Electrochemical Energy Storage
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Module - 05
Characteristics of commercial lithium ion cells
Lecture - 25
Fabrication of Li ion Cell: Pouch and Prismatic Cell

Welcome to my course Electrochemical Energy Storage. And this is module number 5, where I am describing the Characteristics of commercial lithium ion cells. And this is lecture number 25. In this lecture, I will describe the fabrication of lithium ion pouch cell, and same principle is adopted to make prismatic cell as well.

The difference between the cylindrical cell which I covered in the last lecture is the capacity is relatively low because of their size. And here in the pouch cell, you can get each individual cell can give you say 35 ampere hour or 100 ampere hour kind of capacity. So, this is quite important for you to see that how exactly they are fabricated.

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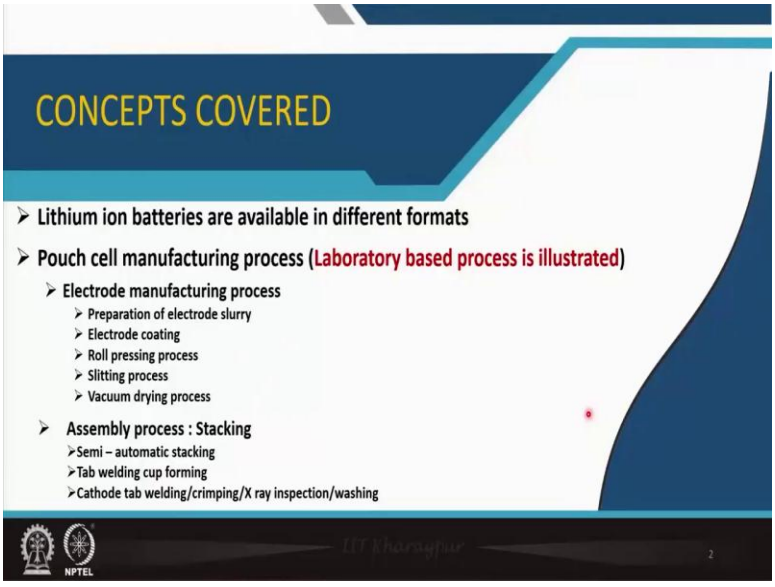

So, if you see the concept that is covered in this particular lecture is the lithium ion battery is available in different formats. So, I have covered all the formats. If you see the cell formats which is used commercially, you know all the formats.

So, pouch cell manufacturing process, again I will focus on the laboratory based process to make the pouch cell in our laboratory. In our IIT Kharagpur, we have the full range facility to make coin cell to make cylindrical cell. And we are augmented our lithium ion battery lab to make the pouch cell also. So, pouch cell also after this pandemic, we think that we will be able to make pouch cell as well. So, we have the whole facilities.

So, again this pouch cell manufacturing process that also have this electrode manufacturing process which includes the electrode slurry which is basically same as in case of cylindrical cell electrode coating, then roll pressing, then slitting; slitting is slightly different here, and vacuum drying process.

And then there is a assembly process which is not winding, but it is some kind of stacking. One after another, it stacks to form the a flat kind of thing. And then tab welding is there. And there is something called cup formation where this stack the so called jelly roll that is put there in, and then there is the sealing the vacuum sealing part after cathode welding. So, we will go step by step how exactly it is done.

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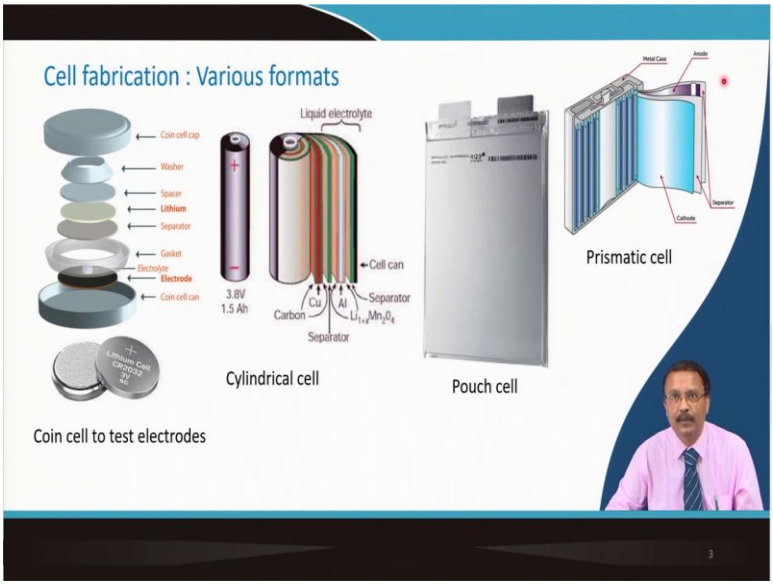

So, these are the different types of cell that you see in the market. Although in your laptop you will see the batteries looks different, but it has several such cylindrical cell which is basically packed in a package, so either it is cylindrical. For small capacity application, you see this kind of lithium ion battery which we called button cell. We have

cylindrical cell which is packed. You can have the pouch cell kind of thing in the prismatic configuration that we will find in your mobile phone.

So, if you take out the mobile phone battery one of such kind of thing this is actually packed in a plastic cover, and you will get a battery like this. And this is fitted into your mobile phone, so that is prismatic cell. Pouch cell is usually used for a heavy duty application in HEV or PHEV or electric vehicles, or some company they use cylindrical cell that is there.

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So, mixing of the slurry that is again the starting point and you know that similar to cylindrical cell. So, I will not repeat it. If you have a small batch, then this kind of machine you can use where you can mix it very uniformly the slurry. And this is the YouTube video. And probably the whole process of the pouch cell manufacturing you can find it here. I am not sure you just click it and see.

Probably I wanted to show you that how the whole process line one how it how all the individual equipment works. So, mixing, coating, pressing, slitting and vacuum drying same procedure is adopted here as well.

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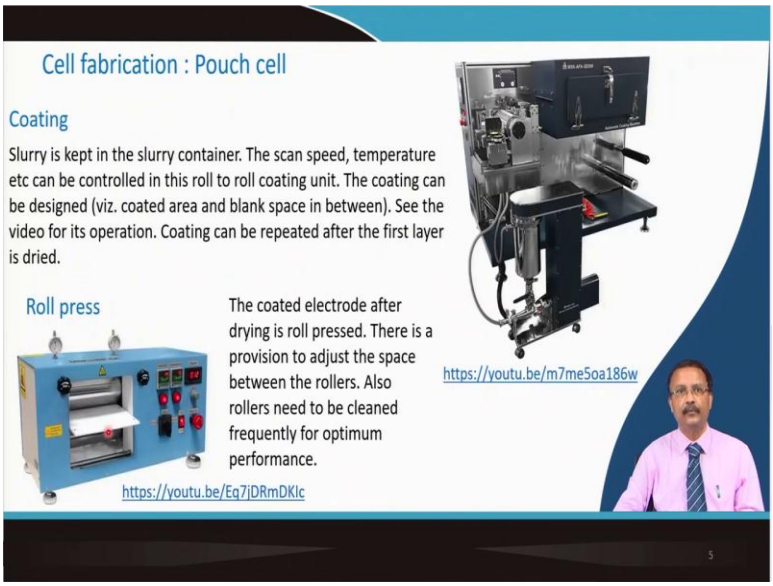

Now, coating here is same, but as you can see a different types of coater is used here as compared to the cylindrical cell coater. And you can see the slurry is stored somewhere here and the rolls are rollers are here. So, this contains this either aluminum or copper roll here. And then they go through this, and getting coated, and wind in some other rollers. So, it is a roll to roll kind of coating which is done inside this. So, this YouTube video again you will have to see.

And once you coat it, then after that there is a hot roll press. And this is just to increase the adhesion and increase the tab density of the battery that you are using I mean the electrode that you are using. So, that process is also identical to the one for cylindrical cell.

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Then instead of the slitting of a of a rectangular kind of piece for rolling, actually this die cutter process, operation you can see it here. So, this die cutter process it takes this coated thing either coating on aluminum, or it is coated on copper. So, you put the strip here.

And then you operate it electrically operate this thing. And this is pneumatically controlled. So, it will just cut the electrode something like this. So, two types of cutting is possible; one for your negative electrode which is coated on copper, and one for positive electrode which is coated on aluminum.

And then basically in between there will be separator. And by the way they are coated in both the sides to increase the capacity. But see that this one and this one, one is at the right hand side, and another one is at the left hand side. So, one it will stack, then you will have several this kind of spot welded electrode on anode and cathode. I will show it afterwards.

But this stacking machine which we call a Z stacking machine that is very important because in hand you cannot actually have separator in between and keep on putting this electrode one by one to build a bigger battery, so that is basically done in an automatic machine.

So, remember this anode is having a copper tab, and cathode is having a nickel tab. So, copper tab is connected with the copper connect current collector, and the nickel tab is connected through aluminum current collector for the positive electrode material.

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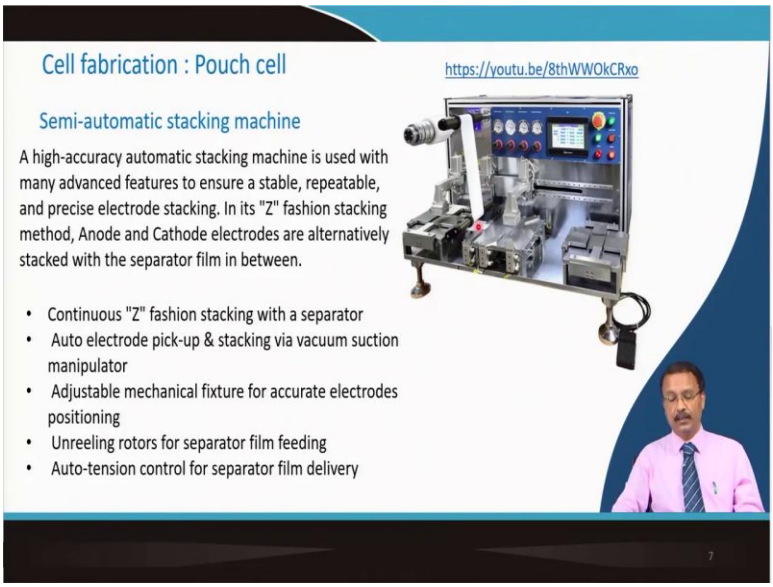

Now, this is your stacking machine. And we call it is the Z stacking machine, very recently we have acquired one, it is not yet installed because of this pandemic in our laboratory. It is lying there in our lab. So, you can see that this separator is there. And you have two sets of places where from it automatically picks up the anode at one end and cathode at one end.

How it works? It is a very interesting video. If you click it, you will see that how exactly it is stacked together. So, it is a high accuracy automatic stacking machine that is used for many advanced feature, the to ensure a stable and repeatable and precise electrode stacking. You cannot do it by hand. So, it is Z fashion stacking. So, it increases like this Z direction.

Anode and cathode electrodes are alternatively stacked with a separator film there in between obviously. So, it is a continuous Z fashion stacking with separator. Then auto electrode pickup as I was saying that you will have to just put this cut electrode, the die cut electrode with copper and nickel tapped already put it there. It is all adjustable. So, it is having a robotic hand to pick it up and stack.

So, unreelling rotors for separator film feeding, this separator in between and the tension needs to be controlled. So, you have a PLC board you can program it what kind of tension you need, how many stacks are there. So, all it can be programmed. And this will just keep on stacking one after another with the separator therein.

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So, this is the situation after stacking is something like this. You can see the whole things are actually stacked together and then in, so that it is not getting displaced you have this high temperature polymer tab though you wind it here, so that this are not disassembled. So, then you will have to do a tab welding.

So, in case of tab welding, you can now imagine there are number of this nickel and copper tab that was coming from each electrode. So, everything should be sealed together along with another tab which gets the connection from this multiple tabs.

So, this machine is very important. And this is a tab welding machine. And it is basically an ultrasonic metal welder that is used for nickel and aluminium tab welding. Copper also can be used. So, in this video again you should see it is designed for welding nickel or aluminum tabs onto the stack electrode sheet with the current collectors of copper or aluminum, and that basically prepares the pouch cell.

So, this pouch cell the heart of pouch cell is therein. Now, you will have to cover it. So, you need a special polymer coated aluminum foil, you will have to cover it. So, you will

have to seal this thing inside keeping this jelly roll inside to get the pouch cell configuration.

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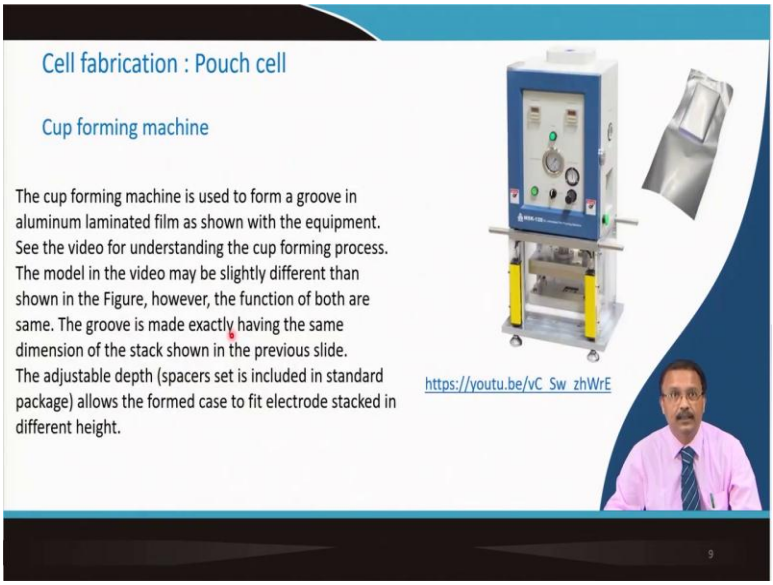

So, in order to do that, you will have to have a cup forming machine because you will have to give space to this polymer coated aluminum thing. So, this cup forming machine what it does? It exactly forms this cup where this type of stacked thing they can be placed here. So, the thing is that depending on the thickness of the stack, you will have to adjust the depth. So, again this video you will have to see.

So, this cup forming machine is used to form a groove under aluminium laminated film we call it that is shown in this equipment. Here is a pressure kind of two platens are there. So, it press it. The model may be slightly different as shown in the figure. This one, in the video it may be slightly different, do not worry about it.

And the groove is made exactly having the same dimension of the stack, so that it is exactly fitted. And the adjustable depth as I told spacer shape set is included in the standard package, so that it is firmly gripped. And you can have different stacked layer.

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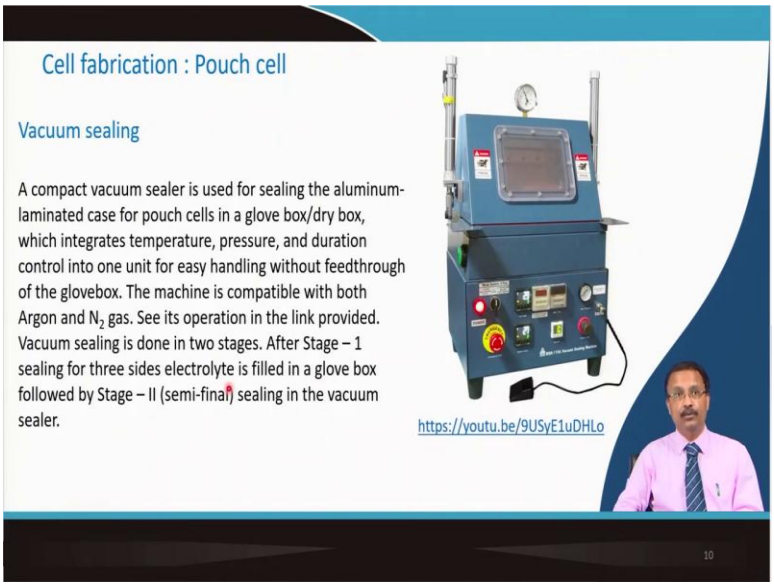

And once you do the stacking, then you know that all ends are open, all ends are open. So, you will have to seal it right. So, three sides are sealed. So, you can imagine a piece of paper. And you have put something in and then you cover it. So, one side, second side, third side – there are three sides they are open. So, two sides are sealed by this vacuum sealer. So, this is a compact vacuum sealer, and that is used for sealing the aluminum laminated pouch cell case.

So, this is controlled dry box. It has temperature, pressure duration control everything there. And you can control and it is a good controller temperature controller, and pressure also can be controlled, and this can be operated with this paddler. So, your two hands are free to do that.

You can also operate it in argon and nitrogen ambient so that that is good for it. So, that once you are sealing, there is no air that is there initially you put vacuum take all the air out, and then fill it with nitrogen. For argon filling, this is a slightly complicated kind of machine is used. So, this is called first stage sealing process. So, that it is sealed in two side, one side is already folded, but still you seal it on top of it; do not believe on the folding part only. So, you sealed one, two, three side, four side is open.

Followed by second stage, that is a semi-final sealing in a vacuum sealer. So, the second stage sealing will also be there after you put the electrolyte filling. So, electrolyte filling is done, after the first sealing, and then once you put the electrolyte, then using the same

machine you can do the second sealing, still we call it is a semi-final sealing. I will explain it why.

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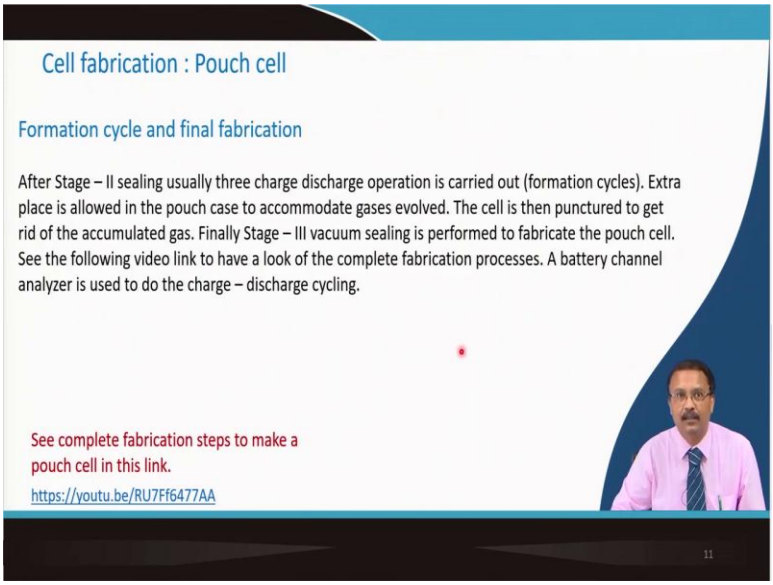

So, after stage – II, sealing usually is done, then you do three charge discharge operation, and that is your formation cycle. So, you know that there is no vent here. And during formation most likely in almost all the instances some gas will come out.

And there will be swelling of the pouch cell. You can see in the internet, there are the swelling is very common, just like a pillow it will swell, lot of gas will come out from electrolyte, from ACI layer formation. If you charge it during the forming cycle using a higher voltage, then this problem will be there. So, there will be some kind of swelling always will take place.

Then what you do is you take a relatively bigger package. You can see in the video, they have cited this, they have shown it. So, you have slightly bigger package and the place space which does not form this cup, inside the cup your stack is there. So, if the gas will form and the gas will fill the remaining part after swelling. So, you press it, so the gas come out there is no vent in the pouch cell. So, the gas will come out.

And then you do the third stage that is the final vacuum sealing, so that there is no gas after the formation cycle a stable SEI layer forms and whatever gas forming we expect that this is over within three to four cycle as long as the cell is swelling. Once you take it

out, then the cell will not evolve more gaseous product it is assumed. So, then you seal, and the extra part you can just cut with another machine you cut, and you get the pouch cell.

So, this is the actual forming process that is adopted. And a battery channel analyzer use to see whether really you are getting depending on your calculation, whether really you are getting the 35 ampere hour or 100 ampere hour whatever you have predicted. And there is no swelling. Then, it is fit for printing the company name, batch name, and its capacity and voltage.

So, this is the complete fabrication process that you are having to make the pouch cell. The link is there if you click it you will see all individual process whatever I mention starting from the mixing of the slurry. And after mixing, your coating operation, then this die cutting, then tab welding, then all the other process sequentially you will see.

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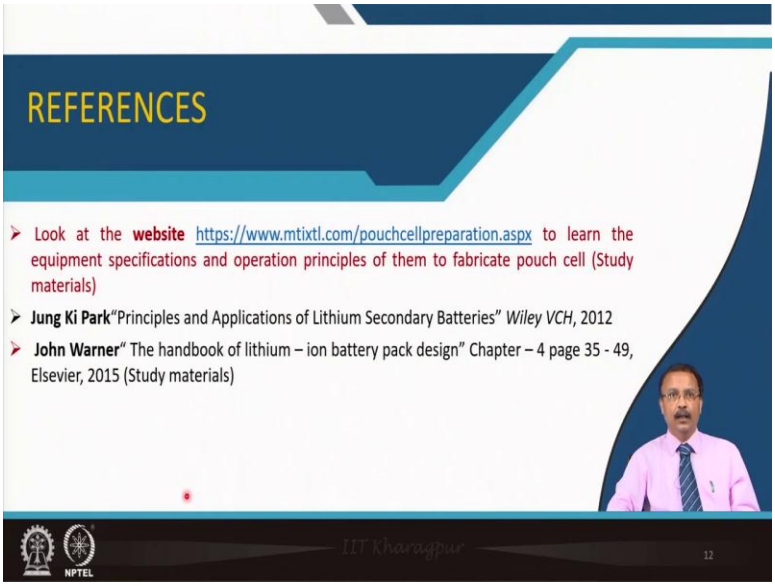

So, look at the website pouch cell preparation. And you need to learn the equipment, specification, and operation principle, principle to fabricate the pouch cell and that is your study material. The Park's book that also talked about it, but to less extent. And again the handbook of lithium battery pack design that is quite interesting.

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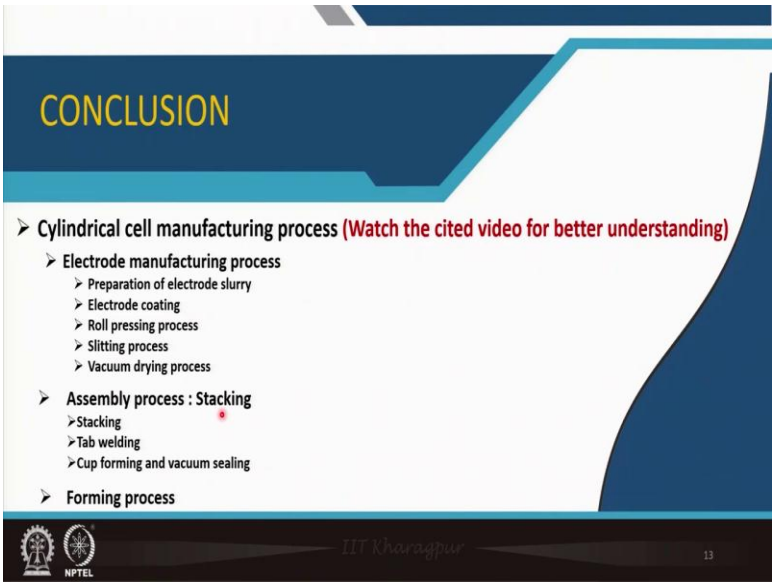

So, in this particular lecture, we talked about pouch cell manufacturing process. And by mistake you can see that this is cylindrical cell manufacturing process is still there. There is a problem of cut and paste. So, this will be pouch cell manufacturing process.

But the electrode manufacturing process remain same, and that includes the preparation of the slurry. Very careful about the preparation of the slurry because the formation of bubbles that is very detrimental because the bubbles will burst during your tab casting, and it will form lot of pin holes.

And pinhole has having a direct access to the current collector. So, we do not want that. So, viscosity if it is too thick, then it creates problem. And also any low boiling gaseous forming material if there is there in the mixing the slurry preparation stage that is also detrimental.

And then you have electrode coating process, so that coating process also I described the machine that is used for roll to roll coating process. Or if you are going for a hand scale stacking kind of thing, then the normal tab casting unit also can be used. In fact, in our laboratory, we can make the pouch cell but only thing is that whatever I told that you will have to do everything inside a globe box.

And if you have a small spot welder, then you can make individual cell kind of cutting by a scissor, and then tab welded, and then stack it this cathode and anode together, and

then again another spot welder so that you can have the total battery. And then you seal it and you have a laminator to laminate it after the electrolyte filling.

So, small pouch cell also one can make just as a demonstration having little bit higher capacity that usually we do in our laboratory not with the, if we do not have when we did not have the access of this sophisticated pouch cell equipment. So, this roll processing, slitting process, vacuum drying process they are same.

Then assembly process they include the stacking. And stacking, tab welding, they are very important. Then another process cup forming, so that your pouch cell looks quite good after this cup formation.

And then you do the vacuum sealing part and vacuum sealing is usually done in three stage; first and second stage. And after that you do the forming cycle. And forming cycle, whatever gases etcetera is present so that goes out. And it is there inside the pouch, and you press the pouch, and then again you seal it and you get your pouch cell in the process.

So, thank you for your attention.