Welding Processes
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Multi cathode GTAW and Activated GTAW

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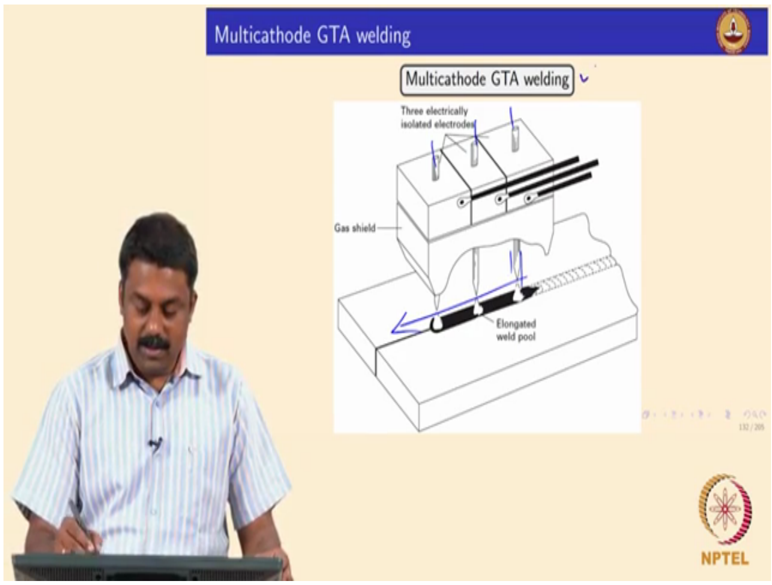

So sometimes if you have a very high energy density process, you always have one undercut. That means the penetration may not be achieved if you do not have a key hole. So in those applications we can also use multi cathode TIG process. So in this case we melt more basically. So if you want to increase the productivity, so we can use instead of one tungsten electrode, because we always greedy. So we can increase the productivity, and we can also avoid the undercut by melting more volume, so liquid can flow and fill the weld cavity. So in this process basically instead of one we used three or even four or five.

And then we can continuously melt and then so generally it does the melting at one area and then we move to next area. So when you are continuously welding, we have a problem. So we melt and then move to next area and weld and continuously we will have overlapping. So multi cathode welding it increase the productivity significantly because obviously you melt more.

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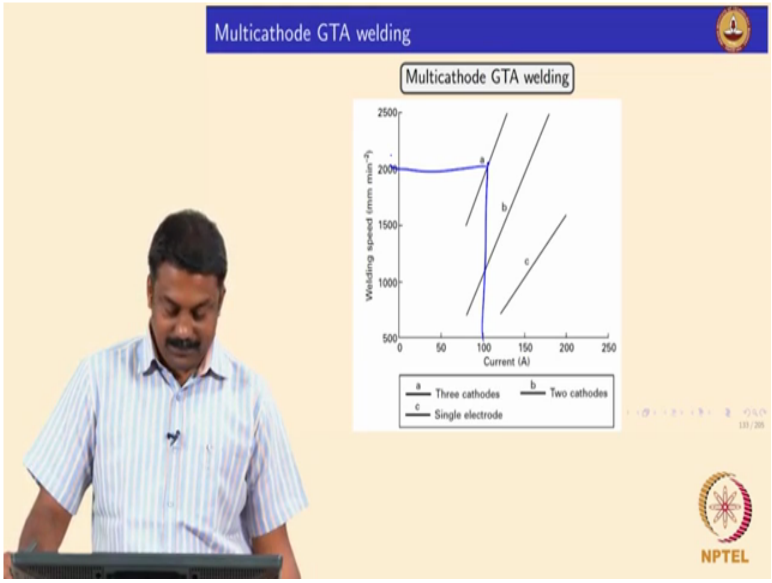

So this graph I borrowed it from and it is very obvious graph. So you can increase the welding speed tremendously by using a multi cathode for example in this case. And a is three electrode with significant lower current and you can weld it in much higher velocities because you have more electrodes.

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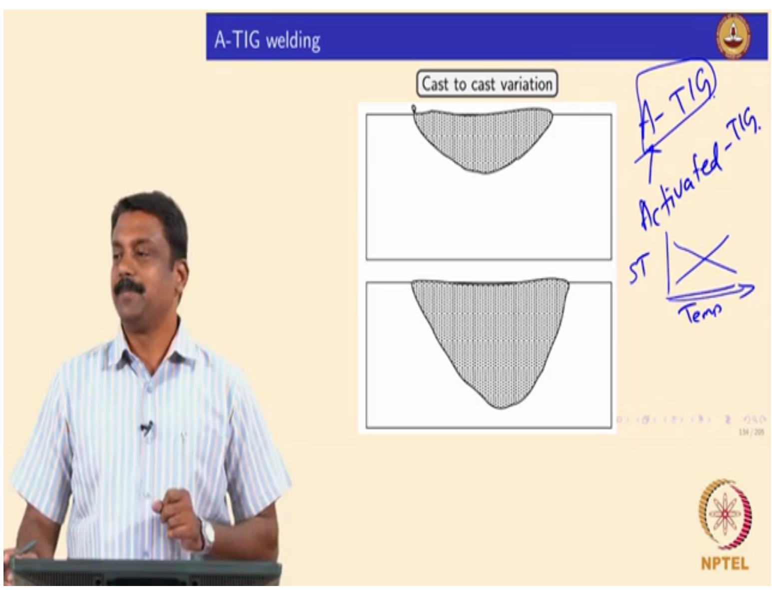

Other development, is very commonly used industrial scale, is known as A-TIG. A stands for activated TIG. What is activated here? Weld, pool is activated. And before that metallurgically lot of challenges, if you are working in a steel plant, I always say no two microstructures are the same. So no two cast are the same. You always have small variations. So you need to have very small compositional variation and your weld characteristics can be very different. For example, in this case I put two diagrams.

Assuming this as the same composition with slight change in sulfur, sulfur is changed to 0.05 into 0.01. And we do not care about it because you always say that it is one grade where you are choosing 65 or 25, because the composition in the standards are defined over ranges. But in a welding case, in a welding condition it can cause significant difference in weld geometry. Say I will give you a classical example. We always face because of the sulfur. So when you have a sulfur, the surface tension of the liquid pool changes significantly.

Imagine in two cases I am going to show you. So one case, you add some element or some element concentration is increased in such a way that surface tension of the liquid decreases as a function of temperature. So surface tension, this is temperature. And when you increase the temperature, surface tension or the liquid decreases. Okay, that can happen, for example, you add elements and you need to reduce surface tension as function of temperature.

Or you add some other element or you change the concentration of some other element such a way that the surface tension increases as a function of temperature. And these two can play significant role in determining weld pool geometry. So you might be one sheet and you see that there is a very nice weld, fantastic. Suddenly you change it to another supply of the same grade, with the same welding parameter you will never get same geometry. Even a small change in the chemistry can change the weld geometry. But what is the role of the activated TIG in that? That is what I am going to see. So imagine now the situation I told you.

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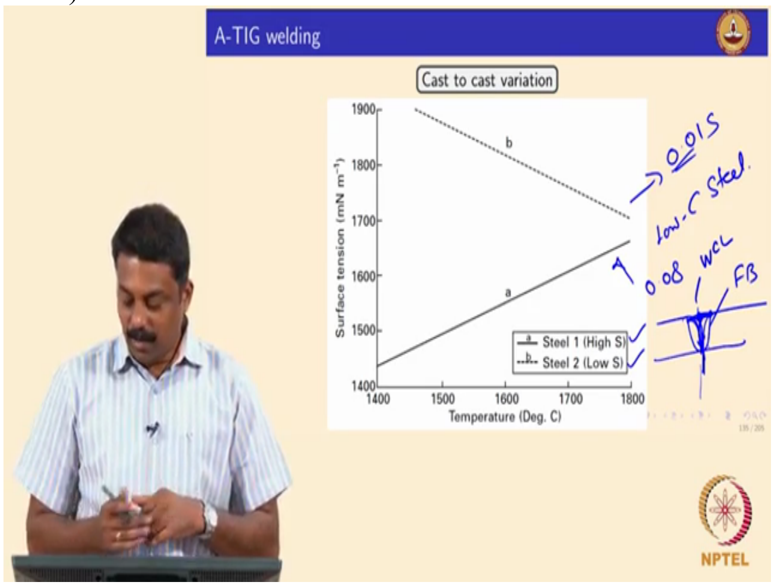

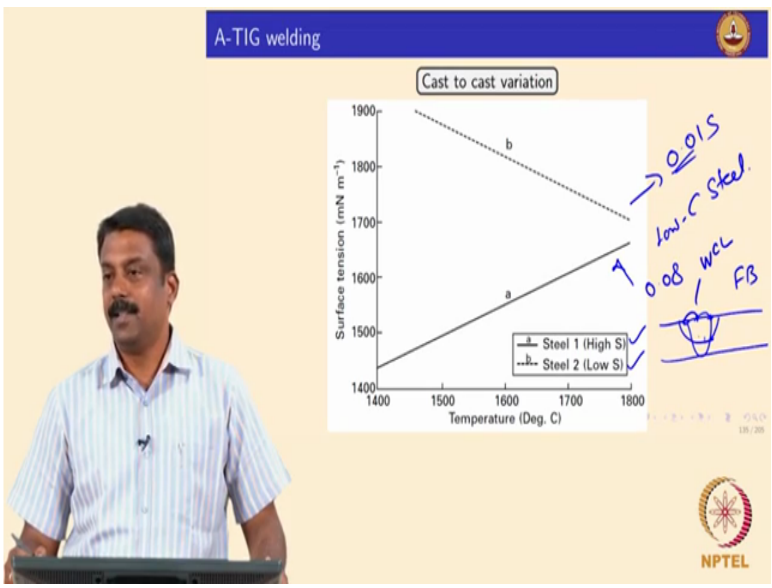

So in this case, two cases, high sulfur and low sulfur. If you add sulfur, the surface tension of the liquid increases as a function of temperature. So this is the curve. So this is for low common steel. If the sulfur concentration decreases, that means that say in this case 0.08, this case 0.01, you see a significant change in surface tension. So if you remove the sulfur, surface tension decreases as a function of temperature.

So how does it influence the weld geometry? So weld you have a temperature gradient, is not it? So this is weld central line, sorry that is not weld central line, that is going somewhere ridge. So you always have a maximum temperature weld central line, and when we move towards fission boundary, you are familiar with the term now, so this is fission boundary and this is weld central line. So you always have a temperature gradient where weld central line always had higher temperature. So now imagine the case a, in case a what it says that the surface tension increases as function of temperature.

That means that liquid in the weld central line will have a higher surface tension than your liquid in the fission boundary. So here high tension liquid and this is low tension liquid. So then what will be the vertex formation? High tension, low tension. So high tension liquid will pull low tension liquid, then you have a flow going inwards. So you will have a flow be going like that. So you have high tension liquid and low tension liquid, and this surface tension gradient is generated by the composition.

Composition is homogeneous. The temperature is different. As a function of temperature the surface tension change. So liquid at the middle will have high surface tension than the liquid in the fission boundary, then you will have inward flow. If inward flow, obviously you will have a very good penetration because the heat is transferred. So you will have a shallow or less wide bid and then deep penetration, the deep weld because the flow is pulled inward.

So now the same condition, all the welding parameters are the same. But you are welding this material, it will be, in that case what happens? You have a weld liquid made, now unfortunately the liquid surface tension decreases as function of temperature. So then what will be the flow? Outwards. So then you will have a wider bid which shallow penetration. So this is the classical example I just showed.

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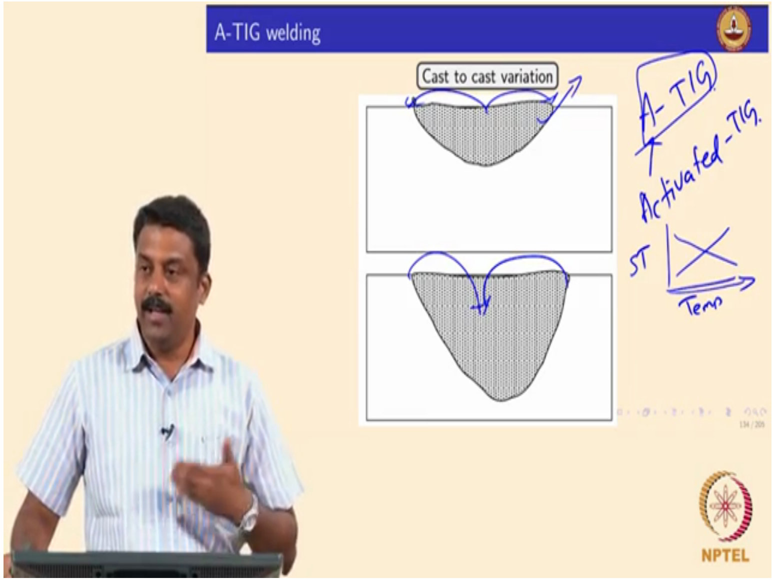

In this case material b where surface tension decreases as function of temperature. So flow is outwards whereas your surface tension increases as function of temperature. Then the flow will be inwards. And this is what known as cast-to-cast variation because every cast, you have a slight difference in sulfur and sulfur significantly changes surface tension. So that can lead to geometrical change. And this is a very common particle problem to achieve good geometry over time and time and again.

So you may be welding almost same parameter. A morning shift guy would make reasonably good geometry and the afternoon shift guy will come up with undercut. And you would go back and look at the material, you cannot really see, everything is same. Same grade, same welding parameter and you will be wondering why it is happening, undercut. So then if you look at the composition very clearly, a small variation in sulfur would lead to a variation in the weld geometry. So this is very commonly observed phenomena, the cast-to-cast variation.

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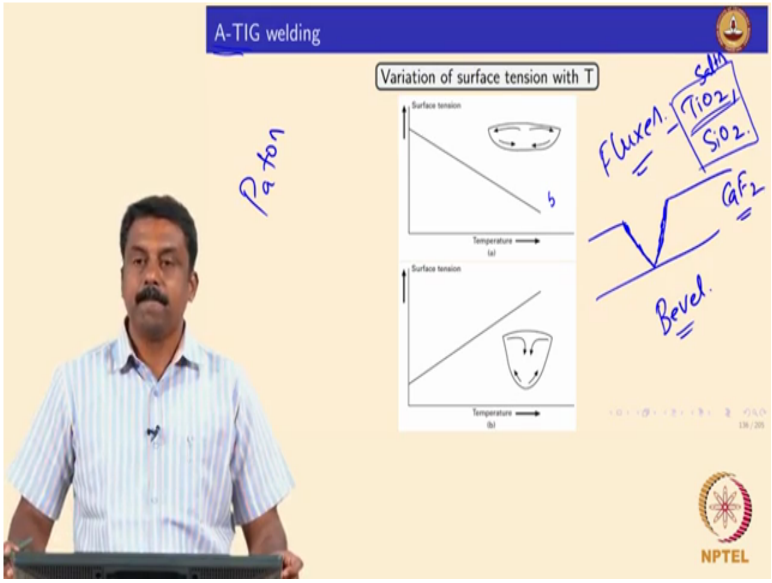

And because of this, so in a classical, in a case b, the flow will be outward. Then you will have wider bid and shallow penetration. And in the case a where the surface tension increases as function of temperature you will have inward vertex formation, the flow formation and you will have narrow and then deep penetration weld. So this problem somehow can be overcome by adding fluxes to the weld wall. So what we do is generally, so if you make a bevel. What is bevel? This machining, so we can have b bubble or k bubble. So we prepare the adjust before weld, that is what known as bevel.

And we apply the fluxes on these walls. And fluxes are generally the oxides or some salts. Generally the titanium oxide is commonly used flux which change the surface tension. So the effect of titanium oxide is more significant than the effect of sulfur. So if you have titanium oxide, the variation in sulfur is superseded by the addition of titanium oxide. So you always have a same flow in the pool and due to that the variation in composition, small variation in composition can be taken care of the addition of these fluxes.

So these fluxes are, the role of these fluxes is still not clear but it is assumed that they have a very significant effect on surface tension or the pool. So if a sulfur changes to surface tension value of 1 unit, titanium oxide can then change thousands of unit. So that means that the smaller effect can be taken out. So you always have effect of titanium oxide seen so that we can have uniform welds made by the addition of these fluxes. So this flux addition is first done by

Russians in the (())(12:36). This is very famous welding institute in Ukraine is called Paton Welding Institute.

And they first thought about this. Again they did lot of work on effect of composition on the viscosity or surface tension. They found that additional titanium oxide is beneficial. And then you could get consistent weld build geometry by adding these fluxes. And they called that process A TIG, activated TIG process. And the flux chemistries are, yeah each company if you buy a flux, they have their own secret weapons, secret compositions. And most of the time generally they contain oxides of titanium, titanium oxide, silicon oxide or calcium floride, CF2. And these are very commonly used fluxes.

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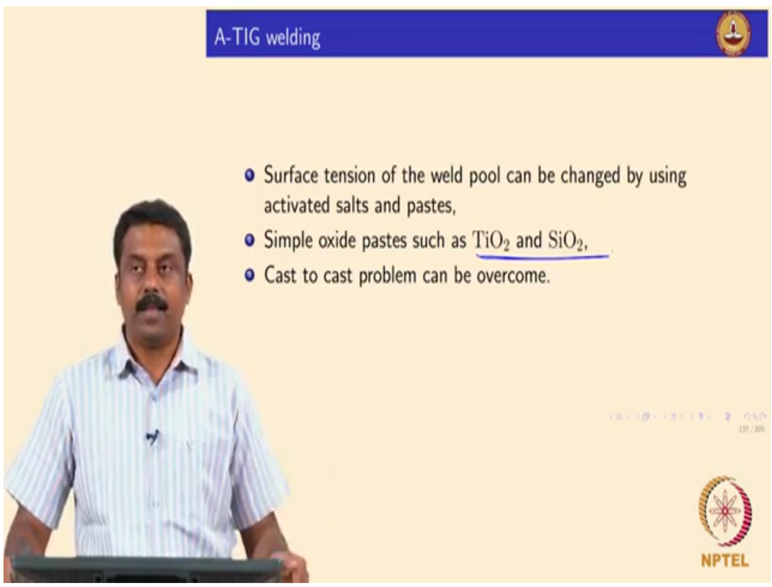

So yeah, that is what I put it in words, what explained. The surface tension of the pool can be changed significantly by adding salts and pastes. The most common pastes are made of titanium oxide, silicon oxide. And by doing so, so we neglect or overcome the small variation that is generally seen with the composition, yes, is clear?