Welding Processes
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Aluminothermic (thermit) welding

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Ok so we will start from the last class. Last class we already started the last chapter on other welding processes, right.

So we looked at two process, processes that are considered I mean not the conventionally used in arc welding process G M A W, G K W. The first one you saw is electro-slag welding isn't it?

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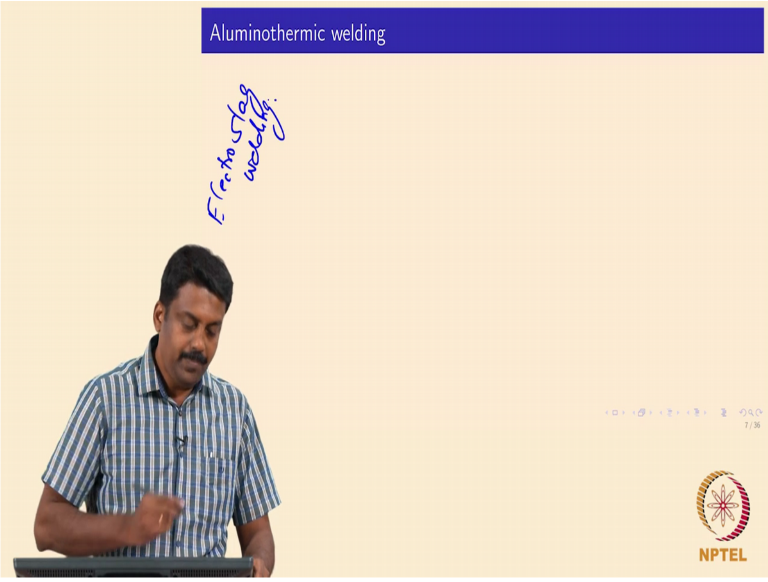

So it is technically not the arc welding process. So we use the arc initially to melt the flux, Ok. Once the flux is molten the flux starts filling. It will have a contact with the electrode, the filler.

So and then the current which is actually passed to the filler as well to the flux would heat up the subsequently the flux which is added and forming a slag. Slag temperature will be much higher, Ok much higher than melting point.

So it ends up welding the material, the filler what you have inside and then you fill weld cavities by the molten filler. And subsequently you can also move the water-cooled copper shoes which actually hold the slag and liquid metal. And the structure solidifies as cast structure, right.

So because of the volume you can melt the filler you can add, you can have much larger weld cavities filled. So electro-slag welding is very commonly used to weld thickest cross-sections, right. So we looked at, and then subsequently the second process is MIAB.

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So the MIAB welding, M I A B Ok,

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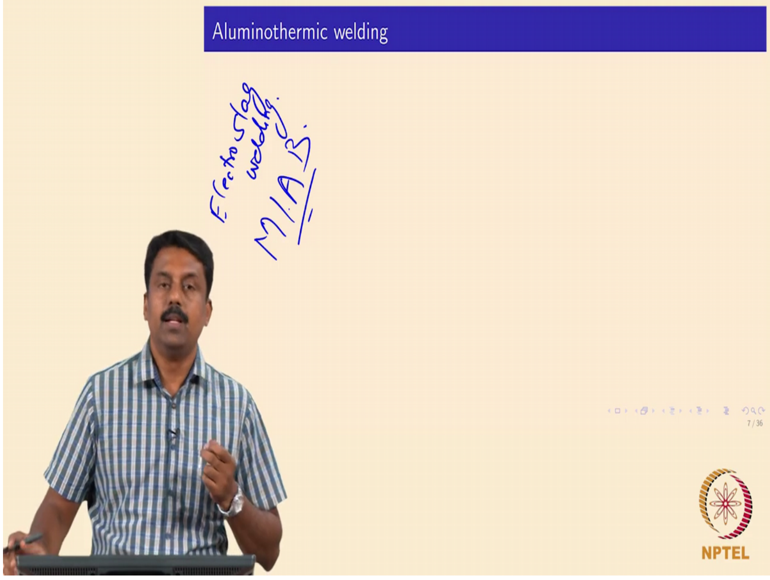

so the MIAB welding is widely used for making the joints of the superalloys for example for very high temperature applications as well as some strategic applications for power plants, reactors, nuclear reactors because the joint here we make, it is technically solid state joint, Ok.

So the problem associated with hot cracking, due to solidification or segregation would lead to subsequent cold tracking, hot tracking or ductility dip cracking. And those kinds of problems can be avoided using the mechanical deformation used in these joints, Ok.

So joint integrity would be much better if you have mechanical deformation and making a coalescence. So that is why M I A B, it is, it is seen as very attractive process to weld the pipes of thicker section, thicker cross-section wall thickness pipes, right.

So we looked at the video as well M I A B, right and then the thermit process we were looking by the time it was over, the class is, so third was thermit welding, Ok. It is also known as aluminothermic welding.

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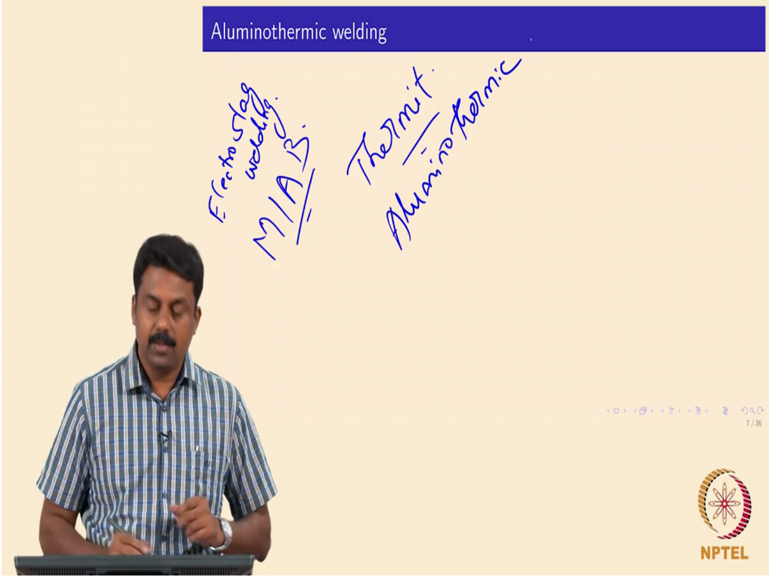

So this is one of the oldest welding processes. We have been using it even now for various applications. One of the main applications is welding of railways. Ok so railways are welded using the aluminothermic process.

The principle is, so when the metal oxide is burnt with aluminum, so aluminum reduces metal oxide, becomes aluminum oxide because of the affinity of oxygen to aluminum, Ok aluminum has much higher affinity of oxygen there than any other metal oxide, Ok.

So you oxidize aluminum. The aluminum oxidation is highly exothermic process. So enormous amount of heat is released and during this process the metal oxide got reduced and that would produce metal and the metal would melt forming liquid metal, right.

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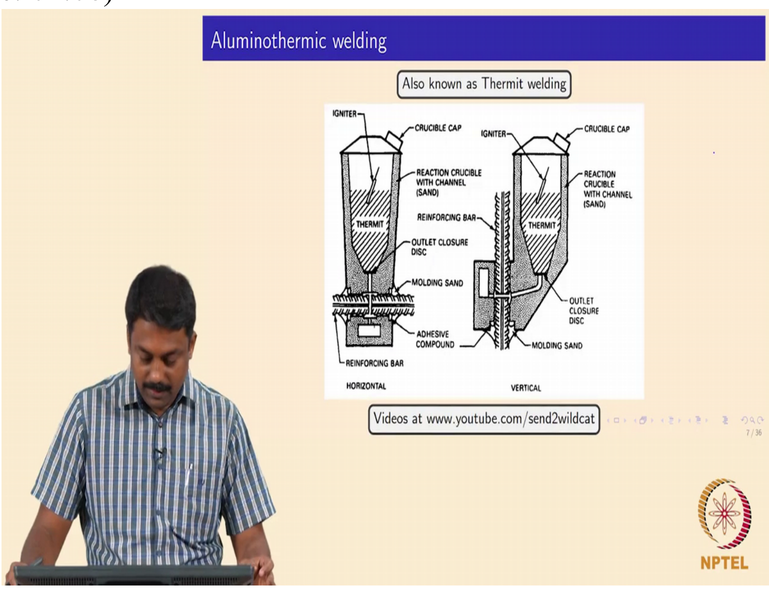

So as I said the thermit welding is widely used for welding railways. So I have given a cross-section of railway, so this is the railway line, isn't it? Yeah so the typical shape.

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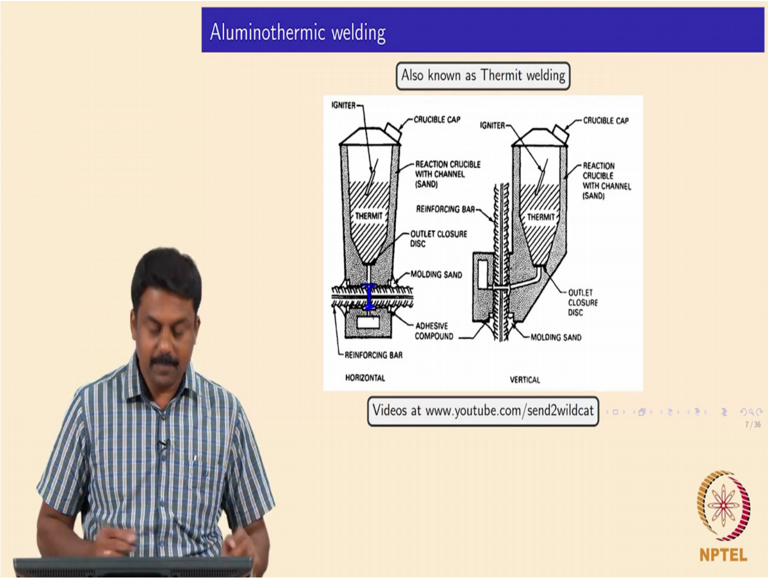

So basically, so you have, you will have to make joints. So this is a cross-section, isn't it? So there will be another line coming from here. We will see the video. It will be very clear.

And then you have a container which is actually generally known as crucible and the crucible, inside crucible you fill thermit mixture. So thermit mixture is metal oxide with aluminum, Ok. And then the metal oxide aluminum is mixed and you ignite with an igniter.

The moment you give, you burn, you start burning the mixture and aluminum readily oxidizes leading to the formation of molten metal, metal of, see if it is iron oxide, molten iron would start forming here in the bottom. And then the exothermic aluminum oxide would tend to go, float as a slag.

So the advantage of this process is aluminum oxide which is actually forming is less denser than the liquid iron. Aluminum oxide would tend to float and form as a slag layer. It will start protecting the liquid metal which is there in the bottom of the crucible.

And subsequently there will be opening which would open up and this opening

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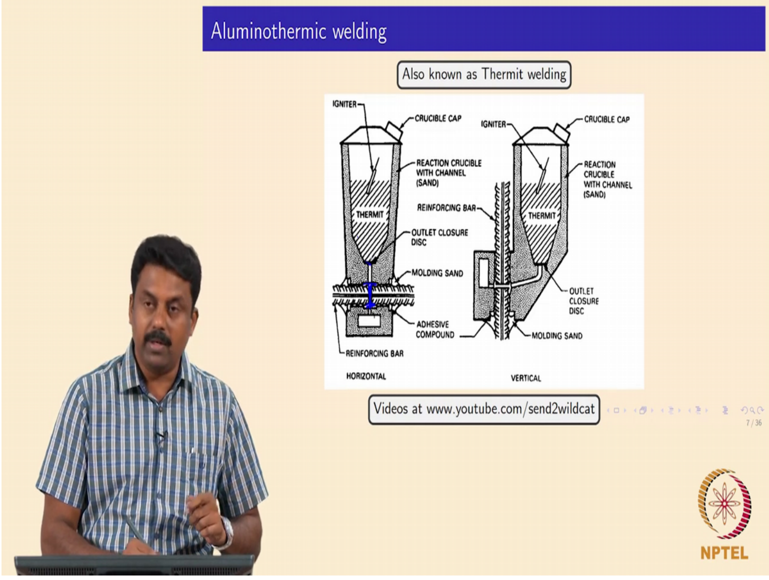

would actually work based on the principle that the moment the temperature goes above certain temperature it will crack and then liquid metal would start filling the weld cavity, yes. Is it clear?

And subsequently once the weld cavity is filled and then the crucible, the mould can be broken out. And then the excess material will be sheared off. Yes, it is clear?

And the moment you have the weld, you can also do a simple grinding, make sure there are no sharp edges. Ultimately once you are done and weld would be as good as any cast structure. Yes, it is clear?

And this can be, basically it is like keeping in a container of a liquid metal, Ok. Either it can be kept on top or kept on side, so you will have a runner and a riser leading to liquid metal transporting from crucible to the weld cavity, right? Is it clear?

As I said this process very widely used for welding, welding of railways. So often we have to go and certify the welders who are actually welding the railways. And you know when you are going over there, I mean you will have to make sure that they are being properly and then we will have to take care of it.

So one such incident I have been there to certify welders in Germany, Ok. So I made a video and so these welders are actually

07:07 demo start

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07:09 demo end

certified to weld German high speed railways. So these are the rails what I am talking about, isn't it? Ok. So what you see over here is the container. So what we are going to see in this video is the first pre-heating the mould or the crucible, right and these two rails are going to be joined by thermit welding process, right.

So I am going to mute it because these welders are speaking in Dutch and as some of you will know Dutch, welders speak their own language all the time, right. So please ignore that.

07:47 demo start

So right now the crucible, the mould is preheated. So generally mould is like a simple sand, green sand mould and compacted. And this contains the thermit mixture. And you cannot buy it just like that. You need a license to buy that because it is very explosive material,

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Ok.

So the preheating is done and they will check the temperature.

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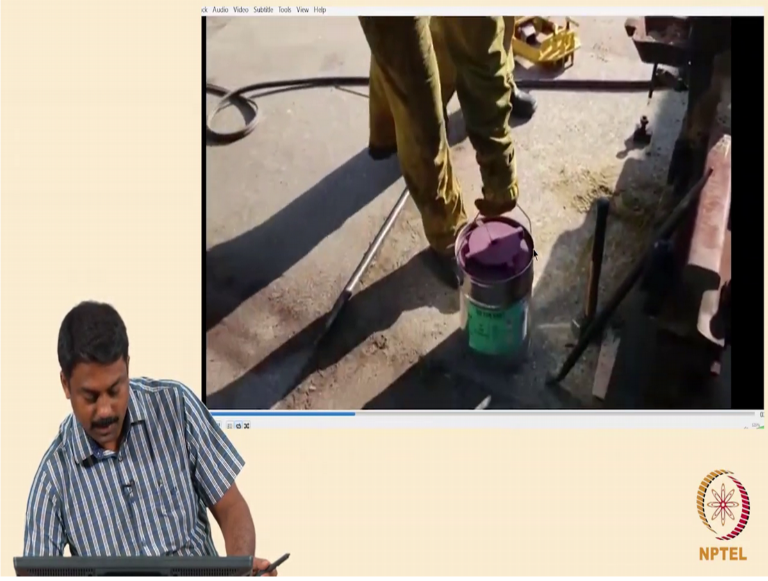

So this is thermit mixture. Ok, so slightly over it,

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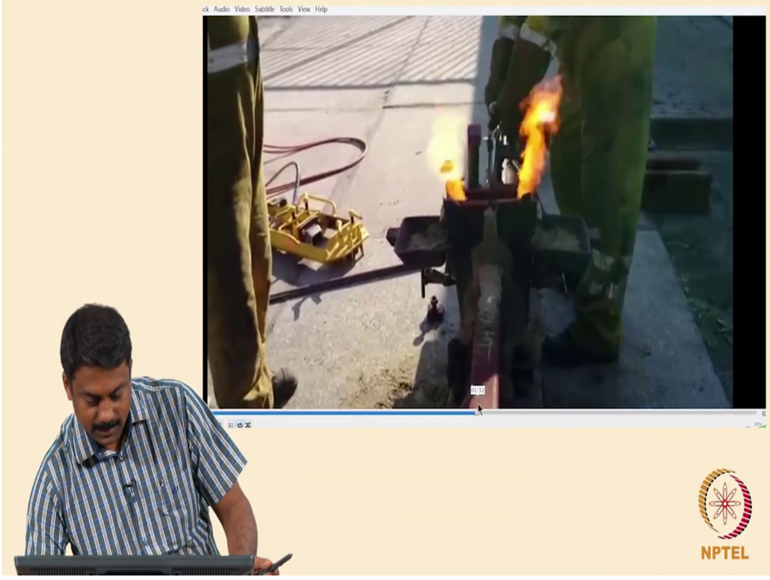

so preheating is done,

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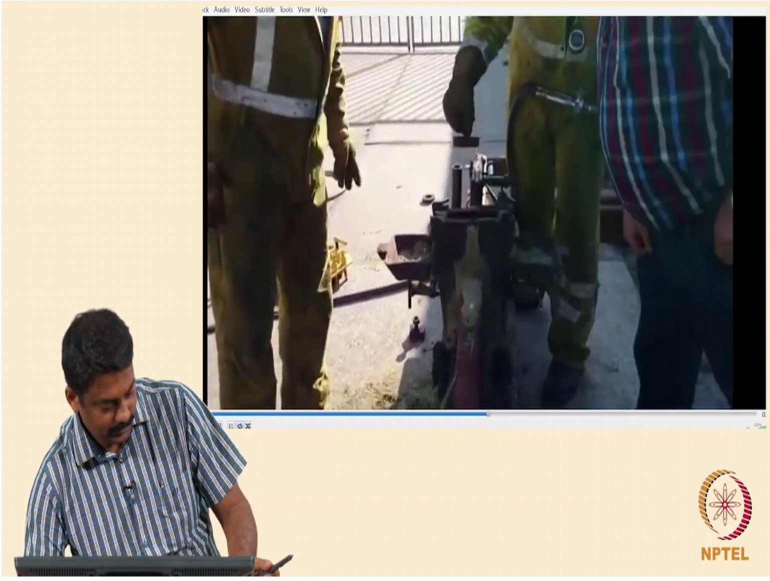

Ok.

So they are going to put a cap on that. So this is the

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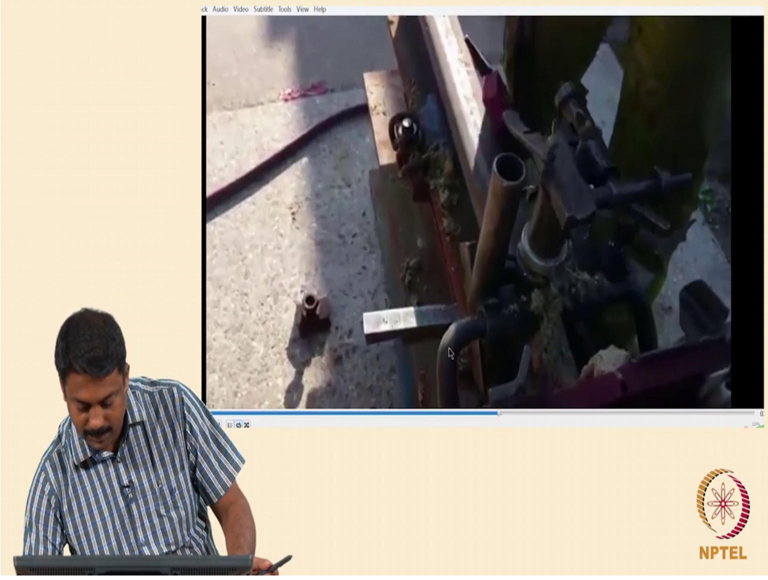

preheated mould.

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You see that inside. So that is the weld cavity. So this is the mould and inside you will have the weld cavity.

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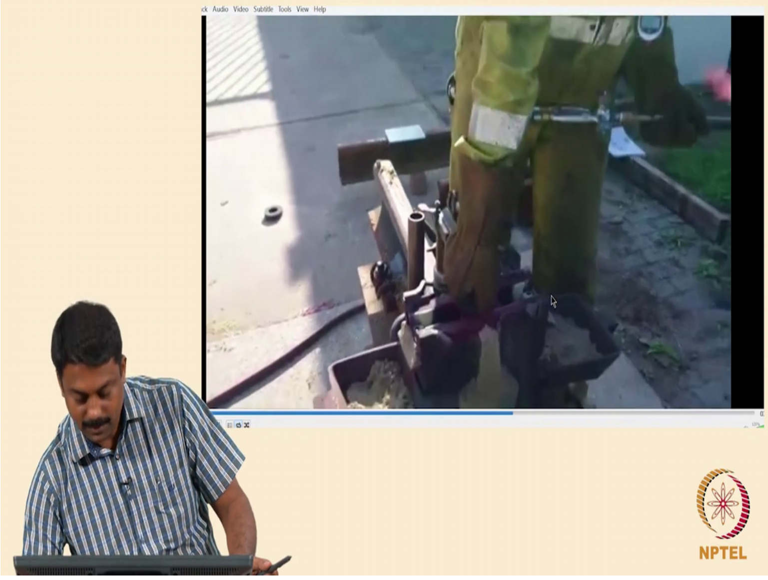

So after preheating they are coalescing the mould and then the thermit mixture is kept

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on top of it, Ok.

So that is the igniter what he has in the hand. So you burn

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the igniter. It is like a firecracker. You have igniter on top of firecracker, right? The same, so he is inserting the igniter inside. So he was my colleague.

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So now reaction is happening, Ok. So upon, yeah so reaching a steady state so you would see the liquid metal

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started pouring down from the bottom cavity towards the mould and these are all runners and risers on the side. So now it is done.

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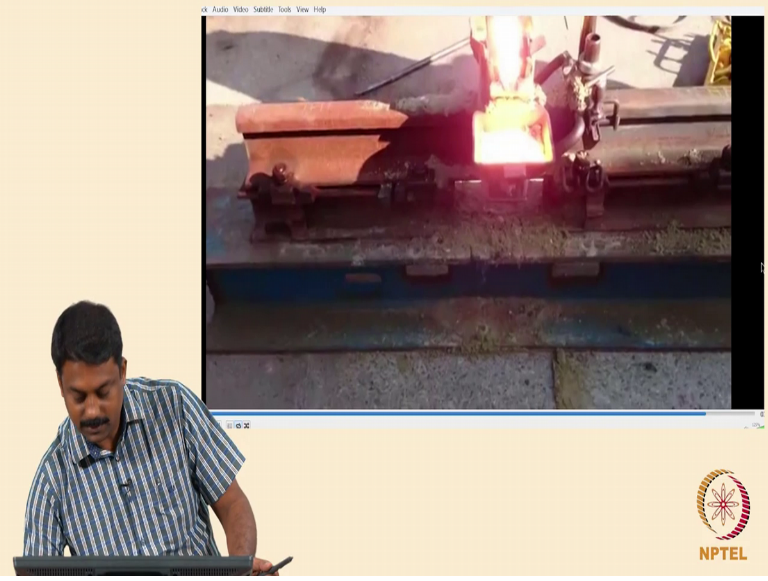

So reaction is done so quickly.

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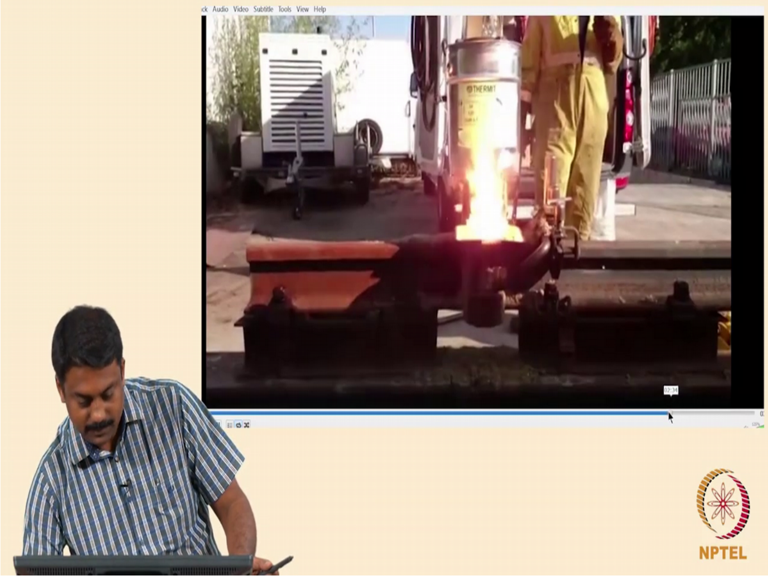

So from, you see the liquid metal flowing sound,

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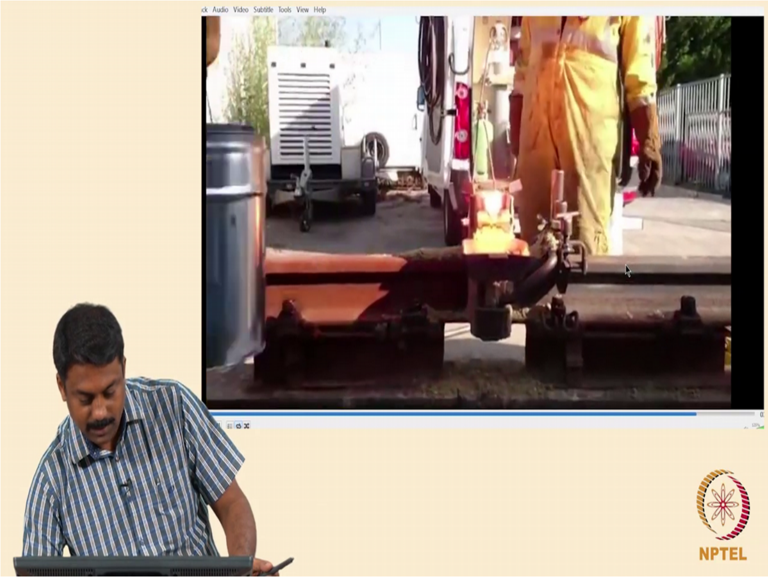

yeah so now it is done. So now the entire mould and the weld cavity is

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filled with liquid metal.

So upon solidification the weld, the wall can be broken,

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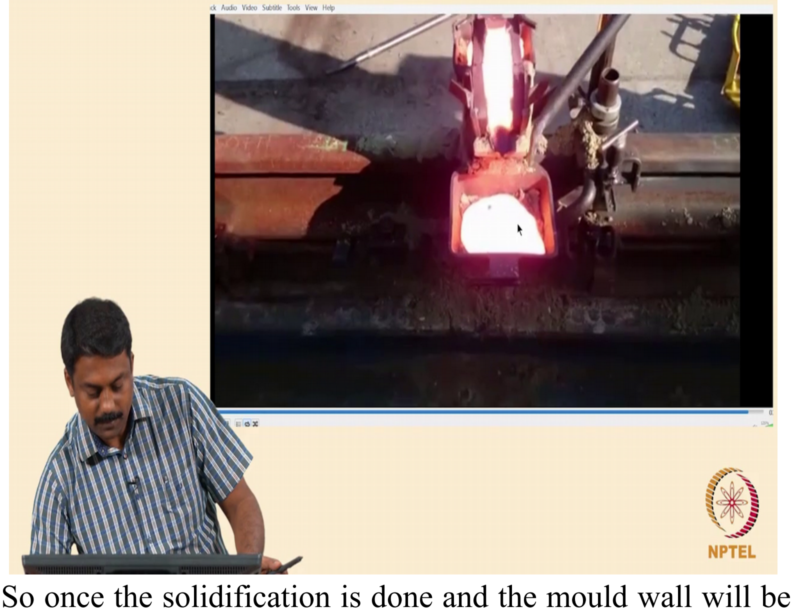

sorry Ok, yeah. So once the solidification is done and the mould wall will be broken and the excess material will be removed using a simple blade. Yes. It is clear?

11:27 demo end

So we will go back to the schematic again.

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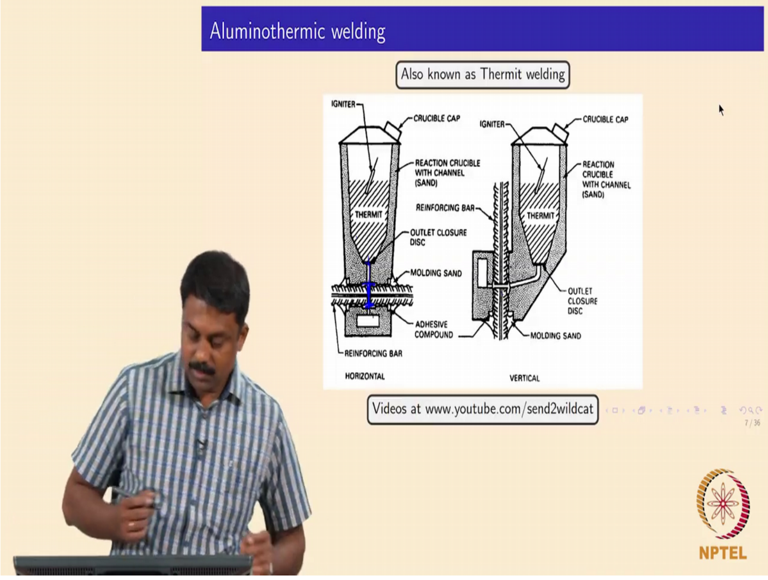

So what we saw over here, video is the schematic of

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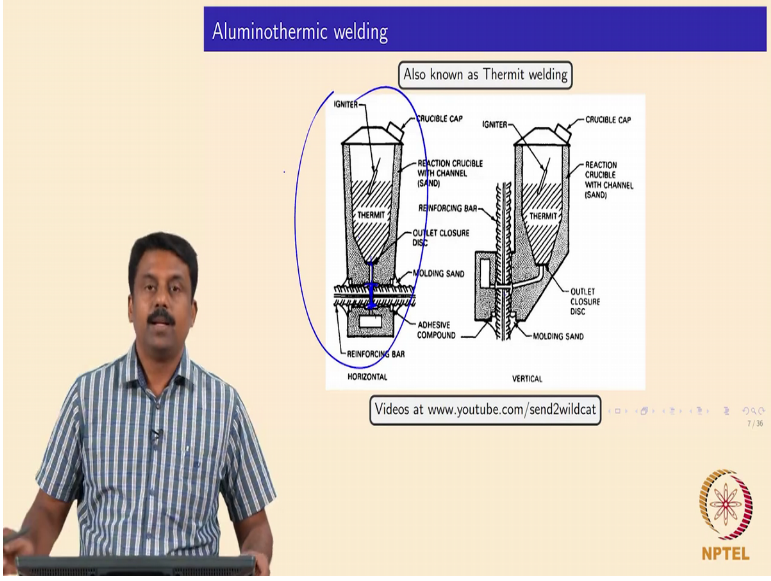

that process is shown over here, this case

So we have a thermit box on top and the railways line so which is going to be joined is actually going to be joined by the thermit reaction so which is the iron oxide plus aluminum is butt and liquid iron which is actually formed at the, at the bottom of the crucible is going to be flown to the weld cavity and then subsequently the moment the welding is happening so we can take this off.

And then we can also take the bottom,

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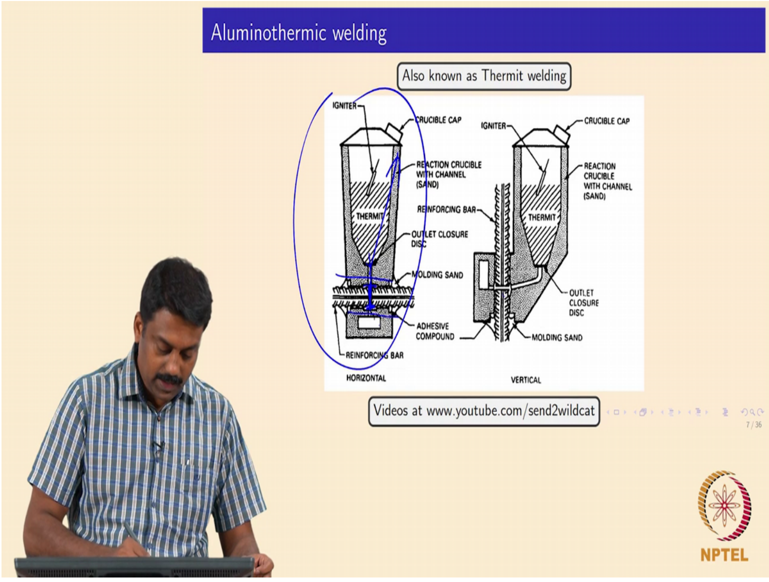

the risers and then the moment you know you take everything out you will not see even fusion joint.

Ok so the weld would be as good as a continuous cast structure. So this is the, typical ride is about you know, mean varying sizes, the one which we use over there, it is about 7 to 8 inches, Ok. And then you can weld the entire, the length, width of the weld in a single pass, isn't it?

Because the container is going to send as much as liquid metal you want. You can also have a bigger, larger thermit container which would give more liquid metal; it can be filled in much larger cross-sections, right.

So based on the need you can do it in horizontal position or you can also do it in vertical positions where you could also have runner which could transport

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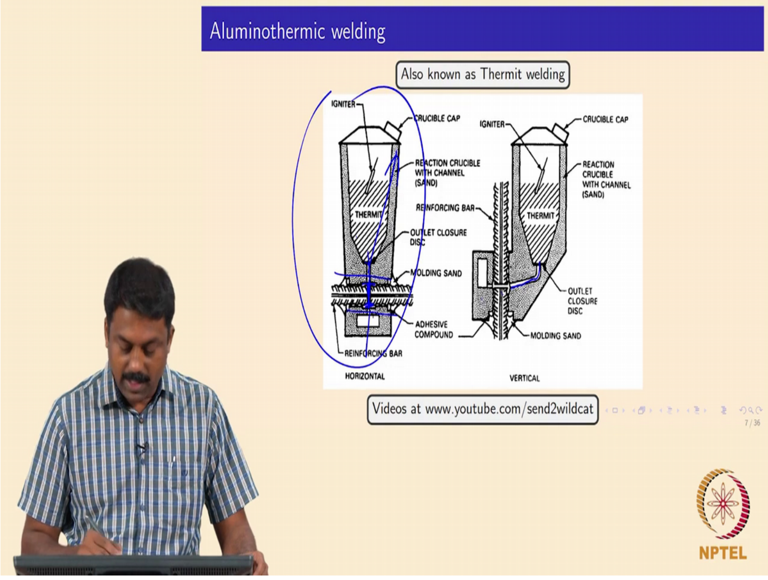

the liquid metal from the container and to the weld cavity, right.

So you can watch lot of videos

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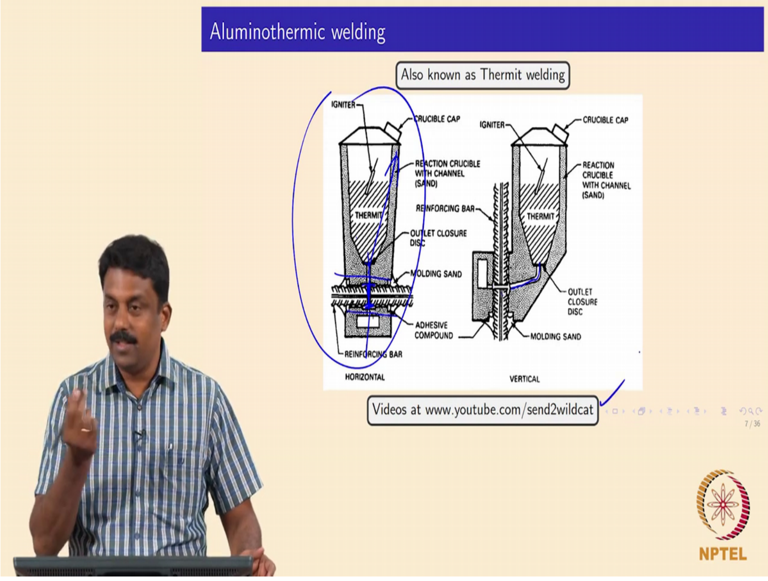

in my homepage in Youtube because you can also see from the beginning, from preparing the weld edges, preheating and then upon welding breaking of moulds, mould of excess material everything you can see there.

I do not want to spend much time on that,

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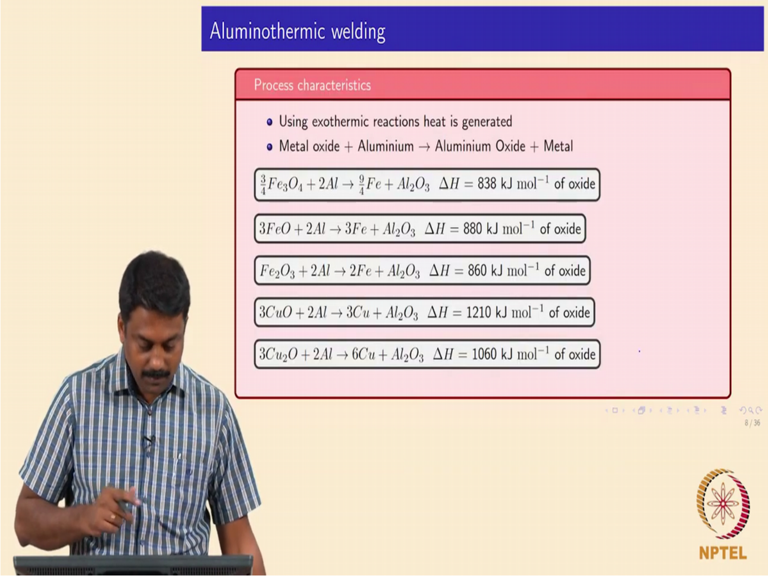

Ok so the reaction what you see over here is the exothermic reaction of reduction of iron oxide metal oxide by aluminum.

It will lead to aluminum oxide and then leading to generation of excess heat and exothermic reaction would melt the metal which is reduced and then this liquid metal would fill the weld cavity. Right, so this can readily be used for welding, making liquid iron or liquid copper. In fact the liquid copper will generate more heat than reducing the iron oxide by aluminum.

Is this clear, the process, any doubts? So next time if you go railway station, if some people are working just have a peep. And they must be doing this.

Ok I have seen in our times, even from my childhood. Whenever I go to railway station and you are not allowed to go inside but you will see the boxes, tin containers of thermit and they would be welding the railway lines using this process thermit welding, right? Good.

Then this process, large amount of heat you put it in. And nowadays high speed rails these are all made carbide free bainites. So those are all very toughened microstructures with proper heating treatment and the composite control. So those kind of railway lines we cannot use thermit welding. So then the, ultimately here the microstructure would be cast microstructure.

Ok so you use thermit welding and yeah, weld would always be brittle. And most of the accidents in railway lines happen because of the fault in the track. Ok so if you have any crack at the weld joint and you have serious problem, right.

So you will have to make sure that when you are doing welding the, of course our railway compositions, rail compositions are, still we are using British compositions rail steel. For example high magnetic steel and they are simple, ferritic, pearlitic microstructure.

So those kind of microstructural steels you know you can use thermit welding because weld would have much higher hardness, better hardness than your base material.

So, suppose we are changing from say, simple high magnetic steel to carbide-free bainite steel so this thermit welding is not feasible. So we will either have to go for either flash butt welding or LASER arc hybrid welding.

So there are some railway tracks which are actually pre-cast, pre-made, pre-weld, Ok. So we would be making about half a kilometer length of railway line, railway track and those are all most likely flash butt welded and then they would be taken to field and then installed. Subsequently they are thermit welded, Ok. Right.

So in most of the cases if you look at our Indian Railway tracks the weld are all thermit welded. Good. Any questions so far? Okay.