Corrosion Failures and Analysis

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Lecture - 27
Crevice corrosion: Case studies and Protection methods

Let us start lecture 27 and the course is Corrosion Failures and Analysis. We have been discussing for the last 2 lectures on Crevice Corrosion and we have seen different examples of crevice corrosion and then we have also tried to understand mechanism and we could see that at the last stage of crevice corrosion it becomes auto catalytic and the growth stage is very fast. The initiation stage takes little time, but growth stage becomes extremely fast and that it spreads out of the crevice.

If you recall we have shown one example that the edge of the door got crevice corrosion, but initially it was within the crevice but as the time passes on the rust started coming out and then the corrosion spreads. And we will try to and at the same time we have seen that there are different conditions which has a crevice corrosion.

For example presence of halogen ions, for example sodium chloride which provides the halogen ions which is chloride ion cl minus. So, it is basically presence of halides like bromide iodide those can induce crevice to a great extent and at the same time we have seen that the passivating metals are highly prone to crevice corrosion.

The major reason is within that narrow portion of crevice it becomes it destroys that particular passive layer at a very narrow position within that narrow level of crevice ok. And once destruction is done for that particular passive layer it actually grows in the depth direction rather than it spreads the rate of growth would be much faster than the spread laterally, because the rest of the part the bulk part also becomes cathode.

So, the large cathode and small anode and it creates that situation at the same time within the crevice it also leads to increase in h plus ion concentration, because of hydro hydrolysis process that iron chloride hydrolyses and then forms h plus HCl acid rather and that acid also creates a situation to crack down or the dissolve the passive layer. So, that is basically the major part in the later stage of crevice. Now we thought that we should show some of the failures.

So, I thought that I will take up some examples from the book, but later I got hold of one particular example which I showed it in my introduction videos bar short video, where I have shown one picture that the top layer of the AC air conditioner, the window AC the part which goes out of the; out of the window and stays in the environment where hot gases come out ok. So, there we always use aluminium ribs ok. So, aluminium cover ok so it is a basically gridded aluminium and that grid aluminium actually allows hot air to come out.

And interestingly there suddenly it was noticed by me that it was in my house. So, where I suddenly I notice that the center part of the top part is absolutely corroded and in fact there was no aluminium ribs available or remaining in the center part, the outside part still aluminium ribs were there. But center part was completely corroded and the reason I will explain in this particular lecture. So, this is the experience what I gained after noticing that particular failure ok.

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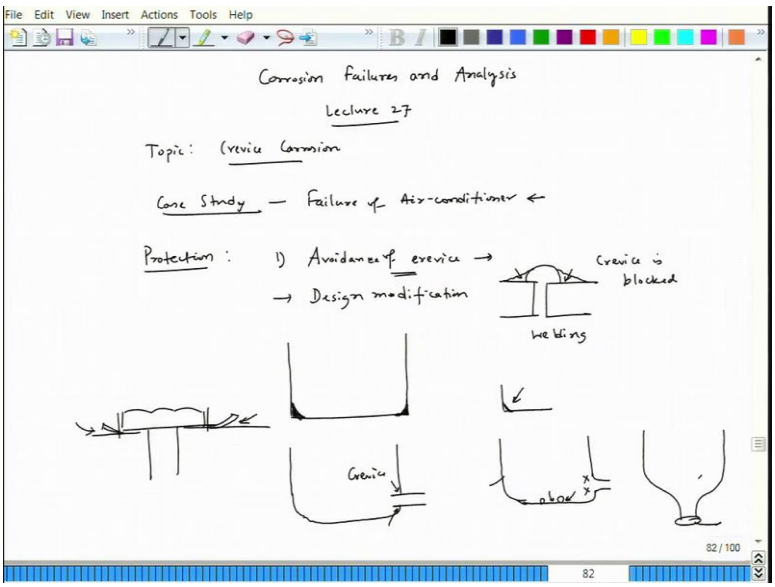

So, the part is this course is Corrosion Analysis in lecture 27 and topic Crevice Corrosion and after analyzing that particular failure we will conclude crevice corrosion by showing some of the protection routes. And interestingly we would find that crevice corrosion especially for crevice corrosion it is more important to look at the design part rather than the material part ok. So, we will show that in fact we have already shown some sort of

examples like the curving of edges or corners that helps preventing crevice corrosion or avoiding crevice corrosion.

So, those we will see in a while, now in order to find example so the so in this case study we will talk about failure of air condition fine.

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So let me go to a PPT, so this is one such picture of that particular AC is somehow we could revive that AC by doing a smart change ok. So, now, one small part of crevice corrosion is if you notice here this part could you see this part is basically this part and this part fine. So now, if you see here it is basically is a basically jacket and within that jacket the main unit of the AC is pushed in from inside of the house that is basically the window AC.

So, first that frame is fixed and then the entire AC unit is pushed in. Now if you see that there are several crevice for example since this particular window this particular part which is the major part of the AC is exposed outside. So, you could see that there are crevice, so there are joints when those 2 sheets are actually joined together and then that creates a crevice. For example, here also it also creates a crevice in this portion entire portion we have crevice so this is the part ok.

So, they are creating lot of crevice and why there is crevice also here in this portion also is there are crevice this portion is also crevice. But that corrosion is not severe because

water accumulation or the electrolyte accumulation is possible here in this particular portion, this particular portion water accumulation is possible. So, here water accumulation is possible that is what we have crevice corrosion. Now I am not talking about this part particular defect. In fact, after some time there could be a leakage of that particular frame the frame can get weakened.

And then this cannot take the load of that particular AC might there might be possibility that because that frame is so weaken the AC with it is own load can fall down ok or rather hang up. Now my point is not there, so you please see this arrangement this is very important we have created a shed ok. So, this shed is created so the shed is created just to avoid water falling on top of it during rain rainy season. Now that shed created little bit of issue let me show you the part.

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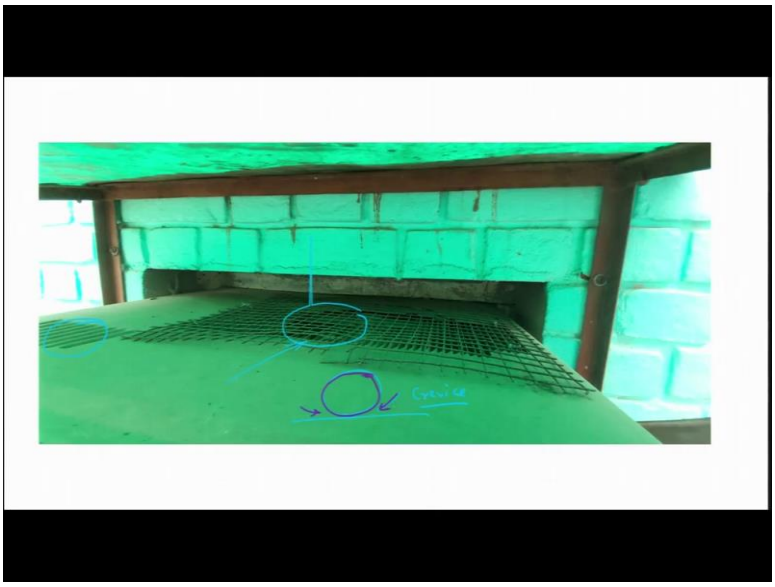

So, this is the shed and this particular part if you notice, if you could notice carefully the center part ok; the center part is actually hollow and interestingly around that initially it was only that aluminium grid. So, this kind of grid was there on top of that AC ok, but since that particular grid got completely corroded.

So, we have put a mild steel grid mild steel externally made mild steel grid and we just put it on top of it, just to avoid some kind of serpentines or snakes to go in and then stay there or lizards to go in and then stay inside the AC when the AC is not operational fine.

So, that is what we try to do that particular protection. In fact, why it happened what happened?

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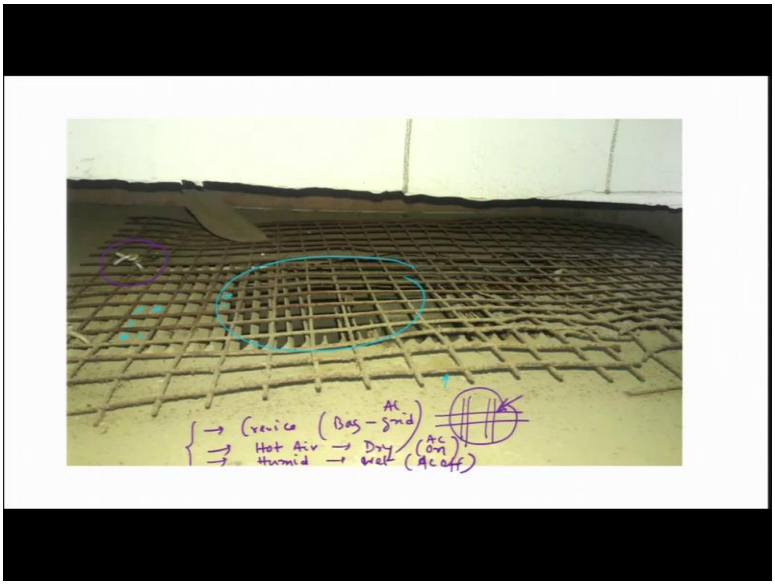

And now let me show you the next picture here the picture is very clear, this is the iron grid this is the iron grid which was placed after we could see that the grid inside of the grid is completely corroded. So, the grids aluminium grid is basically this one. So, these are the aluminium grids these are the aluminium grids which was already inbuilt with the particular AC unit the external casing.

Now what happened our gardener? So, the gardener used to use fertilizer and that fertilizer use to keep in a small plastic bag, now he thought that let me keep it on top of that AC that small bag of fertilizer and that fertilizer will not get drenched because wet because we are keeping the shed the shed is there.

So, that is what he thought that let me put that fertilizer bag here ok. So, it was lying on top of that particular aluminium grid and what happened that particular bag. So, if you put a bag, so this bag is put it like this fine and that bag is full of fertilizer it is a highly corrosive in nature.

Now, we have also created crevice ok. So, this crevice so this is the crevice, so this is the bag let us say the full of fertilizer and this is the crevice the bag was kept just to have just to protect that particular fertilizer to get wet, because the rainfall because we had a shed

on top of that AC unit and that created nuisance. And in fact suddenly I notice that why this fellow has kept this particular bag, I took out the bag and saw that the entire bottom part has become hollow. So, like this, like this.

So now, what happen those grids if you see the small grid. So, this is a small grid this is a small grid another grid. So, these are the grids now we have put a bag on top of it and the bag and the grid part that create a very narrow crevice. Now interestingly when the AC is on it actually gives you lot of hot air coming out and that hot air would dry out that particular moisture that is getting accumulated, but the question comes when the AC is off.

So that time it becomes again so it there are two situation one is the crevice formation and there is also another situation which is drying and wetting and the drying and wetting is a very serious situation in case of corrosion frame process. Now wherever you have a drying and wetting situation corrosion happens very fast ok. So, that situation prevails, but initiation of the corrosion happens because of this crevice formation between the bag and then grids and that is what that grid actually got completely melted you can say it completely corroded.

And that corroded because of the corrosion it created a hole in that particular top part. So now, if you see this this grid it was initially like this and now after corrosion it actually made a hole made a hole in it. So, then it happened you know it happened in just 2 months time ok, I ask that gardener that when did you put it sir I have put it in just 2 months time and the last 2 months I have been doing it and that created this nuisance. So, this is a typical example of how serious crevice corrosion can be.

So, we have to be very careful that whenever you have some kind of structure it is better not to put anything and if it is a grid structure not to put anything on top of it which allows the crevice formation and that can create. And see aluminium is highly corrosion resistant if it is exposed to atmosphere. Now the question is so there are two effects one is crevice due to the between bag and grid aluminium grid that the second part is hot air ok.

This is because these are acting as a vent so this hot air which makes the thing dry and then once the AC is during on position AC on position and the second part is when AC off position again humid and off position this is wet situation this is AC off situation AC

off. So, that creates these two factors led to this folly led to this hole creation within that particular aluminium grid. Now interestingly this mild steel iron grid was placed on top of it after we notice that failure and there is a connection if you see this particular iron grid is fastened with a wire with the iron aluminium grid.

So, this are these are the fasteners these are basically wire we have fastended with the ware small ware and interestingly after that we hardly noticed any corrosion of that particular aluminium grids and this is running for the last 6 years ok. Without any progression of these small small fins which are created the part of that fins you know because of that particular corrosion those fins stay as it is.

The basic logic here is you know aluminium since it is getting hot air it is actually getting oxidized and aluminium oxide when it forms on top of aluminium it makes it passive. Now, iron it is a simple mild steel iron which actually becomes anode, you know it actually gives you a cathodic protection to the aluminium grid that particular top part that is the iron grid what is placed on top of it.

So, it actually this iron grid actually protects the bottom aluminium grid, because once that hot air creates aluminium oxide on top of it that aluminium oxide will be passive and that potential goes up and that because of it go potential goes up so it becomes cathode and the rest of the alumina iron grid becomes anode and it gives you protection.

So, this is way we have protected that particular aluminium grid also. So, this is one typical example of crevice corrosion and also the small kind of mild example is this one. These are the places you know these are the places and in fact if you could see that these are the portion these are the portion which is basically the AC part the main AC unit those are actually also are fins of that AC those fins are metallic and those are also getting corroded, because of that particular crevice corrosion is spreading is actually spreading into the main unit.

So, this is one such example I thought that I should show you I should share with you. Now coming back to the crevice corrosion, so we have explained this one now let us try to find out the protection, protection of course as we see that for the protection one has to avoid crevice or avoidance of crevice ok. So, this avoidance of crevice how can we do it for example some places crevice would be there, so how to how to avoid it? For

example, let us say one is doing welding so this is a welding part this is one welding part and now welding is done ok.

So, that welding actually creates crevice instead of that we can have that welding little bit of metal we can put it up fill a metal. So, that that particular crevice part is blocked crevice is blocked. So, this is in case of welding fine this is a kind of situation where you can avoid crevice corrosion. For example, if you have let us say a tank one can use little bit of even if let us say that tank you somehow that particular edges has become sharp.

So, it is better to put little bit of weld metal, so that this particular edges become this corners become rounded. So, crevice is avoided fine one has to make sure that it should not create a stagnant situation in the crevice, even if you have crevice for example, somewhere you have a crevice ok.

So, somehow this particular crevice part there is a possibility of avoidance of stagnancy and how can you avoid stagnancy you can make little bit of roundish appearance. So, that convection can allow oxygen to go into that crevice and does not allow to form a differential aeration cell formation.

Because the differential aeration cell is the initiation of crevice that from that onwards the next stage of crevice appear, so one has to avoid that part. And if you see this avoidance of crevice basically it indicates the design modification and without changing material even if you have a very very highly corrosion prone metals. For example, mild steel it has a very high corrosion proneness compared to stainless steel, but still in that case I can achieve lot of extra crevice corrosion resistance or control over crevice corrosion just by doing a design modification.

For example one such design modification I have explained previously that let us say you have a tank let us say you have made it like this you have made it like this and let us say this is out the water outlet and that water outlet if somebody has entered that pipe inside the water tank then these are the crevice fine. So, one has to avoid that how do avoid. So, instead of that one can make it like this fine. So now, that crevice is out crevice is out, so it will operate absolutely fine no problem in that.

Now, the best design could be because there would be this deposits are falling. So, deposits can also lead to crevice because the small crevice is creating these are the

crevice portion. So, time to time one has to clean off that particular debris. So, the best way to design is instead of this one can make it like this ok water outlet can be created here. So now, there would be no question of deposit the way things were getting deposited here it will flow out flush out and in fact when the regular cleaning process the flushing would be much easier in this case.

So, these are the kind of design modification one can think of to avoid crevice. For example, if somebody using a kind of let us say this is the bolt; this is the bolt and now this bolt let us say some non metallic washer has been used. So, that non metallic washer because of the tightening of the bolt it can move backwards and that will create a crevice how to avoid this? Chop this off here itself.

So, the crevice part is out no problem now things will be absolutely fine. So, these are the ways so we will talk more on the protection route overall protection from corrosion, there we will talk more about design aspects by simply doing design modification one can prevent many of the corrosion issues.

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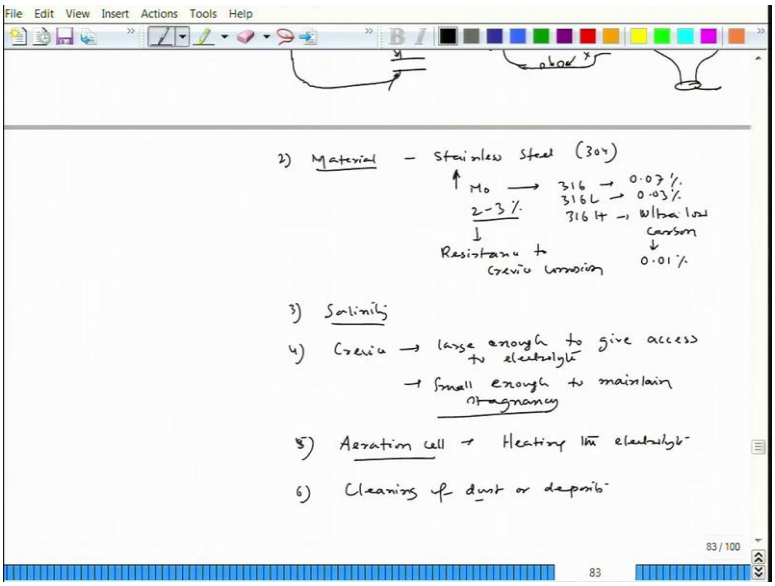

Now, coming to second part of course the material, for example stainless steel fine it is a highly passivating metal and crevice proneness should be very high. Now in the stainless steel if we add molybdenum and then make a grid.

Let us say it is a 304 and if we add molybdenum it will form a grid 316 or 316 L or 316 H. So, this H means ultra low carbon; that means, the carbon content could be 0.01 percent L carbon content could be around 0.03 percent and in 316 carbon content could be 0.07 percent. So, like that way, but everywhere we have molybdenum around 2 to 3 percent molybdenum weight percent.

So, this molybdenum addition can create a situation to avoid crevice corrosion. So, this gives you crevice corrosion protection resistance to crevice corrosion. Now third is if somebody can avoid salinity, salinity avoidance of salinity can create a situation to avoid crevice corrosion.

Because if we could recall our mechanism of crevice corrosion the halide halogen ions; that means, chloride ion it enters into the crevice just to have a kind of neutralizing situation and iron ion forms iron chloride. And that iron chloride later hydrolyses and forms acid and that acidic environment with the pH can go to even 2 to 3 which is highly acidic that can actually create a situation to break the passivity.

So that means, one has to also have a material which has a very good passivity and that can protect basically crevice corrosion just like molybdenum addition. So, similarly salinity if you one can avoid salinity that can have a situation of preventing crevice ok. Now 3rd is 4th is if you could recall that crevice actually starts with the situation the crevice should be large enough to give access to electrolyte.

And it should be small enough to maintain stagnancy fine. Now why this stagnancy is important? Because of that aeration cell, because it is stagnance it stagnant that means, that the convection current within the crevice is not experienced.

So, that is what the depletion of oxygen will happen very quickly and then the crevice part will become anode and the rest of the part which is large cathode and it would lead to the first stage of crevice initiation. So, that is what if we can make a situation that the convection or there is a sufficient convection and somehow we can make sure that the crevice is also getting sufficient oxygen then the crevice part crevice can be avoided.

And similarly in that regard because if we can avoid aeration cell, so that one that way heating the electrolyte can delay the crevice formation. Why? Because due to heating oxygen content in the electrolyte reduces ok, because oxygen content reduces dissolved

oxygen content reduces the time to achieve the situation of differential aeration cell would be lingered ok and then of course the initiation also will be lingered.

So, like that way there are several ways to prevent crevice corrosion. For example, we talked about deposits. So, time to time we can flash out the deposits, dirts falling on the bottom of the tank we can avoid crevice. So, like that the for example 6 cleaning of dirt dust ok or deposits. So, that can also make sure that the crevice is lingered crevice initiation is lingered remember the initiation it is better to stop initiation rather than the growth once crevice starts it grows at a huge rate.

So, instead of pointing at that giving protection to that it is better to prevent crevice in the beginning ok, where crevice actually initiates initiation takes time. But the once it goes into the auto catalytic growth mode it does not stop it is very difficult to stop that. So, that is what about crevice corrosion and we will step into another important localized highly localized corrosion mode which is pitting corrosion from the next class onwards.

So, let me stop here we will continue our discussion on different corrosion failures and now we talk about failures due to pitting.

Thank you.