Corrosion Failures and Analysis

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Lecture - 24
Crevice Corrosion: Introduction

Let us start lecture 24 and the course is Corrosion Failures and Analysis. And today we will start talking on crevice corrosion, which is also a kind of very aggressive mode of localized corrosion and this kind of corrosion leads to a kind of catastrophic failure in the structures. And interesting part is many a times this this actually goes unnoticed, because this happens in the area which is not visible to naked eyes. For example, if it is uniform corrosion, you are able to see through the naked eyes.

But if it is crevice corrosion. Even if it is a pitting corrosion pitting is also a very serious mode of corrosion, but still you would be able to see that there are pits, but crevice corrosion is completely invisible, because it happens the area which actually covered by either a kind of metal block or a non metal block ok.

So, that non metal block could be a film. For example, let us say if you take a kind of nut and bolt, you tighten it and in between if you put a kind of thin slice of plastic and leave it there in acidic nitric acid solution. You would see that the rest of the part would get corroded not, but not much of.

But if you open the and. In fact, you will have very hard time to open that particular nut, because around that portion where the film that particular thin plastic film is actually closing down the nut and the that particular plate.

So, there you will have lot of corrosion and that corrosion is so localized you would see that it will be very difficult to distinguish or difficult to see from outside when that particular bolt is in operation. So, this is I am just giving one example. So, there are several examples.

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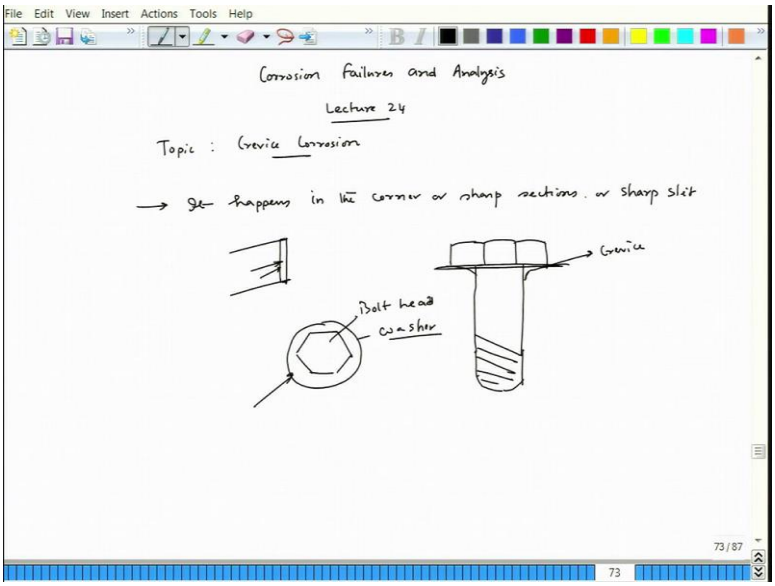

So, the let me show you some of the examples. But let us start with this particular course name Failures and Analysis and this is lecture 24, and topic crevice corrosion fine. Now let us see one example that what is the kind of nature of crevice corrosion you would experience.

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Now if you see this particular this is a handle door handle ok. So, this is a door handle ok. So, this is a door handle. Now it is it was fixed there on the door and it was exposed to the environment fine. There it was getting lot of rain and all sort of thing. Of course, if

you recall that we given one example that galvanic couple and differential aerated cell of that particular small screw ok.

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So, this is a small screw here and the bottom part we gave that example. There is a auxiliary video available you just go and look at it, but in this particular same block you would see as this is a stainless steel block. The top part is corroded, the side part is corroded, but interesting part is this corner part. You just look at this corner part. The corner part here is to a great extent shiny ok.

But you just go to the bottom part of the same corner that part is highly corroded and interestingly if we do the analysis we would I am sure that this particular corner part even if you see at the other corner part. So, this is the top corner part which is shiny, reasonably shiny, but if you see the opposite part of that is a forming a corner. So, that part is highly corroded. Similarly, here ok so this part ok, so this part is corroded heavily, this part is corroded heavily.

So, wherever you have sort of crevice which a corner part there is a possibility of corrosion which is related to crevice corrosion.

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So, this is another example, this is interesting. I have show I showed this particular picture also if you see that this one is basically having due to the stress generation there, because there are lot of stress. Now if you look at individual ribs. This is a ribbed bar and this rib bar if you see the individual ribs ok. So, this particular part. So, let me go close to the; close to the camera.

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So, if you can zoom the camera, it will be better. So, if you see that just at the foot of the rib ok, just at the foot of the rib there is a bit of rust formation. The top part is gray color,

but the feet of the rib is little brownish color. So, because there the corrosion is actually taking place at the feet of the at the foot of that particular rib, not on the top part of the rib. Why that happens? Because that is also creating a small crevice. So, this was actually lying on the road ok. Just I picked it up and then showed that a typical appearance of; typical appearance of crevice corrosion, if you see that part this is interesting.

So, this part if you see just at the foot you have rust on top of the foot, on top the top of the rib there is no rust. So, this is a typical example of crevice corrosion. And in fact, crevice corrosion everywhere you can find crevice corrosion in our surrounding. Wherever you see a corner ok or the sharp edge not sharp edge sharp corner you would find crevice corrosion is highly possibility. So, for example, let me show you some of the pictures, and if you go to the introduction slide there you could find this kind of pictures.

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Now, here is one picture. So, this is the a kind of small room in at IIT Kanpur which is covered by a door iron door. This is a mild steel door. Now interesting part is if you look at if you look at this section fine. So, this portion if you look at and this portion is zoomed here ok. Interesting part is if you look at this part, so this is the part which is a kind of the edge of the door and that edge of the door is actually having a kind of folded sheet metal ok.

So, that folding has led to a small crevice here small crevice here and that crevice part you could see. Since its a folded, so there is a possibility of water seepage in and it forms a serious crevice and that corrosion is actually concentrated on along that portion, first time the corrosion starts there and then it spreads around. For example, if you see here the corrosion starts along this crevice which is formed due to the metal folding at the edge of that particular door and then also here ok also here you see this this place. So, if you see this place. The small portion.

So, this is a another metal sheet bid ok. So, this is a bid which is also a folding. So, that folding allows a small gap between the actual sheet and that particular folding, so that forms the crevice. Similarly if you go to the top part.

So, this part is also zoomed here. you see that wherever there is a metal folding. So, these are the metal folding part there severe corrosion has happened and that corrosion actually spreads across. Similarly here the corrosion happens there and spreads across.

The rest of the thing though its painted. Remember though is painted still the corrosion spreads from those cervice portion ok, so that is what crevice is highly localized. Another example. So, this photograph I took it for showing to all of you and this is another one.

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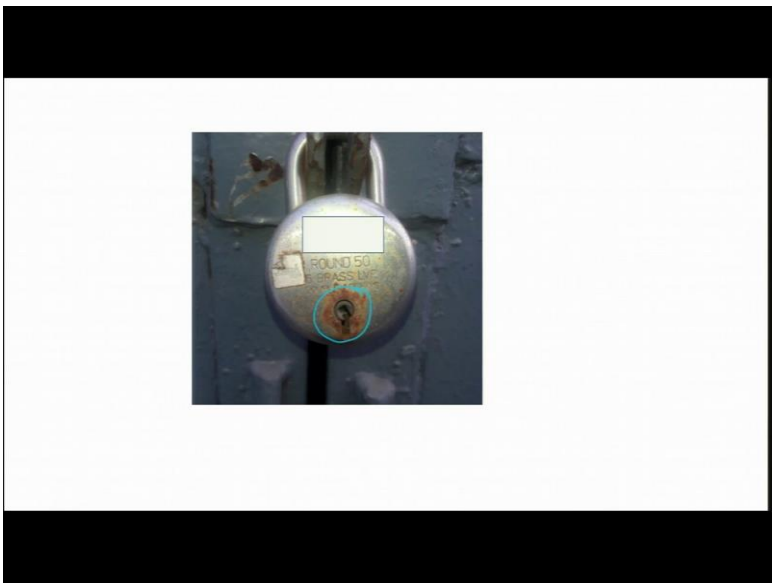

So, I had to cover this top part which of course, company written, so I cannot show that, but if you see the keyhole portion. That keyhole portion is highly corroded, because that also forms crevice. And since it was lying outside because its a basically lock used for closing the door which goes out to the garden ok, so; that means, it stays outside where lot of rain happens and the water is accumulated there and it forms a crevice and the corrosion starts ok.

So, this is also an example of crevice corrosion. So; that means, you could see that wherever there is a corner or sharp section in a structure that is basically liable for crevice corrosion. So, now, if we see crevice corrosion it happens along in the corner ok or sharp sections ok.

So, for example, in this door case we have a sheet metal block and this is the metal part and there small crevice forms. Its a small slit ok or you can say sharp slit. So, through which solution can ingress and then crepes and this is also a kind of if you see the shape wise this is a crevice. So, those are the sections. For example, even bolt, so this is let us say a kind of bolt this is the bolt this is the thread fine. Now when we tighten the bolt we put a washer. This is the washer and sometimes we put lot of you know Teflon tape to make it tighter ok.

And if the teflon tape comes out you know that is the major damage it creates. When the teflon tape comes out, so the teflon tape seems, its a very malleable is not it. So, it actually hangs out outside and that hanging out the Teflon tape and the metal interface that creates crevice.

Even that metal washer when we put that metal washer part. So, if we see from the top part if it is a hexa head bolt, so then you are putting a washer. So, this is washer fine. So, between the washer and this is the bolt head bolt head. Between the washer and this metal part you have a small gap. So, that gap also creates crevice.

So, the corrosion happens inside those gaps inside those gaps. In the door case example case though we are able to see those rust, but actually it starts inside and then comes out. In the beginning of the crevice corrosion we are not able to see that where it where it forms, but as it happens, as it grows then it comes out the rust comes out. Here also those Teflon tapes if this Teflon tapes are hanging out that will also create a crevice and that will also be a problem.

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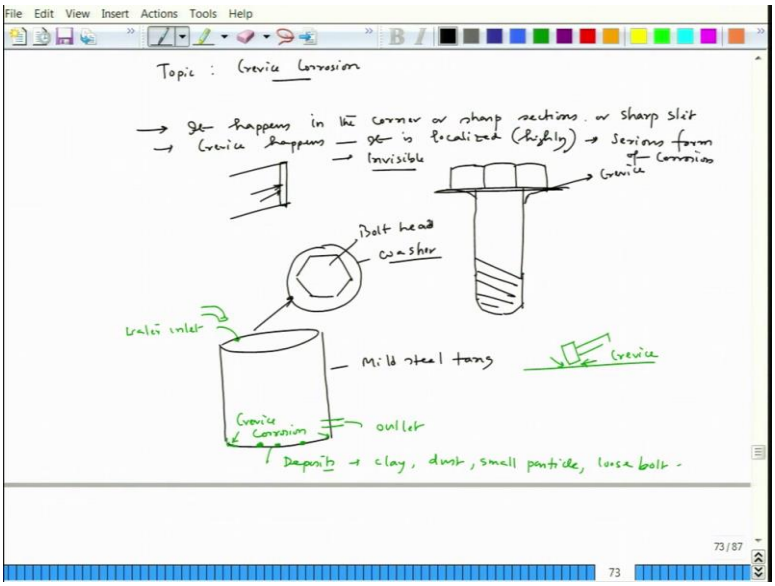

Now, another example for example, if you keep ah, if you see a cleaning of tank ok. So, let us say this is a mild steel tank and let us say you have side from the side you have outlet, and from top you are having water inlet, so this is let us say the tap. This can happen in case of a normal household water storage tank. Now nowadays people are using plastic, but before people used to use a steel made mild steel made tank. So, in fact, big industries where the liquids are to be stored, they use mild steel tank.

For example, in case of cold roll mill you have to have a tank holding coolants or a kind of emulsion which are used emulsion which is used for cold rolling operation. So, now, this is a tank, let us say its a normal household water tank.

You would see that this corners, this corners are liable for crevice corrosion, are susceptible to crevice corrosion. Sometimes at the bottom also you would see some of the places where the rust is very localized and interestingly if you look at that you will see that there are deposits. Deposits could be in the form of clay or could be form of dust ok or small particle.

Sometime there could be possible possibility of having a loose bolt which is which has fallen in that particular tank and which is which has got stationed at the bottom. So, wherever those bolts are forming. For example, if this is a bolt, let us say this is a bolt and that is lying on the platform you are actually creating crevice here. So, those part will be corroded fine. So, rest of the part wherever there is a proper flow of water we do

not experience crevice, but wherever there is a small corner or sharp section sharp slits we have crevice and that corrosion is highly localized.

So, that means, here whenever this crevice happens its localized and rather highly localized. And most of the cases when it starts it is invisible, you do not see it. In fact, in case of galvanic corrosion if you have observed that the crevice the corrosion happens the portion which is not exposed to the environment rather which is not visible to the eye. The example what I showed to this, this one was the example I showed if you go back to that video. The portion of that particular screw which was inside the this is the; this is the part, inside the wooden block that got corroded.

So, interestingly while understanding corrosion its better to look at the portion which is not seen. Which is seen with naked eyes the corrosion problem most of the times will not be that severe, but the portion which is hidden that portion could have extreme corrosion ok. So, that is a kind of a; kind of a rough or there may be a kind of thumb rule that look for portion which is hidden; like crevice corrosion, until unless it grows considerably you do not see that corrosion ok.

So, that is what this whenever something happens localized manner its not a good stuff ok. So, this is a kind of very very serious form of corrosion ok

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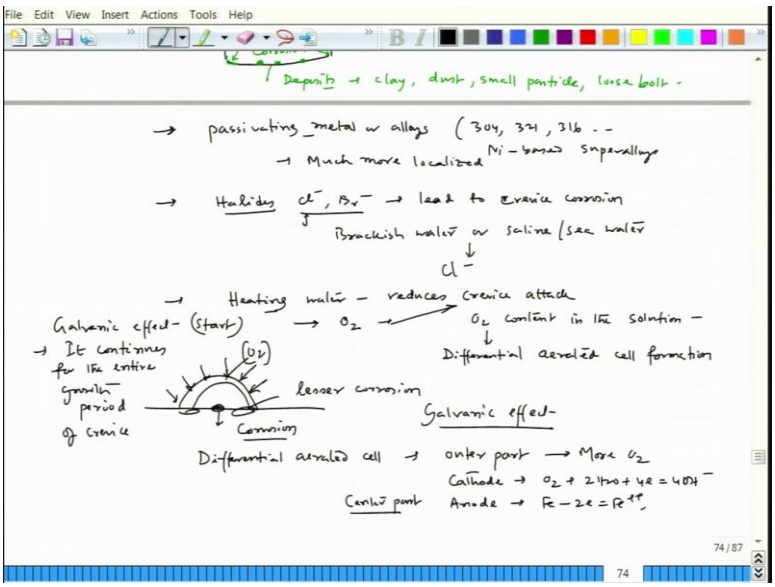

And interestingly this type of corrosion happens very very much more in localized manner in case of passivating metal or alloys ok. So, if something is not very passivating kind of metal the crevice corrosion would not be that localized or that severe, but if it is a passivating metals and alloy.

For example, 304 stainless steel 321, 316, those are the alloys which are highly resistant to normal corrosion there you can. For example, sometime nickel super alloys nickel based super alloys you could experience this kind of crevice this kind of crevice corrosion highly localized form of corrosion.

Interestingly, so if it is a passivating it will be much more localized than normal non passivating type of metal. So, this is another interesting part which is to be noticed, that we feel that the passivating metal we have used. So, we are ok with that particular structure rather we have to be very careful about that crevice corrosion.

And interestingly we have to check its crevice corrosion before we use in a particular operation where crevice corrosion is inevitable. And other part is, if we have halides like chlorine, bromine fine. So, these are the halides lead to crevice corrosion. We will understand the effect of chlorine ion fine, but you mostly the crevices. That is what this particular crevice corrosion is more pronounced in case of brackish water or saline water or sea water where you have lot of chlorine ions fine.

Now, if we try to look at different factors, interesting part another interesting part is let us say you have this kind of crevice corrosion happening in a structure and then if you heat it ok. And of course, it has to be exposed to the air. Now if you heat it the crevice corrosion tendency drops down ok.

So, now, heating water reduces crevice attack fine. Now if it is not heated crevice attack is severe. So, interestingly this also relates to the presence of oxygen in the water ok. While heating oxygen dissolution rate drops down, so its less oxygen and that would lead to reduction in crevice attack.

So, oxygen content is another issue oxygen content in the solution. Now interestingly that would actually lead to the initial stage of crevice corrosion or the initiation of crevice corrosion due to differential aerated cell formation. In this regard let me just point out when we analyze the mechanism of crevice corrosion you would see that the

initiation starts with the galvanic mode of corrosion. For example, if we could recall that water droplet corrosion effect, we saw that the center part will have corrosion, but outer part do not have corrosion.

Its very wrong to use do not have corrosion rather I would say lesser corrosion, and it relates to differential aerated cell. Why? The outer part more oxygen since it is covered with it is actually close to the air. So, then that part would act as cathode and if it is a neutral this reaction would happen. And center part which is highly corroding that part would be anode center part where these ions will form which is corrosion fine and this is basically water droplet on a mild steel surface.

Now interestingly in the beginning everywhere in that water droplet oxygen was same, but now as the corrosion happens both this cathodic and anodic reactions will be happening over the entire iron surface which is covered by that particular droplet. But gradually the center part will be gradually center part will be depleted with oxygen and the outer part will be same as oxygen content what was there in the beginning because most of the all the time oxygen can diffuse in from outside.

So, this is oxygen diffusion from outer layer to inner layer. So, the outer layer will have oxygen more oxygen, but inner layer which is the center part will have least oxygen. So, that is what cathodic reaction would happen on the top surface outer surface and the center part will have anode which is cathodic anodic reaction which is iron dissolution.

So, now this is a typical galvanic effect galvanic effect. Similarly, the crevice starts with a galvanic effect, start and it continues till for the entire growth period, growth period of crevice. So, that means, as we have seen that in case of de alloying in case of inter granular corrosion galvanic corrosion is taking place over there. Similarly, here also galvanic corrosion takes place.

So, that is what I feel that the galvanic corrosion is the most important corrosion process we have to learn properly ok. So, there are other factors. So, we will continue our discussion on that other factor as well as we will talk about the mechanism of crevice corrosion. So, till then let us stop here we will take it up in our next lecture.

Thank you.