NPTEL

NPTEL ONLINE COURSE

NPTEL Online Certification Course (NOC)

NPTEL

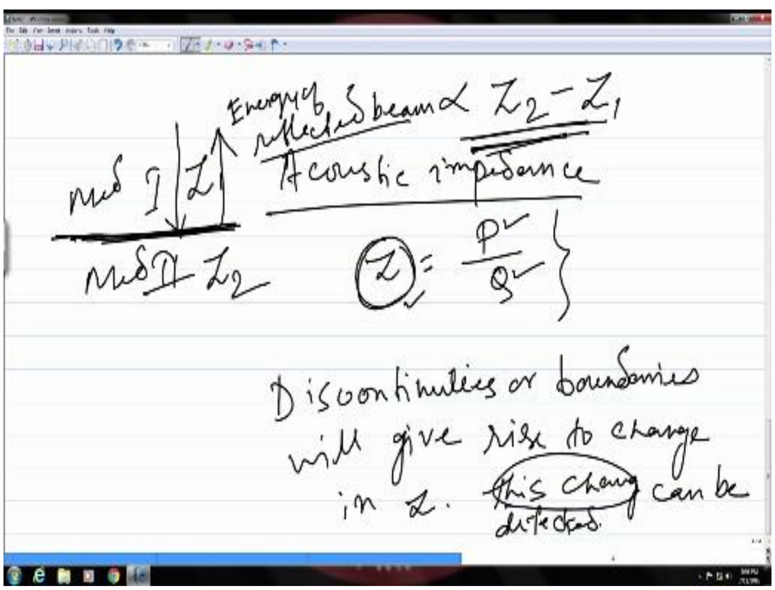
Theory and Practice of Non Destructive Testing

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

Ultrasonic Testing - 2

So in the previous lecture we started this topic ultrasonic testing, and then we first saw the basic properties of ultrasonic waves then we learn about different types of ultrasonic waves and finally we also learn about the basic principle of this particular technique which is based upon reflection of sound waves from an interface which could be the defect itself okay.

(Refer Slide Time: 00:51)



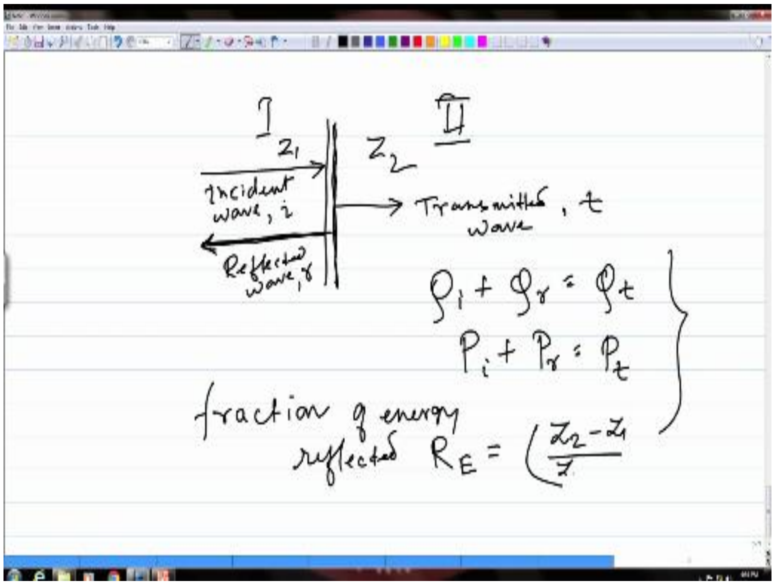
And then we also talked about this particular parameter acoustic impedance which is the total resistance to the movement of sound waves in a particular medium and this is the ratio of the sound pressure and the velocity of the particles are the atoms inside the medium okay. So now in today's class I am going to tell you that how this particular parameter will decide the energy in the reflected beam because that is what is our concern for this particular technique.

We need to capture the echoes or the reflected sound beams which are coming out from the sample. And as I would have said before also in the previous lecture that whether you would be able to capture it or not that would depend on the energy which is there in this reflected sound wave okay. And as I am going to show you right now this energy in the reflected beam will depend on the change of the acoustic impedance Z across that reflecting interface okay.

So what basically happens when the sound waves encounters an interface or a discontinuity so these discontinuities or the boundaries will give rise to a change in Z and as I said this change can be detected when the sound waves are reflected from this boundaries, because the energy as I said before the energy in the reflected beam will depend on this change okay.

So if you have two medium one and two with the acoustic impedance Z1 and Z2 so across this boundary there is a change in the impedance and if you have sound waves coming and getting reflected back from this boundary then the energy in this reflected beam that would depend on this change okay. So that is what I am going to show you right now, as to how exactly this energy is related to this change okay.

(Refer Slide Time: 04:33)



So now let us say you have this medium one and the sound waves are moving through it at a particular velocity. So this is the incident wave we will call that as I and in its path if the wave encounters an interface that means if there is a change in the medium or there is some discontinuity then this acoustic impedance will change. So let us say in medium 1 it is Z1 and in medium 2 or across this interface it is Z2 okay.

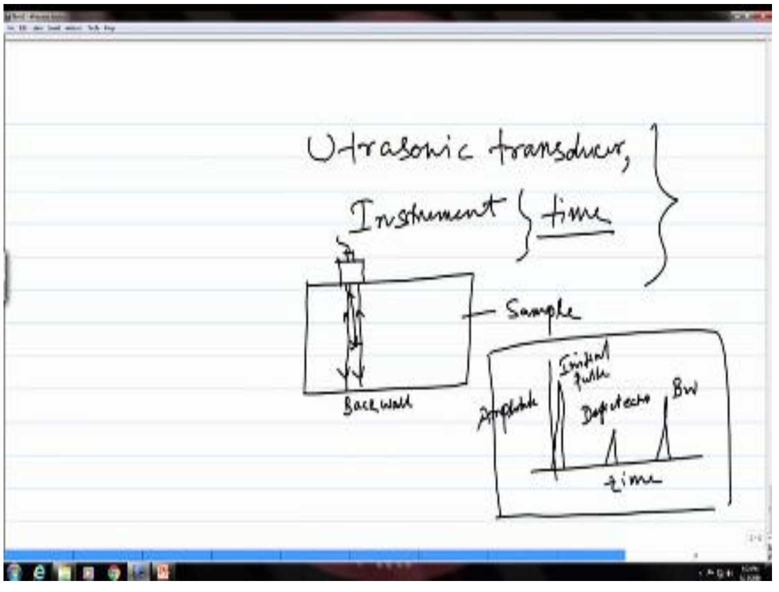
So when there is a change in the impedance and when the sound encounters an interface a part of the sound wave will be reflected and a part of it will be transmitted. So this is the transmitted wave and this one is the reflected let us call them as T and R okay. So the energy of this reflected beam which is our concern for doing entity will depend on what is this impedance change across this interface okay.

So this interface could be the defect itself so when the sound waves encounter the discontinuity it will reflect a part of the sound waves and the energy of that reflected wave will depend on the change in the acoustic impedance across that interface okay. And that can be calculated because across the path of the sound beam the whole thing is continuous in the sense if you have I if I be the incident beam as we have written then you can write like Q+QR=QT this parameter Q we have already defined that is the velocity given to the atoms or we can also say that okay.

So this is across the interface since this is continuous these individual components can be estimated and as I said the fraction of energy into the reflected wave would depend on, so if we call that as R_E so that would depend on the change in the acoustic impedance as I said okay. So if you have enough energy in the reflected wave coming out from a flaw then this can be easily captured through an instrument and then you can generate a defect signal and get the indications about the presence of defects and flaws on a given sample okay.

So this is how the ultrasonic waves can be used for doing NDT, so this is primarily based on the sound echo or reflection of sound waves reflection of ultrasonic waves from the discontinuities which present a scattering interface for reflecting the sound waves okay. So if you have the instrument if you have means to capture this reflected beam coming out from the sample or coming out from a defect then as I said you can use that to do NDT and get indications of defects okay.

(Refer Slide Time: 09:58)



So all you need for doing ultrasonic testing is an ultrasonic transducer which will generate the ultrasonic waves and you need you know the instrument which will have all the electronic circuit and everything necessary to capture the echoes coming out from the sample and with the help of that if there are any echo which is coming out from a defect you would be able to see them in terms of a signal or a peek.

So you take the transducer and keep it over the sample okay and so this transducer will generate the ultrasonic waves, so these waves will go like this, so they will go to the other surface hit the back wall and come back okay. And in between if you have any defect somewhere okay, so these waves will also be reflected from this defect in that fashion okay. And this will generate a signal like this in the time base and let us say this axis is the amplitude.

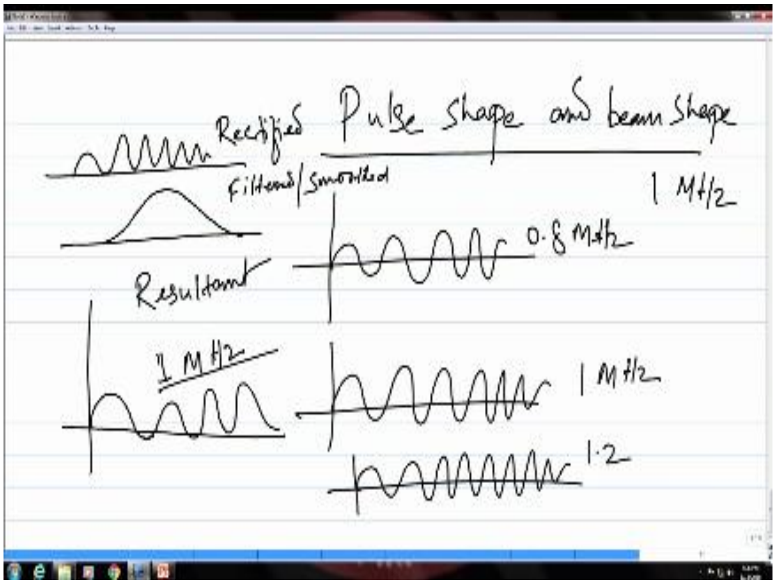
So what you see first you have this initial pulse what is being sent into the sample and then this ultrasonic waves will go and hit the back wall the other surface of the sample and from the back wall you will get this back wall signal okay right. So this is your reference frame for getting the defect signal you have the initial pulse in the beginning and you have the back wall okay.

And this instrument will capture this time that the waves take to go all the way to the back wall and come back and that is what is plotted in terms of the intensity of this pulses or the intensity of the reflected signals okay. So if you have a defect like this so that will come in between the initial pulse and the back wall because the defect is lying between the top surface and the bottom surface so you will see a defect eco like this, okay, right so this is how the defect signal is generated with the help of ultrasonic waves.

So if you have the means and ways to capture this echoes coming out from the small interfaces of the discontinuities then you would be able to get this defect eco and then you will have the display system in terms of an oscilloscope screen or things like that will that defect signal will come between the initial pulse and the back wall signal.

Whole thing can be displayed and then you would be able to know if there are any defect that will that defect signal will come between the initial pulse and the back wall signal.

(Refer Slide Time: 14:25)



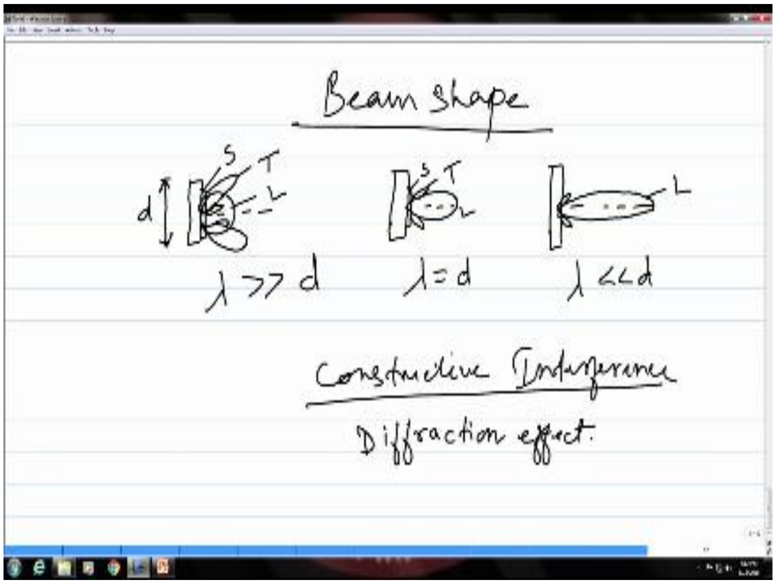
So you need an ultrasonic pulse which is generated through this transducer to send these ultrasonic waves into the sample, okay. So let us talk about that also a little bit the pulse shape and the beam the ultrasonic beam which is generated out of these pulses, so this ultrasonic waves are used in a particular frequency range as I told in the beginning and if you are selecting a particular frequency that may consist of mix of frequency which will be plus, minus to that selected frequency.

For example, if you want to use 1MHz the pulses which are used or which are generated by the ultrasonic transducer to create that ultrasonic beam of 1 MHz can have a mix of for example 0.8 MHz then one pulse could be you know little more 1MHz then you could have one it is 1.2 and so on, okay so this will be a mix of all these pulses which are little plus or minus with respect to the central frequency the main frequency that you are looking for.

So you take the sum of all this which will be 1 MHz or the frequency that you have chosen, okay. So if you take the resultant of all that it should be you know 1 MHz, so this is how the pulses are and sometime it can be rectified so if you rectify then it will be like this so this is a rectified signal or rectified wave and if you fill that or smoothen it then it may be like this, okay.

So this will generate an ultrasonic beam of a given frequency that you want to use.

(Refer Slide Time: 17:35)



So let us see how will be the shape of this beam which is generated out of these pulses and what are the factors which will decide the shape of the ultrasonic beam which is going into the sample, okay. So first we talked about the previous one was about the pulse shape or the nature of the pulses and now let us see this beam shape, so let us say this is the transducer that you have and it has a particular size so let us say it has a diameter d okay.

So in this case where the wavelength of the sound waves is much greater than the size or the diameter of the transducer then in that case you have this kind of beam so you will have the transverse waves which is represented as T the central part is a longitudinal wave which is represented as L and then over here on the surface of the transducer you would also have surface waves which are denoted as s, okay.

So this will be the scenario where the wavelength of the sound waves is much greater than the size of the transducer, okay. Now let us increase this size with respect to the wavelength and then see what happens when these two becomes equal, okay. So as you increase the size of the transducer you would see a change in the shape of the beam and you would also see a change in the appearance of the transverse waves they will reduce so this is the constitutional wave this is the transverse and this is the surface wave, okay.

If you further increase the size of the transducer and make the size of the transducer much larger than the wavelength then you will see that this beam becomes directional and rest of the components will almost be absent and you will have a primarily longitudinal beam which is directional like this, so this is due to the fact that when you increase the size of the transducer it is much bigger compared to the wavelength of the sound waves.

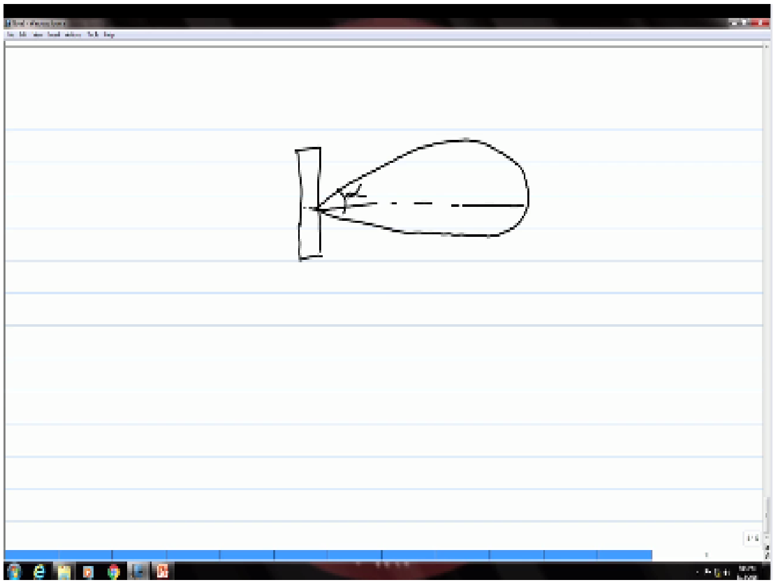
That means this will not act as a single point source, okay like what you have in the case in the first scenario wherein d is much smaller than λ but when dis much larger than λ then these source will act as multiple point source, okay. So although it is the same ultrasonic pulse or the same ultrasonic beam which is generated by a single transducer but because of a big size with respect to the sound waves wavelength this will act as multiple point sources so the sound waves coming out from different sources will interact with each other and there will be constructive and destructive interferences okay.

So this directionality that you see is due to the constructive interference, so in a particular direction you have the constructive interference and the wave increases in that particular direction. So this phenomenon due to constructive interference from multiple sources is known as diffraction effects, okay. So this is due to the deflection effect of the sound waves coming out from different point sources that the beam become directional and it takes shape which looks like a searchlight or like a torch light beam, okay.

So this defection effect you might have seen practically in some other form many of you might have seen this if you have dropped a stone in a pool of water, so the point where you drop a stone that is a source and you have seen it creates the ripples the waves and nearby if you drop another stone so that is the another source of waves, so if you drop number of stones it will create a number of sources of ways and then these waves will move and at some point they will meet each other and then there will be constructive and destructive interferences and it will try and go in a particular direction where you have constructive interference.

So that is how the defects and effect is in sound waves also where you have multiple sources near to each other, right.

(Refer Slide Time: 25:21)



That is what you have finally if I magnify this picture a bit, as I said we will have a beam which looks like a search light like this, okay so it has a divergence so there is a divergence angle alpha and it has a particular spread also, okay. So this is how the ultrasonic beam would be which is used for non-destructive testing okay, so we will talk about this in little more detail but for today this is all I will have in the next class I will show you what are the typical characteristics of this particular beam that finally we have got here and then we will see how this is used and how the ultrasonic testing is done, okay so for today I will stop here I will see you next time.

IIT Madras Production

Funded by

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

www.nptel.ac.in