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Theory and Practice of Non Destructive Testing

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Radiography - 7

Hi everyone and we will come back to one more part on radiographic testing so far we have learned about how the image is formed okay and we have also seen in last couple of lectures how the image quality is controlled and what are those parameters which control the image quality okay so now that we know how the image is formed we can talk about the exposure as to how exactly the exposure is done you know and what kind of things are used for exposure and for a particular material of given thickness what are the exposure parameters particularly lie exposed at time how it is decided okay so that is what we are going to discuss in today's lecture.

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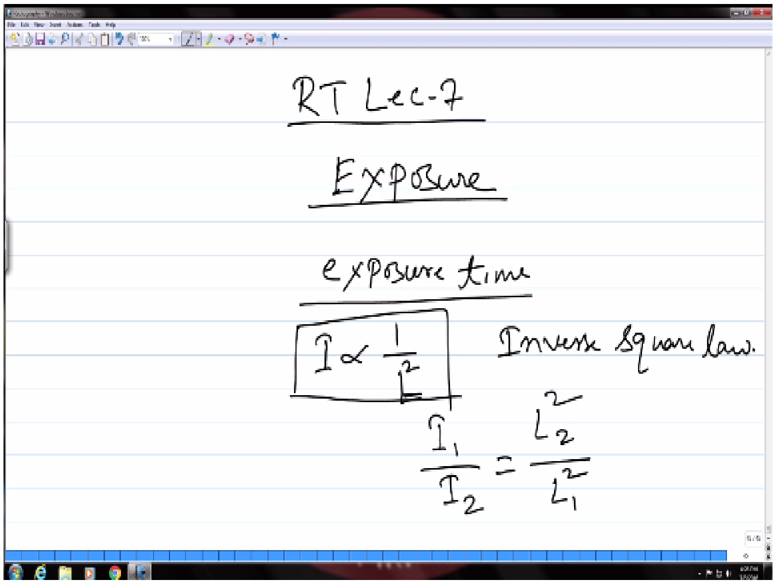

So first let us talk about how the film is loaded when you expose it for a particular exposure okay so in order to capture the image on x-ray film you need to take it to the machine right and you have to load it in the machine or as you all know by now this x-ray films are sensitive to light if you expose the x-ray film to light then they will darken and once the darkened you cannot use them for capturing the image okay.

So when you are take this film to load it into the instrument this film has to be protected from light okay and in order to do that you need some kind of enclosure which will do this job of protecting the film from visible light and that is why this kind of sample holders are used for loading the film first okay this kind of sample holders that you see over here okay and this can be this is available this kind of sample holders are available in different sizes depending on the size of the sample that you have and it has a chamber inside if you open it that you could see that right like this okay.

So you can keep the film inside this and you could see there is a cushion for the film against you know scratching and all that so that the film is not damaged when you keep it inside so this cushion is provided for that and you can keep this and then you can close this okay once you close this figure this becomes a light-tight that means this will no longer be exposed to light it could also see inside this cassette there are a few more things you if you remember we talked about intensifying screens which are used to enhance the image quality or to enhance the efficiency of image formation and as I told you the intensifying screens have to be kept right over the film okay.

So here you do not really see anything externally but this still has an intensifying screen inbuilt inside this chamber over here okay so it has two walls as you could see the top one and the bottom one okay so in the top one in inside this black layer the intensifying screen is inbuilt okay it could be a metallic intensifying screen or if you want to use those fluorescent salt intensifying screen they can also be used as a thin coating on the top surface similarly the bottom surface also here just below the cushion there is a thin LED screen so that you can address those basket irradiation which comes from this bottom surface and apart from that this material if you see the material of this cassette is made of such a material which is low absorbing to x-rays.

So that the x-rays can easily pass through it and on this surface as such there is no a Tunisian to the intensity of the x-rays okay so this has to be made of a material which is low absorbing for example aluminum can be used in fact this cassette that you see over here this is made of an aluminum alloy okay so this is what is being used for loading the x-ray film into the x-ray machine you might have seen these so while doing medical radiography also they have a cassette like this maybe a different size this castle is being held in close contact with our body when a body part is being imaged for medical radiography okay.

Then on this the sample is kept on the top surface okay so right below this you have the intensifying screen and then you have the sample okay so if you remember we also discussed that the intensifying has to be in between the sample and the film and it should be also there on the bottom surface so that the back scattered radiation can be addressed okay so this is one aspect of exposure as to how to load the film for a for a particular exposure okay now when you take a sample and you do this exposure for capturing the x-ray image what you control on the control unit is primarily the exposure time for a given tube voltage and given to current okay.

This tube voltage and tube current on the other hand can also be buried for a given exposure time okay so that means first you need to decide what should be the exposure time for a given tube voltage at a given to current okay so this time would depend on what kind of sample you have that means the material of the sample and the thickness of the sample okay so these are the two parameters which will primarily decide the exposure time for a given voltage and current and in order to do that you need a relationship which could be used to decide this exposure time based upon the thickness of the material.

So this relationship or the equation comes from two laws one of them is this one that we have already discussed probably by now the intensity is inversely proportional to the square of the distance okay so if I be the intensity and L be the distance this will be the relationship between in x-ray intensity and the distance between the source and the sample okay and that is why this is known as inverse square law.

So this means for two different intensities I1 and I2 this will be equal to this so this is a inverse square law and the intensity is a direct output of the number of electrons which are impinging on the anode per unit area per unit time okay so that means the intensity is depend on the tube the tube current.

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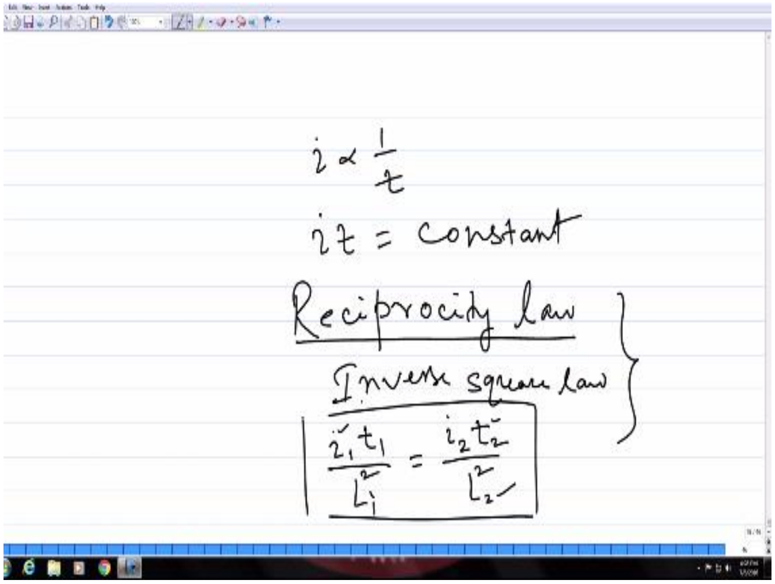

And that is why you have this particular relationship I is inversely proportional to exposure time if the tube current is higher than the intensity will be higher and as a result of that the exposure time will be lower and vice versa okay so this means I times t is a constant or the relationship between the tube current I and the t is reciprocal and that is why this particular relationship is known as Reciprocity law so we have these two laws of these two relationships reciprocity and inverse square and these two can be combined into one in order to decide that exposure time.

So if you can if you combine these two it will give rise to this particular relationship okay and this will tell you as you vary the thickness or the distance L how the time t should vary or if you vary the current for a given distance then also how the time of exposure should vary okay.

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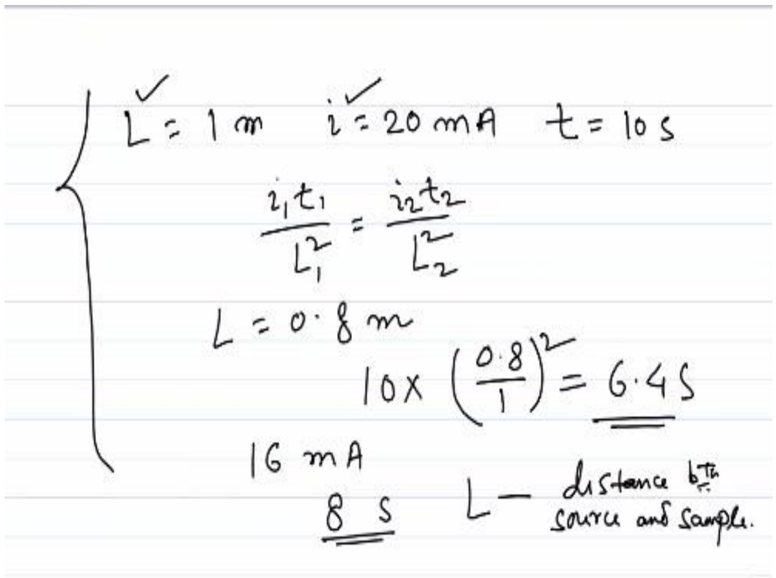

For example if you have a distance of 1m and a tube current of 20Ma and for a given material let us say you used an exposure time of 10s okay now if you change any of these either the distance or the current then the time will change according to this relationship that we derived just now based upon those two laws for example if you change L 0.8 m from one meter then for the same tube current the time needed for a similar quality of image the exposure time for that will be because this varies as the square of the distance so for 1m it was 10 s and for 0.8 m it will be 6.4s okay so this is how if you vary the distance that time will vary according to this relationship and if you change the current also from 20mA to 16 mA now and the distance also is changed 20.8 m.

So for that case when you change both distance and the tube current then again from this particular relationship you can find out what will be the time and in that case it will be eight seconds okay, so like that based upon this particular equation this is how you can find out for a particular cube current and particular sample to source distance what should be the exposure time but here this is about the distance between the source and the sample but as I said before this will also depend on the sample thickness.

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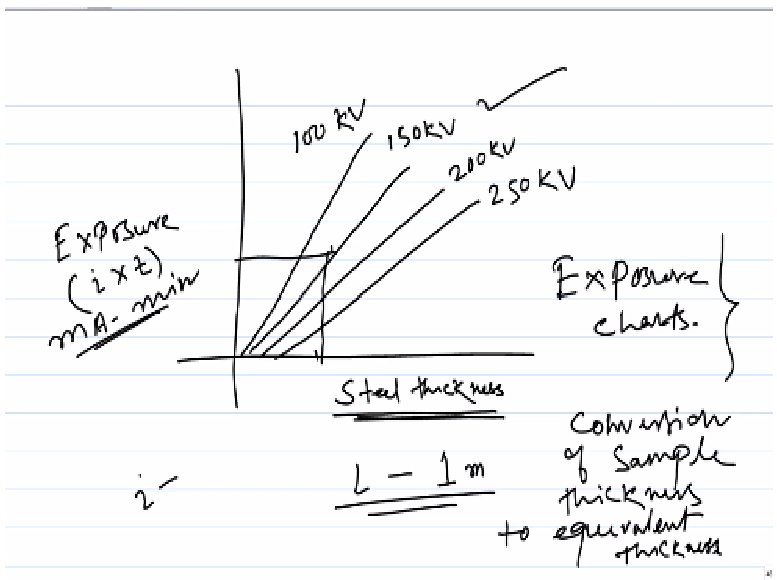

And when you take into account the sample thickness also then you need to use this calibration charts which are obtained for different sample thicknesses and this has to be supplied by the manufacturer of the instrument who has to do this calibration and provide you this kind of exposure charts for different sample thicknesses for a particular sample to source distance okay so generally the sample to source distance is kept at one meter because this is convenient to use when you convert the exposure time for some other distance.

So this chart is in between or this exposure chart or the exposure plots that you have it is in between the exposure, so this is in terms of times the current into the exposure time and this has to be calibrated for a particular material against the thickness okay so it can be done for example on a steel sample for a fixed sample to source distance of one meter and then you vary the thickness and obtain the data and when you plot the data at different 2 voltages this kind of curves will be obtained.

For example if you are using 100 kilo volt like this so it will it has to be done at different 2 voltages and different sample thicknesses over the entire tube voltage that the instrument offers okay like this so when you do the radiographic testing before you load the sample into the machine you should first refer to this exposure charts which are provided by the manufacturer for that particular instrument okay.

And you then see what is the thickness of the sample and based upon that thickness and the tube voltage that you are using you see what is the exposure needed okay, so this exposure could be in terms of milliamps minute or a millions second and this tube current is already known it is generally in the range of five to ten millions for most of the four most of the machines okay and once you know this then you simply divide this by the tube current then from that you will get the time okay.

So this is how based upon this exposure charts you have to first decide the exposure time for a given material of a particular thickness okay so this is done for steel but this has to be obtained for other materials also and you may or may not have this kind of plots for all the materials but what you can have for convenience is you can have this conversion of Steel to any other material thickness, so you can convert any material thickness to an equivalent steel thickness.

So if you have a sample made of any other material that thickness has to be converted to an equivalent steel thickness and then that thickness can be used for this kind of charts which are generated for steel samples okay, I can give you example for that.

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	Cu	Al	Pb
300 kV	1.5	0.19	17
250 kV	1.45	0.17	15
200	1.4	0.16	13
150	1.3	0.12	11

Let us say you have a composite plate or before that just let me tell you what are the conversion factors for different materials to convert their thickness into an equivalent still thickness okay let us say copper aluminum and lid for these three materials if you want to convert their thickness into an equivalent steel thickness that would depend on what is the x-ray energy that is being used so we can see it for different texture energies.

So for 300 kilo volt for example for copper the conversion factor would be1.5 okay similarly for aluminum it is 0.19 and for lead that is 17 okay so you could see depending on the material it varies over a wide range so let us say for example if you have 10 centimeter of the copper that will be equivalent to 15 centimeter of Steel thickness okay then as you decrease the x-ray energy this would also decrease, like this for copper it will be 1.45 at to 51.4 at 200 kv.

And 1.3 at 150 kv similarly for aluminum is 0.17, 0.16 and 0.12 for lead this 15 at 250 k v 13 at 200 kv and 11 at 150 k okay, so based upon this kind of conversion charts which are readily available the thickness of any material can be converted to an equivalent steel thickness and then you would be able to use those exposure charts which are obtained for different thicknesses of Steel okay.

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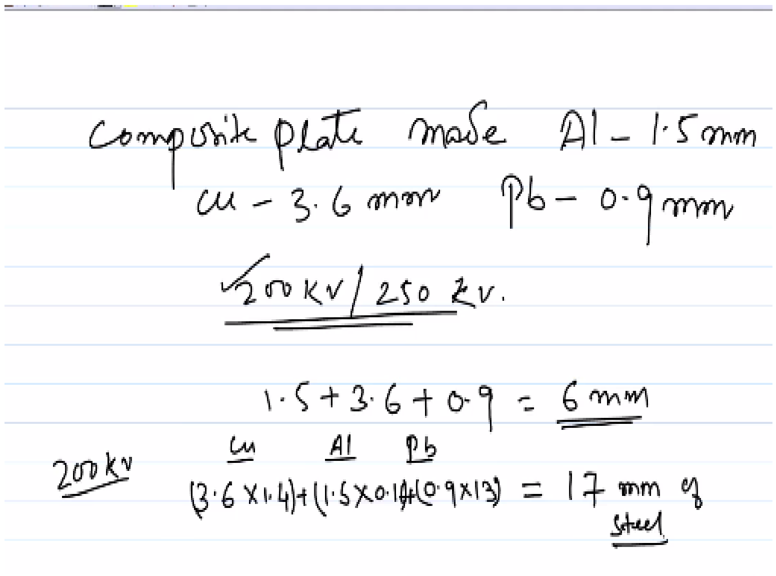

You can take an example as I was telling you let us say you have a composite plate which is made of three different metal sit's aluminum 1.5 mm copper 3.6 mm and lead 0.9 mm, okay so let us say you have a composite plate like this which has these three layers are made of three different materials having this kind of thicknesses okay so for a tube voltage it is a 200 kilo volt or 250 kilo volt if you want to decide the exposure time for a given tube current then you first have to convert the thickness of this particular plate into a steel thickness.

So the thickness of this plate is 1.5 + 3.6 + 0.9 which is 6 mm okay so this a 6 mm thickness of this material has to be converted into an equivalent steel thickness for a given x-ray energy or tube voltage and we have already seen what are the different conversion factors for different materials for these three material at a particular to voltage let us say at 200 kv just now we saw that at 200 kv for copper aluminum and laid if you convert their individual thicknesses.

So in this case we have 3.6 mm of copper and for copper the conversion factor at 200 kv is 1.4 so that will be the equivalent thickness for cover for aluminum it is 1.5 mm and the conversion factor at 200kv is 0.16 similarly lead is 0.9 mm and the conversion factor is 13 okay, so this will give you the thickness at a particular voltage so if you calculate this, this will be 17 mm of Steel okay.

So this is how any material thickness can be converted into a steel thickness when you want to use that exposure chart for calculating the exposure time okay, so with this will we come to the end of this particular lecture so for today this is all I will have so I am going to stop here today and I am going to see you again next time for rest of the things that we have for this particular technique so I am going to stop here today thank you for your attention.

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