NPTEL

NPTEL ONLINE COURSE

NPTEL Online Certification Course (NOC)

NPTEL

Theory and Practice of Non Destructive Testing

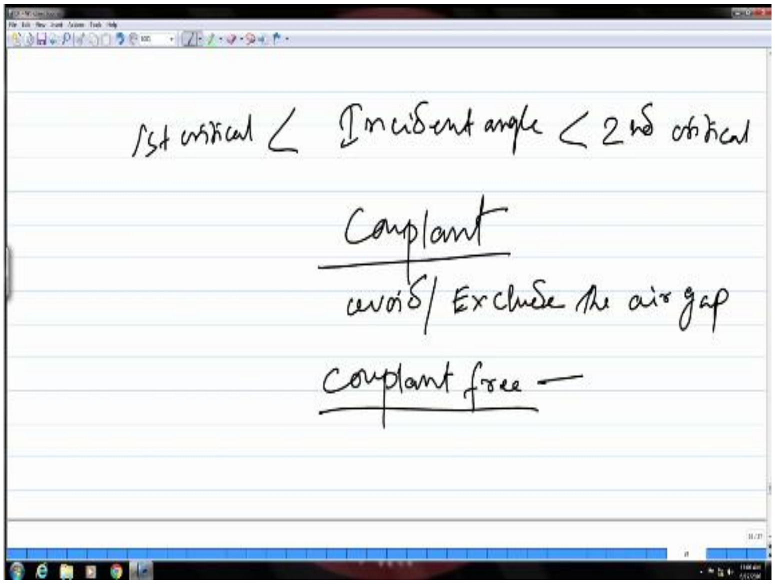
Dr. Ranjit Bauri
Dept. of Metallurgical & Materials Engineering
IIT Madras, Chennai 600 036

Ultrasonic Testing - 6

Yeah so in the last class we learned about a phenomena called mode conversion due to which a part of the longitudinal wave can convert to shear waves or transverse waves when there is a small incident angle across an interface between two medium okay and due to that as we saw there will be two different types of waves going into the sample and that can create the confusion during the test okay so it is necessary that you exclude the longitudinal part and make sure that only shear waves go into the sample.

So that there will be only one type of wave going into the sample and coming back to the probe and there will be no confusion okay and we saw that that primarily depends on the incident angle.

(Refer Slide Time: 01:13)

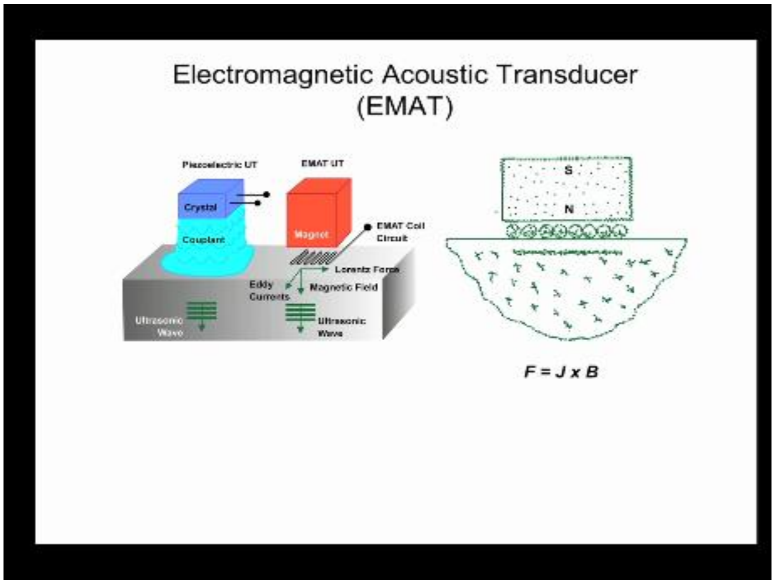


Which must be between the first critical angle and the second critical angle and we have defined this first and second critical angles so you have to select an angle between first critical and second critical angle when you do ultrasonic testing using angle probes okay and then we also saw that you need to use something called couplant in order to avoid or in order to exclude the air gap at the interface.

So this could be an oil grease or some gel which can be easily applied in the form of a thin layer and then we also saw that this couplant should have you know certain properties certain requirements that it must satisfy okay so a couplant is used a to avoid the air gap so that there is no attenuation before the waves entered the sample if you want to do a couplant free test then this electro-acoustic transducer cannot be used because in that case you have to touch it on the surface and once you know touch it on the surface you need to ensure that at that interface there is no air gap and you have to use a couplant.

And okay in order to do a couplant free test you need to use a transducer which operates differently and which does not have to be in contact with the sample like how the normal large ultrasonic transducer are so that kind of transducer.

(Refer Slide Time: 03:36)



The working principle is also different compared to normal ultrasonic transducer and these are known as electromagnetic acoustic transducer because as I am going to show you now this is based upon electromagnetic induction so as you could see in this case when you have a normal piezoelectric ultrasonic transducer you need to use this couplant to avoid that air gap and in this case you do not really have to make a contact between the transducer and the sample because in this case the ultrasonic waves are generated through electromagnetic induction and that is why this kind of probes are known as electromagnetic acoustic transducers okay.

So let us see what is the working principle of this kind of car transducer and how do they work and what is the difference between them and the normal piezoelectric transducers okay so if you remember in the previous topic we had discussed about electromagnetic induction where we saw that if you have a conductor carrying and alternating current it will have and an alternating magnetic field or a changing magnetic field around it and now if you bring another conductor close to it due to that changing magnetic field that the current will be induced in the second conductor.

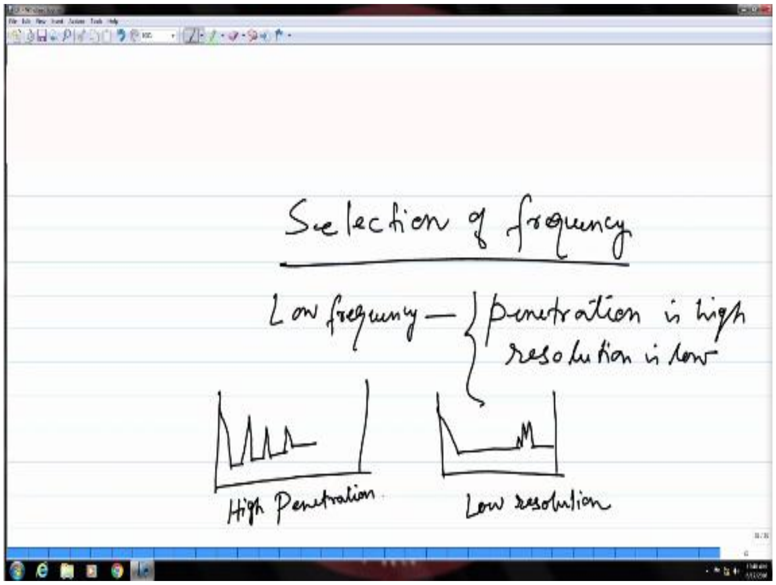
So that is the phenomena of electromagnetic induction or simply induction okay so this is what is being shown over here in this diagram so these are the conductors each carry an alternating current and so this is the sample surface so when you bring these conductors carrying the current close to this sample surface and if it is a conductive if it is an electrically conductive material then as you have seen currents will be eddy currents will be induced on the surface okay.

Now if you bring another permanent magnet if you being another magnetic field around this due to that magnetic field and induced current a mechanical force will be generated which is known as the Lorentz force which is shown over here okay so that Lorentz force is given by this particular equation where in F is the force B is the magnetic flux which is provided by this magnet and J is the induced current density okay so due to this induced current and the presence of an external magnetic field this force will be generated so this is the mechanical force which will generate the ultrasonic vibrations.

So in this case unlike the piezoelectric units the mechanical vibrations or the ultrasonic waves are generated in the sample itself due to the interaction of the induced current and an external magnetic field okay which is very different from the piezoelectric units where you need a pulse generator some electrical signal being sent to this unit and so on so in this case the vibrations the waves are directly generated into the sample that is why you do not really need to make that contact with the sample and therefore you do not need any Couplant in this case okay.

So in scenarios where you cannot use a couplant for example if you have a system which is operating at high temperature then the normal couplant that you use like this oil and grease they cannot be used at high temperature okay so in those cases where the coupland cannot be used and you still want to do the test by ultrasonic testing then you have to use this electromagnetic acoustic transducers or EMF or EMAT which will operate without the need of any couplant okay.

(Refer Slide Time: 08:42)



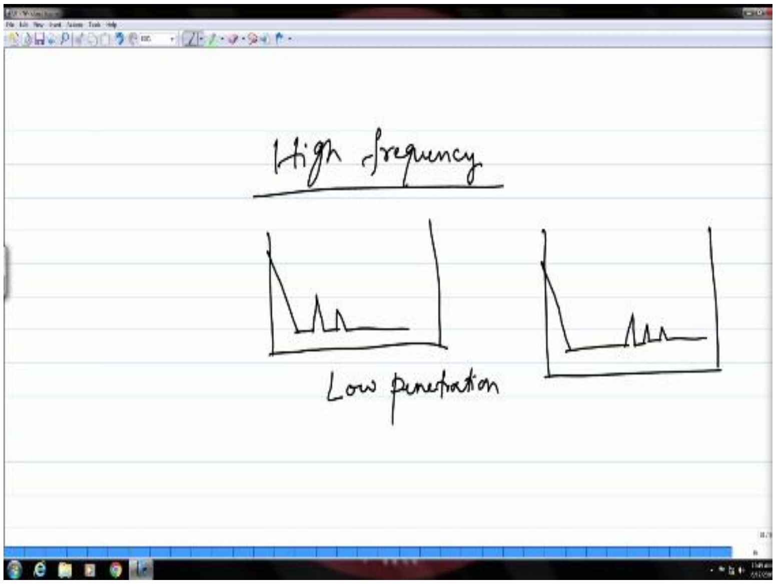
S o in those scenarios these EMPT transducers are quite useful let me also tell you how do you go about selecting a particular frequency for the test so it is a broad range that you have starting from 20KHz onwards and going all the way to 5MHz and sometime 10 MHz also so from this broad range of frequencies how do you go about selecting a particular frequency for the test so when you want to select the frequency then first you know what is the effect of the frequency if you have low frequency what is going to happen and when you have high frequency what is going to happen.

So for low frequency the penetration depth is high but the resolution is low resolution is nothing but ability of the probe to detect two flaws which are close to each other so if you have two defects in very close proximity to each other so then you should have two different two separated defect signals and this would appear as two distinct signal on the display and that would happen only when the resolution is good if the resolution is not good then these two signals coming out from two defects lying very close to each other may just merge into one and will come as a broad peak instead of two distinct separate peaks okay.

So in terms of the display if you show this to features of low frequency it has high penetration that means the signal that comes out will have high intensity and we will see this kind of high intensity peaks even for the higher-order back wall signals okay but if you have two defects lying close to each other then this may not be able to resolve it okay so two defects which are very close to each other Eco the defect occurs should come as two distinct peaks but in this case this might appear like two peaks merged in to one okay.

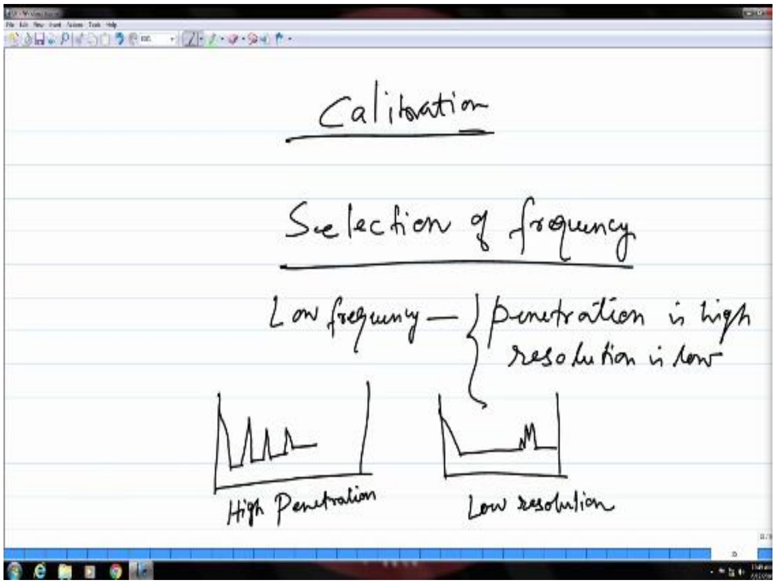
So this is low resolution when you have low frequency but penetration is high so when penetration is high that means the attenuation will also be lower and as a result you will get high intensity Peaks like this but you will compromise with the resolution and for high frequency this is just the opposite.

(Refer Slide Time: 13:05)



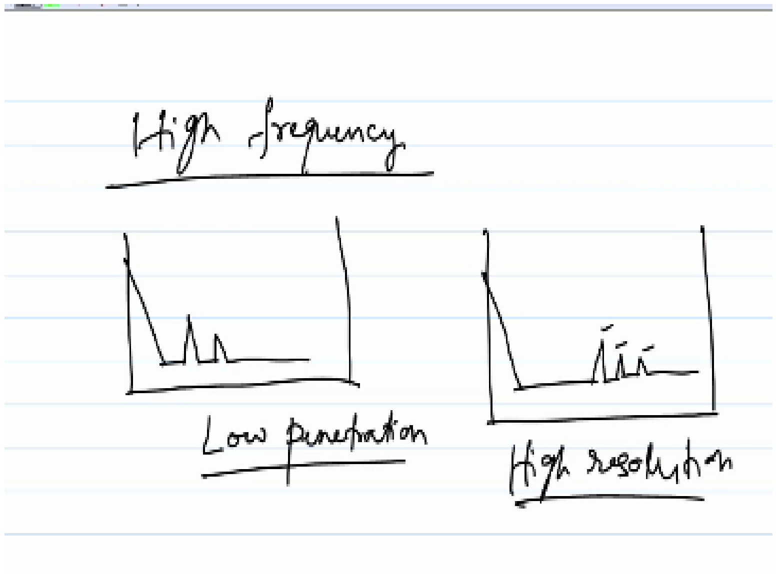
So in case of high frequency the penetration is low so the back wall signals which are coming out they will be lower in intensity compared to a low frequency where because in this case due to lower penetration the attenuation is also high but the resolution in this case is much better so like in the previous case if you have the same scenario two or three defects lying very close to each other then in this case you will get two distinct or three distinct equals like this corresponding to two or three different effects which lie close to each other in the previous case.

(Refer Slide Time: 14:26)



We have seen that you know they are kind of getting mashed into one peak they are kind of overlapped.

(Refer Slide Time: 14:38)

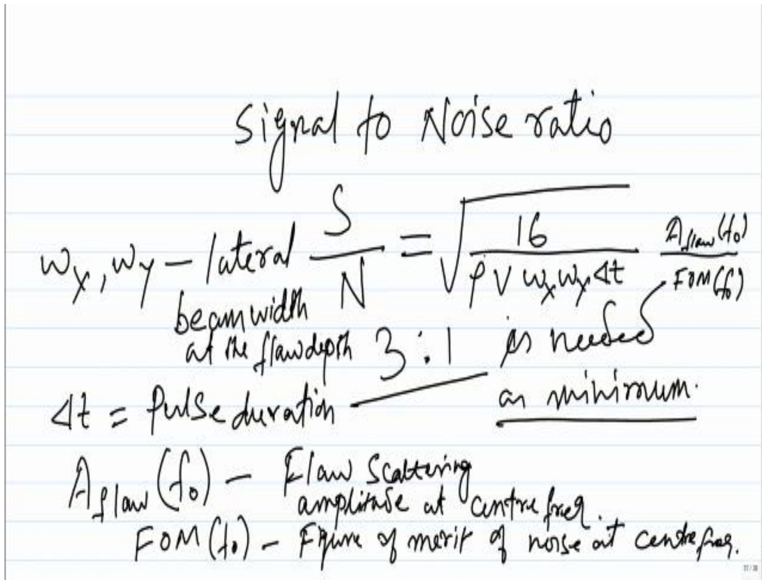


Okay but in this case you do not see that overlap you see three distinct peaks for three different defects although they live very close to each other so high frequency would also give you high resolution and it has low penetration right so that means this also tells you that whenyou want to do a closed surface analysis by ultrasonic testing then you should go for high frequency because as I said in this case the penetration will be lower.

So your waves will be very close to the surface and on the other hand if you want to go much below the surface if you want to go to higher depth kind of inspection then you should select a lower frequency. Because in that case the penetration is higher so it would be able to go to the depth that you are looking for okay.

So that is how depending on you know what exactly you want to do and what kind of defects you are expecting if you have some idea beforehand then based upon this penetration and the resolution aspects as we discussed just now you can select either a high frequency or a low frequency transducer, so when you talk about the defect signal or the detectability of a defect then one parameter comes into picture which is known as signal-to-noise ratio.

(Refer Slide Time: 16:27)



This is written as s/ N and the idea is to minimize the noise so that the signal intensity from a defect is increased and often a signal-to-noise ratio or 3:1 is needed as a minimum requirement okay and this particular parameter it depends on several factors related to probe and the material so let us see what are those parameters which control the signal-to-noise ratio, so this can be written in terms of those parameters in this way okay.

So these are the parameters which control the signal-to-noise ratio or the detectability of a defect so let me define the parameters, this w is the lateral beam width WX and WY add the flow depth, ∆T is the pulse duration this is the amplitude of the signal coming out from a flaw a flaw which is a function of the central frequency F0 so this is flow scattering amplitude, at center frequency and FOM is nothing but this is called a figure of merit.

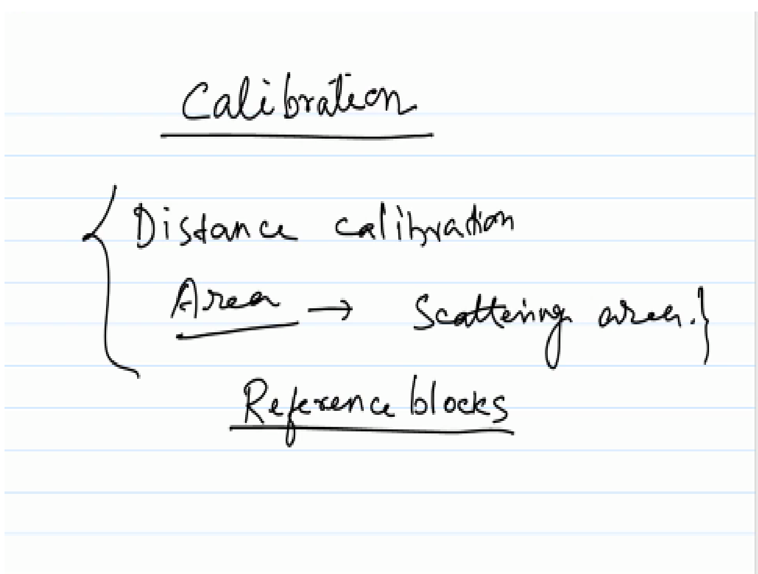
Which defines the you know which compares a parameter with respect to another parameter and compare them okay so this FOM in this case is the figure of Merit for the noise at the center frequency okay, so these are the different parameters related to the probe and you could also see these are there are other two parameters here so ρ is the density of the sample or the medium and V is the velocity of sound wave in the material that the sample is made of okay.

So these are the parameters which will control the signal-to-noise ratio and then based upon this you could see what are those parameters which will increase the detectability of the flaw for example if you decrease the lateral beam width okay so that means if you have a focused beam then the detectability of the defects or the signal-to-noise ratio will be more, similarly if you decrease ΔT that means if the pulse duration is less.

Which means if it is a short length or shorter pulse then again the detectability would be better okay so if you have a shorter pulse the detectability is better and here you could see that it is the signal-to-noise ratio or the detectability is directly proportional to the size of the flaw which is obvious larger the flaw better would be its detectability so that also you could see how it is coming up here in this equation and you could see that if the density of the material is higher.

Or the velocity of sound wave in the material is higher than the detectability goes down okay, so this is how the signal-to-noise ratio will control the detectability of a particular flow okay and these are the parameters which control the signal-to-noise ratio or in other words these are the parameters which control the detectability of a particular flow in ultrasonic testing.

(Refer Slide Time: 23:30)



So today we will talk about a very important aspect of ultrasonic testing which is powered calibration if you remember I have told this before also that whenever the indications are indirect like in this case you get a defect signal you do not get to see the defect directly so that means the indications for the defect and flaws are indirect and whenever the indications are indirect it is necessary to calibrate the instrument before you can use it okay.

Otherwise you may end up with the results which are erroneous so as far as ultrasonic testing is concerned two types of calibration you have to do one is for the distance and other is for the area why area because the intensity of the eco depends on the scattering area or the idea of the interface or the area of the defect which is scattering it so therefore the area also has to be calibrated so that you would be able to get some idea as to how big is the defect whether it is a big defect or it is a small defect okay.

So in order to do that you need to calibrate the instrument for area also so let us see how this calibration is done first we will see how the distance calibration is done and then we will go on and see how area calibration is done in this case, so in order to do this you need to use some reference blocks some standard blocks which will provide you some kind of artificial flaws which is already cut into them.

And the location of those flaws in the block is known and when you do the area calibration the area of the flaw or the size of the flow is also known okay.

(Refer Slide Time: 26:20)

Okay so these are the different types of calibration block as you could see for example it could use a cylinder like this and if you take a close look let me magnify this let me increase the size okay so I do not know whether on the screen you could see around this area there is a small hole okay so this hole is at a distance from the top which is 50 millimeter okay so this is at a known distance as I told so using this you could get an eco and then see whether it is coming at that particular distance or that time corresponding to this distance okay.

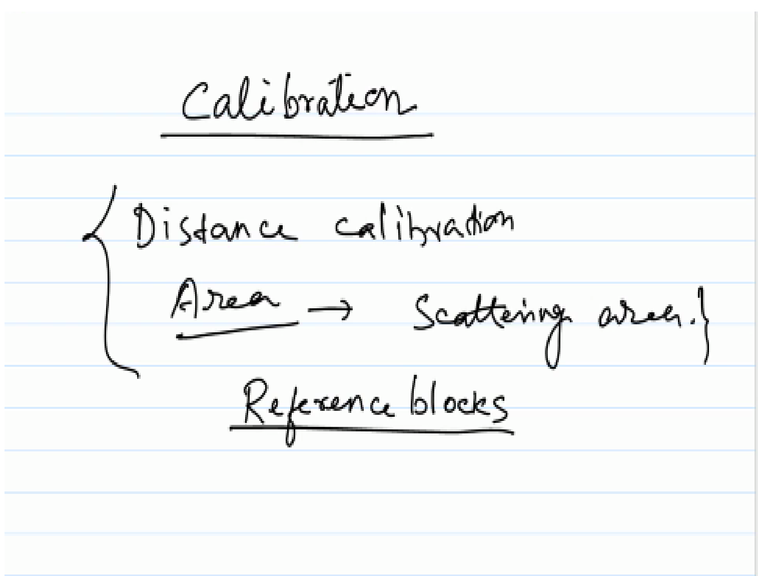
On the time base you can see that and you would be able to see some other holes also which are made in some other distance because you need to collect the data at different distances to come up with the calibration curve or to do the calibration so here again you could see around this area okay there is another hole so this hole is at 100 mm the first one here which you saw is at 50 mm.

And this hole on the same block you have another one at hundred mm similarly in the third one also you could see there is one more hole which is at 150mm okay so like this you can make this kind of artificial flaws on these reference standards or these standard blocks and since the location and the depth of these defects unknown you can get an eco from each of these defects and then see on the display screen whether that eco is coming at the place or at the time where it is supposed to come okay.

So like that by collecting the data at different depths you would be able to calibrate the instrument then you could have this kind of blocks also for example if you see this one over here okay so this is having several steps like this so these steps have different thicknesses so that means this kind of block can be used for thickness calibration in cases where you know that there is some material loss or material thinning and if you want to inspect that kind of damage by using ultrasonic testing.

Then this kind of blocks are quite useful to calibrate the instrument before you do that test similarly here also these blocks also have different heights or different thickness so this also can be used to calibrate the instrument for the distance because then for each of these you can collect the back wall signal itself and that can be used to calibrate the instrument for distance okay.

(Refer Slide Time: 30:00)



So this is the kind of blocks the calibration blocks you have and in the next class we will see how these calibration blocks are used to calibrate the instrument both for distance as well as for area so far today this is all I will have so I will stop here today I will see you next time thank you.

IIT Madras Production

Funded by
Department of Higher Education
Ministry of Human Resource Development
Government of India

www.nptel.ac.in