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Theory and Practice of Non Destructive Testing

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Eddy Current Testing – 4

So we are on this topic of eddy current testing right now and in last few lectures we have seen different aspects of this particular technique including the basic principle and in the last class I discussed about different types of the eddy current probes as you could see here.

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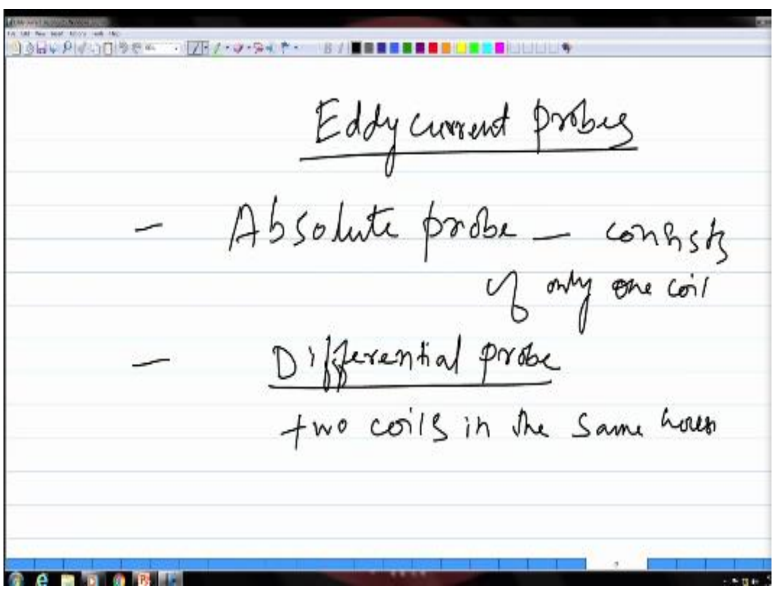

These are all listed here and we have discussed this already in the last lecture.

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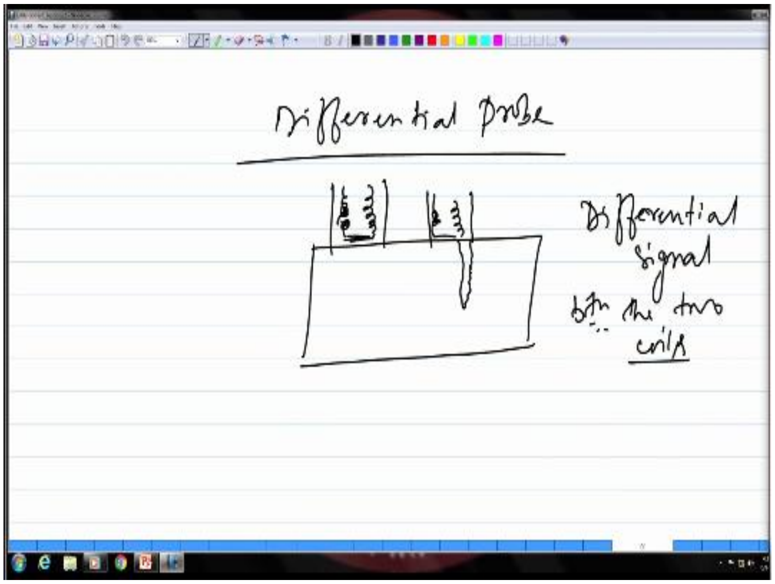

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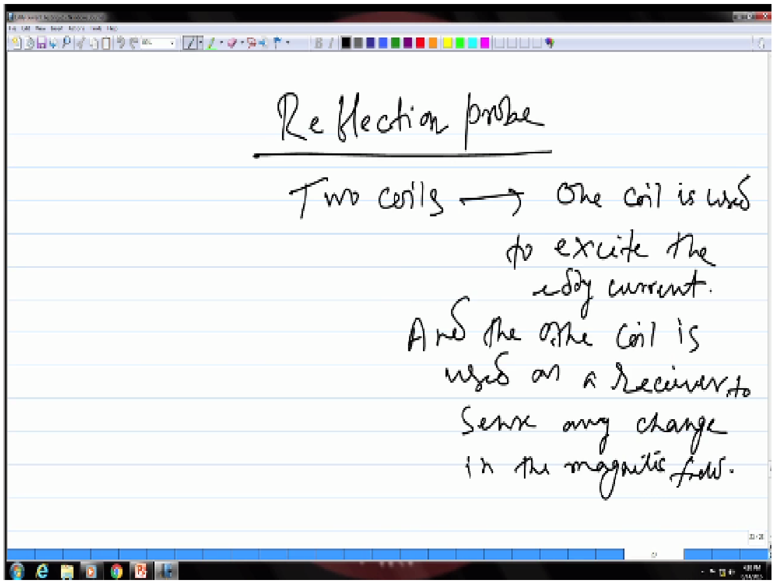

Then we also talked about what kind of circuit is used.

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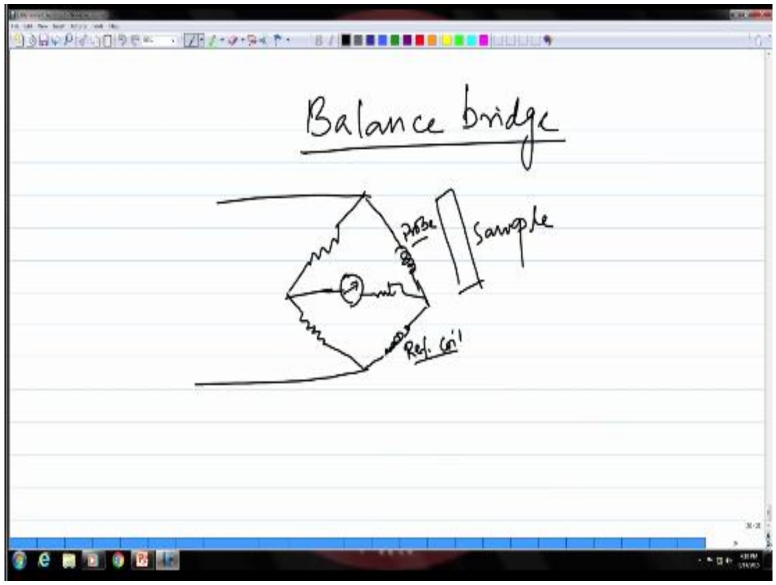

To sense the change through which you can get a signal from the defect and this balance bridge circuit or the balance bridge method is one of them through which you can sense the change the magnetic field and that is how a signal from the defect is generated and shown on the display screen of the system ok and we have also talked about the eddy current systems the different parts of it so today we will continue and see the other aspects of this particular technique.

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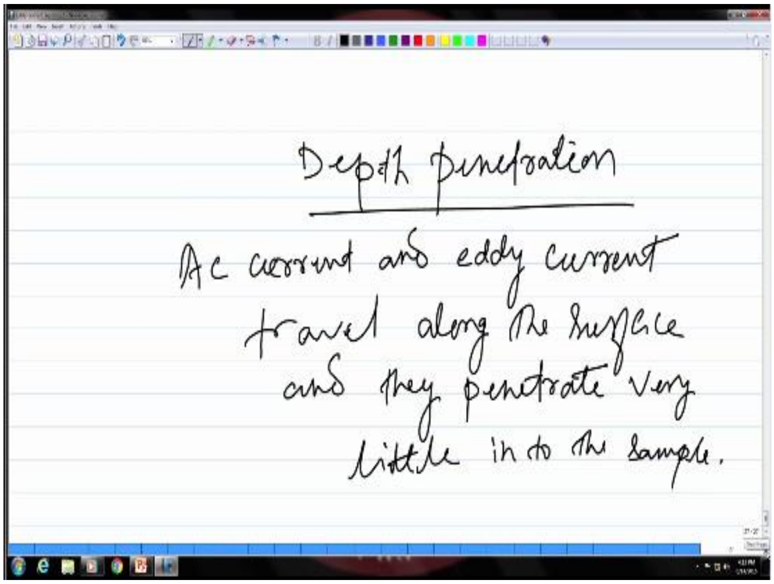

I have told you before the induced currents or the eddy current is primarily limited on the surface and it can go up to certain death which depends on first of all the frequency which is used and it also depends on the property of the material on which the current is induced okay so let us see what are those parameters which control the depth of penetration of eddy currents in a given material.

So both alternating current and the induced eddy currents as I said travel along the surface and they penetrate very little into the depth to certain extent they can penetrate and that would depend on as I told on the frequency which is used and the electrical and the magnetic properties of the material okay.

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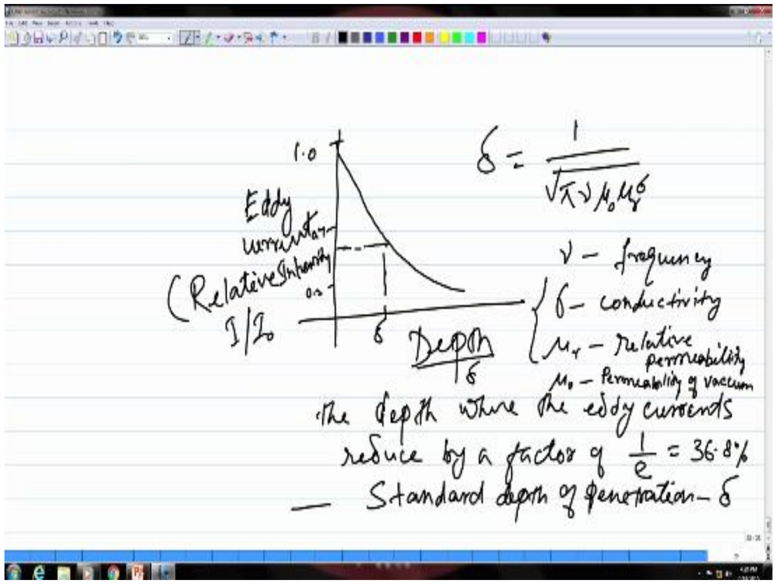

So if you plot the current as a function of depth from the surface so let us plot this in terms of the relative intensity which is I / I_0 wherein I_0 is current right at the surface and I is current at any given depth okay so that means this if it is one if I / I_0 is one that is right at the surface and as you increase the depth from the surface the eddy currents will decrease like this okay and there is a depth around 37% is 37 % or 36.8% to be exact that particular depth is known as standard depth of penetration which is denoted by δ okay so this is the depth δ at which the eddy currents will reduce by a factor of 1/e or it will reduce by 36.8 % okay.

So this depth is sometime also normalized by the standard depth and it is plotted with respect to the current at the surface okay right so now if you look at the parameters which control the standard depth of penetration this depends on as I said on the frequency of the current which is used let us say the frequency we call it by ν and the magnetic and magnetic and magnetic and electrical properties of the material on which the current is induced okay so ν is frequency σ is conductivity μ R is the relative permeability of the material and μ0 is the permeability of vacuum okay this μ R and σ this to are the material property and the other parameter which control the depth of penetration is the frequency.

Oh if the frequency is high as you could see from this relationship the depth of penetration will be lower and vice versa similarly as the conductivity increases the depth of penetration reduce this depth of penetration is inversely proportional to the square root of both the frequency and the conductivity of the material and it is also inversely proportional to the magnetic property which is the relative permeability µ R okay now when you say a depth or a material thickness is thick enough with respect to eddy current in the sense that what thickness will you say that beyond that eddy currents would not be able to penetrate.

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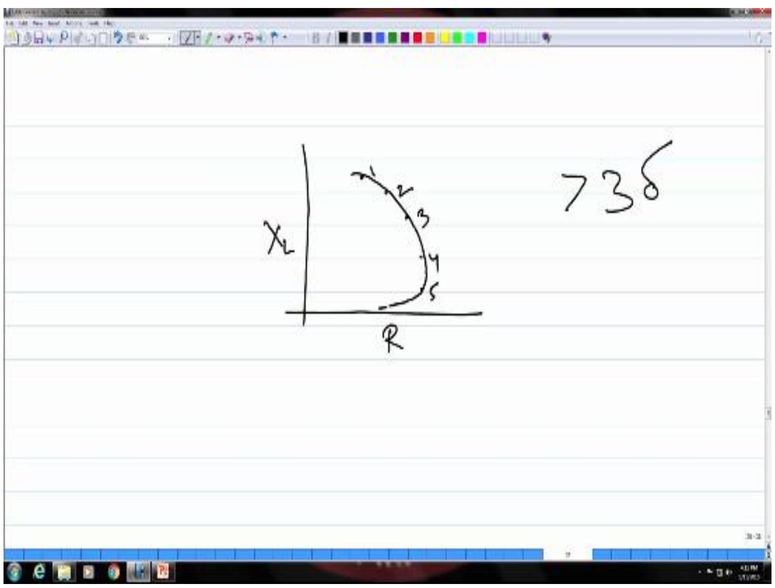

So the effect of that sample thickness can be again demonstrated with the help of this impedance plane for a given material let us say you have brass as the sample and then if you keep increasing the thickness of the sample by let us say adding the number of seats of grass one over the other then at some point as you increase the thickness like this so let us say you start increasing the thickness in this manner by adding let us say this is the first seat and then you are adding the second seat third seat and so on so as you keep on adding the seats of brass the thickness will increase and this is how the thickness curve will be with respect to the eddy current.

And at some point you will see that the variation in the impedance of the coil will stop and it will kind of become independent of the thickness okay so that point at which the impedance Z does not vary anymore with respect to the thickness that particular thickness corresponds to a thickness which is greater than three δ where δ is the standard δ of penetration as we have seen before so at this point at this particular depth or thickness you can call the sample as a thick sample beyond which the eddy currents would not be able to penetrate because at such thickness where it is more than three δ.

Then the magnetic field of the eddy current will be completely trapped by the thickness of the material okay so that is how that is why this thickness with respect to eddy current is called a thick sample and beyond reach you would not be able to penetrate the eddy currents okay so this is the effect of sample thickness now the other important parameter in eddy current testing is the frequency

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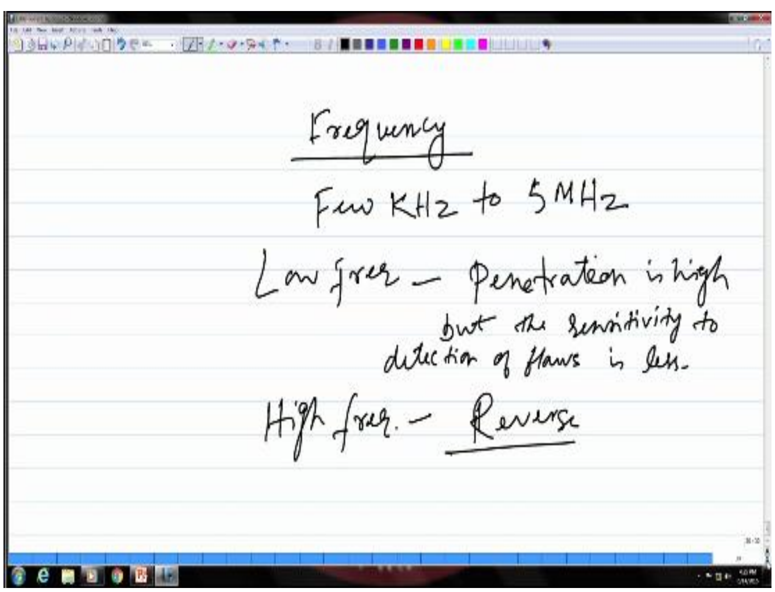

And the range of frequency I would have said this before also is from few kHz 25 MHz that is the generally used frequency range for a different testing and as you could see from the previous equation that you just now derived with respect to the depth of penetration so if you have low frequency then penetration is high but the sensitivity to detection of flaws is less and high frequency it is just opposite it is just the just the opposite just the reverse scenario that means the depth of penetration would be low but the sensitivity would be high okay so this is the effect of frequency in terms of the penetration depth and the detection of flaws now the question is how do you decide the or how do you select the test frequency when you're doing the testing okay.

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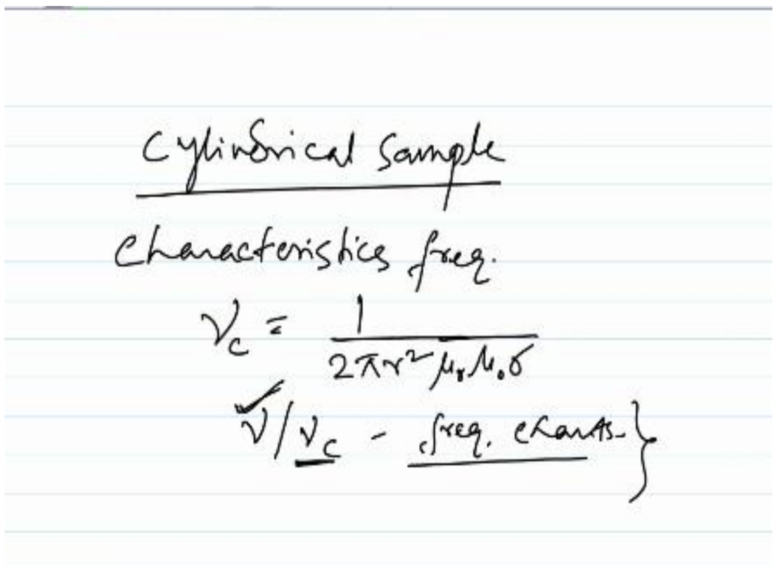

So that would that depend on what kind of part you have and what exactly you want to do for example if you have a cylindrical sample so in this case the characteristic frequency can be defined first let us call that as ν_c which would depend on the dimensions of the part and its magnetic and electrical properties in this fashion, so r is the diameter of the cylinder and the properties which control the eddy current that is μ_r and the conductivity σ okay, so this is how first you can define a characteristic frequency which should depend on the size and the properties of the material and then based on this characteristic frequency this frequency charts are prepared the characteristic frequency for a given part of a given geometry.

So from this frequency charts once you know the characteristics frequency ν_C the test frequency ν can be decided. And now let us see what exactly is done when you do that as trial first so you few images then I will so a demo video also like what I have shown you before also for the other two techniques so that will give you an idea as to how exactly the whole process is done.

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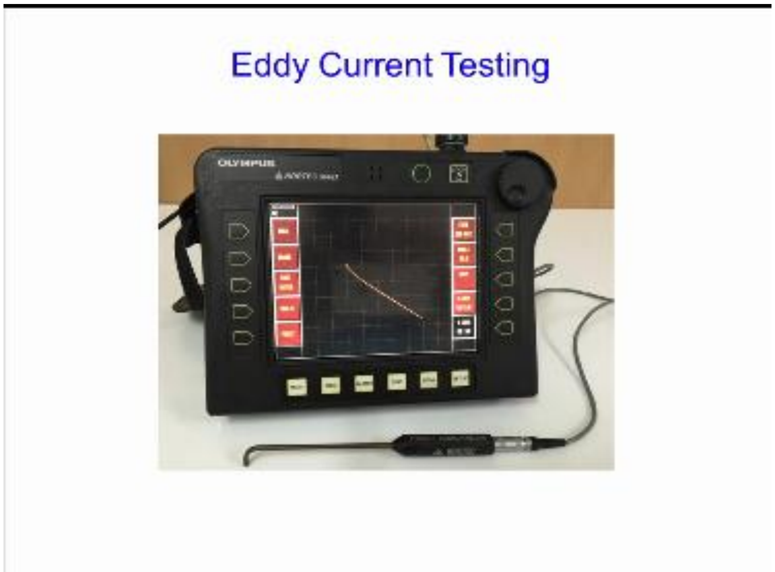

As you could see on the screen and as I would have said before also this is a very compact and portable system which come inside this small box H contains everything whatever is needed for doing the test so this box has the necessary electronics for connectors the battery for powering it everything inside this box and then through the connectors that you have you can connect a probe you can see a probe of over there lying in front of the system in front of that box so you take this probe and then you have to bring it near to the sample surface you can touch it on the sample surface.

And then you could see the eddy current signal coming out and you could also see here there are so many press button and there is a knob which will control different parameters corresponding to each of these buttons okay, so with the help of this buttons and this now you can vary several parameters during the test for example you can select a particular frequency you can change the phase angle of the eddy current and so on so this switch buttons are very easy to use and as a system this is very easy to operate as such okay.

Yeah so that is how the system looks and if you take a close look this is the display and you can see a curve over here which is the lift of curves that we have talked about ok so when you touch the probe on the sample surface this is what you see so this is the beginning point which is the point in air or that is also called as null point as I am going to show you in the video also okay, so when you touch the probe on the sample surface then you will see this is coming down from this point and going like this giving you this liftoff car.

And when you have any defect on the surface when the probe encounters any flaw on the surface then you would see a defect signal over this liftoff car which I am going to show you in the next video okay, so this is how the whole system looks and now we are going to see the video and then see how exactly the defect signal appears on the display.

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And these are some of the probes that we have in our lab so you could see these are primarily those surface probes or flat probes because the end if you see is flat these this and even this also although this is this looks like a rod at this end we will actually be on the sample surface this end is flat so these are the flat type or surface probes which are primarily used on flat surfaces and then with the help of this as I will show you now with the help of a video you'd be able to get the signal from cracks or other flaws which are there on the surface. So let us see this video now.

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So this is the system and in order to show a crack signal I am using this reference block which is being shown right now okay so this is made of aluminum a small plate of aluminum and over this as you could see there are three lines which are precisely cut on the surface and these three lines would serve as artificial flaws like cracks and with the help of those we will see how the crack signal is obtained in eddy current testing okay, so this is what right now I am showing that on the surface there are three precisely cut lines of different width.

So this will serve as three different flaws having different sizes okay so you could see that these two lines are prominent and there is one more on the right hand side which is very thin so that will be the smallest defect that we have in this case okay so on the right here it is very thin so that is the first one that we are going to use and show you how the defect signal is obtained okay, so what is done in the beginning the first switch that I am pressing that is called null, so null means you first balance the probe in the air.

So if you remember we come down from air and then we decrease the liftoff distance and as you go very close to the sample surface then you see the lift of car when the eddy currents are induced okay, so this point as you see here is the beginning or that point in air and as we move this probe onto the surface you would see the lift of curve originating from this point and going down like this yeah so that is how the liftoff is coming on the moment I bring it to the surface of the sample the moment I touched the probe on the surface of the sample you could see the liftoff curve so let us have a look again okay and once I move it over the first crack which is the smallest one you can see a small signal which is coming and then the second crack you can see a bigger crack signal coming.

Because that is a bigger defect and then I am going to the third one now and we can see a further bigger crack signal which is coming out over the liftoff curve okay, so this is how the moment the probe moves over a defect you could immediately see a spike above the lift of curve like this okay where the arrow is so this is the crack signal I am showing it again now this is the first one the small crack so you can see a small signal then the second one you will see a bigger one this one so this is the medium sized crack.

That we have in the middle and then finally the third one which is the bigger crack and you can see a bigger signal corresponding to that yeah, so this is how the whole thing works is a very simple technique as you would have seen all you need is that box which will have everything as I said including the powerhouse the electronics and so on and then you can connect your probe on to that instrument and you can take it and simply move it over the surface and the moment you encounter the moment the probe encounters a defect you can see a signal coming out like a spike over the lift of car.

If you do not have any defect or any crack as you move on the surface the signal will simply move over the liftoff car back and forth as you go up and down okay you will not see anything extra apart from the lift of car so you see a signal in this case unlike the previous cases in magnetic particle testing and dye penetrant testing where you saw the direct indications of the flaw but in this case the indications are indirect.

And that is why it is necessary I had to first calibrate the instrument and then do the test so whenever the indications are indirect the first thing that you need to do before you do the NDT you need to calibrate the instrument okay so in this case also we need to do that if you do not calibrate then if then the results that you get may be erroneous okay so in order to do that in order to calibrate the instrument you need some reference blocks some standard blocks.

Which will have precisely cut out artificial flaws and one of them I have used as I said in this video so those three lines are precisely cut on the surface of this aluminum block so this is a standard reference block which is known as a calibration standard which is used as a crack standard to see and to calibrate the instrument when you are trying to inspect surface flaws.
And you expect defects like cracks and that is why these kinds of lines are made on the surface which will represent cracks okay and there could be other types of reference standards also.

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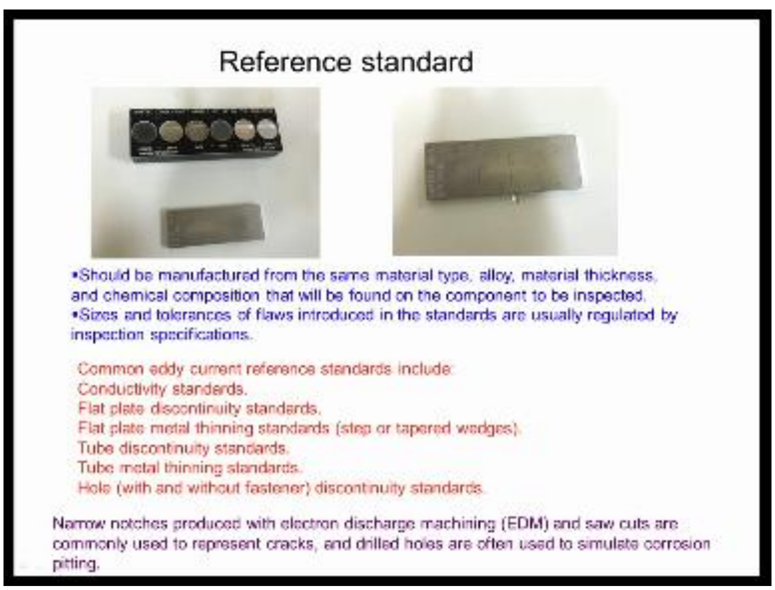

Like this so this one you have seen in the video which have this precisely cut lines which represents crack which is here also this is a conductivity reference standard because you have seen conductivity is one of the important parameters which controls the depth of penetration of the eddy currents so in certain cases you need to calibrate the instrument with regard to the conductivity as well.

So whenever you use a reference standard like this okay you need to make sure that it should be manufactured from the same material as the sample okay so if you have a sample for example which is made of aluminum alloy then I should also select the reference standard which is made of aluminum alloy similarly if you have a steel sample then your reference standard should also be made of testing, okay.

So that is the first thing that one should keep in mind while calibrating the instrument the reference standard and the sample material should be same okay, right so for today this is all I will have there are a couple of more things about this particular technique including calibrating the instrument which I will talk about in the next lecture okay, so for today I will stop here thank you for your attention.

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