Welding Processes
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Other welding processes-Electroslag welding

So we move onto the other welding processes.

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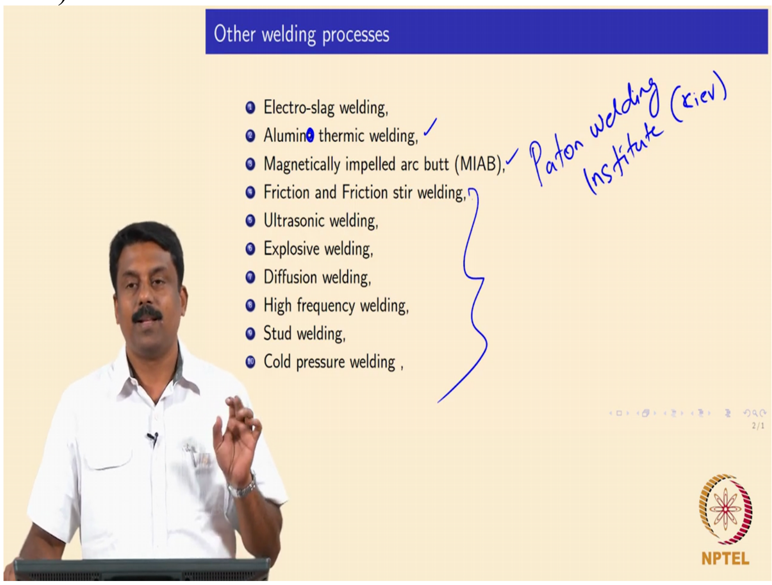

So we looked at arc welding process, GTAW, GMAW and then resistance spot welding. In arc welding, also looked at variance of the arc welding processes, resistance welding processes, resistance spot weld, Flash butt, resistance upset, right? For cushion welds. Then laser welds, electronbeam weld. So we move onto the other welding processes. Right? So this will take 2 or 3 classes and then we look at last class the building positions and the typical weld designs we use in any applications, then we wind up. Okay.

So first the other welding processes, we have 4 more classes okay. We have electro-slag welding okay. So electro-slag welding is widely used for a large cross-section welds like as showed you in electronbeam welding. Okay. In one slide of 150 millimeter okay. So if you have one weld in such a large cross-section, then we can use electro-slag welding. And electro-slag welding is actually invented in US but only Russians, the former USSR, they commercialised and they made it in various applications in electro-slag welding.

And it is it is basically a casting process. Okay. It is not a welding. But you melt so much volume and then you progressively solidify when you go up. Okay. So we look at electro-slag welding and then alumina thermic welding. What is alumina thermic welding? It is one of the oldest welding processes. Okay. So even now we use it for our Railways. Okay. And it is obsolete technology in western worlds but our rails are still welded with alumina thermic. Okay.

And in the magnetically impelled arc butt weld. MIAB, we call it. And this is very useful process to weld pipelines, okay this MIAB welding. It is widely used and it is extremely efficient to weld pipes of wall thicknesses more than 20 mm or so. So and then we will move on to solid-state welding processes. Friction and friction stir, ultrasonic welding, explosive, diffusion welding, high-frequency, stud welding and then cold forming, cold pressure welding. Okay.

And these are all solid-state welding process or non-welding, non-fusion welding processes because they do not melt. Okay. So we will do the welding in solid-state. Right? And then MIAB process. MIAB is both, we melt and we also apply some upsetting force, same as in Flash butt weld. okay. There is some difference between Flash butt and the MIAB. We will see when we are looking at these process. Right?

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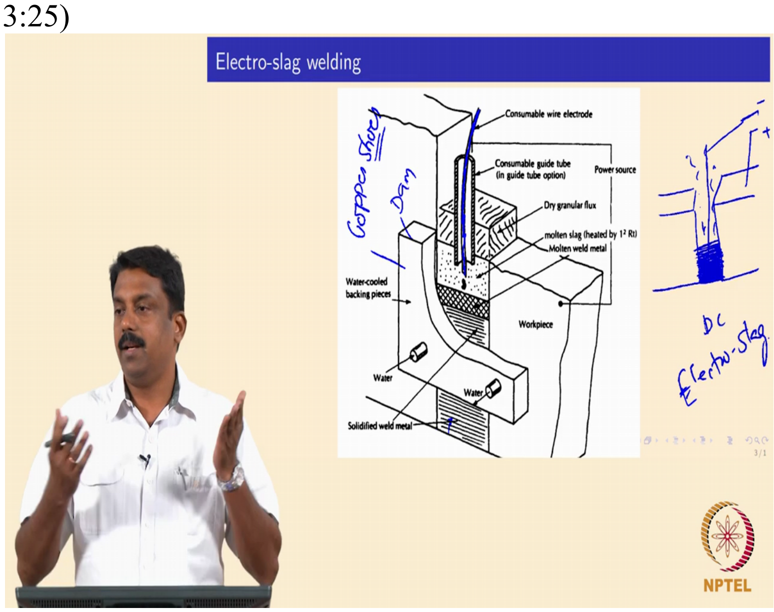

So first is electro-slag welding. Okay. The electro-slag welding is widely used for thicker sections. So we process work like this. Okay. So we have filler material. Is not it? So this is the wire, filler. Right? And filler is actually first fed into the weld cavity. So this is the interface to be welded. Okay. So this is the interface to be welded. And the filler is first sent and the filler is connected to the power source and the workpiece is also connected to the power source.

So we use a DC current most likely in most of the cases, its direct current. Okay. And then at the start of the weld, we strike an arc between the seller and the base material, the interface. Right? So the arc is there to melt. Initially but the moment the arc is cut, we start adding fluxes to reweld cavity. Okay. But the arc heat, the flux would start to melt and then form slag. Okay. So we start adding the flux powders. The moment the filler wire strike an arc with the weld interface, we add fluxes inside and then the flux would start melting with the heat of the arc.

A slag would form and then you the slag melts because it is molten slag reflects melts and then slag forms and molten slag would start filling up. And the moment it comes in contact with the electrode tip, the arc extinguishes because there is a continuous contact. Right? So the arc would extinguish. But you still pass the current. Right? The current is still passed through the slag would start heating up by resistance heating.

Right? It is clear? Yes or no? Okay. So you have weld cavity something like this, I will just simplify it for you. okay. So we have first the filler inside and then the filler is connected to the power source and then the workpiece is also connected to power source. So for example, negative and positive. Make your electrode negative. Okay, so you have diode current and then you strike an arc between the workpieces.

And the moment you strike an arc you add flux powder inside. So this flux powder because of the heat of the arc, will start melting and form a slag and you form a layer. So the moment the electrode is filled with the molten slag, the arc would extinguish. But you still pass a current and that current is now used to melt the flux and form a slag and continuously the slag would melt the electrode. Right? Because it is molten, heated, okay. So the slag temperature would be more than 3000 Kelvin.

Okay. And then that heat would melt the filler and then the filler would melt and then we will deposit and the slag would always float. Is not it? Slag has less density than the molten metal. So the slag will float away and the liquid metal will go because of the density difference. It will fill the cavity and you keep on adding fluxes and the slag would melt and the slag, molten slag would protect the molten pool and then you can continuously feed the wire to create more amount of volume of liquid metal and the resistance heating would melt the fluxes to form a slag continuously and then the molten liquid metal would start filling the weld cavity.

Right? It is clear? And because the building, the melting of the filler is carried out by the slag, okay and the slag is formed by the fluxes which are resistance heated. Is not it? So that is right it is known as electro-slag welding. Slag melts the filler. Okay. The filler fills the weld cavity and then the slag is kept at a higher temperature by resistance heating. The heating by the resistance of the slag which is actually formed by the decomposition of the flux, right?

So that is why this process is known as electro-slag welding. So you need to always have some sort of a container. It is known as a dam. Okay. So this is generally copper shoes through watercooled copper shoes kept between the weld cavity to contain the liquid. Right? Because the amount of liquid you melt and generate, both of the molten filler as well as the slag, it is so high. And then you see that the wall thickness usually it is 15 centimetre and you can weld it in a single pass because you can choose a filler wire in such a way that you have enough material.

Enough wire is molten to fill the weld cavity and subsequently you can add fluxes to protect the molten metal and it is like in a sequential casting. Okay. So the molten liquid metal is generated and then it is contained between the wall of watercooled copper shoes. So that is like in a mould. Is not it? So the mould, liquid metal is poured and then you move the liquid metal from the bottom to the top and (())(9:16) for liquid metal and form the weld. Yes? It is clear?

So this, the mould or the in this case, we call it copper shoes. They are watercooled because they just would not melt. Is not it? So the trick over here is you strike an arc in the first with the filler and the base material and then you melt the fluxes by the heat of the arc, you form a slag. Slag moment touches the filler wire, arc extinguishes but then there is a contact. Okay. The current is still passed.

So the resistance heating would start maintaining temperature of the slag. We have more and more flux, we form more and more slag and the wire is also continuously fed to the weld cavity. So we melt more liquid metal and the liquid metal, it goes down and slag comes out because of the density difference and then you can move the weld the copper shoes sequentially once the bottom material solidifies because we extract the heat by the watercooled copper shoes.

So liquid metal solidifies and then we can sequentially move the copper shoes from the bottom to the top of the job. Yes. It is clear how it works? Right? And because of the productivity and this is advantage, yes and if you are welding a very high thickness material, you can yes weld it in a single pass. What do we mean by pass this container? Holding liquid and then you fill container with liquid metal and then it solidify. Right? It is clear? Okay. Good. Any question on this process?

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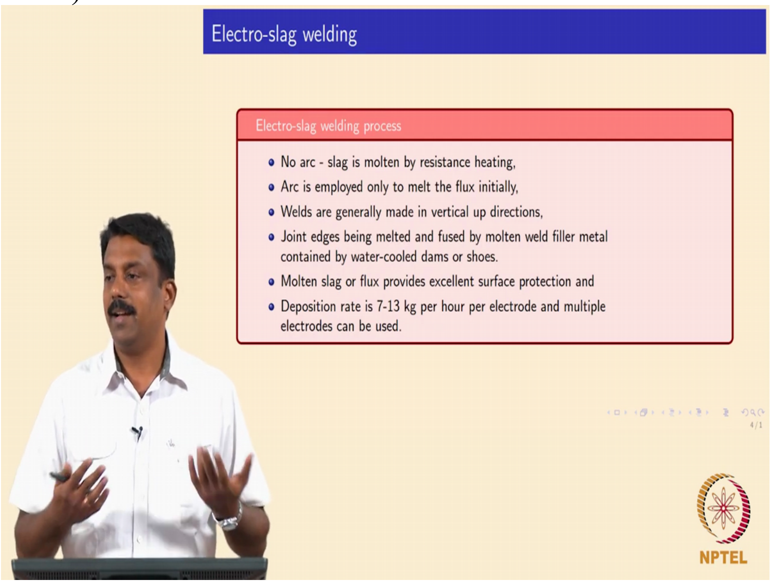

So these are some of the characteristics of electro-slag welding as I said. So no arc, okay. Slag is molten by resistance heating. The arc is struck at every beginning to generate the initial heat needed to decompose the flux to form a slag. The moment slag touches the electrode tip, arc extinguishes and then subsequently only resistance heating of the flux and the slag will provide heat to melt the filler. Okay. So arc is employed only to melt the flux initially. Okay. So generally it is, the welds are made in a vertical position.

So if you are doing other positions, then you cannot contain the liquid metal. Okay. okay. The joint is melted and fused with the molten material and they are contained by the copper shoes, the dams what we call it. okay. And because we have the flux in the slag protecting the atmosphere, the the the weld material is completely protected from the atmosphere from oxidation. Okay. And we can achieve huge deposition rates.

It can sometimes go up to 30 kilograms per hour. Okay.

Student: Sir?

Professor: Yes.

Student: Initially, this dam is decomposed by that arc only no?

Professor: Yes. So initially, at the beginning of the flux because now when we are adding just flux, we are achieving resistance heating is the efficiency is much lower because flux is powder. Okay. So initially you strike an arc so that the fluxes can be molten by the heat of the arc. Right? And then moment flux melts, decomposes, you form slag and then slag starts flowing, reaching the electrode tip. The moment electrode tip is immersed in the slag, so obviously then the arc extinguishes. Right?

So you can achieve a huge deposition rate. So I just put 10 or 13 kilogram. But sometimes it can go up to 30, three zero kilograms per hour. 30 kilograms deposition. And if you are using multiple electrodes, fillers, generally you know it is also used, the multiple electrodes over a range and it is like you know you are creating in a cast structure. Good.