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Theory and Practice of Non Destructive Testing

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Ultrasonic Testing - 1

So far we have covered the three topics in this course and all the three topics were on surface entity methods so today I am going to start a new topic which will be on bulk entity and the topic that I have chosen for this will be on ultrasonic testing so this is a technique which can be used for doing entity into the bulk of the material if there is any flaw or defect which are much below the surface ultrasonic technique is one method which can be used for inspecting this kind of defects which lie into the bulk of the material and this technique can also be used for doing surface entity.

So it can be used for both that is why ultrasonic testing is one of the most versatile entity method and from today onwards in next few classes we will be discussing about this particular technique so since this technique as the name suggests based on ultrasonic waves so let us first see what ultrasonic waves are and what their properties are and then we are going to see how these waves are used for doing NDT okay.

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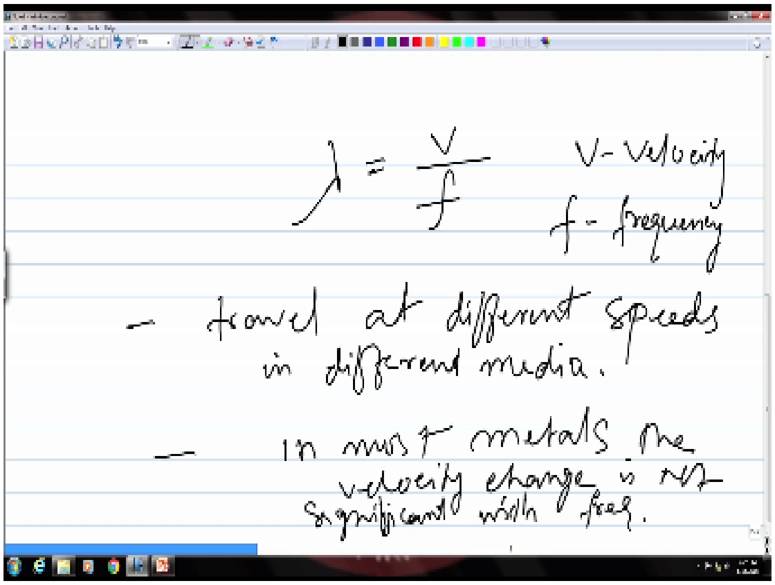

So let us first learn little bit about ultrasonic waves ultrasonic waves are nothing but sound waves which have frequency greater than 20 kHz okay so anything below or 20 kHz would be in the audible range when you go to a frequency beyond 20 kHz then the sound waves are in the ultrasonic range okay so this is what all de sonic waves are and if you see their nature and properties for example if you see the wavelength it is in the range of 1 to 10 millimeter frequency is 0.15 MHz but generally for doing ultrasonic testing a frequency within 10 MHz is used so 209 kHz and above up to 10 MHz is used for ultrasonic testing for doing NDT and this wavelength λ is a factor of the velocity of these waves and the frequencies in this fashion.

Okay and then they travel at different speed in different medium and in most of the metals the velocity change with frequency is not very significant so these are some of the typical characteristics of ultrasonic waves okay and now let us talk about what kind of ultrasonic waves you have what are the different types of waves.

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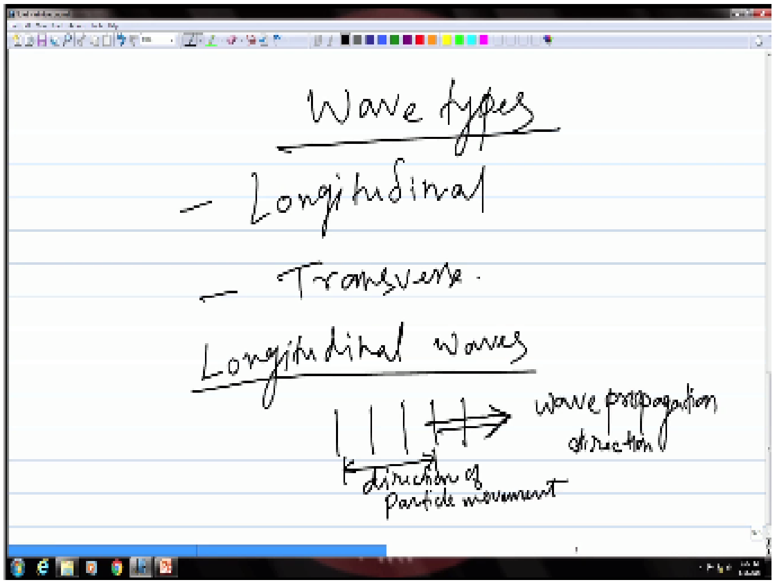

Primarily as far as entity is concerned you have two types of waves one is longitudinal and the other one is transverse okay let us see why it is called longitudinal and transverse and what is the difference between them okay so now if you talk about the longitudinal waves in this case if you see the propagation of the wave through a medium let us say the wave is moving in this direction so this is the wave propagation direction and when sound moves through a medium it creates a local pressure local sound pressure which will push the atoms or the particles and create a lattice wave inside the solid.

So it will create some elastic waves and with the help of these elastic waves the sound moves from one part to other another part in a medium okay so there is a movement of the particles or the atoms inside the medium okay so in this case the direction of particle.

Movement is parallel to the direction of the movement of the wave okay so in this case it is moving in this direction so the particle movement direction also will be the same so this is the direction of particle movement okay so that means the movement of these particles will be coordinated in the sense that the first atom can push the second one and the second one can push the third one and soon since they are moving in the same direction as the wave okay so in this case the movement of the particles are coordinated and they can help each other in moving when the sound wave is moving through the medium okay.

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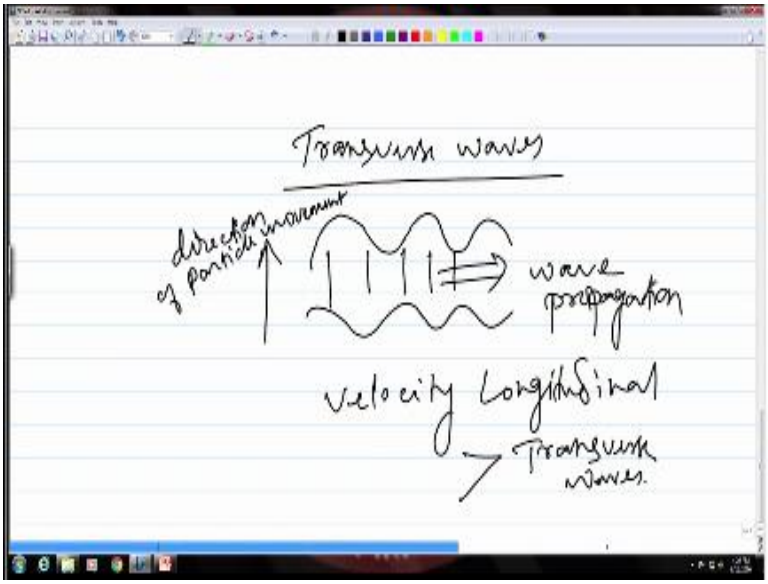

On the other hand if you look at the transverse waves in this case if this be the direction of wave propagation the particles will move in a perpendicular direction like this so in this case the movement will be like this okay that means the particles are going up and down and the wave is moving horizontally okay so in this case as you could realize while the sound is propagating through the medium in order to create that elastic wave which helps in moving the sound wave the particles have to pull each other okay and then create this motion in the direction of the propagation of the wave and that is how these wave propagates in this case.

So here the movement is not as coordinated or the movement of the particles is not as easy as in the case of longitudinal waves and that is why the velocity of the longitudinal waves is always greater than that of transverse waves this is due to the difference in the movement of particles with respect to the direction of wave propagation okay so in one case in the longitudinal case the direction of wave propagation and particle movement are same.

And as a result the particles can move easily and in the case of transverse waves since the direction of the particle movement is perpendicular to the movement of the wave propagation here the difficulty level for movement of the particles is more compared to the longitudinal waves and that is why the velocity of the longitudinal wave in a particular medium will be more than transverse waves. So these are the two primary types of ultrasonic waves now when you talk about the velocity.

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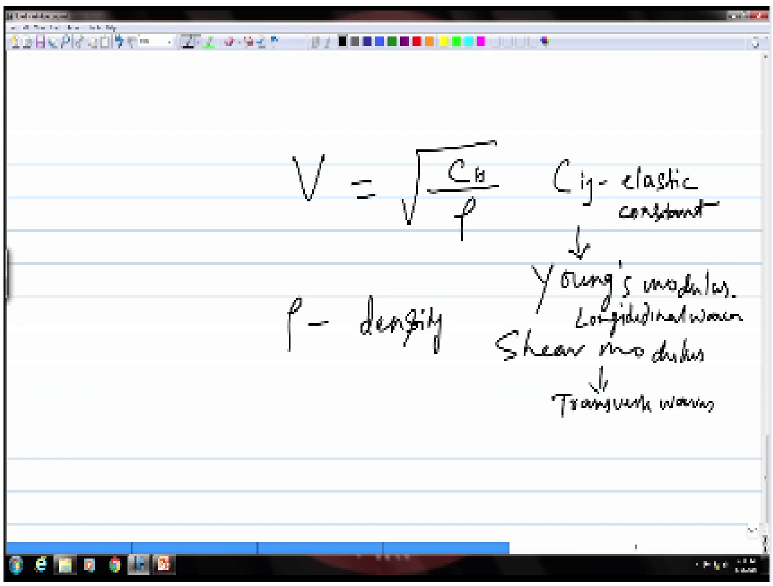

It is related to the elastic constant of the material through which the sound waves are moving and the density of the medium in this fashion so C_{ij} is the elastic constant of the material for example it could be the young's modulus or the shear modulus so shear modulus can be used for transverse waves and young's modulus can be used for the longitudinal waves sometime poisons ratio is also used and ρ is the density okay so the properties of the material will decide what will be the velocity of sound through that particular material.

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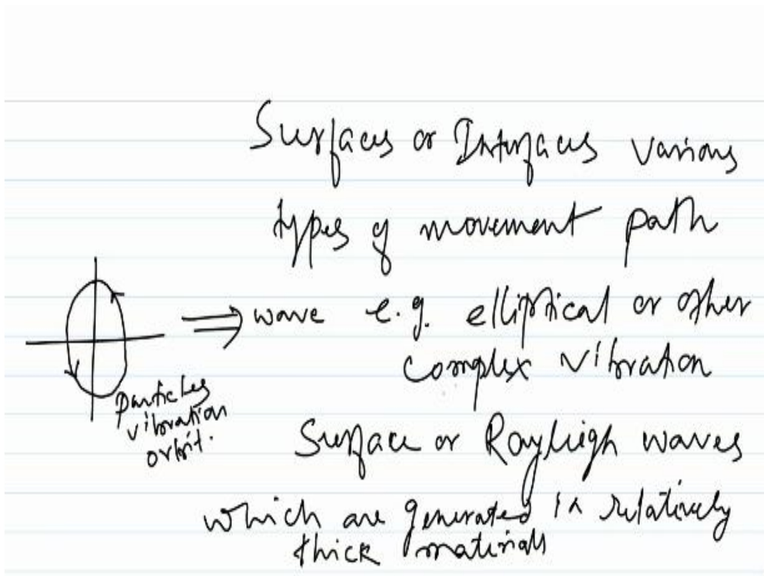

Now there are certain other types of ultrasonic waves also since we are talking about different types of waves let us talk about those also for example in surfaces or interfaces you could have various types of particle movement and that would give rise to other type of ultrasonic waves for example you could have elliptical or other complex kind of paths in the movement of the particles as the sound moves through the medium.

So this kind of elliptical or other complex vibration which are generated on the surface known as surface or Rayleigh waves which are generated in relatively thick samples, okay so let us say if the sound is moving in this direction so you can have a particle movement path like this like in an elliptical path as I said so this will be the movement of the particles and through this kind of movement you will generate the motion for the waves in the horizontal direction.

So this kind of waves which are generated at surfaces or interfaces in thick materials they are known as surface or relatives, okay and in thin plates you could have some other type of waves being generated.

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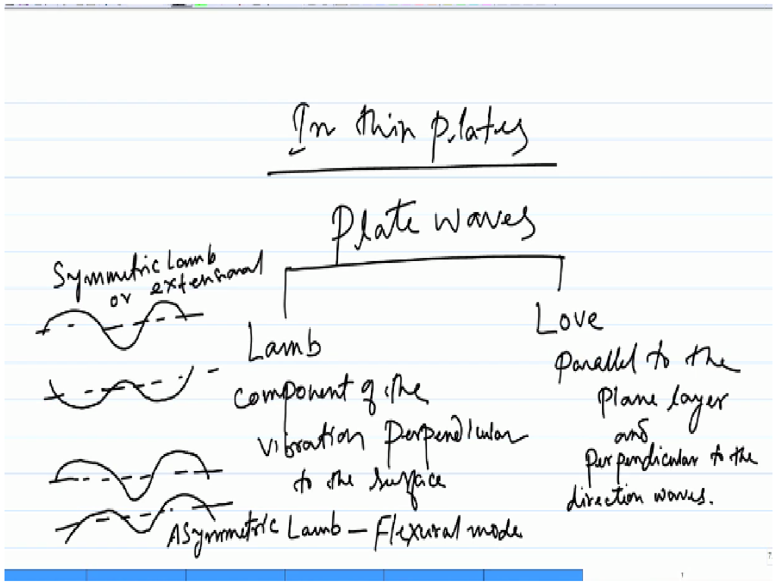

Which are known as plate waves and this can be further divided into two categories one is known as Lamb and the other one is known as love okay so Lamb is the component of the vibration which is perpendicular to the surface and love is parallel to the plane layer and perpendicular to the direction of the waves okay so these are two different types of plate waves that you can find on thin plates one is lamb and another is love, okay.

And in the lamb waves you can have a symmetric lamp like this symmetric lamb or these are also known as extensional waves and you could also have a symmetric like this and this is in flexible mode okay so these are different types of ultrasonic waves our primary concern for ultrasonic testing for NDT would be the longitudinal and the transverse waves so we will talk about more about them only when we talk about ultrasonic testing as a NDT method.

Now let me tell you how this ultrasonic waves are used for doing anything the basic principle behind this is fairly simple we all know about reflection of sound waves or the echo of sound like for example if you talk loudly in an empty room the walls will reflect the sound and you will get an eco okay so while doing ultrasonic testing what is done is this ultrasonic waves are sent into the sample and when these waves are reflected back they are collected by a transducer which is finally will generate the signal if there is any defect okay. So this defect will also act as a reflector which can reflect the sound waves ok but in that case the reflection interface is much smaller compared to a wall so that means the energy which is there in the reflected waves should be enough for the transducer or the instrument to collect this signal back okay.

So the energy in the transmitter the sound waves will depend on the sound pressure which is created by this a traveling waves okay you might know that sound waves travel through a medium by oscillatory movement of the atoms or the particles and this movement is due to the local pressure which is created by sound so this pressure is the excess pressure above that atmospheric pressure okay.

So when sound waves are travel through a medium this local pressure provides some movement to the atoms and due to the bonding between the atoms it creates an oscillatory movement which in turn will create a wave okay so that is how the sound waves are propagate through a particular medium okay so let us say this local pressure which is created.

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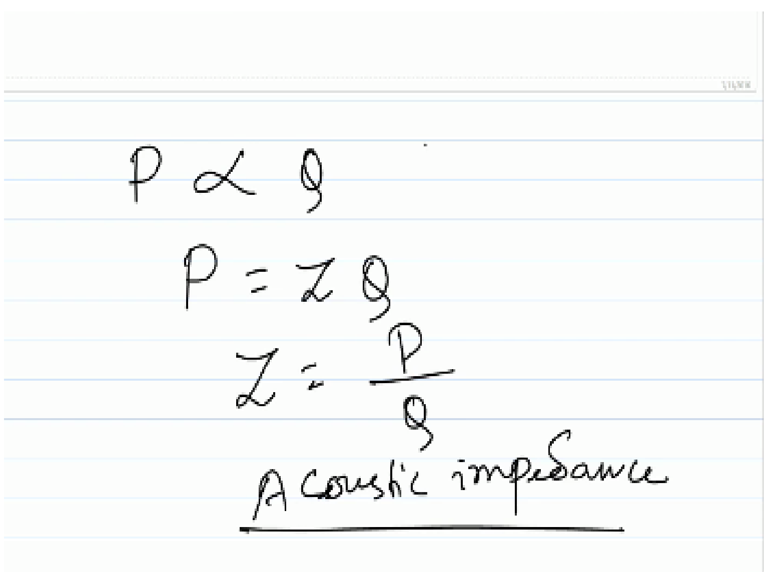

By the sound is P and let us say it provides a velocity to the particles or the atoms which is Q okay because as I told this will provide some movement to the particles of the atom so let us say the velocity of that movement is Q so P will be proportional to Q higher the P higher will be the movement between the atoms now if you introduce this proportionality constant then you can write in this fashion and this parameter Z which is P / Q this is known as acoustic impedance.
So this is nothing but the total resistance to the movement of sound waves through a particular medium okay and the energy of the transmitted beam.

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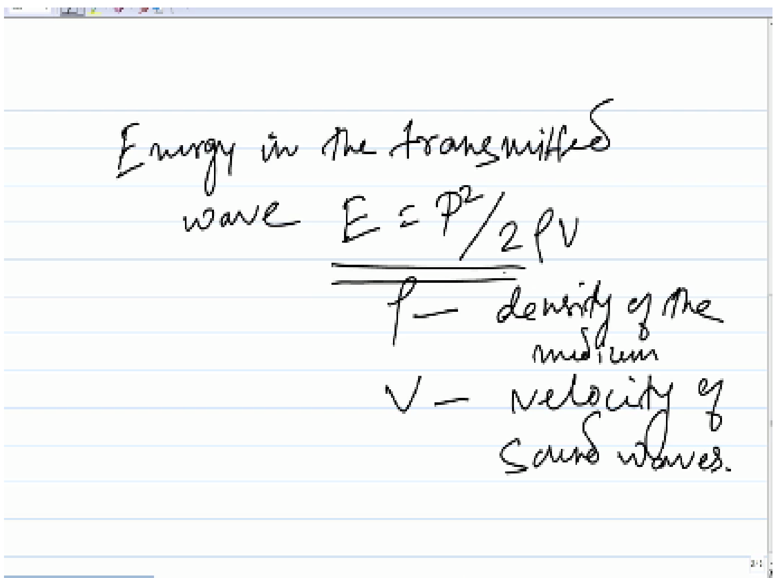

The energy in the transmitted waves E is again dependent on the pressure P in this manner were in ρ is the density of the medium and V is the velocity of sound waves through the medium okay so you have why you should have enough energy first of all in the transmitted sound waves which go to the sample and then when it is reflected back that reflected waves also should have enough energy so that the instrument which is used for doing ultrasonic testing should be able to capture it okay.

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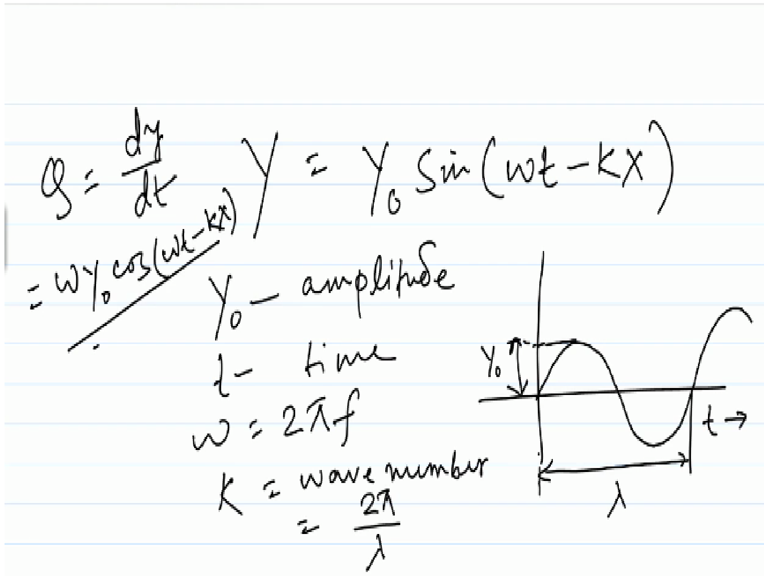

And if you want to get an expression for P and Q if the wave is represented by an equation like this so if this be the wave okay so if this be the wave where y0 is the amplitude T is time, ω is the angular frequency which is 2 Π F where F is the frequency and K is known as wave number which is equal to 2 Π/λ, λ is the wavelength okay so if this be the wave then the velocity which is given to the particles or to the atoms Q is this dy / dt.

So Q will be equal to this so this is the effect of sound waves when it travels through a medium it provides this velocity cue and the resistance to the movement of sound wave is provided is given by that parameter acoustic impedance okay so based upon this transmitted beam energy it will enter a particular sample or a particular medium and then when it encounters an interface a part of this sound beam will be reflected back okay and the energy of that reflected beam that will depend on this particular parameter acoustic impedance.

As to what is the change of impedance across that reflecting interface okay so that is what we will decide the energy in the reflected beam and as I said if the energy is enough in this echo or in this reflected beam then you can use an instrument a transducer to capture that energy and convert that into a signal which can be shown in the display of the system and that is how you will get to know about presence of defects if that reflecting interface be a defect okay so that is how the basic principle is behind this particular technique.

It is a fairly simple one is based upon the reflection of sound waves from a discontinuity which provides a reflecting interface to the sound waves which are propagating through the sample yeah so with that today I am going to stop here and in the next class we are going to see how these ultrasonic waves are used to do non-destructive testing and rest of the things also about this particular method we are going to see in the subsequent classes so for today I will stop here thank you for your attention.

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