Electrochemical Energy Storage
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Module - 12
Other types of batteries
Lecture - 59
Redox flow battery vanadium redox battery, operational principle, and main characteristics

Welcome to my course Electrochemical Energy Storage and we are in module number 12 where I am describing the other types of rechargeable batteries. And this is lecture number 59 and we will talk about Redox flow battery particularly, the vanadium redox battery, its operation principle and main characteristics.

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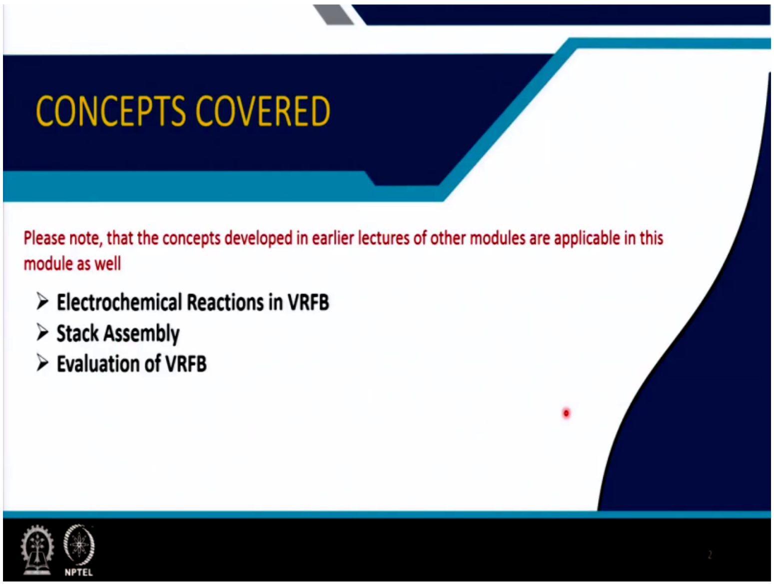

So, this already I had introduced in one of my earlier lectures. So, in this particular lecture we will talk about the electrochemical reactions in vanadium redox flow battery and then the stack assembly and the typical characteristics of these batteries.

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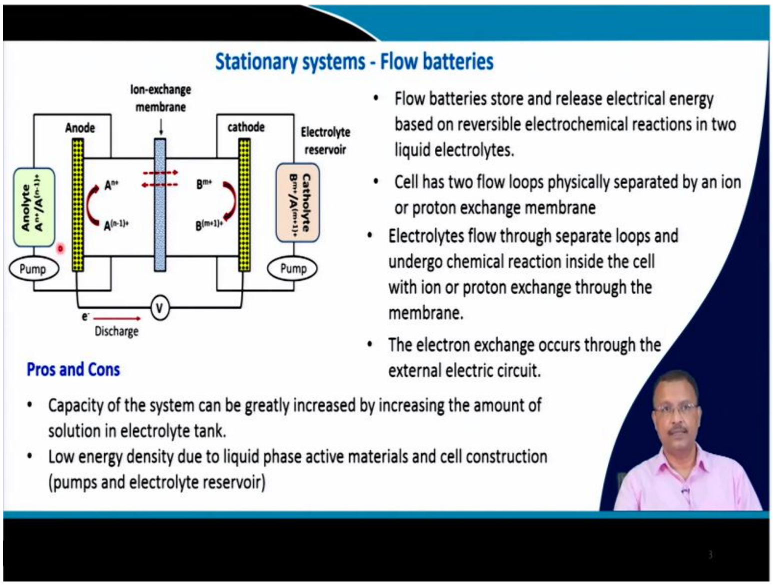

So, this slides already I described earlier. So, the flow batteries that basically store and release the electrical energy and that is based on reversible electrochemical reaction of two liquid electrolytes. So, this two liquid electrolytes are stored in the tank and pumps are attached to push it through to separate component.

So, the cell has two flow loops which are physically separated by this ion exchange or proton exchange membrane. And electrolytes they basically flows through this separate loops and undergo the chemical reaction this redox reactions inside this particular cell. And electrons they are gone to the external circuits, so you get power. So, this is a stationary system because, so many things are involved. So, it cannot be mobile for storage applications they are being studied.

So, capacity basically as you can understand that you can increase by increasing this amount you have a huge tank of the electrolyte, so capacity that can be increased. But the energy density will be sufficiently low, because you will have to add the weight of the cell construction including the pump the reservoir for the electrolyte. So, energy density is not that great, but capacity you can get quite large.

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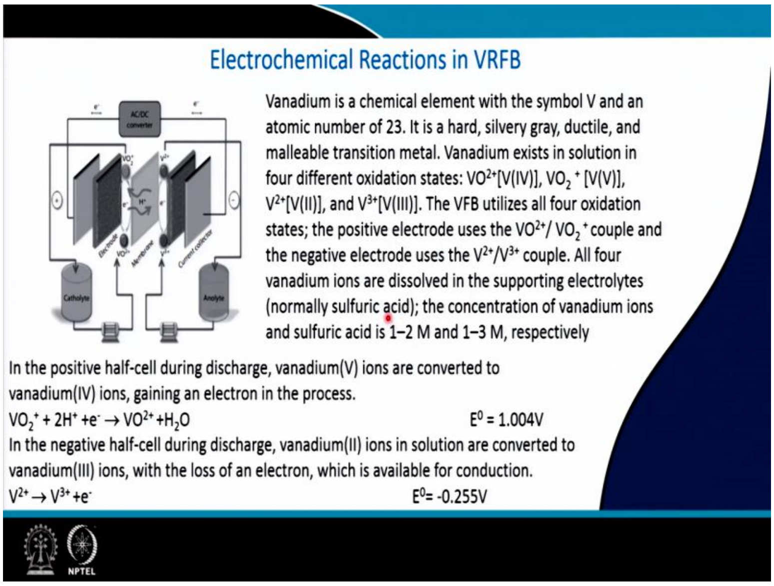

So, vanadium redox flow battery this is a popular chemistry. So, vanadium you know that is a chemical element serving as symbol of V, atomic weight typically 23. And it is gray colors, silvery clay gray colored metal and it is ductile. So, it has different oxidation state VO 2 plus where vanadium is plus 4 state. Similarly, VO 2 plus where it is plus 5 state that is possible for VO 2 plus sorry, I am sorry the first one was VO.

And then vanadium is 2 plus and vanadium 3 plus that is there. So; I mean, all four types of oxidation state that can be used. So, usually in the positive electrode they use the couple of VO 2 plus and VO. So, VO 2 plus and VO 2 plus this couple and the negative use this V 2 plus and 3 plus couple. So, this vanadium they are dissolved in electrolyte normally sulphuric acid is used. And the concentration is quite high 1 to 2 mole, sometimes 1 to 3 mole concentration is used.

And the positive half cell the reaction that is going on is this one and that gives the voltage about 1.00 volt and in the negative electrode this reaction takes place and this gives a potential minus point 0.255. So, you can add these two up, so this minus minus of this. So, that will give you the potential which is roughly about 1.2 volt, slightly above 1.2 volt that you get out of this batteries.

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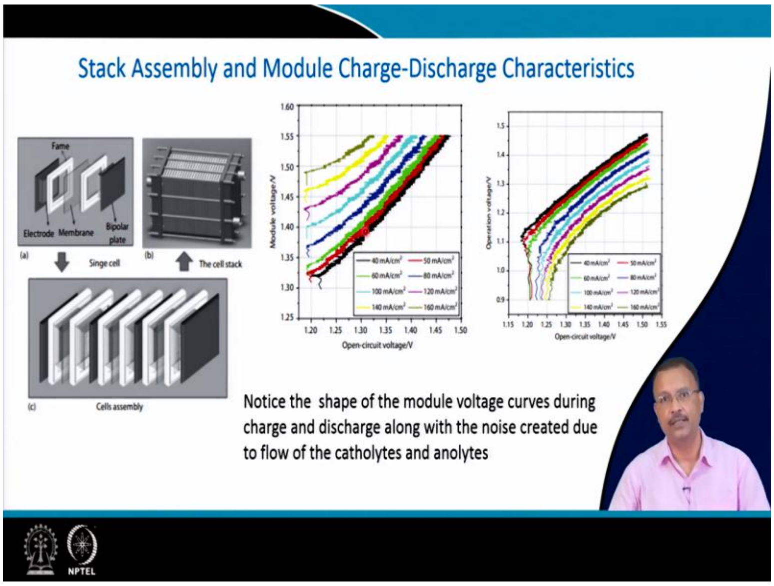

So, one can make a stack of this batteries this individual cell they are connected in parallel. So, you can make a stack something like this of this kind of cell. So, that is a typical cell assembly and one can measure, so voltage will remain same.

So, this is a typical charge and discharge type of characteristics of this particular cell, which is typically goes up to 1.45 volt. And you can see the noise that noise during both charge and discharge that is apparent. And that is coming because of the flow of this cathode light, so called cathode light and anode light.

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Now, if you see the typical performance of the battery. So, the first one is the constant current mode already I have described it when we talked about lithium ion battery. The current remain constant and this is the charging part. So, the voltage increases and then during discharge the voltage profile is something like this.

So, and you can calculate the power also, so the power is also plotted in constant current mode. Similarly, constant power mode also this can be charged where the power remain constant during charge and discharge it is kept constant. And huge capacity sorry huge voltage you can get from the stack. So, this is the performance of the constant power mode.

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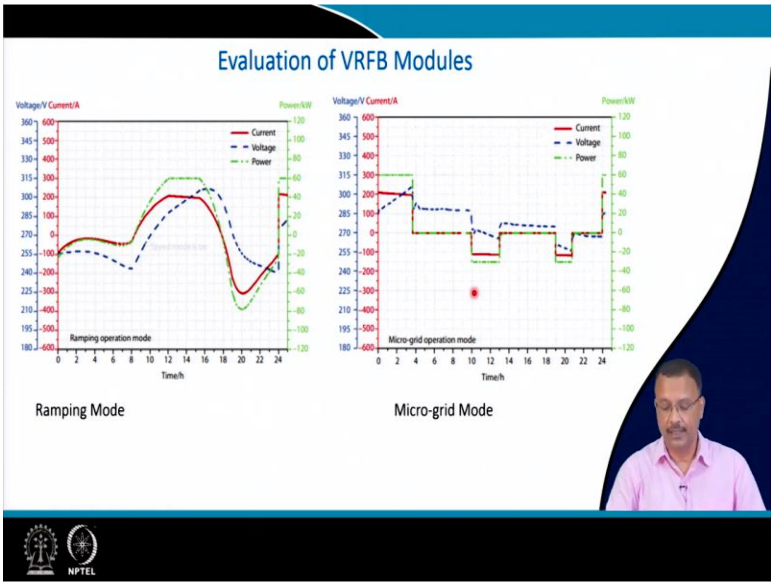

Similarly, it has also been tested in the ramping mode, where the current is not constant. So, sometimes the current and this is basically useful for a storage battery for renewable energy storage. So, for full 24 hours you can see starting from the midnight then the charge operation this is very nominal and then 8 o clock in the morning till 6 o clock in the evening roughly, 4 O clock.

So, the charge operation you can see the follow this blue lines and then the discharge takes place mostly in the night. So, the performance is plotted for a typical redox battery. And also this kind of battery you can use in the micro grid mode where the current is not in ramp mode, but almost constant current mode of different times types of profile. So, the voltage can be also followed whatever output voltage you get out of this redox flow batteries.

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So, for redox flow battery I did not cover it in at length because they are becoming popular for storage of the renewable energy. And this book is quite good, which talks about the fundamentals and applications for redox flow battery. So, interested person can look into it for more details.

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In this particular lecture we briefly introduce operation principle of vanadium redox flow battery. And then how the stacks are assembled and then typical performance of the vanadium redox flow battery is introduced.

Thank you for your attention.