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Theory and Practice of
Non Destructive Testing

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Ultrasonic testing 5

Hi everyone so I am back with yet another lecture and this time we are going to continue on the topic that we have been discussing in last few lectures which is on ultrasonic testing so before we proceed let us see quickly what we have learned.

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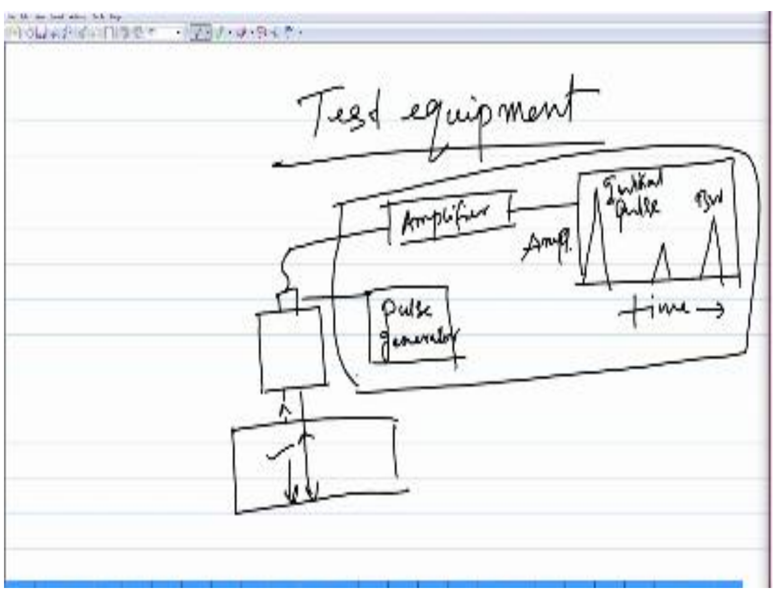

So far till last class this is what we had we first discussed about the basic principle we have learned about that and then we saw the different kinds of ultra sonic probes and then in the last class we saw this the different parts of the test equipment which is used for doing all the sonic testing okay so we will continue on this and we will see the other aspects of this particular technique.

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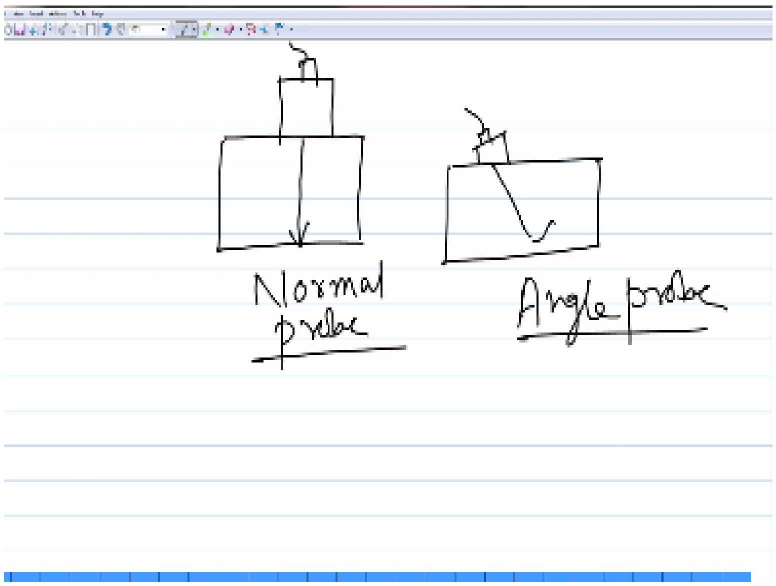

So in terms of the incident angle we saw that there are two scenarios when the incident angle is 0 then this goes vertically down like this the ultrasonic waves goes into the sample in this fashion and in some cases you need to send the waves at a particular angle like this okay because there could be cases as I would have said before also where the defects and flaws might lie at an angle or the part itself is such that you need to send the waves at some angle okay.

So this is the scenario which is known as a normal probe because the ultrasonic waves are going vertically down perpendicular and this is an angle probe right so depending on what kind of part you have you know and what kind of defect orientations you are expecting so based upon that he could either select normal probe or an angle probe okay.

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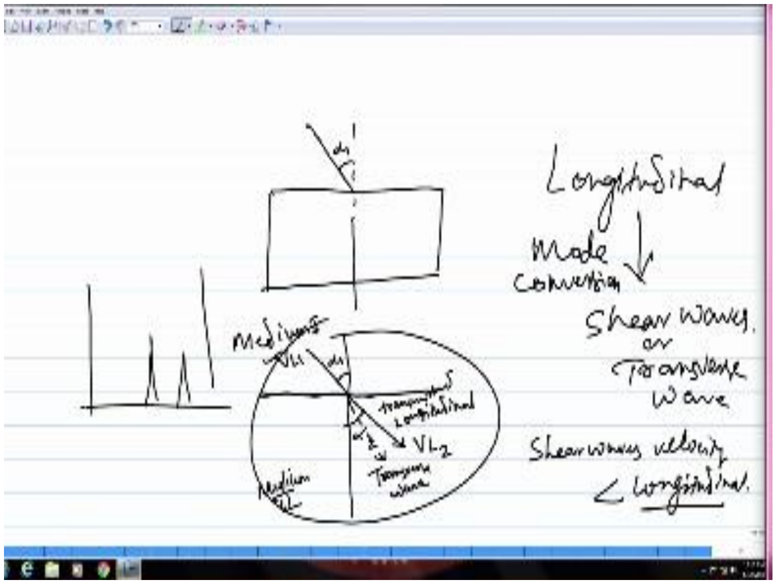

So when you send the waves are at a small incident angle so across an interface there is a possibility that if you are using longitudinal waves you there is a possibility that at the interface there will be some kind of mode conversion and a part of the longitudinal waves will be converted into a transverse wave which are also known as shear waves when the incident angle is more than zero okay.

So this is a scenario like this if you are if you have an incident angle its alpha 1 okay and let us say these encounters an interface between two medium so let us say this is medium one and it is going into another medium which is here so this is the interface so if you have an incident a small incident angle at this interface then there is a possibility that a part of this longitudinal wave that you have okay will be converted into shear wave and across this interface since now it is entering another medium there will be a change in the path of this wave k due to refraction effects and let us say this is the velocity in medium 2 and PL one is the velocity in medium 1 okay.

And as I said a small part of this can also be converted into a shear wave or transverse wave so this is the transverse wave due to mode conversion this is the longitudinal wave transmitted into the second medium and this one is the transmitted transverse wave okay so when you are using an angle for doing the test that means because of this mode conversion two kinds of waves will enter the sample longitudinal wave and shear wave both of these waves will enter the sample.

And we have already seen that velocity of shear waves is lower than that of longitudinal waves okay so that means when these waves reflect back from an interface which could be a discontinuity also they will arrive at the probe at different time okay so that means the reflections from the same interface will arrive at different time and you will see them on the screen on the display as the same signal appearing at different times okay.

Because the velocity is different okay so this will confuse the examiner okay so this will create a confusion and that is why it is always better to have only one kind of wave going into the sample and coming back to the probe okay so if you want to do that when you have this kind of scenario then you need to exclude one of these waves and as we are going to see now you have to exclude the longitudinal wave and the reason for that we will see in a moment.

So in that case when you do that you have to send it at a particular angle which will ensure that only shear waves enter the sample and longitudinal waves will be reflected back they will not be transmitted to the sample okay so that will depend on the angle of incidence and let us find out what that incidence angle is okay.

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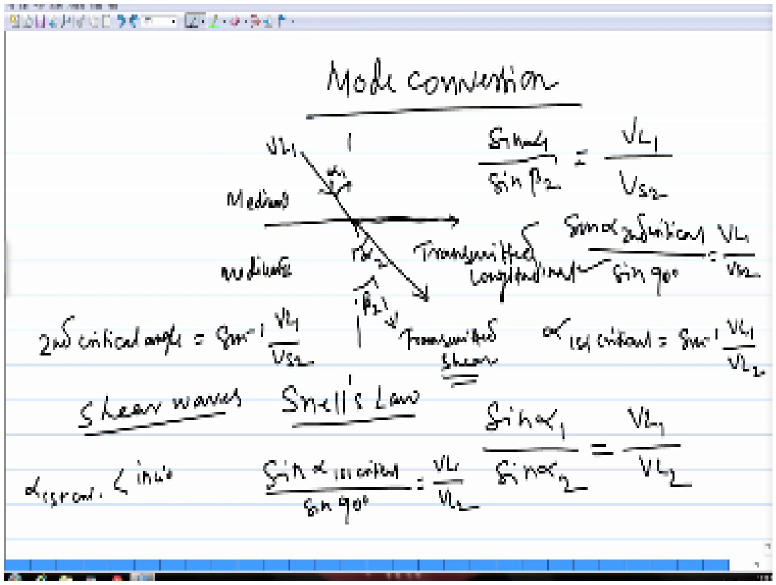

So let us say this is the incident longitudinal wave and the velocity in medium one is the L 1 and then this is the transmitted wave and this is the incident angle α 1okay and as I said a part of this will be converted into shear wave so this is the transmitted shear wave okay so if you want to exclude this transmitted longitudinal wave and only want to keep this here then you have to send it at a particular angle and that angle can be found from Snell's law which says that the ratio of sin angles in these two medium that is sin α 1/sin α 2 will be equal to the ratio of the velocities in those two medium.

So this will equal to VL l and VL 2 to where in VL1 is the velocity of the longitudinal waves in medium 1 and VL 2 is a velocity in medium 2 okay so now if you keep increasing α2 or if you keep changing α 1 such that α 2increases at some point α 2 will become 90^0 and be parallel to the interface okay, so that particular angle where α 2 becomes 90^0 is known as the first critical angle so this corresponds to α 2 to becoming 90^0.

So this gives you the first critical angle as sine inverse the ratio of the velocities okay now if you run angle is little more than this little more than the first critical angle then this longitudinal beam will be reflected back into the first medium and it will not be transmitted okay so with respect to medium one then it will go thru total internal reflection and nothing will be transmitted into the second media okay.

So that means if your angle is beyond first critical angle then you can ensure that the longitudinal waves are not entering into the into the sample which is medium to okay but if you look at this the shear waves there also you could have an α one at which β 2will become 90^0 okay so the angle at which the β2 becomes a 90^0or the transmitted shear wave becomes parallel to the interface.

That particular angle is known as second critical angle so this relationship between the incident angle α1 and the transmitted shear wave angle β 2is given by again the loss in the ratio of the velocities that is VL one and this β 2 corresponds to the shear wave in medium two so that means this is the velocity of shear waves in medium 2which will call as VS 2 okay so the second critical angle that is sin α second critical corresponds to β to becoming 90^0.

So we have the second critical angle now which is sin inverse VL1/ VS2 okay so if the incident angle is beyond second critical angle then nothing will enter the medium to know ultrasonic wave will enter medium two so that means if you want to have only a shear waves entering the sample which is medium to then the incident angle should be in between first critical and second critical angle so it should be greater than first critical.

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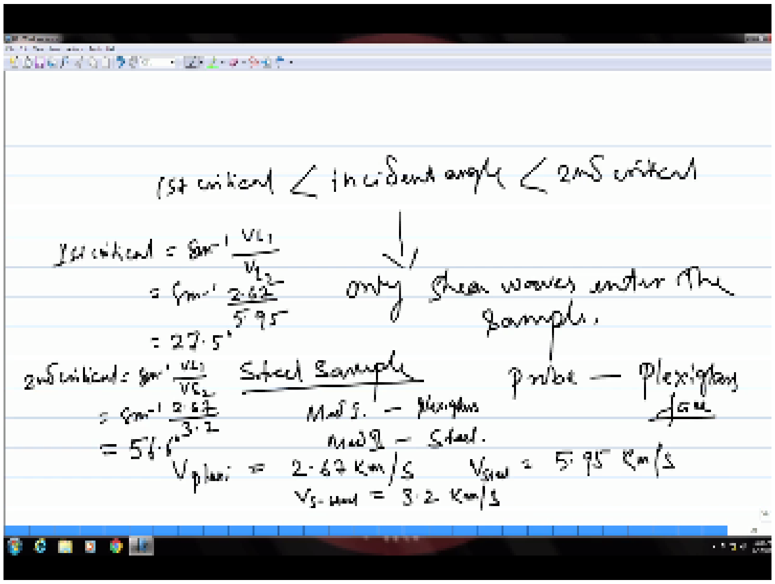

And lower than second critical so it should be in between the first critical and the second critical angle which will ensure that only shear waves enters the sample and then you will do the inspection using share waves and the confusion that you had that the same signal coming back at different time that can be avoided okay so in order to do that you have to ensure that you have only shear waves entering the sample and for that the incident angle has to be in between first critical and second critical angle.

So we will take an example and then see for a particular material what could be that angle let us say we have a steel sample and we are using a probe he has this Plexiglas phase okay so the front face just in front of the active element if you have seen the construction of ultrasonic waves is some kind of fiberglass kind of thing is that okay just to protect it and also keep it inside that housing so many times this phase material which is in contact with the sample is made of Plexiglas.

And the sample is made of steel okay so that means our medium one in this case is the Plexiglas because the waves will first come out through this Plexiglas phase and then it will go to the sample so that is the medium to which is in this case steel okay now if you look at the velocity of sound wave the longitudinal waves in steel and in Plexiglas these are velocity in Plexiglas is 2.67 kilometer per second velocity of the longitudinal waves in steel is around 6 or 5.95 kilometer per second.

And the velocity of shear waves that is v s steel that has to be lower than the longitudinal velocity so it is 3.2 kilo meter per second okay so let us calculate the first critical angle and the second, second critical angle for a steel sample where the face of the probe is made of Plexiglas okay so the first critical is sin inverse pl1 by pl2 so that means this is VL one is 2.67 because medium one is Plexiglas and VL to is 5.95.

So this will give you an angle which is around 27.5 degrees and the second critical is sin inverse VL1 / VS2 okay so that means if you want to inspect this steel sample using an angle probe so as I said you need to ensure in that case that only shear waves are entering the sample to avoid that confusion so you need to ensure that incident angle is in between27 and 56.

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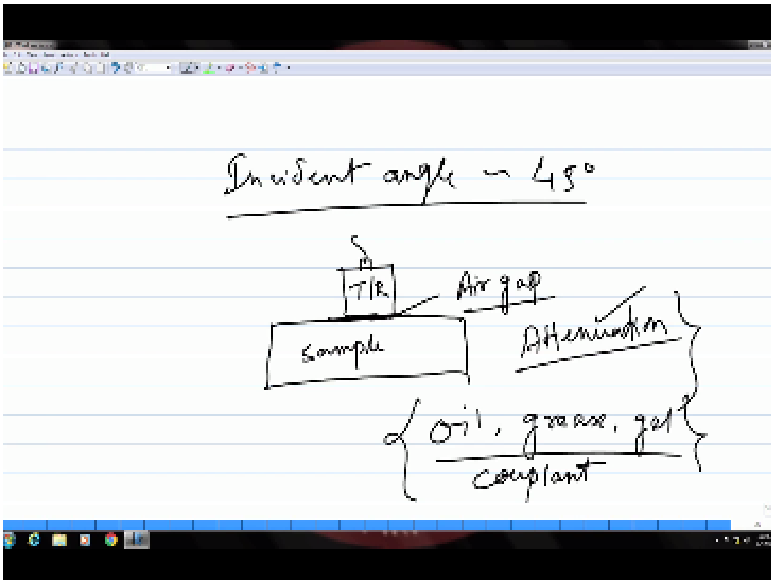

So an incident angle for this case for the steel sample which is between these two so an incident angle like 40 to 45 degree will be good in this case okay so this will ensure that shear waves are only entering the sample and the whole sample will be inspected by these surveys okay so this is how when you do the inspection by using angle pros this is how you choose the angle depending on the velocity of sound waves into the material that the sample is made up okay.

The next thing is how do you send these waves into the sample so when you do the testing you take the probe so this is the transducer you have this is the sample okay so you touch it on the sample surface and then you switch it on so the waves will be going into the sample but at this interface as you could realize there is an air gap okay and if this air gap exists then there will be decrease in the intensity of the waves or there will be a Tunisian okay.

Into the air so you need to ensure if you if you want the entire energy of the sound waves going into the sample and if you want to prevent this a Tunisian or decrease in the intensity then you need to exclude this air gap before you could send the sound waves into the sample okay so in order to exclude this air gap you need to apply something on this interface which will exclude the air okay so if you apply some kind of oil or grease or some gel in the form of a thin layer okay.

That will ensure that the air gap is excluded and now this attenuation or the decrease in the intensity can be avoided okay so this particular thing which is applied to avoid the air gap is known technically as Copeland so this coupling should satisfy certain requirement for it to be used effectively.

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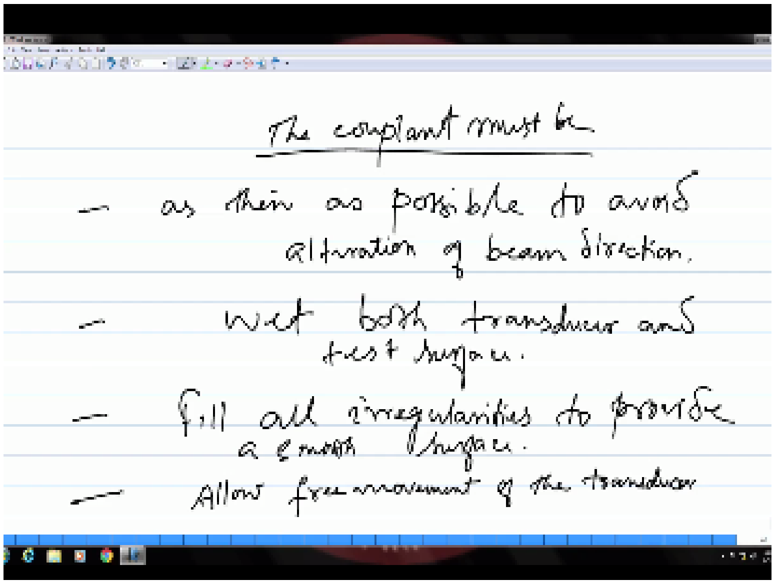

And for it to exclude the air gap so the Copeland must be the complaint must satisfy the following requirements it should be as thin as possible to avoid any alteration of direction of the beam if it is a thick layer then that itself would act as a different medium okay and due to the presence of a different medium then as you have seen before this sound waves will change their direction okay so in order to avoid that you need to ensure that this is applied as a very thin layer.

So that the direction of the beam does not change when it is passing through the Copeland layer then it should wait both the probe surface as well as the sample surface so it should have good wetting or good spreading property then it should also be able to feel the small irregularities that you might have on the surface of the sample so that it can provide a smooth surface for the probe to move on.

So this is another advantage you have when you apply this complaint it will fill up all the regularities on the surface and it will provide a smooth surface for the probe to move and it not restrict the movement of the probe so it should allow free movement for the probe and it must be easy to apply and easy to remove.

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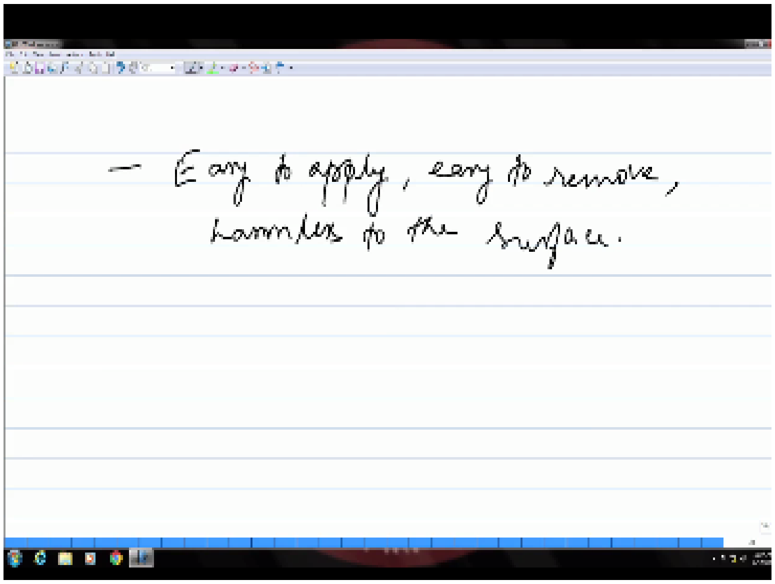

And it must be harmless to the surface on which it is applied so these are the property requirement from a couple and for it to be used effectively okay so this is how when you do the test you might have seen that some kind of oil or grease is applied on this surface and then on that the probe transducer will be kept and moved over the surface okay right so this is all I will have for today so in the next class again we are going to see the other details of this process so far today I will stop here thank you for your attention.

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