**Welding Processes**
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**Friction Stir Welding Part 01**

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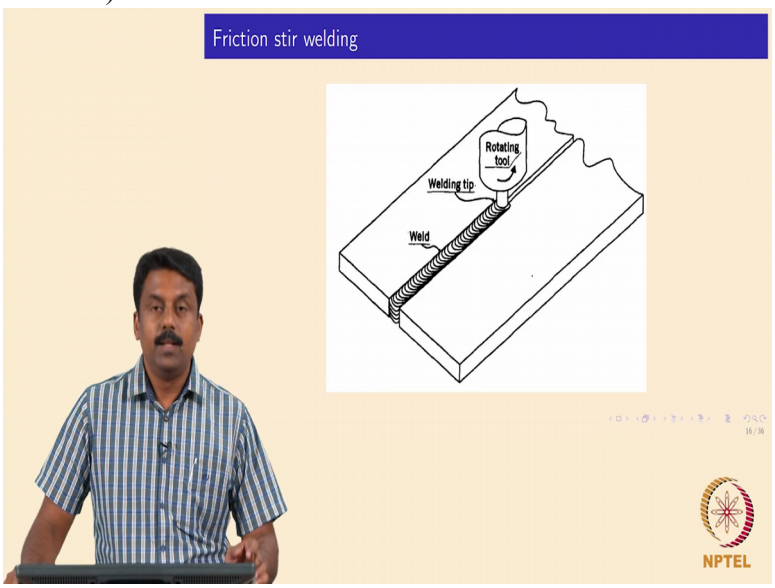


So we move to the other interesting process, Ok. In friction welding what you saw that the job is rotating, isn't it? The interface, one of the interfaces is rotating all the time.

There is no external pins or any other external member is rotating except in this

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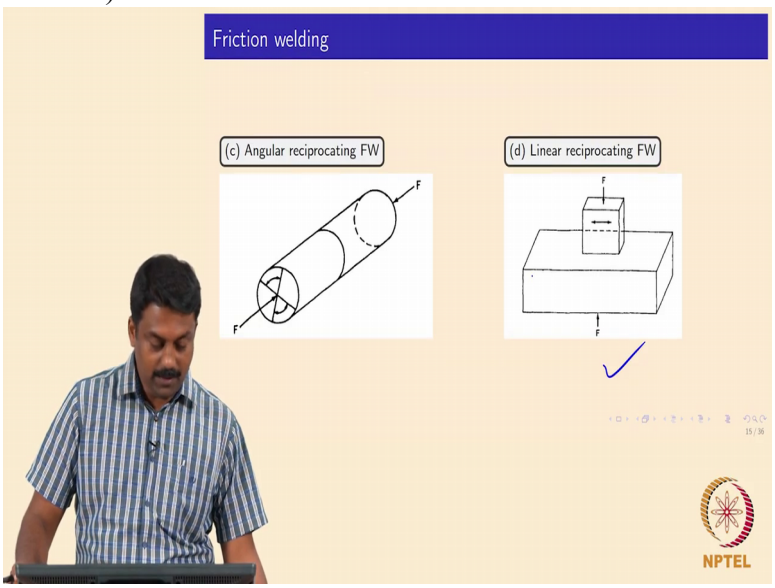


radial friction welding where you

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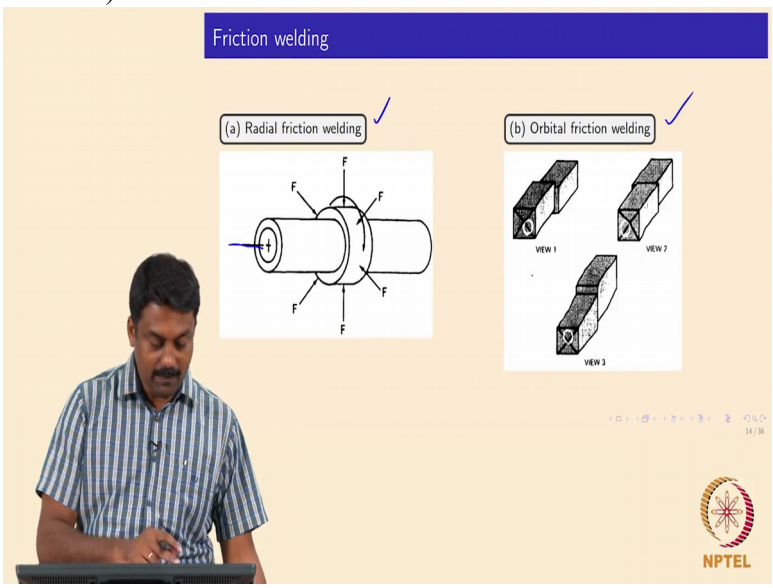


have a ring is rotating, right.

So we can also achieve

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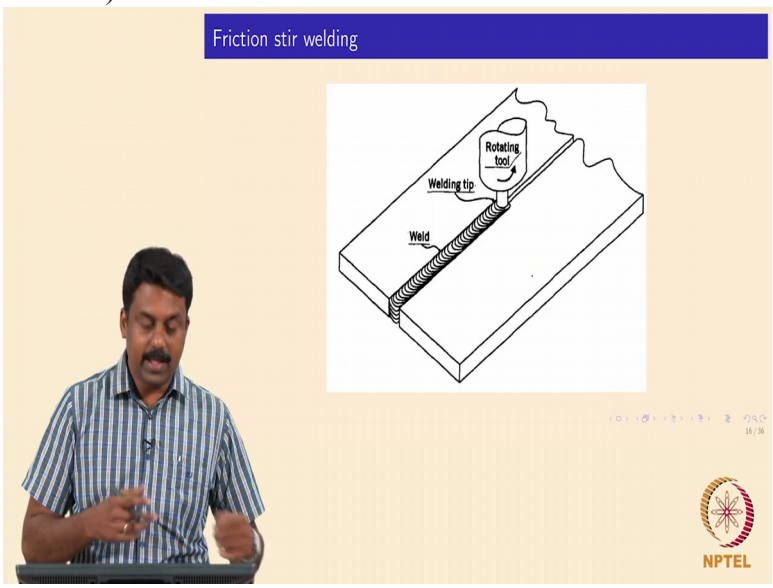


the heat by inserting a pin and make it rotate at the interface, isn't it? So you take a simple nail, insert it at the interface and then clamp it together and rotate the nail.

And there is also interface, Ok between the nail and the interface is going to be heated up by friction because of rotation of the nail and ultimately once the material softens, because nail is rotating and nail can be made into somewhat hard material.

And during this process, when nail rotates, Ok heat is generated and interface ductility increases. So when the nail is rotating it can also bring the material from one interface to other interface, Ok causing mechanical deformation at the interface and the material can be moved from one place to another place by rotation of nail, right.

And this process is known as friction stir welding, Ok. So you have a rotating tool at the interface and this tool is plunged into the interface initially. And then it is rotated.

And during this rotation obviously there is friction between the tool and the interface. So the heat is generated, because of the rotation of the pin on the interface. The moment the temperature is increasing the interface becomes softer.

So the tool, when it moves when temperature is high the interface can be deformed, the rotating motion of the tool can deform the material from one interface to another interface, Ok and during this process the interface becomes coalesced forming a joint, right. So this process is known as friction stir welding.

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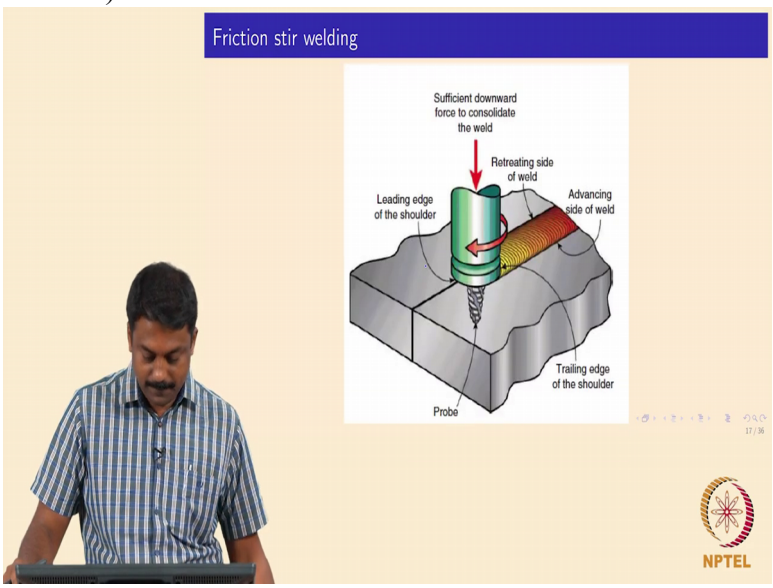


And this is very commonly used for aluminum alloys, right. So you need to make sure that the nail is inserted and subsequently the nail is rotated at the interface causing a frictional heat generation, and subsequently the mechanical deformation by the motion of rotation of the pin would cause interface to coalesce.

And this process, I mean is slightly complex than simple friction welding Ok because there are various process parameters which controls the welding properties.

For example, of course we also have the force but there is no upsetting in this case, isn't it? What you have it is a rotation of the pin, right. So the force you are applying would determine the weld quality and apart from that you also have a pin, the geometry of the pin.

So Ok what all types of pins we can use? And that would determine the flow of material from one interface to another interface, isn't it? And the pin geometry, the pin surface characteristics would also determine the heat generation, isn't it?

So there are various other effects would also control the process stability than the friction welding. In friction welding, only 3, isn't it? The r p m, rotational speed, the upset force and upset distance.

Here there is no upset distance. There is no upset force. What you have is a downward force Ok acting on the pin which is rotating at the interface, Ok.

So we can see, you know in a typical, resistance spot welding, some nomenclatures. So we need to have a pin which is actually inserted, plunged into the material and then you have, the pin is rotated.

And you have advancing side which is advancing side is, so when pin is moved along the clockwise, suppose it is moving clockwise so we have an advancing side and then when the pin is going you have retracting side, Ok.

So when pin is rotating you are having advancing of the motion and then retracting of the motion. Ok so we have two sides, the advanced side, advancing side

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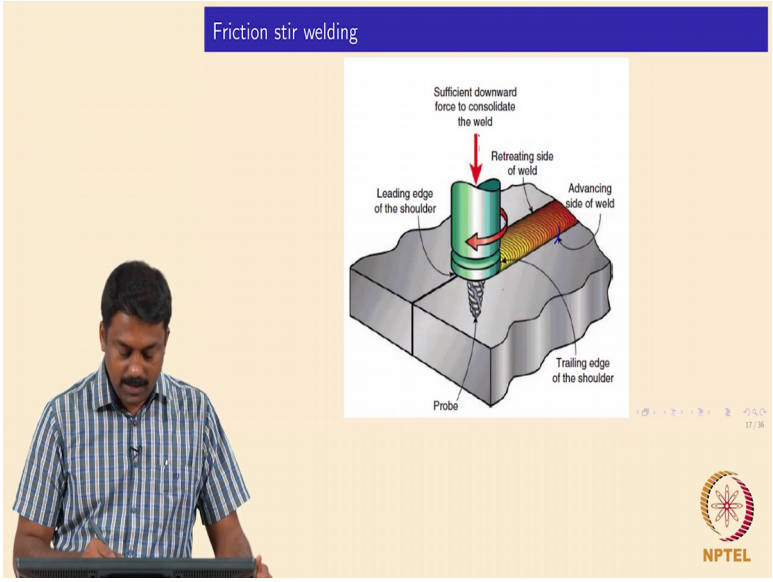


and then retractor side,

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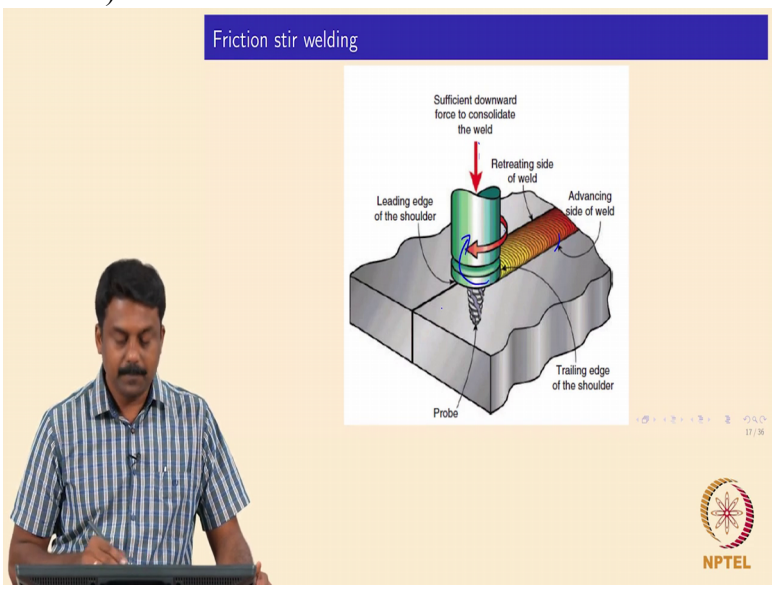


isn't it?

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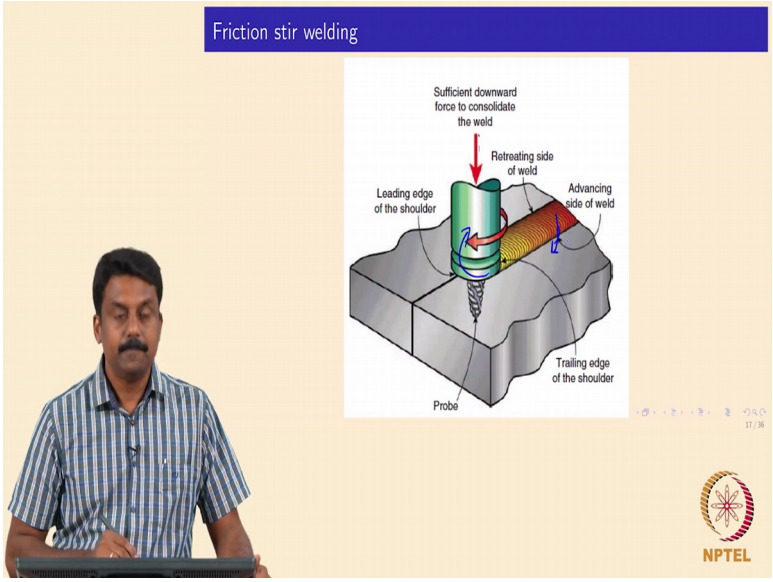


Ok.

And then we also have the starting of the weld, ending of the weld so we have the leading side and then the trailing side isn't it? The leading side is the front of the tool and trailing side is the back of the tool, right.

So we will see in this process what are the stability factors, Ok so how we can increase stability, what are the forces that control the weld characteristics, right. Then we look at some of the tool geometries and some of the advantages and disadvantages of this process.

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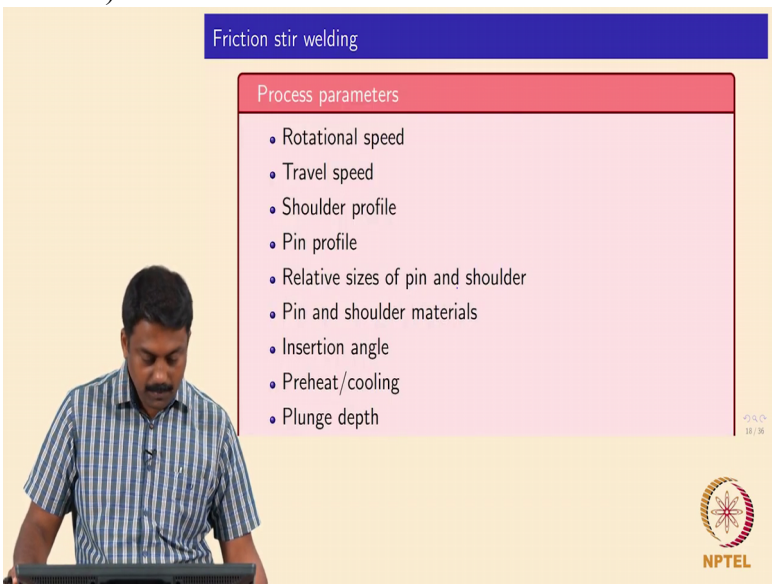

So if we look at the process parameters those are controlled in the weld characteristics in friction stir welding is first rotational speed of the tool itself, Ok r p ms, how fast you are going to rotate, Ok.

And then welding speed because in this case the pin is moved along the interface. We are doing very slowly, we are doing faster, that will also determine your weld quality, isn't it? And also welding geometry.

And then

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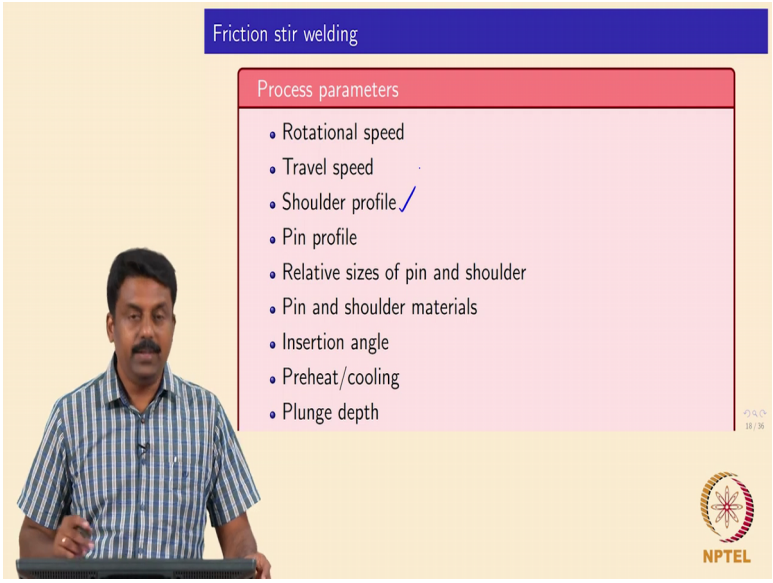


the profile of the shoulder itself. What do we mean by shoulder? We have pin like this and this shoulder,

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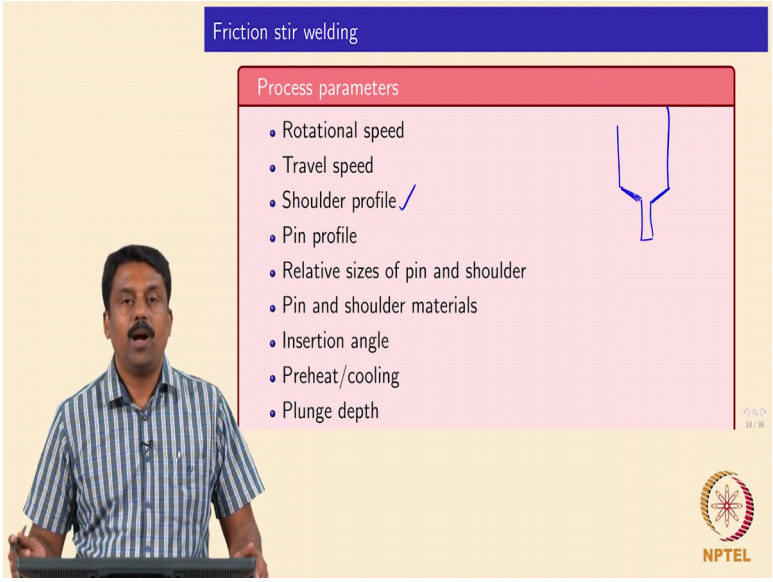


how you make the shoulder?

So it can be flat shoulder, it can be also with an edges, it can

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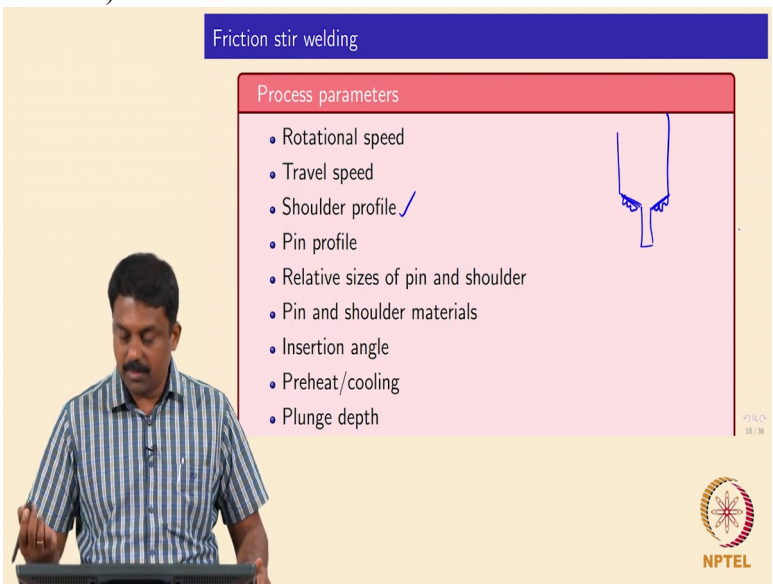


also be in various configurations because that is also going to affect the frictional heat generation as well as the mechanical deformation.

Similarly the pin profile, the shape of the pin. Ok whether it is simple circular or you have some helical or you may also have hexagonal and various pin profiles and you can use it to achieve required welding characteristics.

The size of the pin with respect to shoulder, Ok that will also determine the process characteristics and the material itself, so what material use it to make these pins and these shoulders.

Generally the friction stir welding is commonly used only for aluminum alloys because steels and the other material it is very difficult to weld using friction stir because of the problem with pin itself.

Because for welding steel obviously, you know steel is stronger than aluminum and you also generate more heat if you want to friction stir weld 2 steel plates. So the pin should withstand the temperatures, right.

So you will have to make very expensive tooling with ceramic coating for example or tool itself is made of tungsten carbides or some carbides so that the pin does not deform, or does not heat up, does not buckle.

And then angle of insertion, it can be vertical or can be slightly inclined Ok. So that will also determine the weld characteristics.

And then

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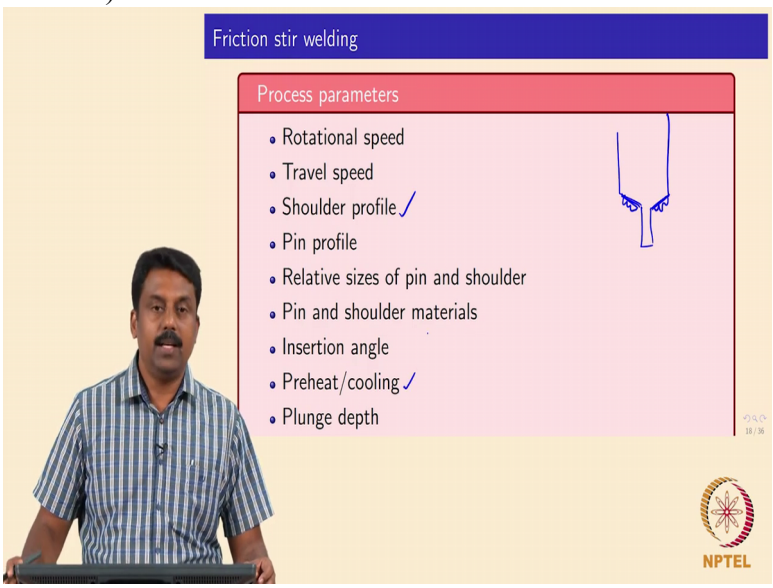

you may also have preheating and cooling, Ok that will also influence the welding characteristics

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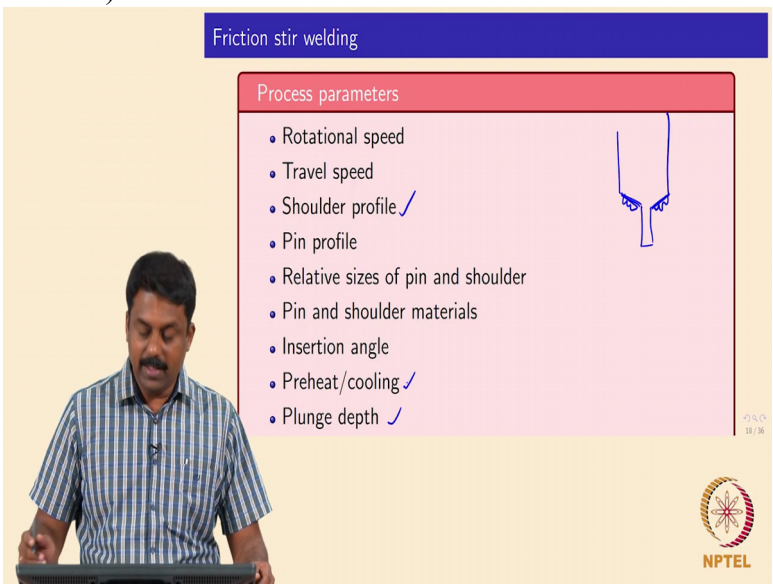


and plunge depth Ok so and what depth do actually, insert the pin to the interface, right.

So it can be in full thickness, or it can also be in half thickness. Mixed with that the material is heated up much more than you are doing full insertion so that we will also have mechanical deformation in the unplunged region as well. Ok so these are all the process characteristics commonly varied to achieve the decided weld geometry.

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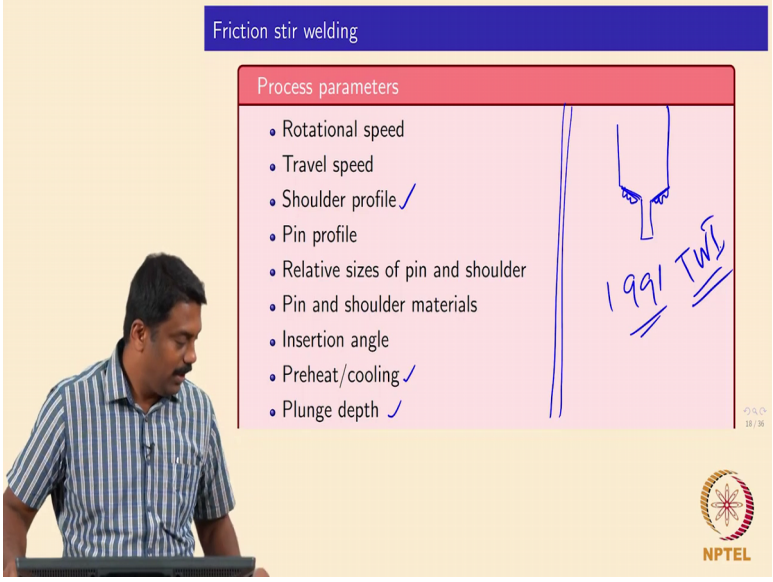


So I have got recorded video from T W I where the weld

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aircraft is (()) (09:15). Ok so this is the brand Electrostir, EuroStir they call it.

So this is the flaperon. Ok so when you see and you sit next to the window on top, I mean next to the wing you see that flaperon is going up and down, right. And that is made of aluminum. So the aluminum 5000 series I think. Ok so this is getting welded, I mean T W I and this is for Airbus.

Ok so you see this structure is the flaperon structure,

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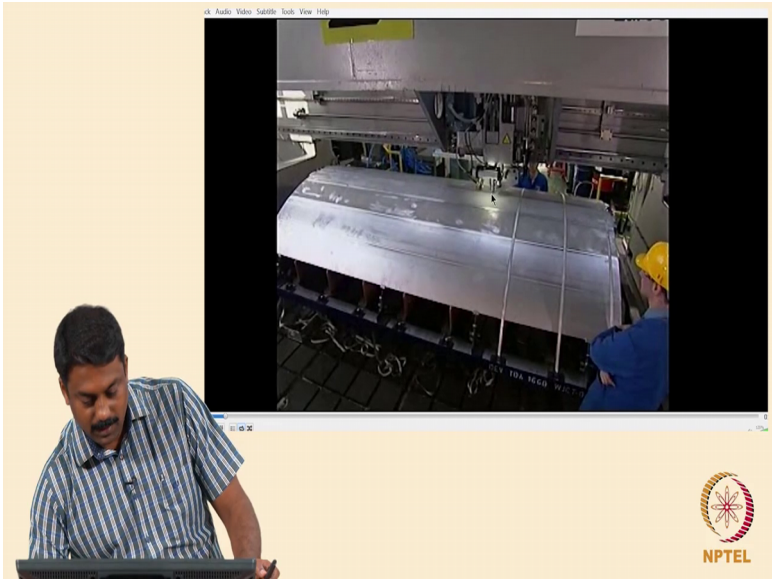


Ok. So what you see over here is the tool is rotating.

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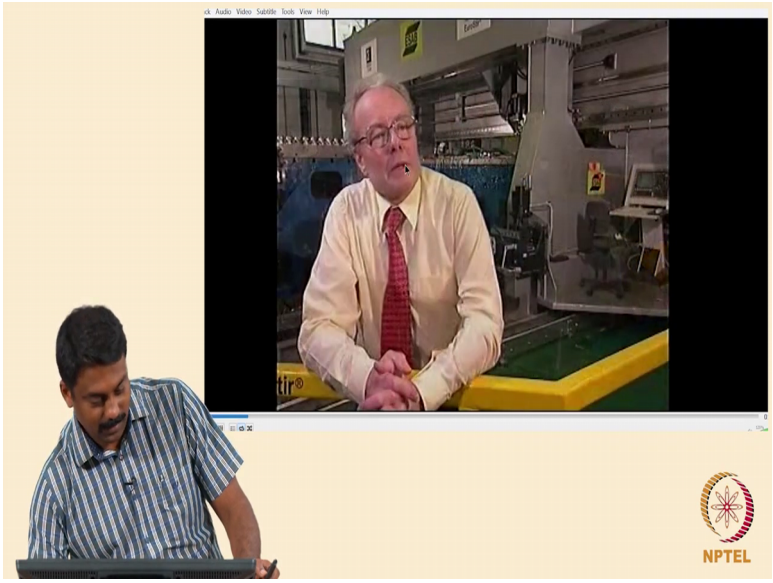

So he is Chris Dawes, I will just

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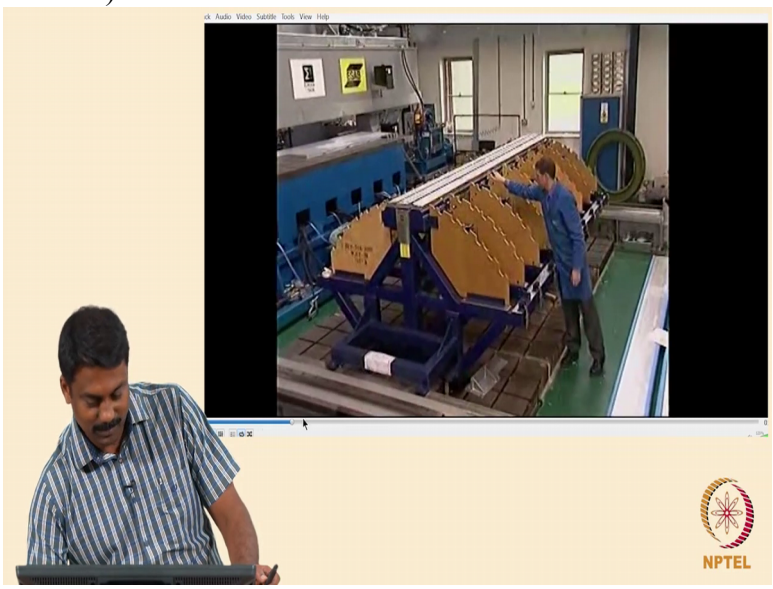

fast forward it.

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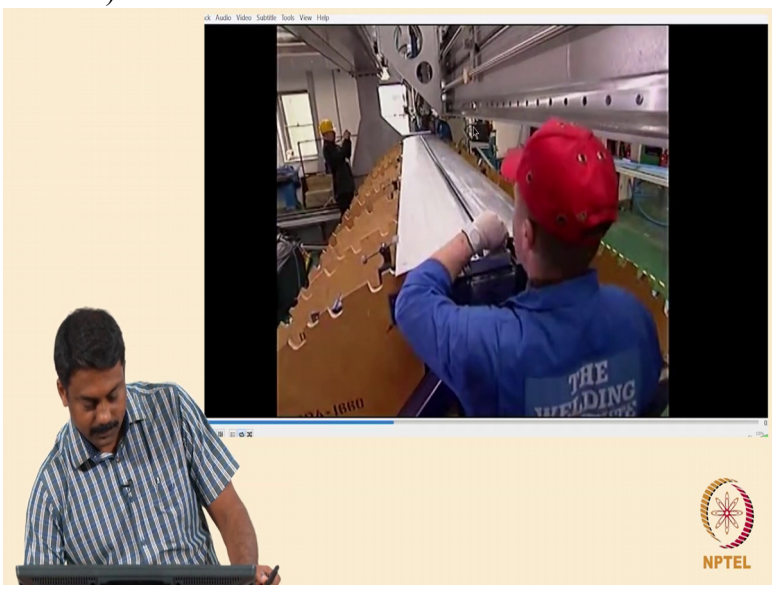

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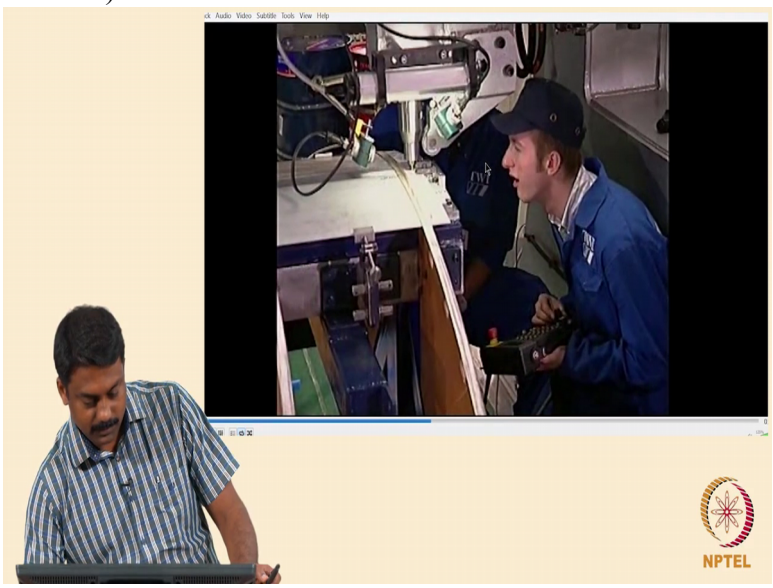


So this is the flaperon structure. This is going to be friction welded.

So this is the tool and the pin and they are going to align that.

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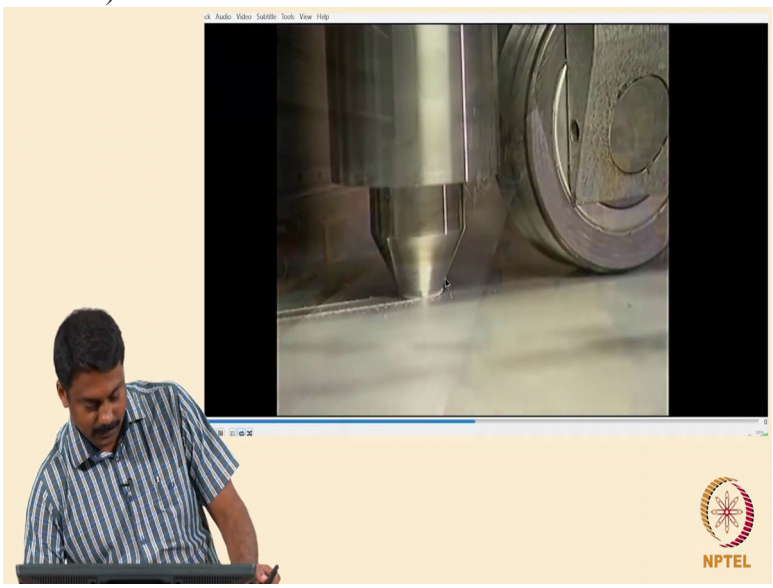


So we will see this process. So this is the shoulder, what you look at it. Ok shoulder is extending and then pin is plunged into the base material. And it is rotated causing mechanical

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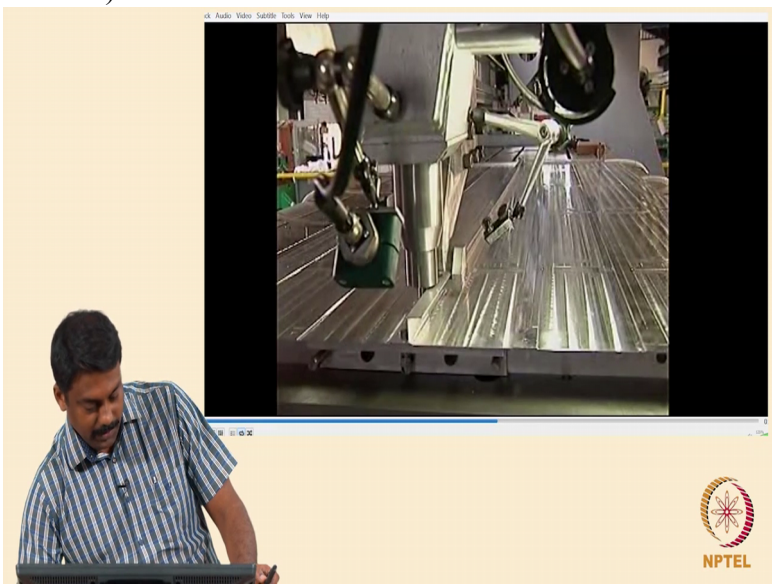


deformation. And this is very simple process.

Ok so you do not need a

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complex physics to understand the arc, plasma, ignition, ionization Ok all you have here is the tool is rotating.

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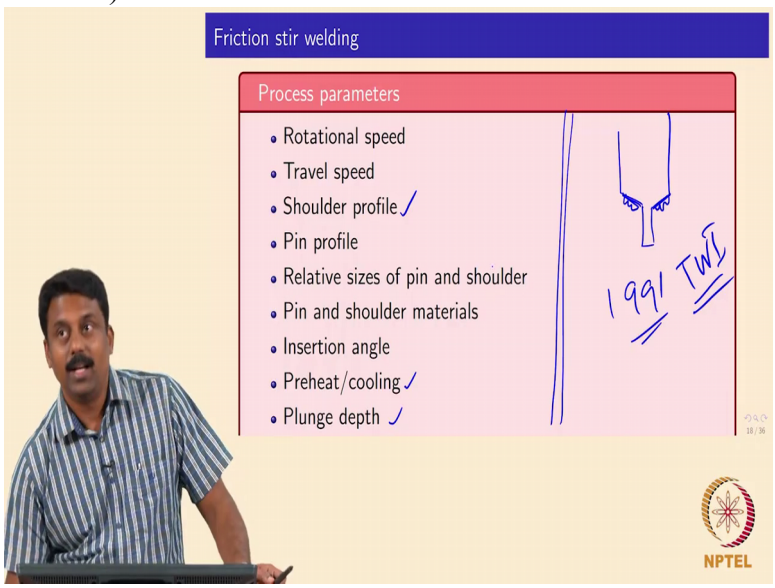


I think we will wind up here and then we will see in subsequent next class the more physics of this process.