Welding Processes
Professor Murugaiyan Amirthalingam
Department of Metallurgical and Materials Engineering
Indian Institute of Technology, Madras
Magnetically Impelled Arc Butt (MIAB) welding

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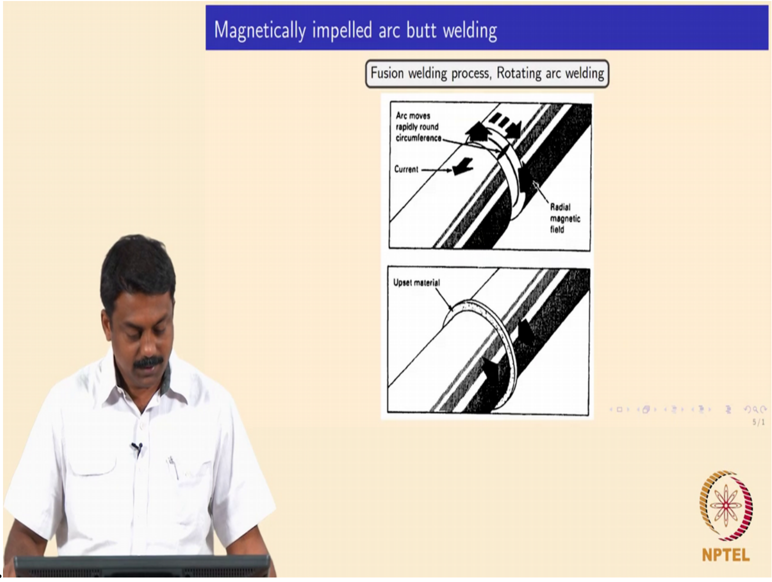

Let us move on to the second process. The physics of this process is really covered. It is the arc. It is based on heating. Ok, so they are all done. So we just quickly look at the process characteristics of all these things.

So the second is the magnetically impelled arc butt welding, Ok. And in this case we do not use any filler, Ok. So we strike an arc between the two faying interfaces same as in flash butt welding, right.

But in flash butt welding when you are doing welding, when you strike an arc the characteristic of the electron path, the electron would always like to travel on the surface, least resistant path.

So when you strike an arc, for example in two material Ok so the arc will be struck only

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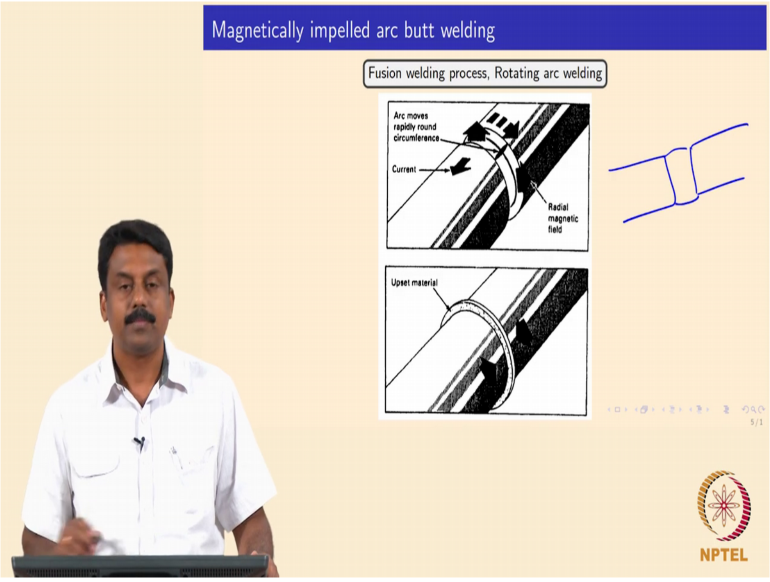

from the surface because that is the path the electron would always take, isn't it?

So then if you are welding it for a say pipe configuration, circle configuration

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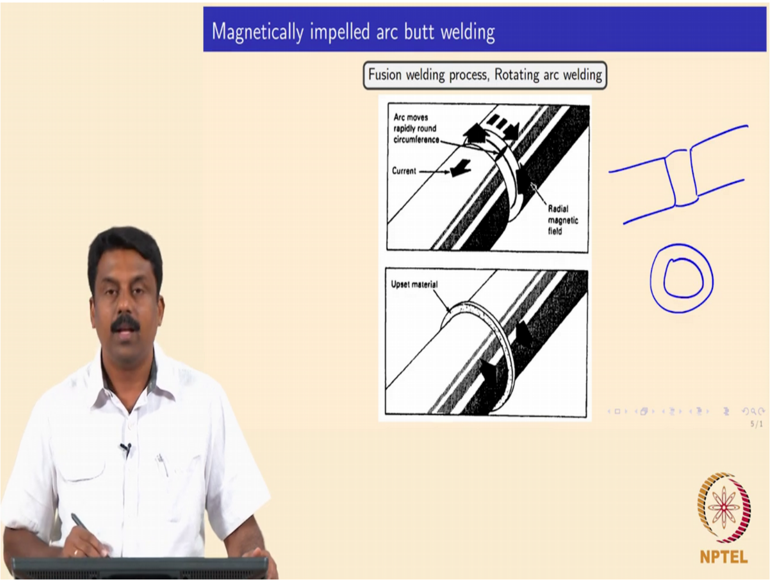

and you have two pipes, you want to strike an arc. Arc would always be struck at the surface, the I D and O D of the pipes, inner diameter and outer diameter surface of the pipes.

Suppose if you want to use the arc as heat source, and you strike the arc only at the top and bottom surface of the pipe and you are not going to melt the entire cross-section thickness, isn't it?

So we will have to find a way to manipulate the arc or you need to strike an arc through entire cross-section but that is not physically possible because electron would always travel at the surface, isn't it?

So we make sure that the arc is striked or arc is travelled throughout the cross-section of the thickness, right? So we have some tricks because these arcs can be deflected by magnetic field, isn't it, right?

So by attaching very strong magnets surrounding the weld job, in this case for example pipes, these arc can be impelled or can be deflected throughout the cross-section. And they can also be made rotated throughout the circumference of the pipe using a strong magnet surrounding the pipe.

So otherwise you would never heat the entire cross-section of the pipe, isn't it, thickness of the pipe. Because when you strike an arc and for flash butt welding it is Ok because the thicknesses what we use are very small, (()) (03:01) 2 m m, 3 m m.

But if you want to weld a 20 m m wall thickness pipe and you will have a strong temperature gradient because the arc will be struck only at the surface. So the center thickness will never melt, right.

So the heat may not be conducted. And if you want to weld you will have to keep it for longer time. Ok then productivity is lost, isn't it?

So that you will have to strike more current, more energy you will have to spend. So in a way, if you attach a magnet surrounding the arc, see the arc can be impelled not only through thickness but also impelled along the circumference, isn't it?

Otherwise you will never strike an arc throughout the cross-section because the electrons will pass, it will pass where it finds the least resistance, isn't it?

So it will go only on the surface, inner and outer thicknesses, the surface and it will not go entire cross-section, Ok. It will travel at varying distances, varying coalescence. So by attaching a very strong magnet surrounding the pipe, so we can impel the arc throughout the cross-section and through the thickness.

So you can melt much more uniformly by using the magnets, right? And these magnets would impel the arc along the circumference as well as along the thicknesses so that you can melt and the moment you melt, you will have a upsetting, Ok.

So upsetting is very important because the molten material, the molten liquid would also contaminate with atmosphere through film oxides, Ok so intrusion will be formed. And we do not want that in the weld.

Ok so what we do then? Then it is same as the flash butt weld. We will do our flashing or upsetting to expel the liquid metal.

And we will have the mechanical coalescence of the heat affected zone which actually mixes with the molten, the surface, coalesce; will form the weld, right. It is clear? It is the same as the flash weld.

So in flash weld we strike an arc, (()) (05:16) gas, strike an arc. We melt and then we do the upsetting. So the molten material would go as a flash and then the solid regions would mechanically deform and coalesce and form a joint.

The same also over here. So the only problem here is we achieve, we can achieve across the large cross-section welds by making so that arc is impelled through the cross-section and through the thickness, right.

And then later the upset material can be removed off, right. And we are going to get this equipment in a month's time. Welding is the, and this process creates huge noise because you can see the arc is, when is impelled it makes huge noise. I have video for that as well.

So we fix the camera inside the pipe, Ok. You can look at, and appreciate the role of magnets.

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Ok, so nothing is moving. Only arc is moving, Ok. So what

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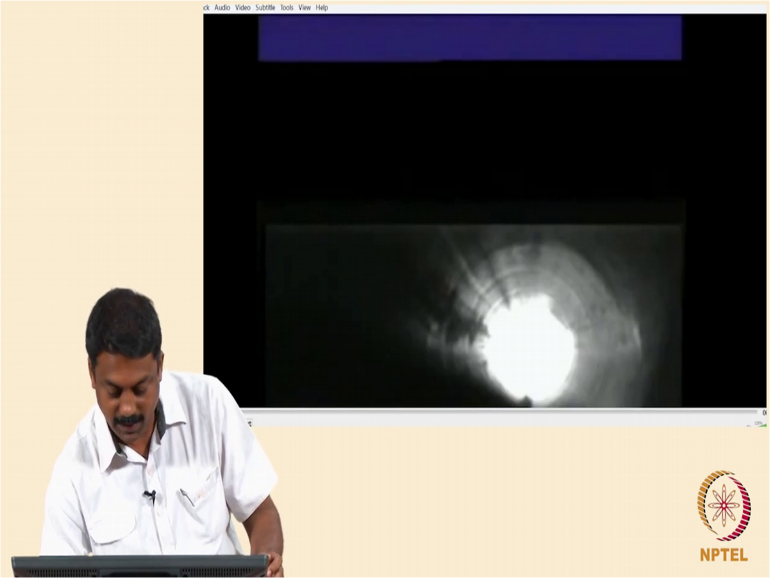

you see over here is the, Ok

06:19 demo start

06:28 demo end

So you see that, so the entire circumference and thickness is arc because we have magnetic field of about 3 Tesla, Ok and that magnetic field is deflecting and impelling the arc through the cross-sections as well as along the thickness.

Ok otherwise we would never achieve such a arcing and along all the cross-sections, Ok. So it will be somewhere here and somewhere over there only at the surface.

06:57 demo start

Yeah, now upset

07:03 demo end

That is it. Ok, so upset is done at the last stages.

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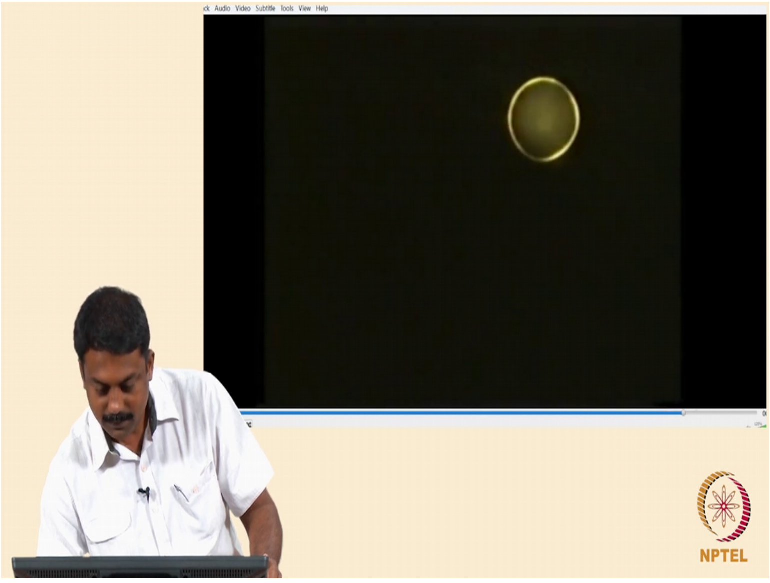

07:09 demo start

07:11 demo end

Now it is moving towards each other. So a preset gap is maintained to strike an arc. Then you make the magnet work so the arc is impelled along the circumference as well as through thickness.

You melt enough volume, heat up enough material and then you bring both the interfaces together with very high speed upsetting. It can repel, it can impel the liquid metal out. Here is the flash and then heated up solid regions can coalesce, make the joint. Ok, that is it.

So it can be fantastic, I mean I do not have high speed video of this process but I have seen a nice video but we will record it once the equipment is there. But you can see,

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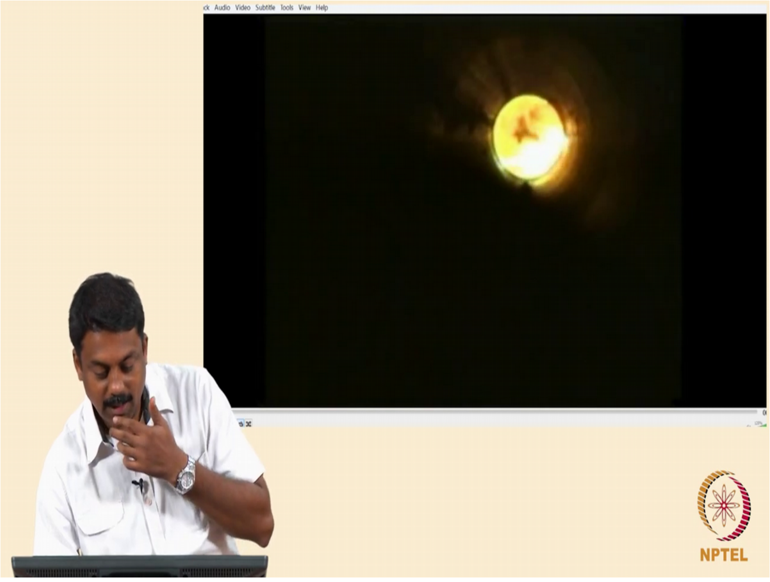

the arc, the impellent, the frequency is extremely high.

Can you see that?

Noise is over here because we fix the camera inside the pipe. Ok so this is the interface from the one side.

08:19 demo start

08:25 demo end

Right? Is it clear, the process?

08:29 demo start

08:36 demo end

And yeah

(Professor – student conversation starts)

Student: (()) (08:39) can come even inside the pipe

Professor: Inside the pipe, yeah. Generally we leave it. Ok, so the machining is done only outside. That is a good point.

(Professor – student conversation ends)

So for

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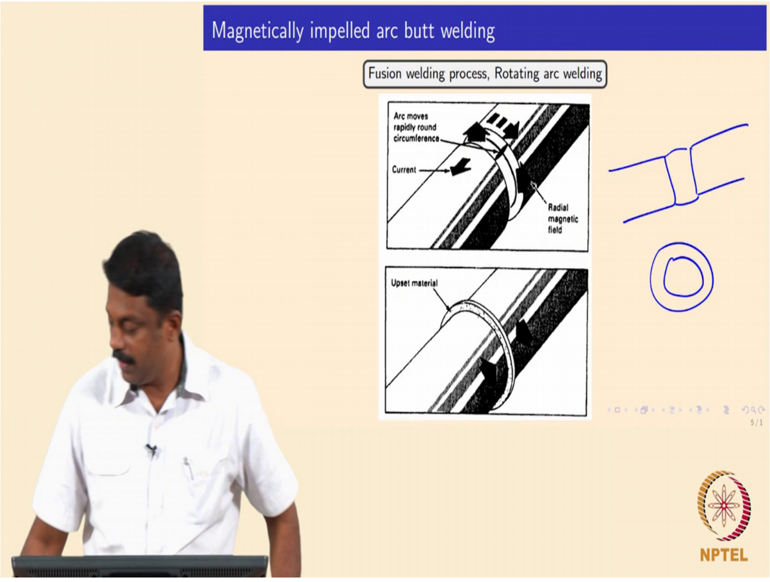

the gas pipeline so we will have to remove the flash even from inside as well. So then, now we have robotic heads with the machining which will travel inside the pipe and then machine it off. Ok so that is possible.

So otherwise if it is not like used for high pressure transportation we do not, I mean leave the pipes, not a problem. For gas pipelines it is not a problem.

For fluids we will have to remove the inner flash. And that is machined off because with the moving machining head inside the pipe. That is commonly done, Ok.

So this process is clear? Now trick is using a magnet, Ok. It is very high power magnet we use and equipment which we buy it has a permanent magnet, Ok so permanent magnet, it is attached to the clamp.

So the clamp which is actually going to hold, it also has a magnet, Ok. The magnetic clamp is going to be attached, Ok and then yeah the material which is going to weld may not be magnetic, Ok.

So it is non-magnetic material also because the arc is electromagnetic and it is going to be deflected, impelled by the magnetic force, right? It is clear? Good

It is also known as rotating arc welding because arc is rotated, Ok. Most commonly used terminology is MIAB, magnetically impelled arc butt welding,

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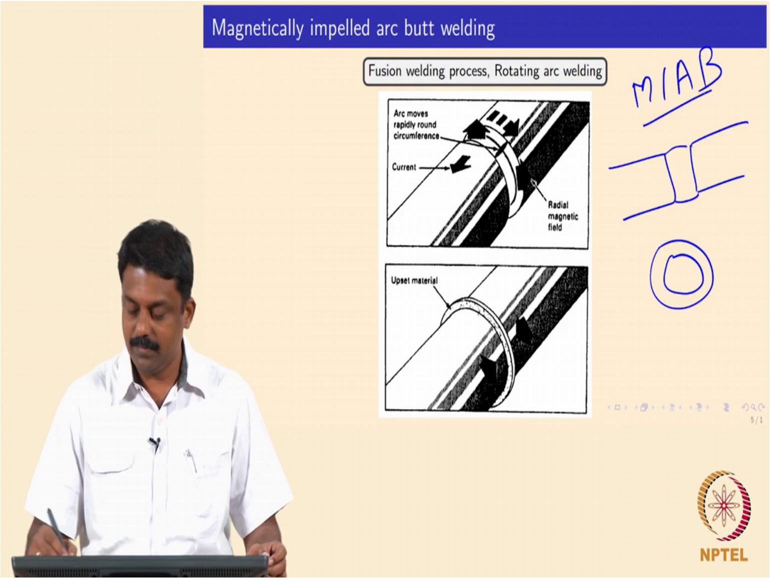

yeah, Ok.

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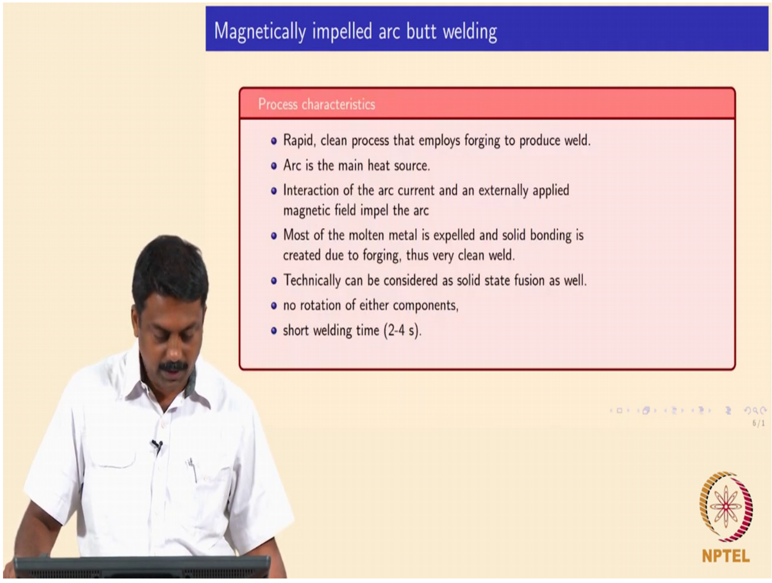

So what is the advantage? Again so the MIAB, it is a very nice process to weld pipelines of varying thickness, Ok and so we, the final joint does not have any solidification structure, isn't it?

The liquid is expelled so you have a deformation. So ultimately, finally when the weld joint after removal of flash, it does not have any (()) (10:58), isn’t it?

So all the, the problem that is associated with solidifed microstructure, it is not there. The pipe will have a mechanically deformed interface, Ok. So that will be recrystallized, will have much finer grain size, Ok.

So that is why you know this process is very widely, can be used for welding the pipelines, for (()) (11:20) applications, Ok.

The arc is the heat source with which it melts, Ok and then the arc expels, expelled and then impelled along circumference thickness to heat the material and subsequently all the molten material is expelled by the upsetting. Then we have a solid bonding, Ok solid state bonding or welding of the interface, Ok.

So technically it is a solid state process, same as flash butt, right. But it still melt, Ok. And we do not need to rotate the component, Ok or suppose you are using condensed G M A W, you have to weld in 5 G configuration

That means the heat source should also be going around the pipe, or pipe has to be protected. It is not necessary here in this case, right. Because the arc is made to rotate, Ok and then you can achieve the welding in very short time in 2 to 4 seconds. Yes, it is clear? Good

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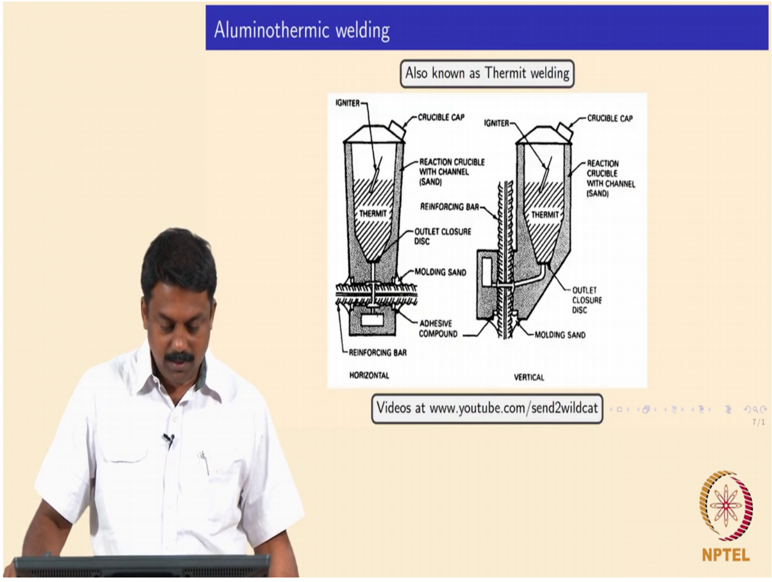

So we will see one more and then we wind up, Ok. The last, the liquid metal process what we are going to look at is aluminothermic welding. And aluminothermic welding, it is very commonly used to weld rails, Ok. So rails, I do not know how many of you have seen thermit welding in railway station.

So when you are, in most of the cases when the welding is done in railway lines you would see 10-12 engineers standing. One guy would be welding. So these 10-12 engineers will make sure that welding is done properly. The guy who is actually there and welding, he would be working extremely hard, right?

Because these 12 guys are all responsible for the quality of the weld, Ok. So if you go to my Youtube page there are 3 videos of thermit welding. So railways are really the lines are welded in field by thermit welding.

Ok so thermit welding it works in the principle that, so when the oxides of metals react with aluminum and they burn, Ok, you generate aluminum oxide and enormous amount of heat by exothermic reaction of oxidation of aluminum.

Ok so that is the heat source and then metal oxide will be reduced and it will form a molten metal, Ok so it is a simple principle right.

So do have a look at my Youtube page. I have 3 videos. So how you do is, so this is railway welding. So railway, you see that?

Guy is there, Ok so you make mould. It is a casting process, Ok in a way. Ok and then you fill with thermit and iron oxide mixer and then igniter burns and then the reaction happens.

So what is reaction? So you have iron oxide plus aluminum, right A l 2 O 3 F e

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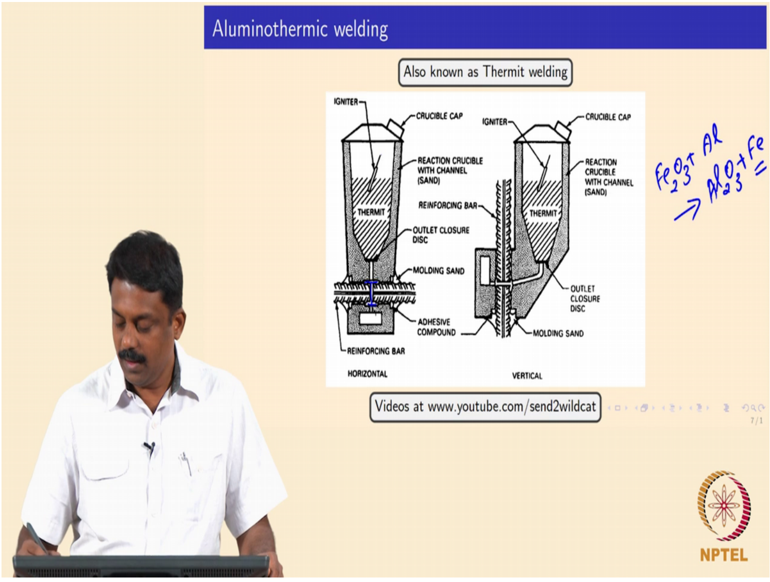

and then you generate heat because reaction is

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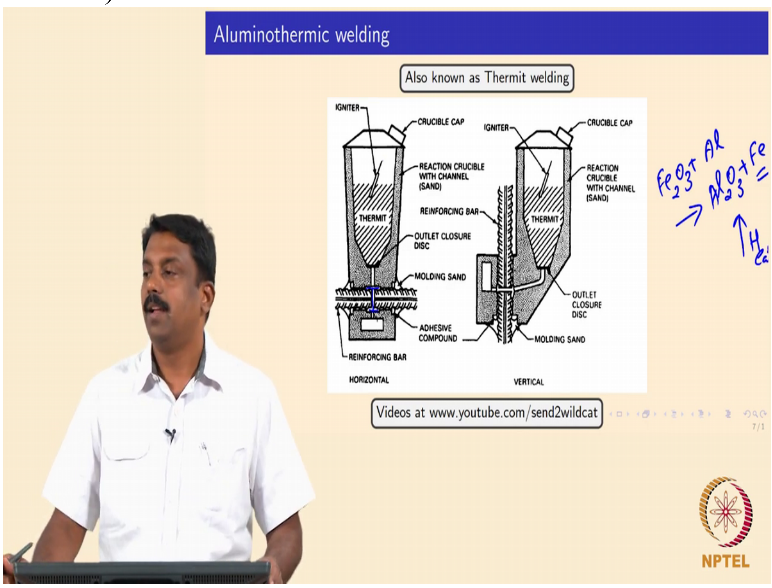

exothermic.

Ok, during this process the iron which is actually produced in the reaction melts, Ok fills the weld cavity, isn't it, right? And you also generate the molten liquid by filling it with the thermit mixture which is mixture of metal oxide and aluminum.

You ignite and then you contain the resultant molten liquid by the mould. OK and then this liquid metal penetrates the weld cavity then solidifies at the weld cavity and then subsequently you can machine off the excess material,

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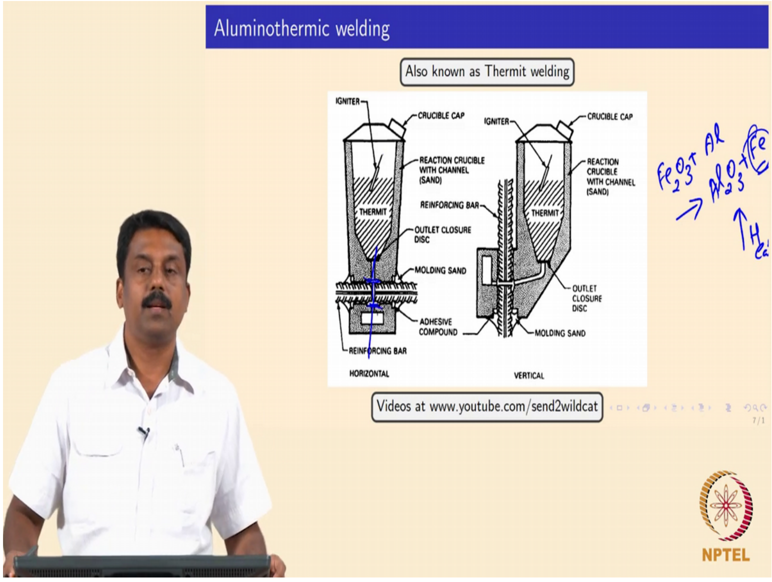

riser and then the joint will be made after subsequently made, Ok.

So this is my Youtube page

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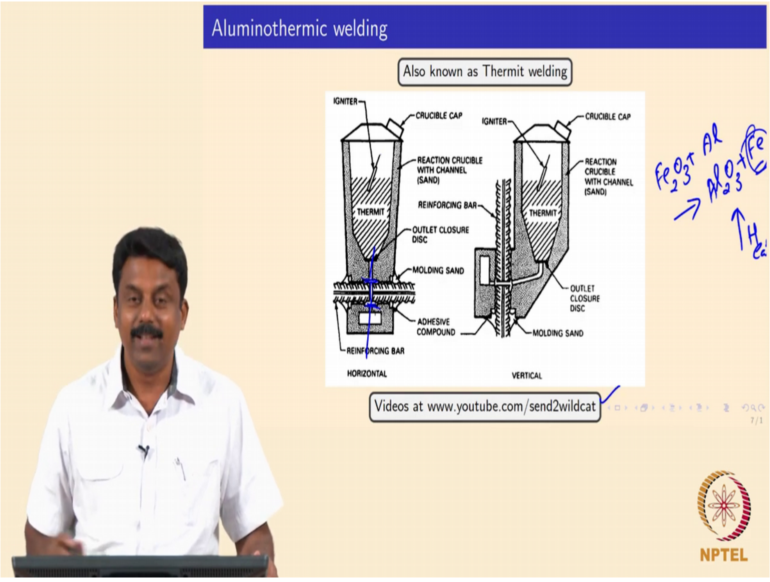

so you can look at it. There are 3 videos which actually, very long videos. You can enjoy from the beginning, right. So it is very clear, right?

The main

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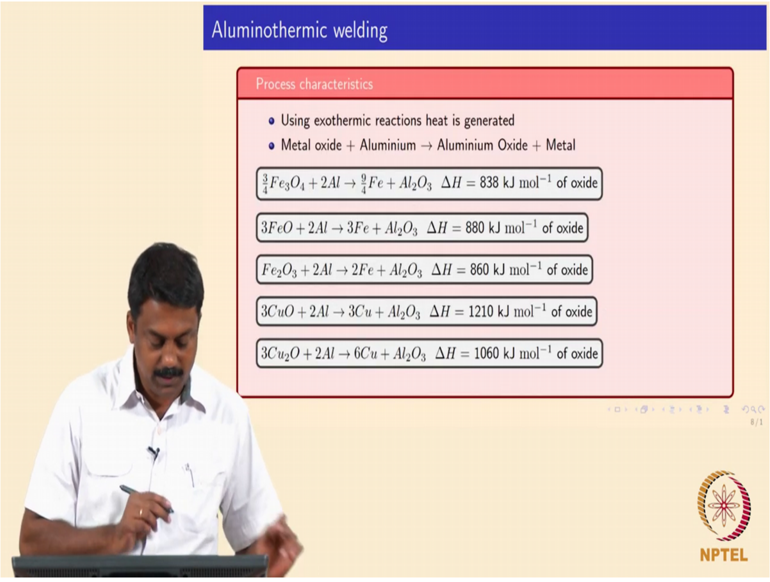

principle reaction what you use is the exothermic reaction, when the metal oxide reacts with aluminum, it burns, it forms aluminum oxide and liquid metal and the amount of heat you generate can be very high, right.

For example the first reaction, so F e 3 O 4 reacts with aluminum, forms iron, aluminum oxide. The enthalpy of

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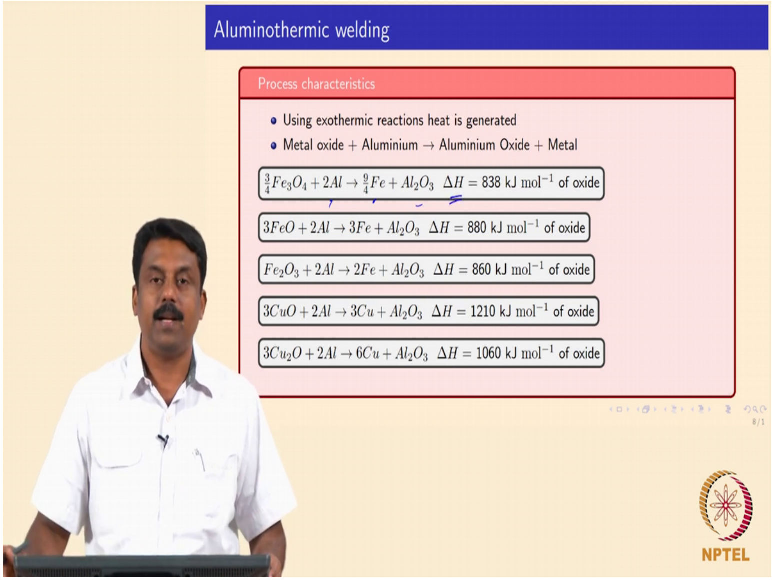

this reaction is 838 kilo Joules per mole of oxide, Ok.

So that is a huge heat and this heat actually produces molten iron, Ok so you can also use F e O and also there with the copper as well. So the delta H of the

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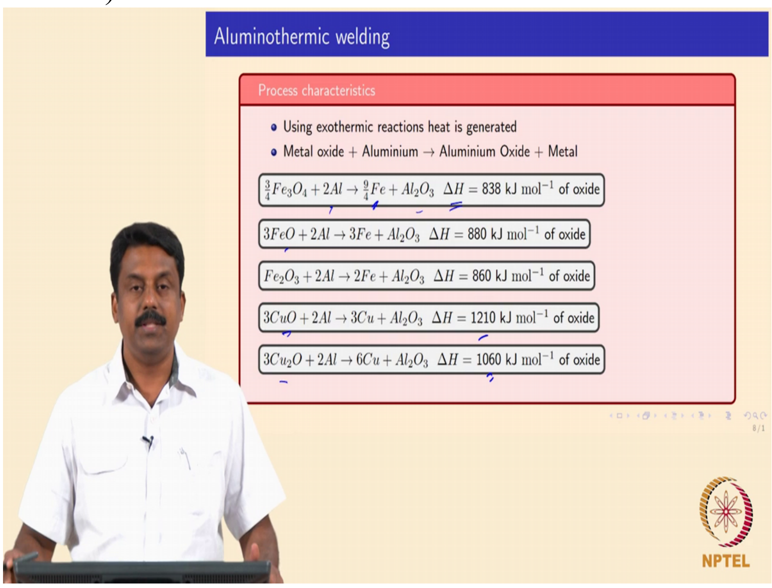

reaction is even higher, right? It is clear?

Ok so we will look at it again next class. I will try to bring these videos,

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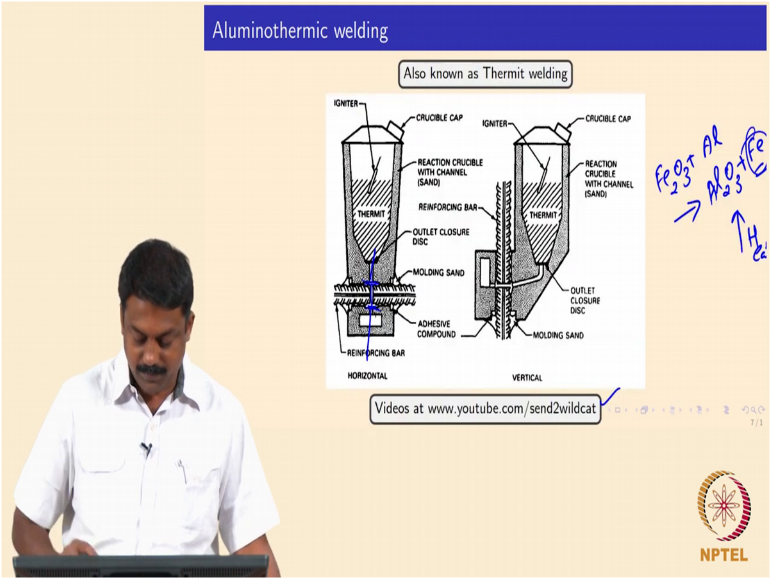

Ok but it is really a long video. But we will see.

And then so we can appreciate because almost the entire railway lines in the field even in India it is done with the thermit welding. Ok so it is very effective, very simple process, very clean process but it is very old, Ok.

So nowadays we are also developing technologies to weld railways using flash butt but flash butt cannot be done in fields. Ok you have to an upsetting as well, right?

So flash weld, now it is time to get into railways. We are also trying to develop LASER hybrid to join two rails but those are far-fetched ideas. So right now railway lines in the field, they are all welded with thermit welding.

Ok we will see video next class.