Corrosion – Part I
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Lecture – 27
Estimation of Corrosion Rate–II

Let us begin lecture 27.

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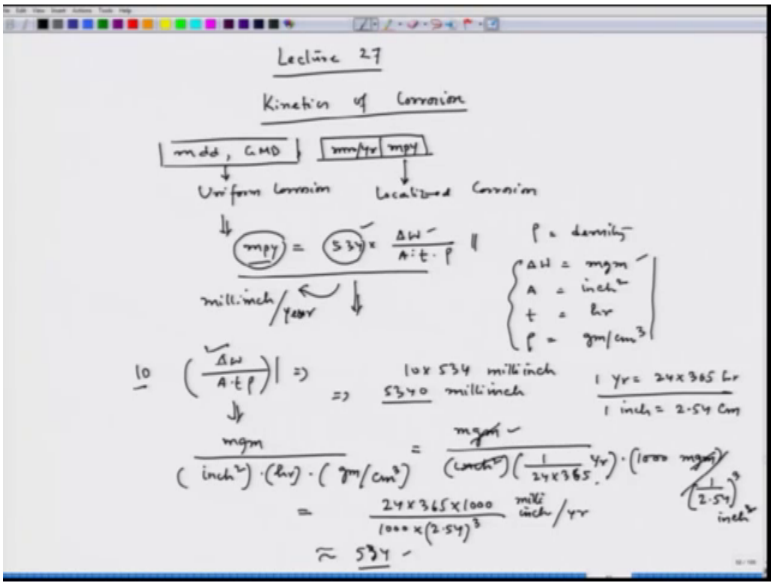

Here we will continue our discussion on Kinetics of Corrosion. Now, in the last lecture we talked about expressing corrosion rate in the form of either mdd or GMD, means gram per meter square per day, millimeter milligram per decimeter square per day, or there are one more section which is basically mm per year or mpy. So, now, mpy, and mpy is nothing but milli inch per year. This is we talk about uniform corrosion and this one is nothing but localized corrosion.

Now, then we thought that we would get into the electrochemical mode of corrosion expressing corrosion rate in the form of current. Because you would see in a while that current is nothing but the rate of charge transfer, and for corrosion is nothing but the anodic reactions or the formation of metal ion from metal, and then electron will be released and that electron will be taken up by some cathodic reactions.

Now, sometimes we have to see that this units are interchangeable. Let us say the we know that what is the amount of metal loss and then calculate the corrosion rate in the form of mass loss per area per unit time. And then after that we see the surface and then see that the surface does not change much. So, then we have to convert it into the another unit which is nothing but the depth attacked or the depth penetrated per unit time. So, that conversion is quite straightforward only thing is we have to divide it by the density.

And in addition to that while we change the units there could be some conversion factor. So, like one conversion factor which is very popular is mpy is considered as 534 into del W by area by time by density or the rho, the rho is density of the metal, where del W is expressed in the form of milligram, A is inch square, time is hour and rho is gram per centimeter cube.

Now, this is the convention people have used. So, I think from the first when it was first understood that time this particular expression existed. But now I would say that you do not bother about this expression only I am showing it that how to why this conversion factor 534 comes in. I just would like to mention that, otherwise you simply consider the units after taking mass loss area time and density whichever way would like to consider but it should yield milli inch per year. So, then you would get different conversion factor. But at least let us see how this 534 arrives.

Now, when we talk about del W A t rho, let us say somebody expressed these are the considerations that weight loss was taken in milligram area was taken in inch square, time is in hour and rho is in gram per centimeter cube. Now, if that value is let us say 10 unit of this, now we have to consider in terms of mpy.

So, if we consider this part milligram per, area is in inch square then we are taking time in hour, then we are taking in gram per centimeter cube. So, unit milligram I am just doing the conversion in order to arrive to this particular mpy, so I have to make it in the form of milli inch per unit area per unit per unit year or rather milli inch penetration in a year.

So, inch should be converted into centimeter square or I could say centimeter should be converted into milli inch. This inch square, so I just simply keep it inch square first, and then hour should be converted to year. So, this should be 24 into 365 year because 1 year equal to 24 into 365 hour. So, from that I can write 1 hour is nothing but 1 by 24 into 365.

And then gram I can convert into milligram since this is a milligram, so 1000 into milligram, 1000 milligram divided by inch centimeter I can convert it to inch. So, 1 centimeter equal to rather 1 inch is equal to 2.54 centimeter. So, 1 centimeter is nothing but 1 by 2.54 cube, inch cube now then I can write it as, so this one would get cancelled. So, this part would get cancelled, and then this one would go to 24 into 365 divided by 1000 into 2.54 inch per year, this should be cube.

Now, in order to convert inch into milli inch, I can multiply with 1000 so this would become milli inch. Now, if you calculate this then you would see that it is coming about 534; roughly it is coming about 534 that it will come around 535, close to 535 something. So, you can roughly consider it as 534. So, that is what if I consider 10 of this particular amount, then this should become into 10 into 534, this much milli inch. So, this would be equivalent to milli inch. So, this is coming about 5340. So, you understand that how this 534 comes up.

It is basically converting these units these units in the form of the units what we desire or what we want here it is mpy. And if we consider all those parameters in the form of this units then there should be a multiplication factor of 534, and this is coming because when we convert those units we have to see all those conversion and then finally, we achieve 534 that is the multiplication factor. So, like that way you can convert any unit into any other unit.

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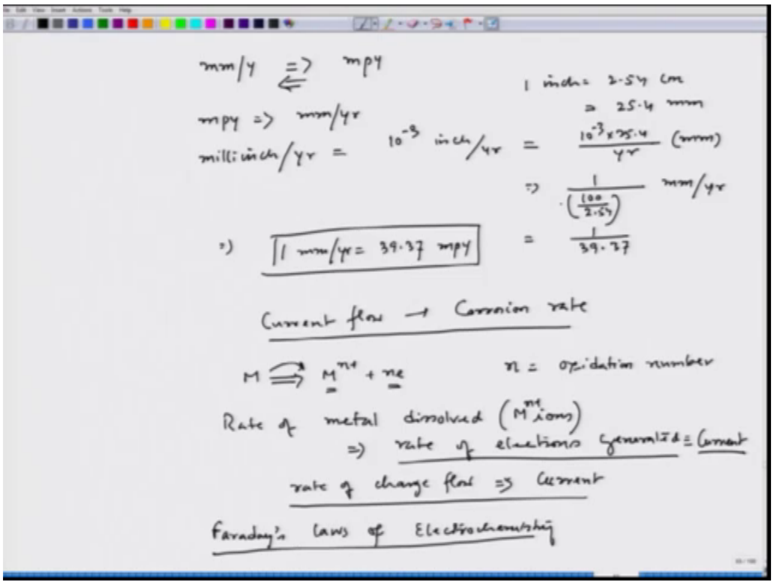

For example, if we consider let us say millimeter per year I have to convert into mpy or vice versa. So, then also it can be done like, let us say I want to convert mpy in to millimeter per year. So, mpy is nothing but milli inch per year. So, this is coming out to be, this is and then we have to make it in terms of millimeter, so 1 inch equal to 2.54 centimeter is equal to nothing but 25.4 millimeter.

So, it this becomes 10 to the power minus 3 inch per year. So, this, so it was 10 to the power minus 3 into 25.4 divided by year, so 1 by 100 divided by 2.54 millimeter. So, this becomes millimeter now the top part year. So, equal to 1 by 39.37. So, 1 millimeter per year equal to 39.37 mpy. So, this is another conversion. So, you can see that you can convert one into unit to another with some conversion factor. So, that factor is decided by what is the unit we are considering.

Now, let us get to the electrochemical ways of expressing corrosion rate or we would now consider the current flow for the corrosion rate. Now, when we talk about current flow as the measure of the corrosion rate we have to see that why this current flow should give us corrosion rate. Now, let us say the metal dissolution. So, metal is going to n plus ne, and where n is basically the oxidation number, oxidation number. So, when we consider one atom of that particular metal is coming into the solution in the form of ion. So, then we are seeing that any number of electrons are released.

Now, if we keep seeing this particular conversion from metal to metal ions that means, we are seeing that the loss of metal is continuing and then we are also saying the number of electrons are also released that number is also increasing. Now, the rate at which these metal ions are forming that would also be related to the rate at which electrons are getting released from that particular metal ion atom.

So that means, rate of metal dissolved in the form of metal ions. So, that is also somewhat equivalent to rate of electrons generated. So, and when we consider rate of electrons generated and we also know that rate of charge flow is nothing but current. So that means, this is nothing but current. Of course, the current could be different current could be anodic current could be cathodic, and here since we are considering anodic reactions this current is nothing but the anodic current. So, it looks like that the current flow is guiding the rate of dissolution, or if we can have the knowledge of that current which can be easily measured with an ampere ammeter so we can know what is the rate of corrosion.

Now, when we talk about the rate of corrosion is related to the current or the flow of charge per unit time, then we have to take care of we have to consider the faradays laws of electrochemistry or popularly the laws of electrochemistry. So, this is very important when you consider the rate of corrosion in the form of current flow. So, let us see what are those two laws of electrochemistry, these are exact laws.

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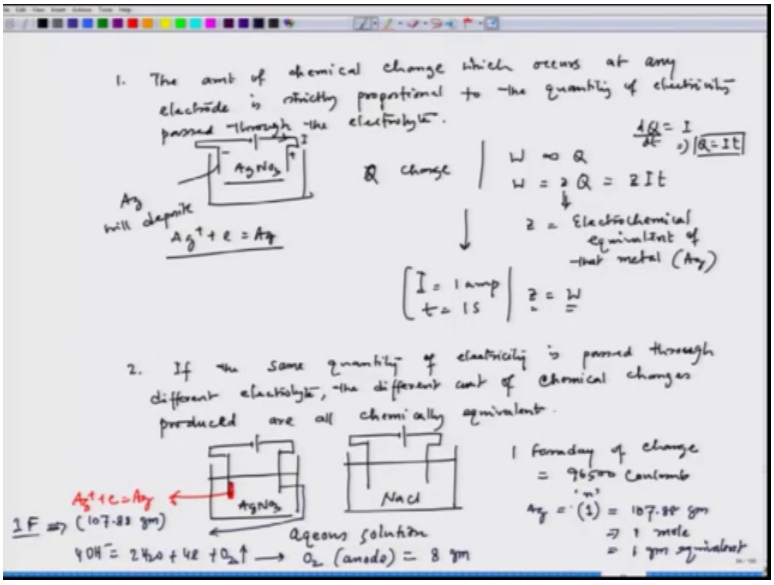

Now, first it says the amount of chemical change which occurs at any electrode is strictly proportional to the quantity of electricity pass through to the electrolyte.

Now, when we talk about electrolysis let us say, if we send let us say we are taking AgNo 3 that is the solution aqueous solution of AgNo3. And then if we send current, and if we send current let us say I then we would see that this is positive electrode, this is negative electrode, here Ag will deposit since these reaction takes place.

Now, if I send Q amount of charge. So, then we would see that the weight that is deposited in the cathode is proportional to Q or simply write W is proportional to Q. And the proportionality constant this Z is nothing but electrochemical equivalent. This is the electrochemical equivalent of that particular metal. Here it is silver.

And this we can convert into Z I t, since Q is equal to nothing but dQ dt is equal to I. So, Q is equal to I t. Now, Z, the definition of Z would be if I equal to 1 ampere and t is equal to 1 second, then Z is equal to W.

Now, if we consider the second law of electrochemistry, it says that if the same amount or the same quantity of electricity is passed through different electrolyte, the different amount of chemical changes produced are all chemically equivalent.

Now, let us see the, what it says. Let us say we have two cells, one is the cell what we have shown there this is two electrodes and then here AgNo 3 and another electro another cell where we are supplying current and here it is NaCl aqueous solution, both are aqueous solution. And if we supply 1 faraday of charge, if we supply 1 faraday of charge which is nothing but 96500 coulomb, then the amount of metal that will be deposited on this surface here it will be Ag plus plus e equal to Ag. So, this will be deposited. And that amount would be this amount if we send 1 faraday if we way that it would become 107.88 gram which is basically 1 faraday charge.

Now, on the anode, this is my anode I will have this reaction and then we will generate oxygen and that time the amount of oxygen anode for the supply of 1 faraday of electricity is also equal to 8 gram. Now, if we see this AgNo 2, Ag has got oxidation number 1, so 107.88 gram is nothing but 1 mole or 1 gram equivalent, because since Ag the oxidation number which is n is 1 here.

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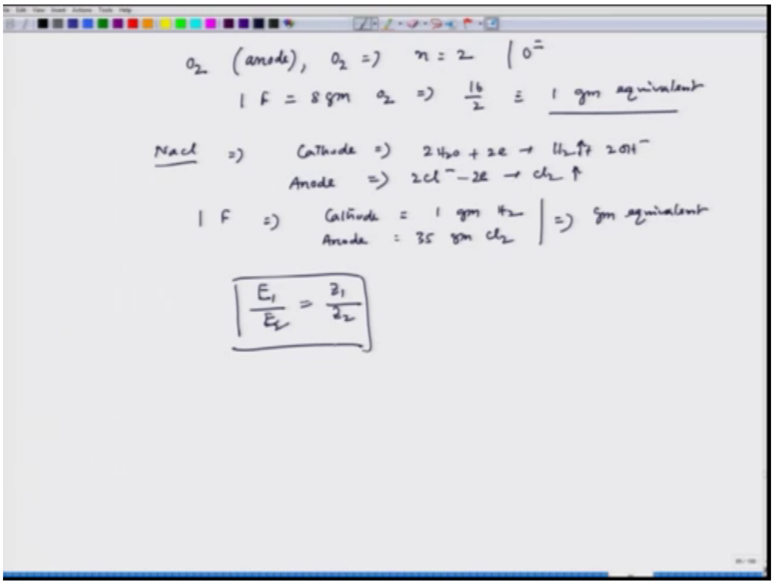

But if we consider oxygen on anode its n is equal to 2 since we have to consider oxygen ion, so the 1 faraday is equal to 8 gram of oxygen which is nothing but 16 by 2, 16 is basically the molecular weight of oxygen is equal to 8 or this is nothing but 1 gram equivalent.

Now, the chemical product that will be formed here is so, 1 gram equivalent of oxygen. Now, similarly if we see the NaCl here on the cathode you would get following reaction, where 2 H 2 O it will react with it will accept 2 electrons and then forms H 2 plus 2 OH minus and anode it will be equal to here cl minus will release 1 electron or 2 cl 2. So, this H 2 gas will generate on cathode and chlorine gas will generate on anode.

Now, here also you will see that if we sent 1 faraday of charge on cathode it is 1 gram of, roughly 1 gram of H 2 and anode it is around 35 gram of chlorine. So, these are also their gram equivalent. So, now, what we see that if we send the same electricity or same charge we are getting similar amount of the equivalence the chemical equivalents amount of products that means, if we send 1 faraday of electricity we are getting 1 gram equivalent of that product. So, 1 gram equivalent of silver, 1 gram equivalent of oxygen, 1 gram equivalent of chlorine and H 2 in those two cases, so that means, the second law is validated.

So, now that means, E 1 and E 2 should be equal to Z 1, Z 2; so E 1 and E 2 are the chemical equivalent for two substances and Z 1 and Z 2 are basically the electrochemical equivalent for those two substances, and then second law says that they are equal; if the ratios are equal. If you send similar amount of charge. So, we will get same amount of chemical product which is chemically equivalent.

So, let us stop here. So, we will continue our discussion on this and try to get some relation with the current and corrosion rate.

Thank you.