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Theory and Practice of Non Destructive Testing

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Eddy current testing - 5

Yeah so in the last lecture we have seen how exactly the eddy current testing is done with the help of a small instrument like this a small box like this.

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This is a very anti setup which can be carried anywhere so you can do the test anywhere inside the lab or on-site if you want to do it because this is a small compact set up which can be carried

anywhere and then we have seen there are different types of probes and with the help of these probes when you connect it to the instrument and then you see the lift up curve and if there are flaws or defects they will give a signal which will come over this lift of curve as we have seen for one of those artificial flaws which represent cracks okay.

So that means in this case the indications that you get in terms of this signal are indirect unlike the previous two cases magnetic particle testing and dye penetrant testing where we saw the direct visible indications of the flaws in this case the indication is a signal and it is indirect okay, so in a NET method wherever and whenever the indications are indirect it is important to calibrate the instrument first before you do the entity okay.

So in this case also we need to calibrate the instrument first because here also the indications are indirect so how dos you dos that how do you calibrate the instrument so let us see that in this particular lecture.

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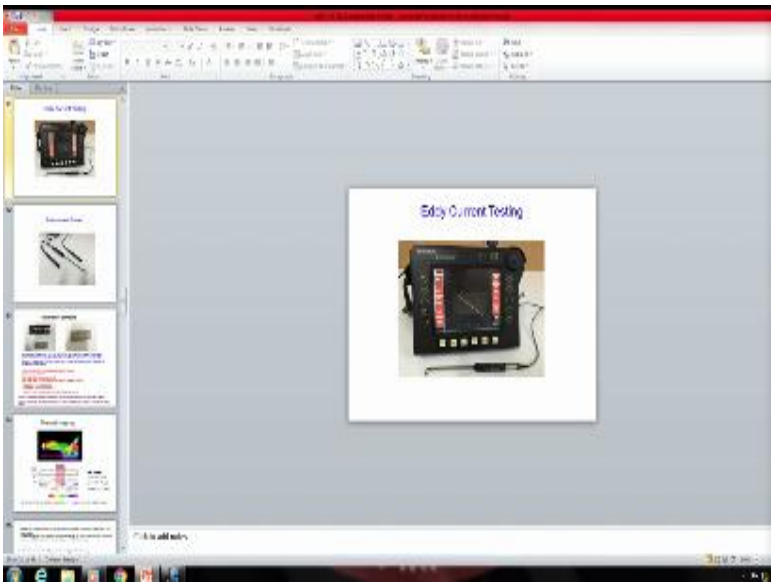

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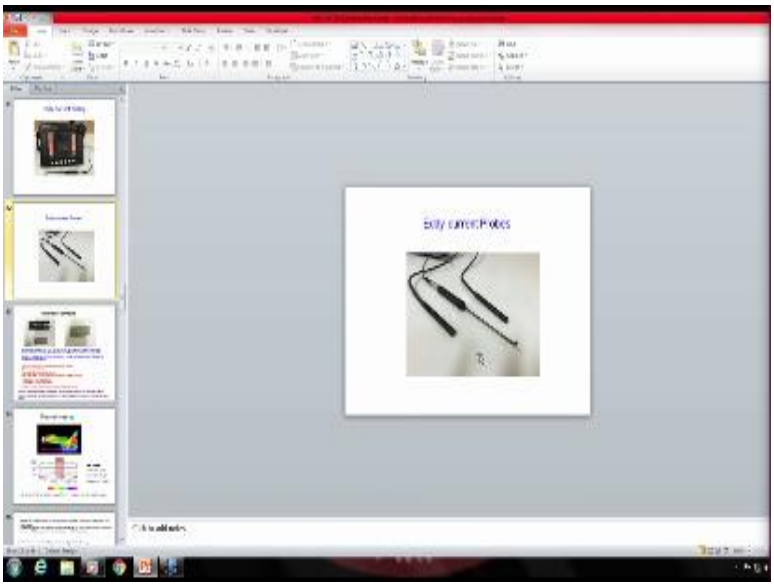

So if you want to calibrate the instrument you need to take the help of some standard blocks.

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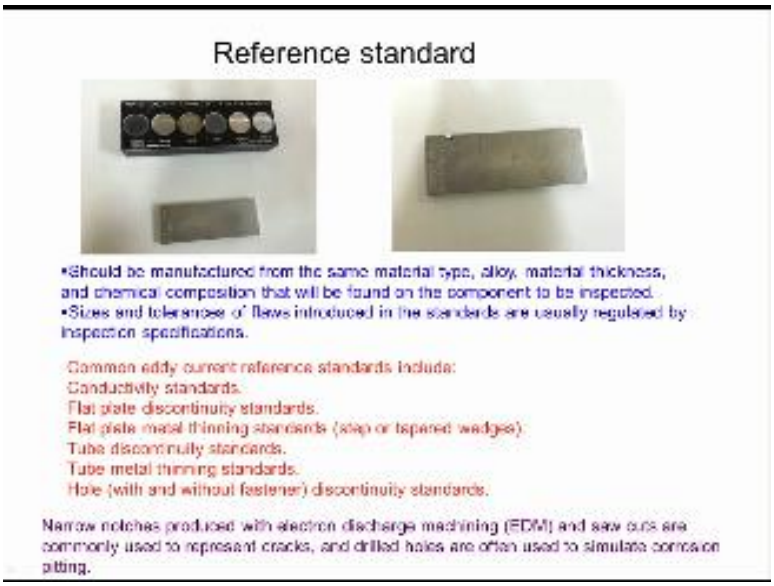

Like this what you have over here and this is the one we actually I used in that demo video so this will have certain features on the surface so in this case we have three precisely cut out lines one is very fine over here and then the other two which are little bigger so this kind of features on the surface will represent artificial flaws and with the help of this kind of features you would be able to generate a defect signal on the display of that system in the eddy current system and with the help of that signal you would be able to calibrate the system okay.

There are certain other types of standards also for example over here this is a conductivity standard which is used for calibrating the instrument in terms of the electrical conductivity because you would have seen that the conductivity is one of the important parameters we control the eddy current and that is why sometimes the instrument has to be calibrated for the conductivity as well okay, so the first thing that you should remember while calibrating the instrument is that the calibration block that you are selecting that should be made of the same material as the sample okay.

For example if you have an aluminum sample or an aluminum alloy sample then the reference standard should also be made of aluminum alloy like for example this one is made of an

aluminum alloy so if I have an aluminum sample I should choose this one similarly if you have a steel sample then the reference standard or the standard block that you are selecting for calibrating the instruments would be made of steel okay.

So that is the first thing that one should remember while calibrating the instrument okay, and the other important aspect is the size and tolerances of the flaws which are introduced in the standards and this has to be regulated through some kind of specifications following some standards like ASTM standards and so on so the artificial flaws that you introduced on the surface of these standard blocks should be according to some inspection specific assets.

So these are the two main requirements from a standard block which is used to calibrate the eddy current setup and these are the commonly used eddy current reference standards which includes conductivity standard which is this one so these blocks are of known conductivity and they have different conductivity so using this blocks of different conductivities you would be able to calibrate the instrument for dye electrical conductivity.

Then you have a flat plate discontinuity standards and one of them we have seen in the video which is this one sometime eddy current testing is also used to detect metal thinning or material thinning for example if corrosion happens it will lead to material thinning because due to the corrosion some material will corrode away will be removed from the part so in those places where the corrosion occurs will have material thinning so that kind of damage or that kind of defect can also be inspected by eddy current.

When you do that you should first calibrate the instrument using flat plate metal thinning standards which could be a step or tapered pages then for inspecting tubes this is again one of the application areas of eddy current testing for inspecting tubes of different sizes and different wall thickness and so on so when you inspect this kind of tubular parts then you should have this tube discontinuity standards and tube metal thinning standards if you are expecting corrosion to occur in this kind of tubes.

Then this tube discontinuity standard and tube metal thinning standards are used when the instrument is being used for inspecting this kind of parts then if you expect that the conditions of corrosion is such that it may lead to pitting kind of corrosion eh leaves behind small holes or small pits so then I should have holes on the reference standards which will represent these pits which form due to corrosion okay.

So if you are trying to inspect corrosion damage using eddy current testing then you should also have this whole discontinuity standards which will be used you know to replicate corrosion damage which leaves behind pits ok so in order to introduce any of these flaws you need to cut them or you need to make them on the surface very precisely for example if you want to replicate cracks or very fine cracks then you should take the help of electrical discharge machining or EDM to cut this lines precisely like what you have seen in this case.

And sometime saw cuts are also used to represent cracks okay, so this kind of lines which are cut out by EDM or saw cuts are used to represent cracks and you can drill holes when you are inspecting corrosion damage so for those kind of standards you for calibrating the instrument before inspecting corrosion damage and defects due to corrosion then you should have these drilled holes as I said which will represent the corrosion pits so they have to be drilled again precisely on the surface to simulate corrosion pitting.

So these are different types of standards which are used depending on the actual use of the system and what kind of defect you are going to inspect based upon that one of these reference standards should be selected and you should calibrate the instrument before you use it so the point to take home here is you must calibrate the instrument before you use it so that you do not end up with erroneous results. So we have seen how the material property controls by eddy current the conductivity of the material and the permeability also.

There are certain other factors which are either related to the material or to the geometry of the part being inspected or the surface condition so these are few other factors which will have some effect on the eddy current testing so let us talk about those also because when you do ad current

testing you should be aware of all the factors which could affect the test results okay, so if you talk about the material properties first.

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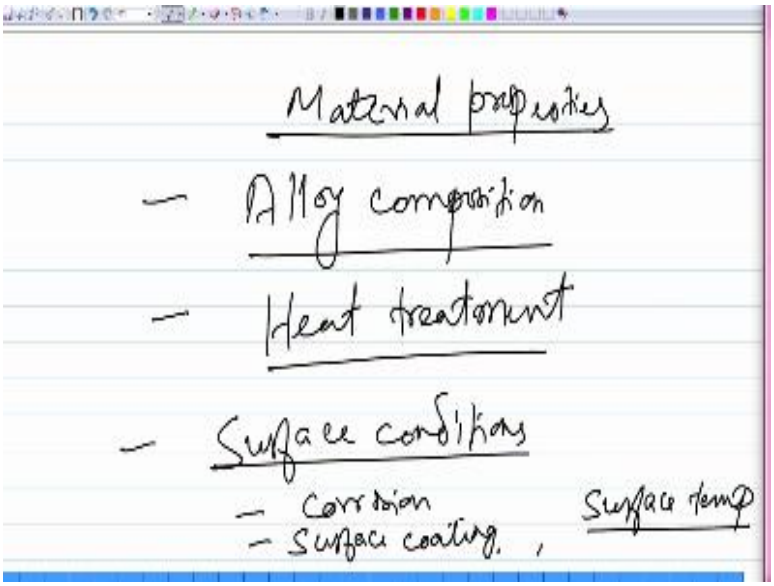

So factors related to materials are this the composition or the chemistry of the material so if you if you have an alloy so different alloys have different properties including the conductivity which can vary from one alloy to another then most of our many of the parts are subjected to heat treatment to impart certain properties on the surface so anything which can change the surface property or the bulk property of the material which is connected to eddy current will affect the results of the eddy current for example the alloy composition that can change the conductivity and as you have seen before conductivity is one of the parameters which controls eddy current.

Similarly heat treatment can change the property of the surface and since eddy current is to do with surface inspection so these will also affect the results of the eddy current testing so this is related to the material this is a surface entity method so surface conditions will obviously have some effect like if you have some corrosion damage that will alter the surface condition and it will affect the level of ad current being induced on the surface then if you have surface coating

so this coating could be of a very different material compared to the parent material over feet it is coated.

So then the property of this coating will control the eddy current and the parameters related to the eddy current and then the surface temperature can also play a role because if you vary the temperature on the surface the surface properties would change so surface temperature is again is a factor which might affect the eddy current testing results okay.

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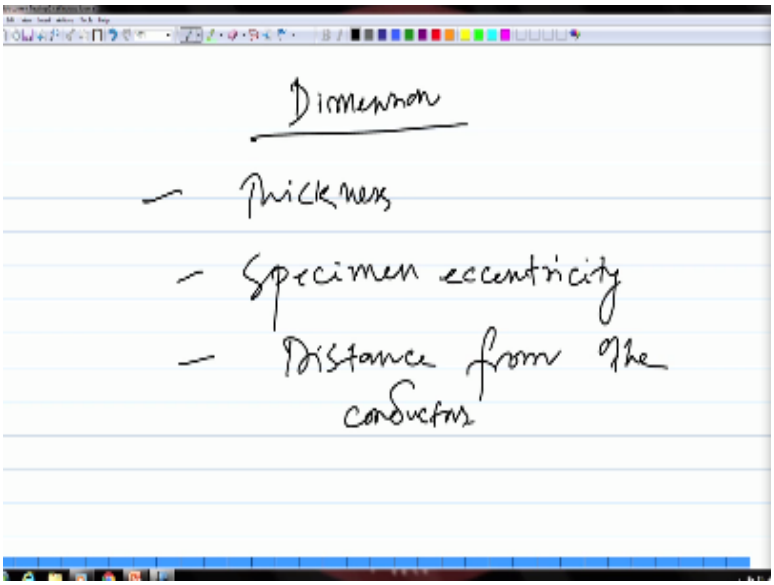

Then related to the dimension of the part or the part geometry there are certain aspects which can affect eddy current testing like the thickness the eccentricity of the specimen that means when you have variation in the geometry from one part to other part on the surface that could affect it and if you have nearby any other conductor apart from the sample so you should be careful about that also so distance from other nearby conductors should also be kept in mind so you should not have a third conductor very close to the eddy current probe.

You know which might draw some current from the coil okay see if that happens obviously the idea current levels into the sample will be affected and that is why distance from other nearby conductor is also a concern that one should be careful about.

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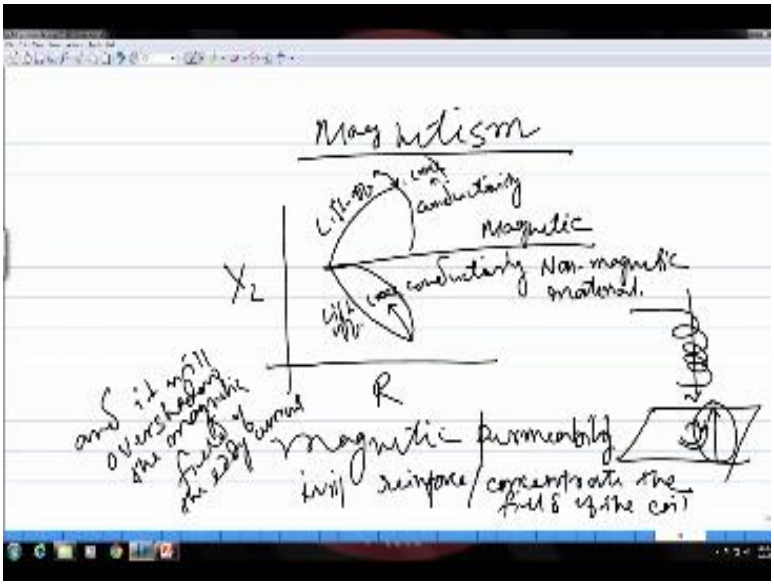

But the parameter which has the most profound effect on a different response is the magnetism so far whatever you have seen it was all for a non-magnetic material which is electrically conductive okay, so the eddy current curves that we have seen so far they are all from materials which are electrically conductive but non-magnetic so now if you bring in the magnetism into picture there will be some change in the eddy current response that means if you have a magnetic material the eddy current response that you get from this kind of material will be different from the response that you get from non-magnetic materials.

So let us see what is that change that magnetism brings in into the picture and how will be the eddy current response when you have a magnetic material okay so we come back to this again and we have seen this lift up car k and we have also seen that the magnetic field that degree the eddy currents is opposed to the primary magnetic field okay and that is why the reactants component in this case comes down.

Now for some reason if this magnetic field of the eddy currents is suppressed or overshadowed then this decrease in the reactant will not happen okay and that is exactly what is going to happen when you have a magnetic material because in that case when the eddy currents are induced the magnetic material will have its own magnetic permeability its own magnetic field and the magnetic permeability of the sample will overshadow the magnetic field of the eddy currents okay and it will also reinforce or concentrate the magnetic field of the primary coil okay as a result of that the reactants will increase instead of decreasing.

Unlike the non-magnetic material case where in the reactant decreases okay so this is the effect of the magnetic permit ability of the material it will reinforce or concentrate the field of the coil and it will also over saddle the magnetic field of the eddy current okay and as a result of that as I said now the reactants will increase and the lift of car in that case will be like this okay because resistance is anyway going to increase because you are drawing energy from the primary coil but in this case apart from resistance.

The reactance is also increasing and as a result the liftoff car will go up instead of going down like what you had in case of non-magnetic materials so in this case you have seen that you have a conductivity curve like this and the clock signal was like this and in the case of magnetic material this crack signal is going to remain the same because the effect of the crack will be same and the conductivity car will also be similar like this because the effect of conductivity is also going to remain the same okay.

Only the reactants component is going to be different for the reasons that we have already discussed just now so this is how the response of the ferromagnetic material will be due to the magnetic permeability of the sample itself okay so this will be the response for a magnetic material and this will be the response for a non-magnetic material so this is how the magnetism brings up a change in the eddy current response and you will see the lift of curve like this in case of a magnetic material okay.

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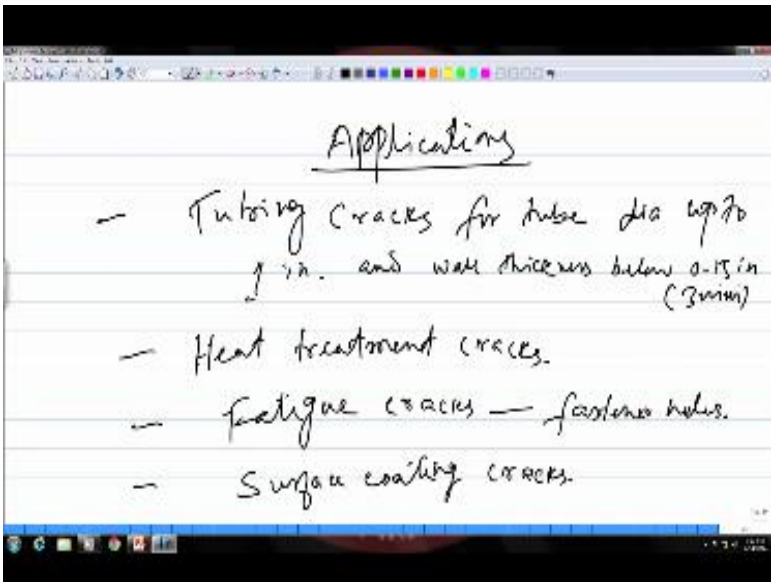

Fine and finally we will see the applications of this technique and then we can close this particular topic one of the common applications of this technique is on inspecting tubes so tubing cracks for tube Dyer up to one inch and wall thickness below 0.15 inch or3mm then heat treatment cracks this can be detected by eddy current testing fatigue cracks because this is again will be on the surface like four in aircraft structure in the fastener holes you could expect this kind of fatty crack to develop.

So those areas can be inspected by a different testing and then if you have any crack on the surface coating surface coating crack scan also be detected by this technique finally one more.

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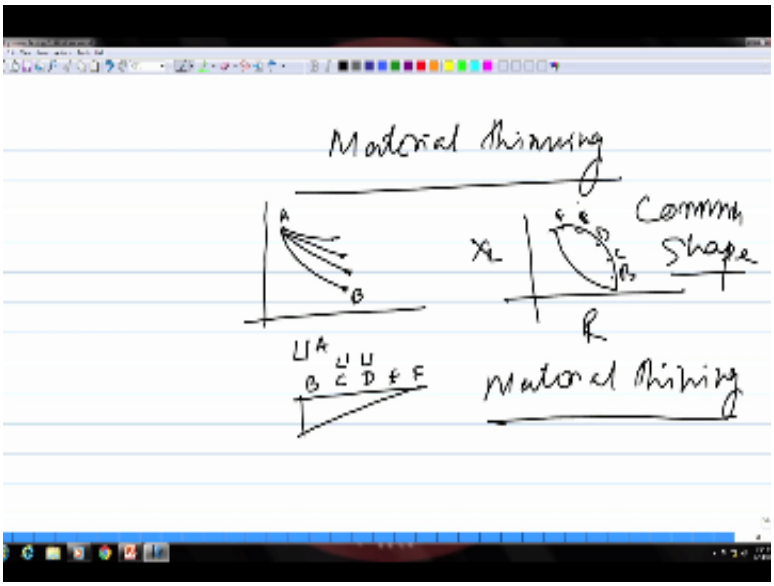

We have on this which is material thinning so this technique is very useful for this also if you have material thinning due to corrosion as I would have mentioned before then this technique is very useful to detect that because when you have a gradual reduction in the thickness from one portion of the part to the other then you will see a considerable difference in the lift of curve also as the thickness is because the thickness decreases.

So let us say you have first in the air and then you put it on different locations like this as the thickness decreases you would see that so this is a and this is B so that is the first point where you have full thickness and as you move the probe to other point c d e f the thickness is less then you will see the lip top curve is changing like this like this and soon okay. So if you connect all this point and finally when you come back when you when you come to F this will go back to the initial position because there you have almost nothing.

So if you connect all these points 10 points of this liftoff curve you will get a comma shaped curve like this okay so these are the if you connect the endpoints of all the lift of curve so this comma shaped curve if you get this kind of Comma shape curve when you move the probe over

the surface then this indicates that there is material thinning in that particular direction in which you move the probe like what we saw in this case.

As you move from b2f there is a gradual decrease in the thickness and that is being indicated by a change in the lift of car and when you connect the endpoints of all this lift of curves you will see this comma shaped curve like this and this will indicate the material thinning so this is how this particular technique can also be used to, to indicate material thinning in a given part and finally like what you do for every process.

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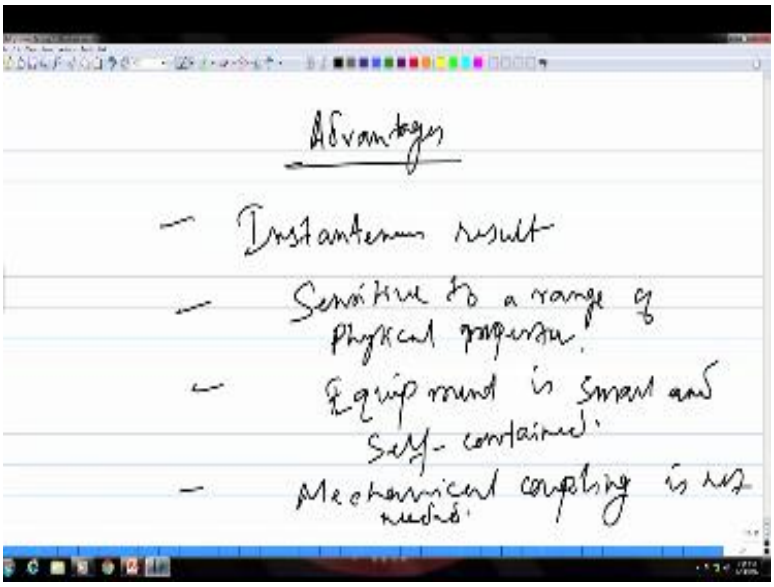

We will see the advantages and disadvantages so in this case the advantages are you get instantaneous result you immediately see the crack signal then this is sensitive to a range of physical properties equipment is small and self-contained as we have seen and here you do not really need any mechanical coupling between the probe and the sample surface okay so these are the advantages every process will have.

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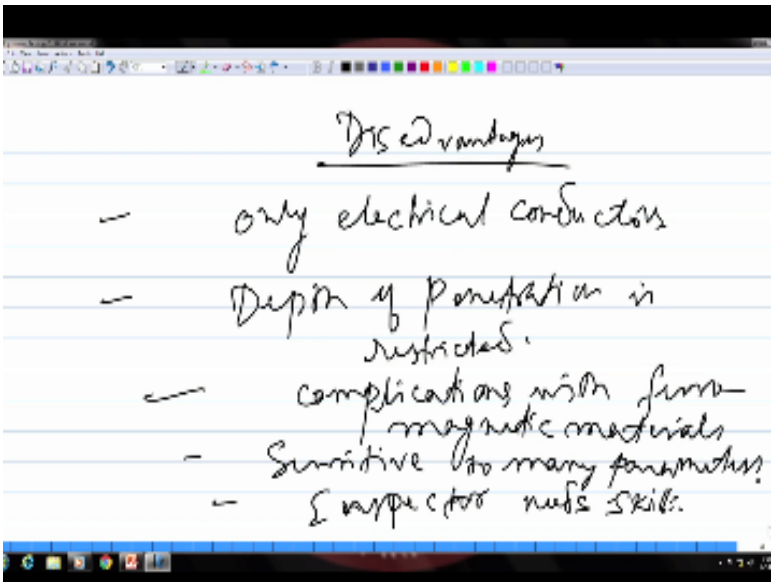

Its own disadvantage also so for this process let us also have a look at the disadvantages only electrically conductive materials can be inspected if it is not electrically conductive you cannot inspect that by eddy current testing depth of penetration is restricted and we have seen there are complications with ferromagnetic materials and the sensitive too many parameter and the inspector needs some skill you know to do it and then to interpret the results you need a skilled personnel to do this okay so these are the advantages and disadvantages of this process. So this will bring us to the end of this chapter so let us take a moment to summarize.

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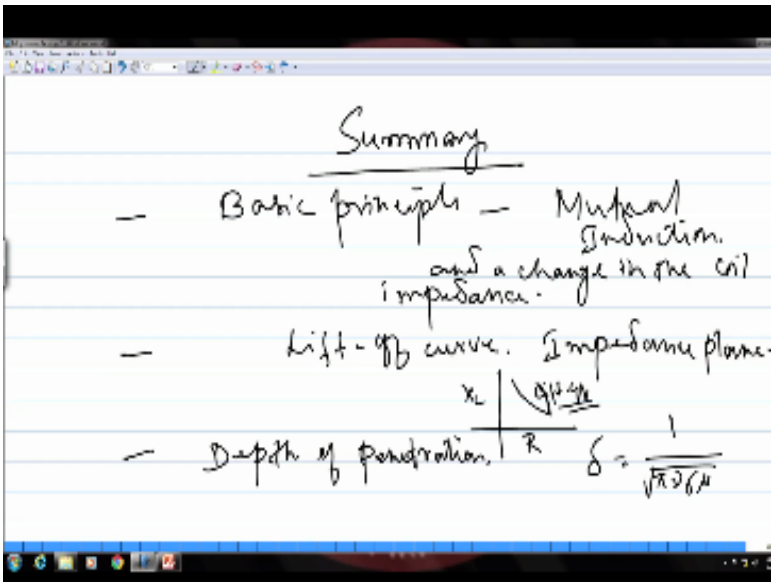

First we learned about the basic principle of eddy current testing and this was based upon mutual induction and a change in the impedance of the primary coil due to the presence of surface defects on the sample which changes the eddy current which is flowing on the surface of the sample okay then we learned about the liftoff curve which is the basis for this particular technique which is shown on the impedance plane which shows the relationship between the inductance reactants and the resistance which constitute the total resistance or the impedance.

So this impedance plane as I said which comprises of the inductive reactance XL and R is what we always refer to and you see the lift of curve okay and then we saw that if there is any defect that is going to come over this lift of car as a spike as a signal spike like that and that is how the presence of defects and applause will be indicated by this technique then we saw what will be the depth of penetration for the eddy currents and that depends on primarily the frequency and the conductivity of the material.

And this is one parameter that we defined for depth of penetration and this parameter is called as standard depth of penetration delta which is given by the frequency the conductivity and the magnetic permeability of the material.

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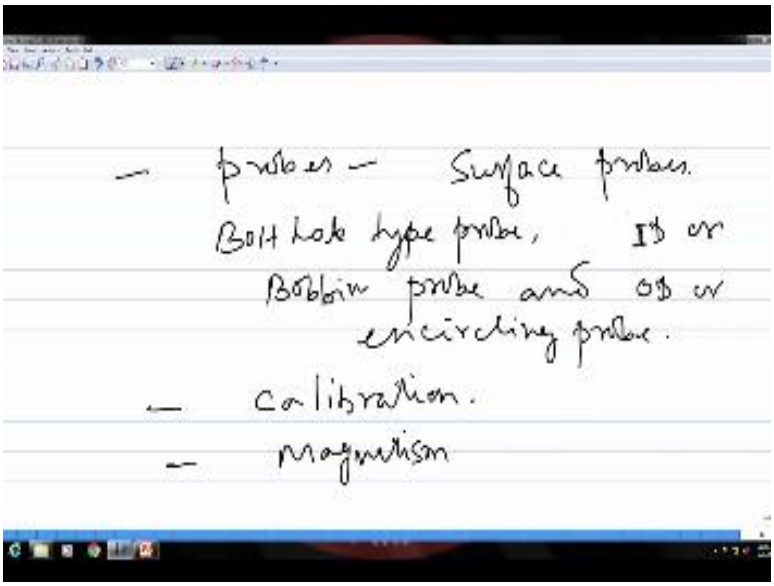

Then we learn about different types of probes different types of eddy current probes and in this we saw surface or flood type of probes then we had bolt hole type row IB our bobbin probe and OD are encircling pro we also learn about the calibration of the ED current probes and the instrument and finally we saw the effects of some of the parameters and magnetism is one of them each has a very profound effect on the eddy current response and then finally we saw us some applications of this particular technique and its advantages and disadvantages okay so this was all about eddy current technique this is all I will have for today so I am going to stop here today and I will see you next time with a new topic thank you for your attention.

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