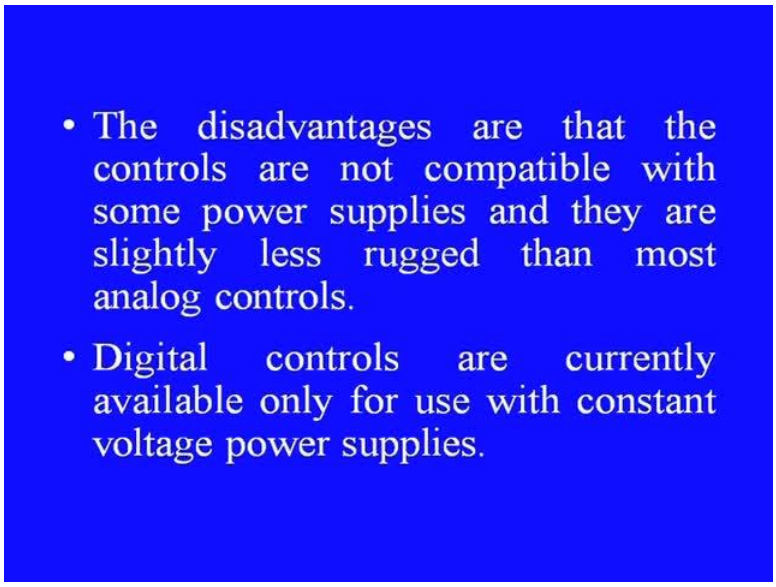

The disadvantages are that the controls are not compatible with some power supplies and they are slightly less rugged than most analog controls. Digital controls are currently available only for use with constant voltage power supplies. These controls provide wire feeds feed adjustments, that is current control then power supply adjustments. That is voltage control and weld start stop automatic and manual travel on offs.

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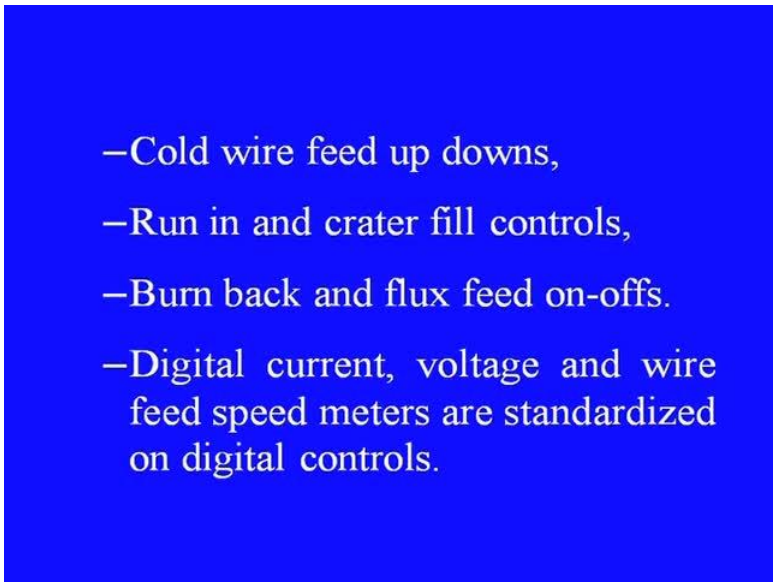

Also, cold wire feed up downs. Run in and crater fill controls, burn back and flux feed on offs, digital current voltage and wire feed speed meters are standardized on digital controls. These are some of the control aspects; that we can obtain through the control unit. Analog controls are available with use for both constant voltage and constant current power supplies.

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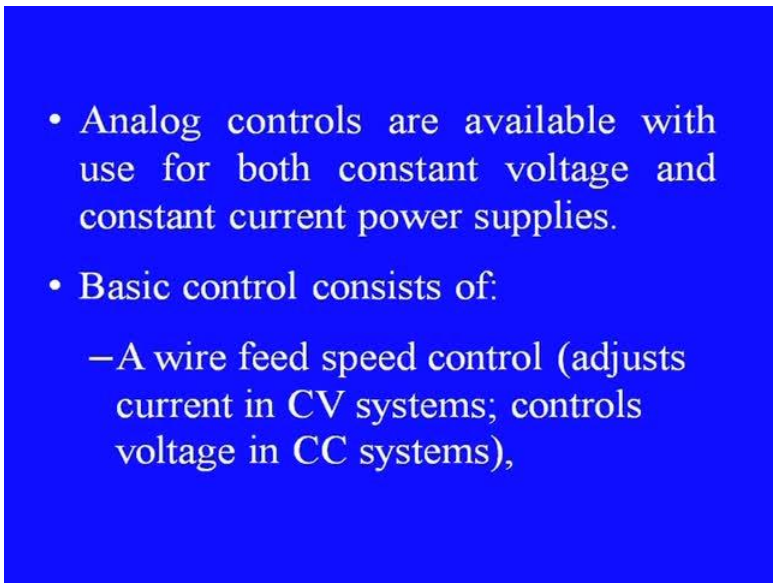

Basic control consists of a wire feed speed control, which adjusts current in constant voltage systems and controls voltage in constant current systems. A power supply control

which is just voltage in constant voltage system and adjust current in constant, current system. A weld start stop switch automatic or manual travel on off and cold wire feed up down facilities are also available. These controls have the same advantage as analog controls for semi-automatic submerged arc welding process. These are however prone to drift and do not allow precise process control. Now, let us see some effect on polarity.

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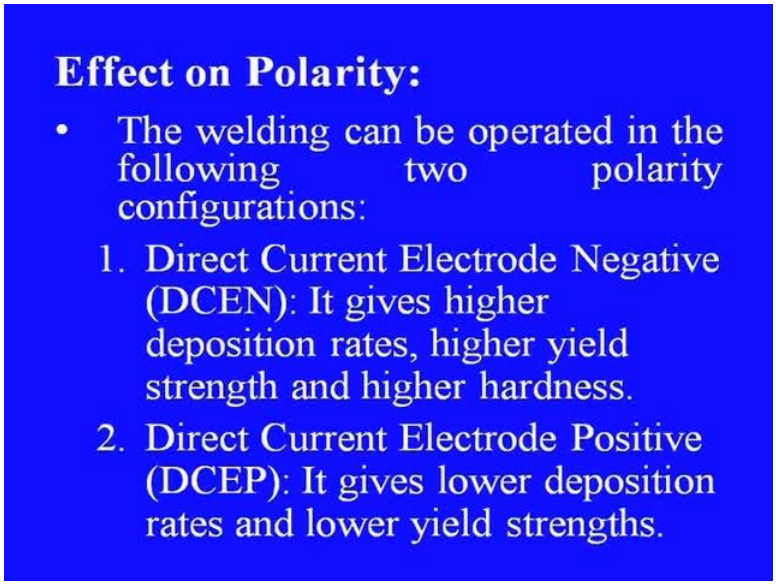

The welding can be operated in the following two polarity configurations; as we have already indicated one is, direct current electrode negative mode, in which the electrode is connected to the negative terminal of the power source. It gives higher the position rate, higher yield strength and higher hardness. Other mode is direct current electrode positive mode DCEP. It proceeds lower deposition rates and lower yield strengths. Now, let us look at other accessories and equipment, which submerged arc welding.

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The commonly used accessories are travel equipment, flux recovery units, fixturing equipment and positioning equipment.

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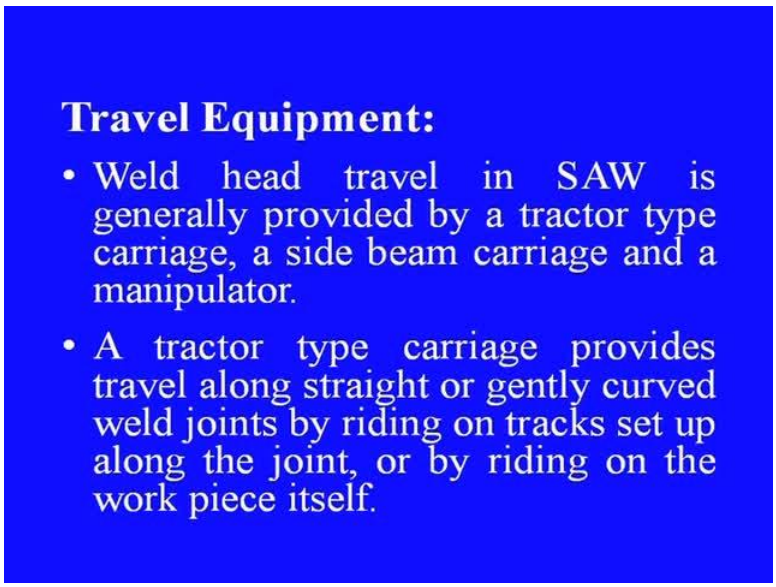

Let us look at the travel equipment. Weld head travel in submerged arc welding is generally provided by a tractor type carriage, a side beam carriage and a manipulator. A tractor type carriage provides travel along straight or gently curved weld joints, by riding on tracks set up along the joint or by riding on the work piece itself. Some guiding welds or mechanical joint tracking devices are also used. Side beam carriages provide linear

travel only with rated speed travels. They are fixed and the work pieces must to bought to the weld station. Its greatest use is for soft welding.

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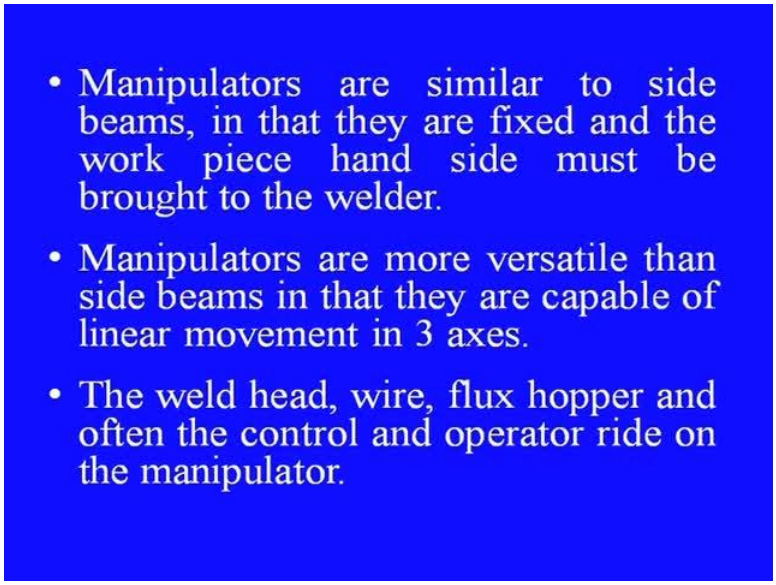

Manipulators are similar to side beams, in that they are fixed and the work piece hand side must be brought to the welder. Manipulators are more versatile than side beams., in that they are capable of linear movement in three axes. The weld head wire flux hopper and often the control and operator ride on the manipulator itself. Next is the flux recovered unit. These units are frequently used to maximize flux utilization and minimize manual cleanup activities. Flux recovery units may do any combination of the following.

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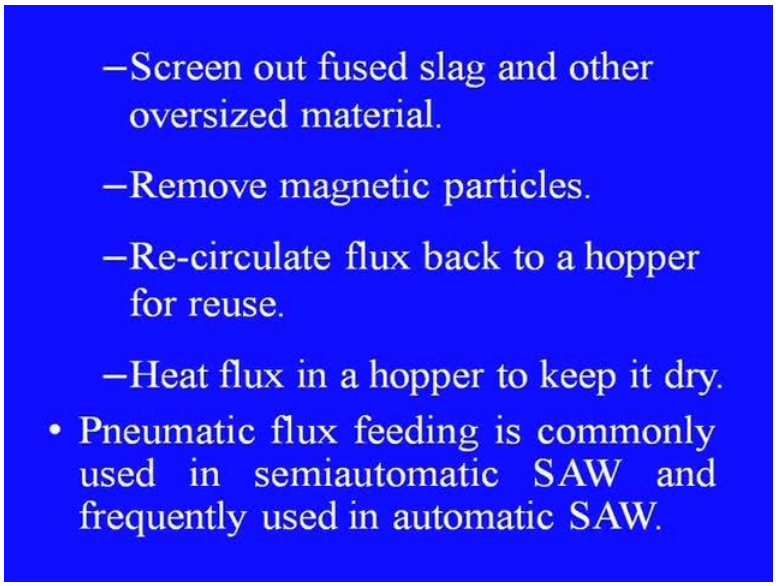

Remove unfused flux and fused slag behind a weld head. The next is screen out fused slag and other oversized material, next is remove magnetic particles, next re circulate flux back to a hopper for reuse and lastly the heat flux in a hopper to keep it dry. Pneumatic flux feeding is commonly used in semiautomatic SAW and frequently used in automatic submerged arc welding process. Next components are positioners and fixtures.

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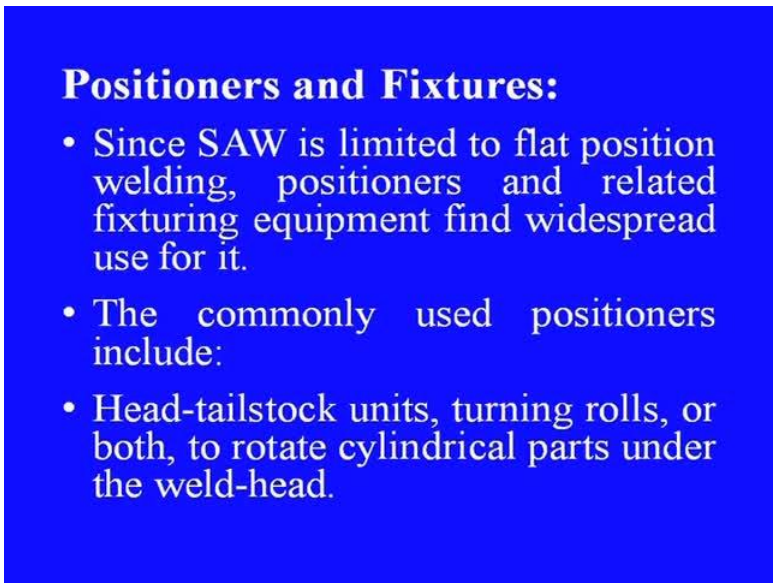

Since, submerged arc welding is limited to flat position welding, positioners and related fixturing equipment find widespread use for it. The commonly used positioners include,

head tailstock units, turning rolls or both to rotate cylindrical parts under the weld head. Tilting rotating positioners to bring the area to be welded on irregular parts into the flat position, then custom fixturing often includes positioner to, and to aid in setting up positioning and holding the work piece together.

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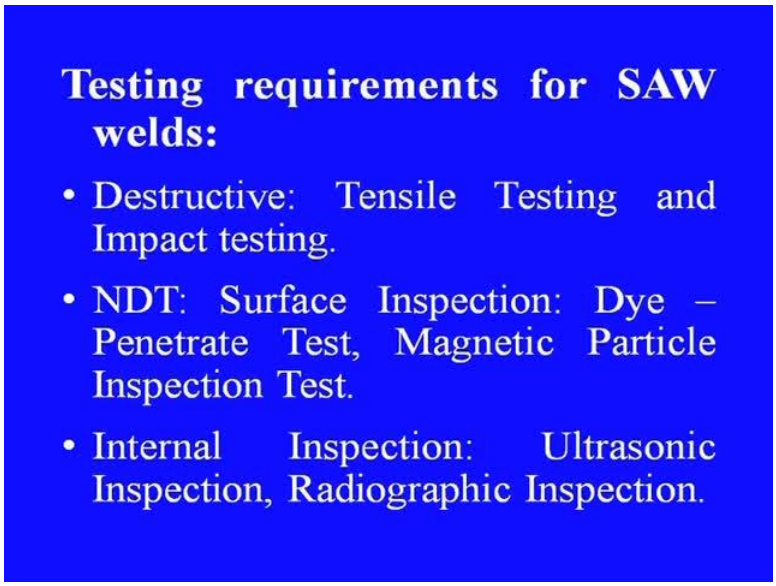

Testing requirements for submerged arc welding welds. Number one, destructive testing, these testing include tensile testing and impact testing. As we know in both these cases the specimen or the weld joint is to be destroyed and the corresponding strength tensile strength and impact strengths are measured.

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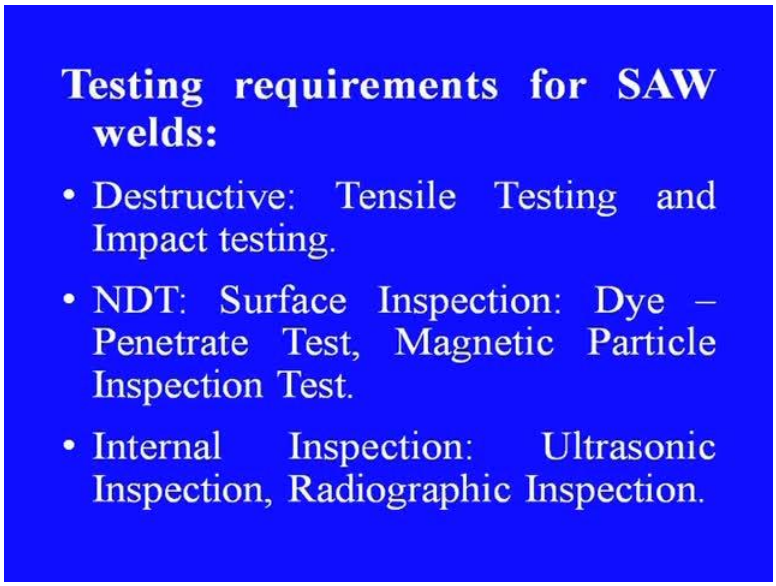

The other category is non distractive testing. These category include surface inspection through dye penetration test, magnetic particle inspection test, etcetera. Then another category of inspection is internal inspection method, which include ultrasonic inspection and radiographic inspection. Through these methods, one can assess whether there is some cracks or holes inside the welded portion. Now, let us look at submerged arc welding application, this welding finds applications in the following.

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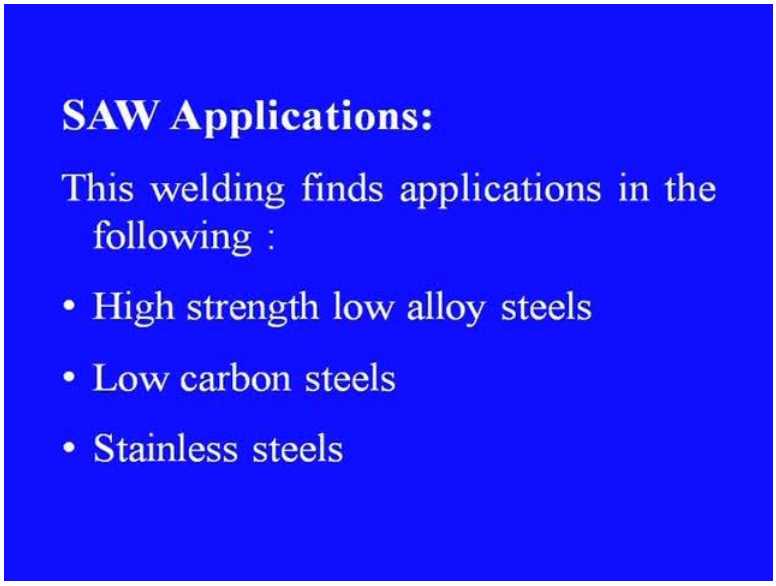

Number one, while welding high strength low alloy steels, then for welding low carbon steels for welding stainless steels, this method is or this submerged arc welding processes is found to be suitable.

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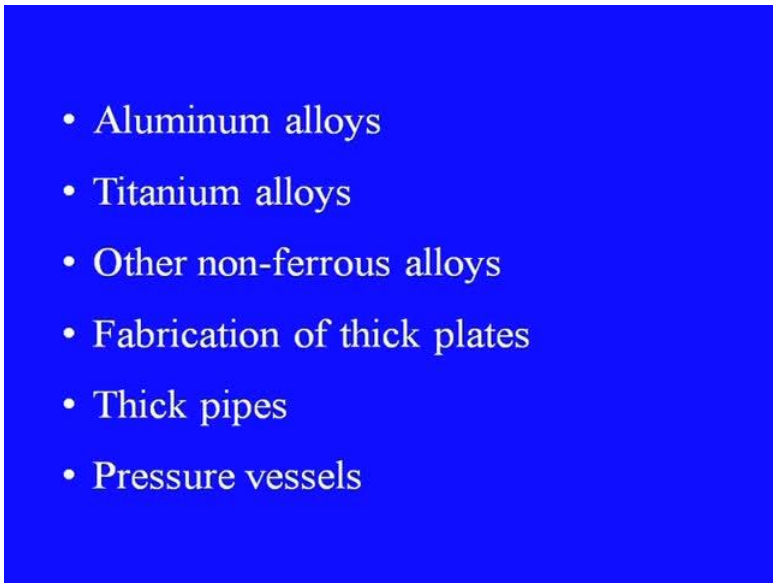

For welding aluminum alloys, titanium alloys and other non ferrous alloys, this method can be suitably used. Then fabrication of thick plates, then thick pipes and pressure vessels also this submerged arc welding is commonly used. Then for welding of rail, road, tanks, ships, heat exchangers then over laying, this method is used.

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A common submerged arc welding application is in the welding of cylinders, the home gas cylinders, in which as shown in this screen. This joint is made through submerged arc welding process. Now, let us summarize what we have discussed in this particular session. In this session we have discussed in detail about the requirements of advanced welding methods and the submerged arc welding process. The details of the process have been discussed along with its requirements, features and applications.

We have also seen that this matter can be carried out in two different modes, that is DCEN, direct current electrode negative and DCEP, direct current electrode positive. Moreover, we have seen the applications of this process and is found to be very versatile, as far as the joining or welding of the engineering most common engineering materials are concerned. These materials include both ferrous as well as non ferrous materials like aluminum titanium alloys etcetera. We hope this session was useful and interesting.

Thank you.