Electrochemical Energy Storage
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Module - 12
Other types of batteries
Lecture - 56
Lead Acid Batteries: Operational principles, main characteristics and applications (Part - I)

Welcome to my course Electrochemical Energy Storage and this is module number 12 where I will very briefly introduce other types of batteries and this particular this type of batteries already I introduced as a part of my earlier lectures in module number 1 if I remember correctly. So, it was all introduced.

And for this module 12 there will be very short lectures only highlighting the important points that I will cover. So, first I will start Lead Acid Batteries and Operational principle already I have introduced it earlier and main characteristics and applications that I will cover.

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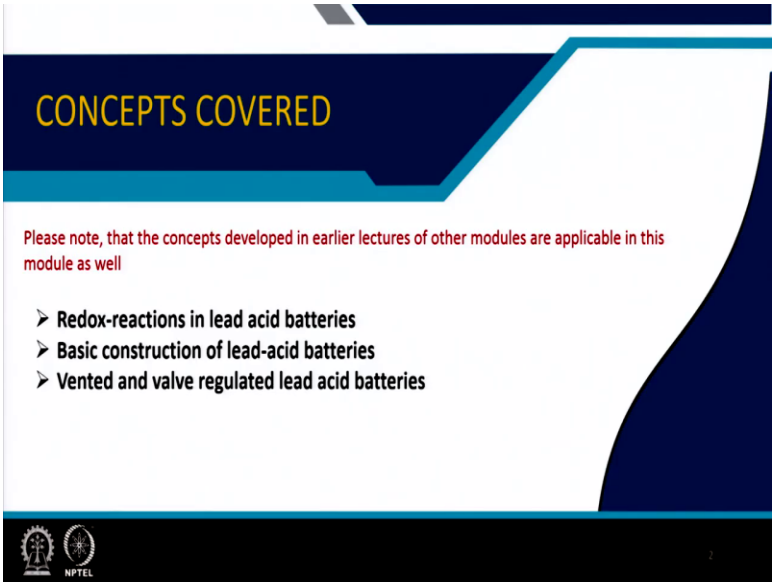

So, in this particular lecture we will be talking again on the redox reactions in lead acid batteries and then briefly introduce the basic construction of lead acid battery. And then two major types of batteries one is the vented type and another one is the valve regulated type these two types of batteries I will illustrate.

And throughout this lecture, I have developed already the basic electrochemical principles. So, those concepts which already I have developed earlier in earlier lectures that is also valid for this particular module lectures.

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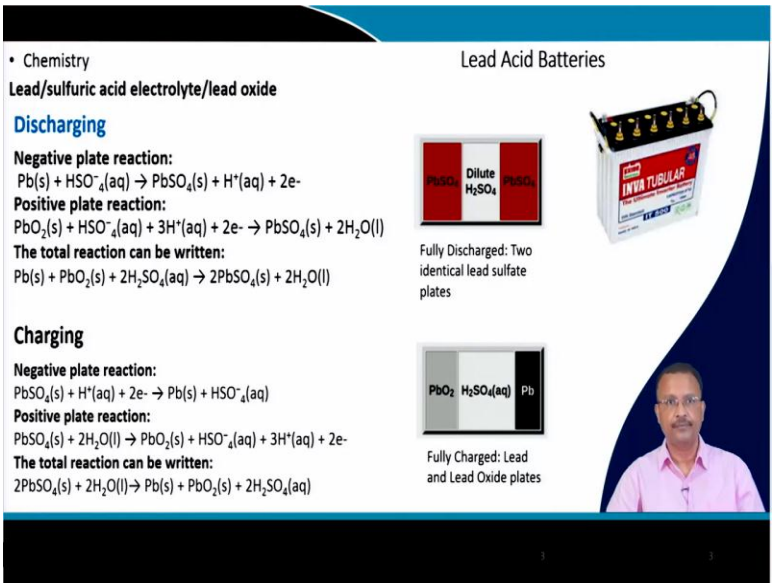

So, the chemistry is pretty straight forward. So, we have discharge and charge reaction for lead acid battery as well. So, you have the negative plate which is lead plate and it reacts with the electrolyte particularly HSO 4 minus this is aqueous solution and it forms lead sulfate.

$$Pb(s) + HSO_4^-(aq) \rightarrow PbSO_4(s) + H^+(aq) + 2e^-$$

And of course, the electron goes to the outside circuitry and in the positive plate you have lead oxide which again reacts with the aqueous ions along with the protons to form basically lead sulfate. So, if you add these two up then the total reaction you can write as the solid lead and this lead oxide the basically forms lead sulfate in both the end.

$$PbO_2(s) + HSO_4^-(aq) + 3H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O$$

So, you have lead sulfate formation that is important and you will see that it is important for you to control the lead sulfate concentration and the charging this reverse reaction takes place. So, lead sulfate that basically gives you back the lead which was originally this lead as anode material and also you get back lead oxide. So, that is the total reaction

that is taking place. So, that is why in fully charged condition lead and lead oxide plates you are getting back.

$$Pb(s) + PbO_2(s) + 2HSO_4^-(aq) + 2H^+(aq) \rightarrow 2PbSO_4(s) + 2H_2O$$

So, typical battery looks like this, you all may be familiar with that this kind of batteries being used for starting of the car and also in the UPS as a storage. So, lead acid chemistry is also very much used in modern perspective.

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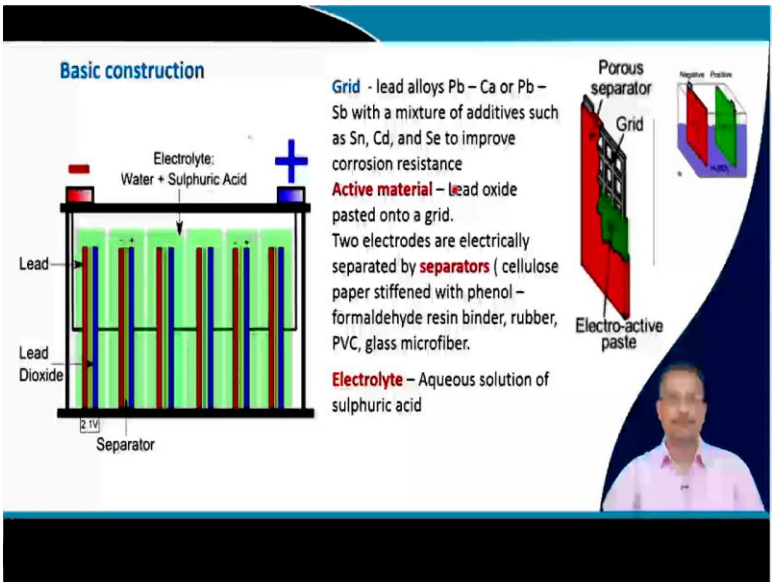

So, I have just shown the basic construction of the lead acid battery and here as you can see that it is not a only single cell each cell will give you about 2 volt. So, typically you need 12 volt. So, there are 6 cells which are connected in series and the grid that is used for containing this electro active paste like lead oxide. So, it is coated on top of the grid and then you have a porous separator something very similar to the lithium ion battery which I have talked in details in earlier lectures.

So, this grid is important that is made out of lead alloys, lead calcium is used or lead antimony with some kind of mixture like tin or cadmium just to improve the corrosion resistance of this grid because it is dipped in sulphuric acid dilute sulphuric acid.

So, corrosion effect needs to be retarded. So, that is the function of the grid. So, that also acts as a current collector. So, you take the connection out from here. An active material is lead oxide that is basically pasted on this grid and this two electrode lead and lead

oxide that is separated by separators usually separators are paper based cellulose base separator that is stiffened with phenol formaldehyde resin binder.

Sometimes, rubber is used, PVC is used or glass microfiber separator that is also used in different types of batteries and electrolyte is as I said aqueous solution of sulphuric acid. So, that is the basic construction of the lead acid cell and you have these two terminal positive and negative terminal that basically give you the total lead acid batteries.

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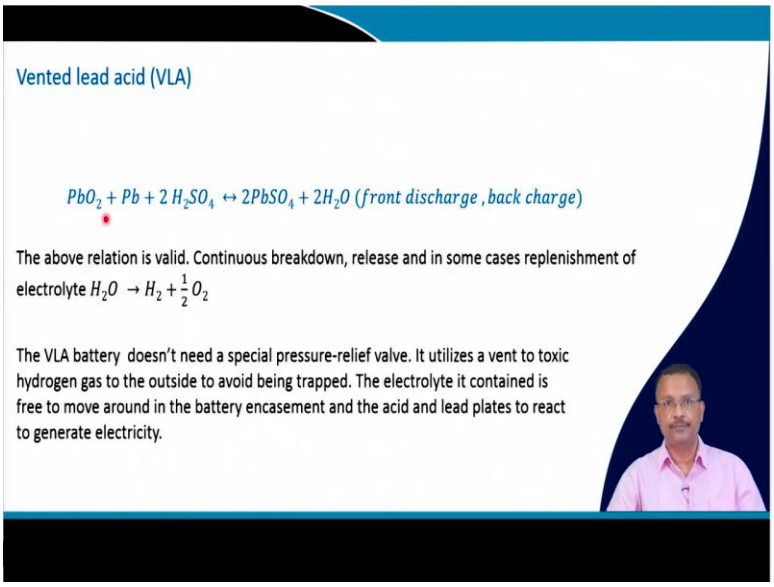

So, there are two types of batteries first one is vented lead acid batteries. So, the reaction if you remember the reaction after charge and discharge this is the basic reaction. So, this front arrow that is during charge a discharge sorry and the back arrow left hand side arrow that is the charge. So, you are getting back this to initial material. So, during this reaction if continuous breakdown takes place of the aqueous electrolyte. So, that creates hydrogen and oxygen gas.

So, you need to that there is a requirement of replenishment of the electrolyte. So, you need to add water into it for this vented lead acid batteries and they do require this water to be added. So, it basically utilizes a vent to toxic hydrogen gas to go outside the system.

And sometimes, it is important because if it is in a closed environment and hydrogen is coming out you know the lethal explosive limit of hydrogen is about 4 percent. So, that

needs to be evacuated otherwise explosion tendency is there. So, that is not a good thing for this kind of battery. And the acid and lead plate they basically react to form the electricity which is required. So, this gas formation is there in case of this vented lead acid batteries.

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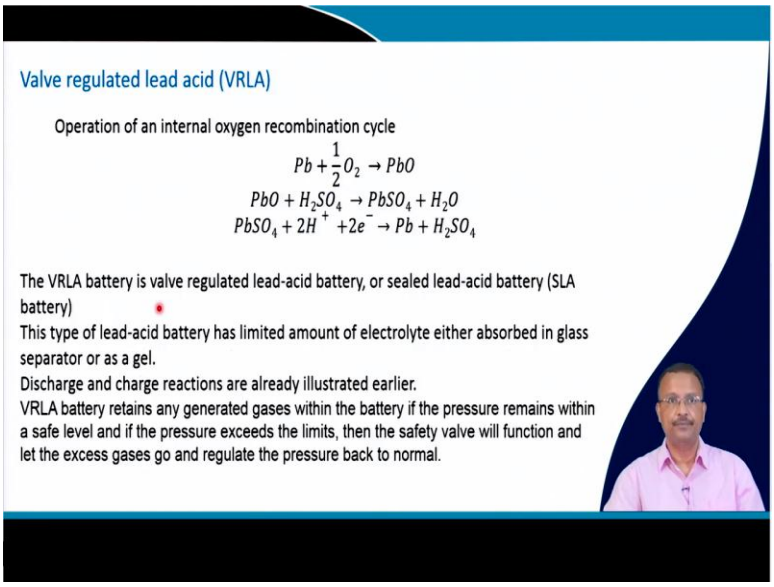

If you have a this valve regulated lead acid battery which is abbreviated as VRLA then there is a internal oxygen recombination cycle is involved. So, there lead reacts with the formed oxygen to form lead oxide and then this lead oxide that reacts with sulphuric acid to form lead sulfate and lead sulfate eventually that react to form lead and sulphuric acid. So, this VRLA batteries they are Valve Regulated Lead Acid battery or we other words we call it is a sealed lead acid battery.

So, that is abbreviated as SLA and this type of lead acid battery has limited amount of electrolyte. So, that is basically absorb in a glass separator or a gel electrolyte is used. So, based on that we have different types of this VRLA batteries and the charge and discharge reaction that already I have illustrated earlier.

So, this type of battery they retain the generated gas within the battery. So, the pressure will have to be maintained within a safe limit, but once it exceeds the limit then there is a safety valve and this safety valve is will start to function and this excess gas will go out to regulate the pressure back to the normal. So, that is why this VRLA battery is a Valve Regulated Lead Acid battery.

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So, there are two types of this valve regulated lead acid battery one is the Absorbent Glass Mat type. So, it is abbreviated as AGM. So, the electrolyte is basically soaked in thin fiber glass mat between the plates and this AGM works in various range of temperatures and they are also vibration resistant. So, this is good for any mobile application there is no chance of spillage of the electrolyte this sulfuric acid.

Other type is the gel type of battery where the silica dust is added to the electrolyte and they form some kind of thick gel putty type gel and the difference between these two that gel type of battery and this absorbent glass mat type of battery is the charge rate lower than the latter one. So, this the latter one; that means, the AGM battery the charge rate is lower than the latter one as compared to the previous one.

So, the gel battery can widely be used in hot temperatures condition. So, you can use it as a storage and solar system to reach its full performance and this batteries they do not have the problem of spillage.

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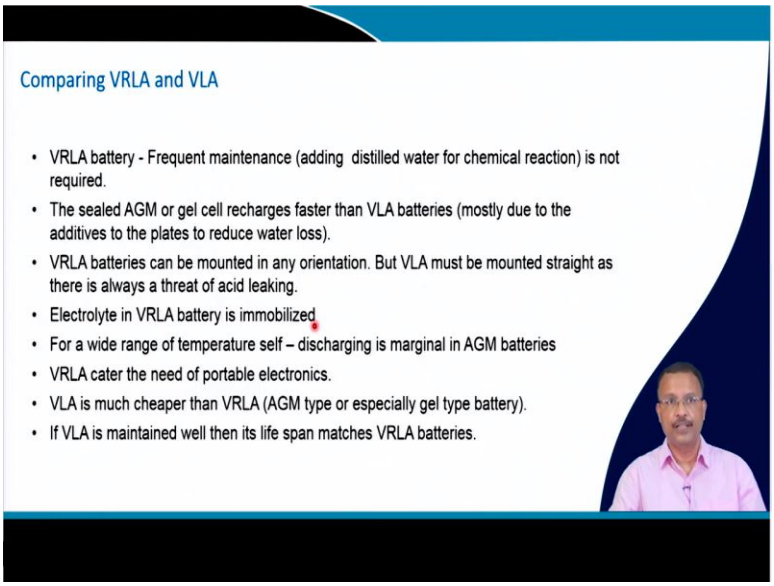

So, if you see if you compare the VRLA battery with the VLA type of batteries. So, in VRLA battery frequent maintenance is not required. So, you need not to add distilled water for the chemical reaction to continue and the AGM type the cell battery they recharge faster than VLA batteries.

Because mostly the additives are added to the plate to reduce the water loss. And this VRLA type of battery valve regulated type batteries they can be mounted at any orientation because there is no need for you to think of the spillage of the electrolyte.

But, on the other hand, the other type of battery the VLA type they must be mounted straight so, as there is a threat of acid leaking. For a wide temperature range the discharging is marginal in AGM type of VRLA batteries and as I said that VRLA type they cater the need of portable electronics device.

But, VLA type of battery they are much cheaper than VRLA type of battery particularly AGM type or gel type of battery are more expensive as compared to AGM type and as compared to that VLA batteries they are really cheaper. If you can maintain VLA batteries then the life span can match with VRLA batteries. So, they are expensive VRLA batteries are expensive, but if you can regularly maintain the VLA batteries then it is cost effective.

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So, this part you can study from the book Advanced Material and Technologies in chapter 10, particularly page number 219. So, you can use it as a study material.

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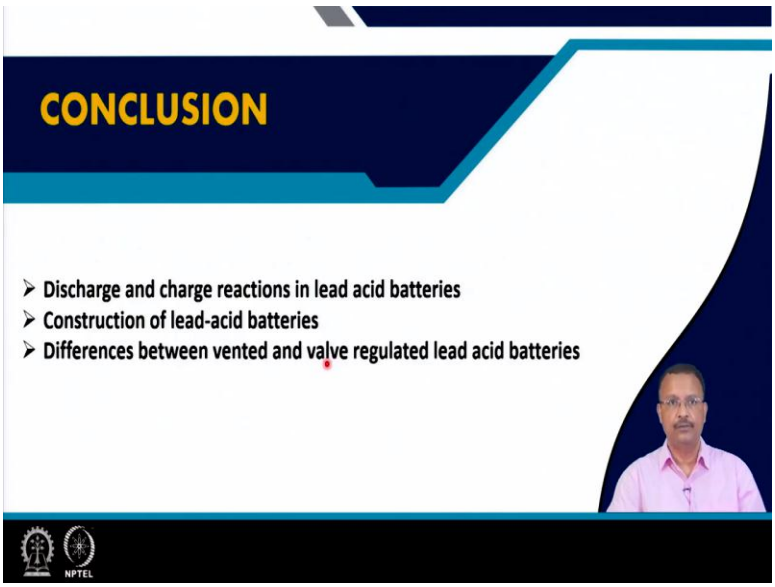

So, in this particular lecture we have covered the discharge and charge reaction of lead acid battery and then briefly introduced the construction of the lead acid battery. And we have illustrated what is the difference between the vented and valve regulated lead acid batteries.

Thank you for your attention.