Inspection and Quality Control In Manufacturing
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Lecture - 10
Ultrasonic Inspection

Hello my friends, today we are going to discuss about the, Ultrasonic Inspections. So last couple of lectures just we are discussing about the different types of non-destructive testing methods. So ultrasonic inspections is one of them so basically the ultrasonic inspections it is also a non-destructive testing, that means we are not going to harm our materials or maybe that we are not going to destroy our materials, and here from the name itself, you can understand that, we are using the ultrasonic waves to conduct the examinations and make the measurements.

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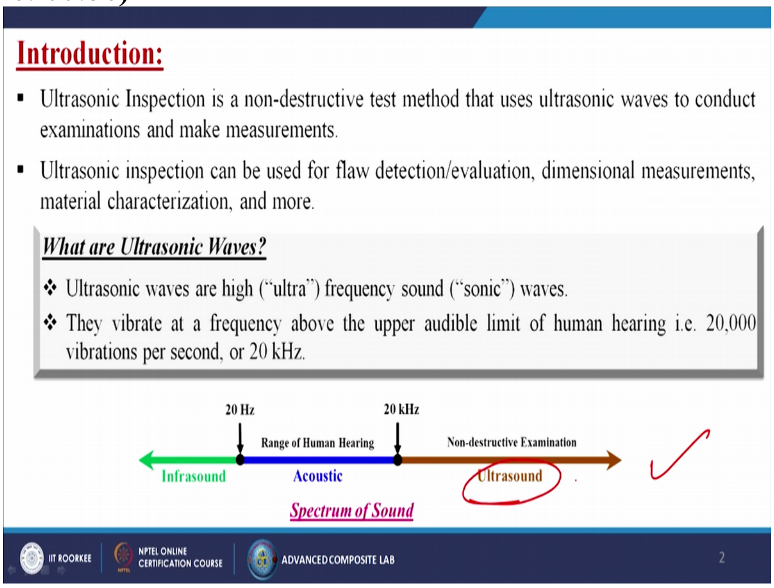

So generally the ultrasonic inspections can be used for the flaw detections or maybe the evaluations, dimensional measurements, that what is the sample weight or maybe the height or maybe the thickness, material characterizations and other more. Then what is the ultrasonic wave? Ultrasonic waves are high frequency sound waves so when I am talking about this particular chart so you can see that below 20 Hertz, generally you are calling it as a infrasound.

So from 20 Hertz to 20 kilo Hertz generally it is called the acoustic generally, within this range our ear can hear all the sounds over there, and if that sound in frequency is more than 20 kilohertz that time we are calling it as a ultrasound, and generally that frequency we are using for the non-destructive testing.

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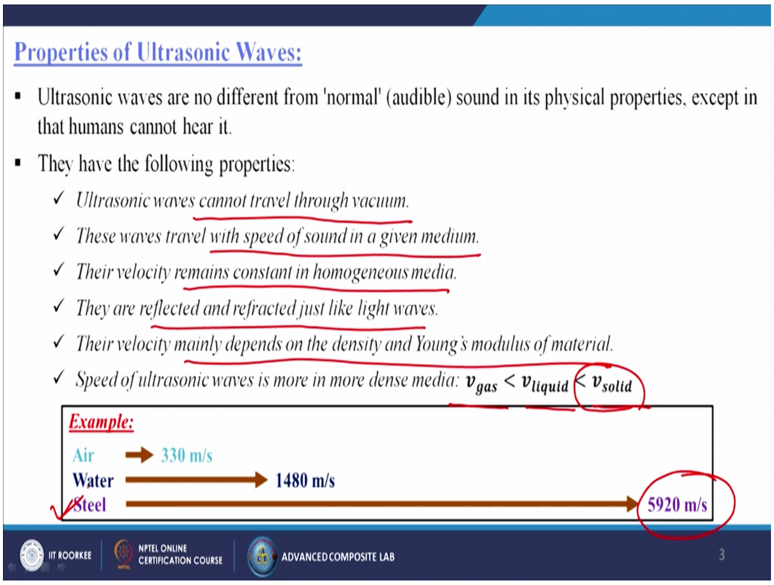

Properties of ultrasonic waves: So ultrasonic waves are no different from normal sound in its physical properties except in that humans cannot hear it. So it is beyond our audible capacity. They have the following properties. What are those? Ultrasonic waves cannot travel through the vacuum, so always it needs some media. These waves travel with speed of sound in a given medium. Their velocity remains constant in homogeneous media.

They are reflected and refracted just like the light waves that means, if I pass any kind of ultrasonic waves and if I am having one certain materials so it will come and it will be reflected or maybe the refracted through that particular surface. Their velocity mainly depends on the density and young modulus of materials. Speed of ultrasonic waves is more in more dense media, like so in this case you can see that velocity of solid is the maximum than the liquid and then liquid is maximum than the gas.

Examples, for air, the velocity are 330 meter per seconds, for water, it is 1480 meter per seconds, and for steel, it is 5920 meter per seconds. So in that case you can see that when you are talking about the solid that is like steel the ultrasonic wave's velocity is moved.

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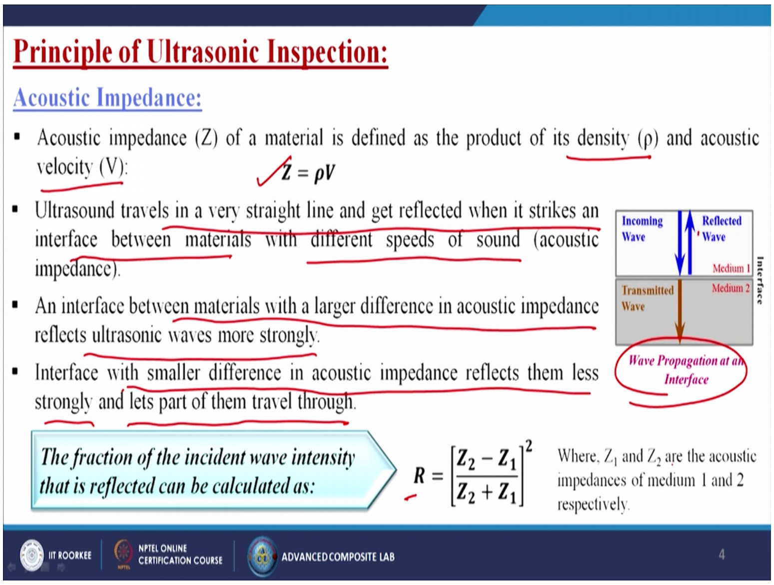

Now Principle of the Ultrasonic Inspections: First is called the Acoustic impedance. What is that? Acoustic impedance Z of a material is defined as the product of its density Rho and the acoustic velocity V. So simple generally we are calling acoustic impedance Z is equal to Rho and V. Ultrasound travels in a very straight line and get reflected when it strikes an interface between materials with different speeds of sound acoustic impedance.

An interface between materials with a larger difference in acoustic impedance reflects ultrasonic waves more strongly. So in this particular case, you can see we are having one medium and we are having another medium like medium 1 and medium 2. So, some incoming waves are coming, some is reflected and some is transmitted. So generally we are calling it as wave propagation, at an interface.

Interface with smaller difference in acoustic impedance reflects them less strongly and lets part of them travel through. The fraction of the incident wave intensity, that is reflected, can be calculated as capital R = Z 2 - Z 1 by Z 2 + Z 1 whole squared, where Z 1 and Z 2 are the acoustic impedance of medium 1 and 2 respectively.

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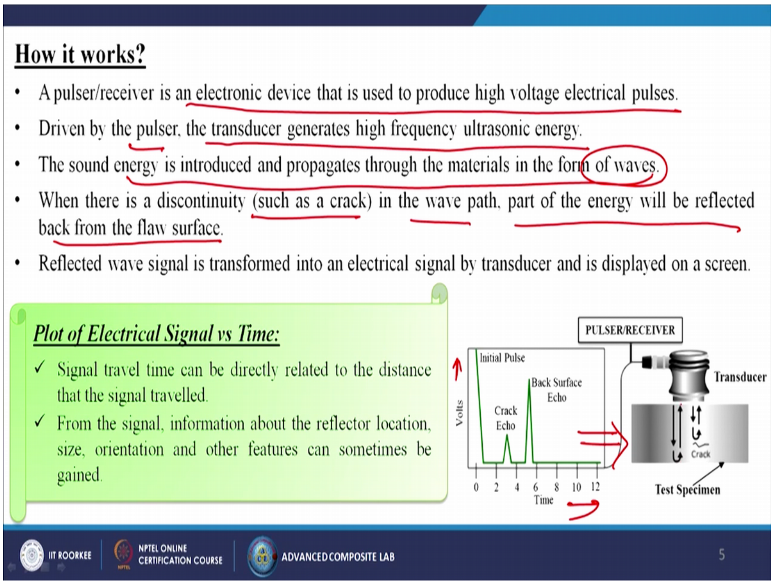

Now how it works basically the working mechanism so a pulser or receiver is an electronic device that is used to produce high voltage electrical pulses. Driven by the pulser, the transducer generates high frequency ultrasonic energy. So simple, I am having one probe, so simple, I am giving the current over there, and then after that, it is creating the ultrasonic pulse or maybe the energy. The sound energy is introduced and propagates through the material in the form of waves. When there is a discontinuity, such as a crack, in the way path, part of the energy will be reflected back from the flaw surface, otherwise it will go through the substance itself.

Plots of the electrical signal versus time, so if you see that electrical signals, that means, volts in the y-axis and time into the x-axis, signal travel time can be directly related to the distance that the signal traveled. So, initial pulse we have started and then it is coming down when the time is increasing, then cracks echo is taking place, back surface echo is taking place, so like this way. So now you can get or we easily correlate this plot with this image.

So when there is no crack so directly it is coming at the bottom of that surface, and then it is reflecting, and if there is any crack present in between the ah thickness, or maybe in between the surface, two surfaces, so automatically the waves are coming and it is reflecting from that particular point. So now if you calculate the time that how much time is required, so automatically can calculate, that what is the depth of your particular cracks are present.

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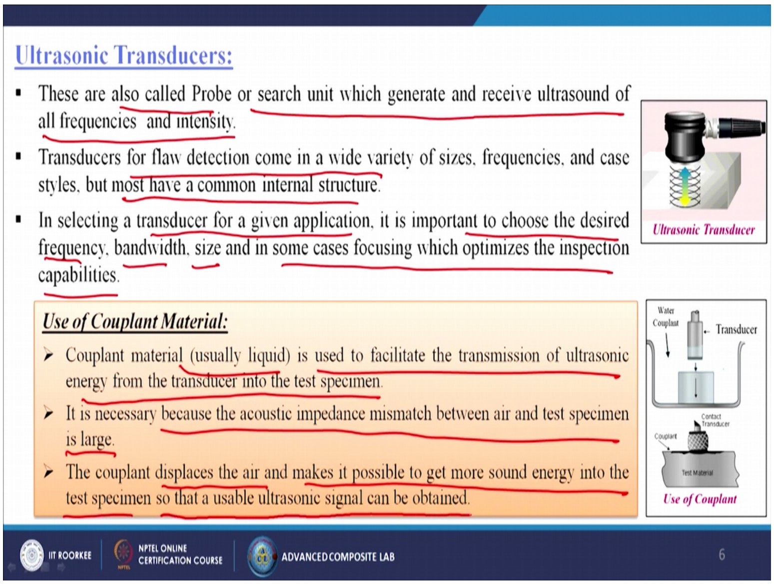

Ultrasonic Transducers, they are also called the probe or search unit which generate and receive ultrasound of all frequencies and intensity. Sometimes we are calling it as a probe or maybe the horn also. Transducers for flaw detection come in a wide variety of sizes, frequencies and case styles, but most have a common internal structure. In selecting a transducer for a given application, it is important to choose the desired frequency, bandwidth, size, in some cases focusing which optimizes the inspection capabilities.

Yes, suppose you are going to check the simple ship or maybe some complex shapes differ, depending upon that, you can choose your different size and types of your room. Use of coupling materials, coupling materials usually liquid is used to facilitate the transmission of ultrasonic energy from the transducer into the test specimen. It is necessary because the acoustic impedance mismatch between air and test specimen is large.

So that is why nowadays, you can see that this ultrasonic, we are using heavily for the medical purposes. We are doing the ultrasound testing and if you see properly that when we are doing that kind of testing, so we are having that probe and then which body part generally we are going to test, simple, we are rubbing that probe onto that surface. But not into the dry conditions because as I told already ultrasonic wave propagation is only required some media.

So, in that case what you are using, we are using some kind of gel kind of materials, so that simple, the ultrasonic wave directly through that gel it should pass your body. So the couplant displaces the air and makes it possible to get some sound energy into the test specimens so that a useable ultrasonic signal can be obtained. So now it is clear to us that what kind of medium generally we are using.

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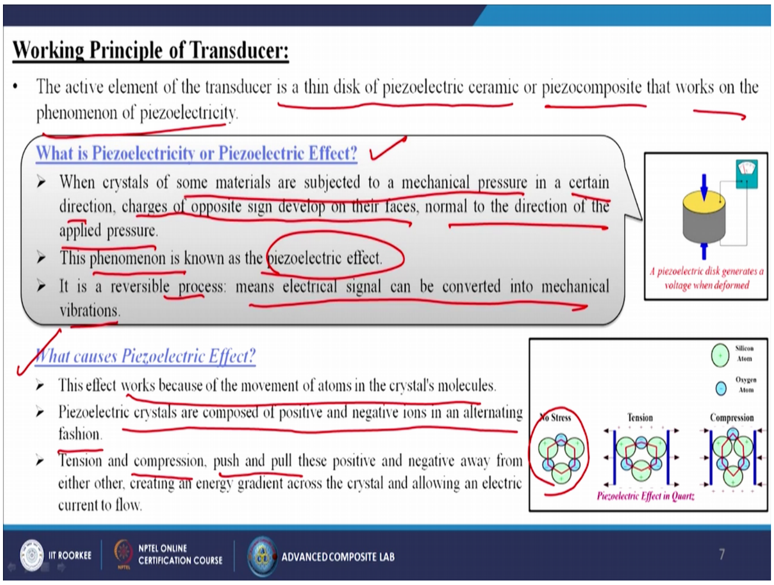

Working Principle of the Transducers: The active element of the transducers is a thin disc of piezoelectric ceramics or piezocomposite that works on the phenomenon of piezoelectricity. So generally we are using some kind of crystal kind of things over there. What is Piezoelectricity or maybe the piezoelectric effect? When crystals of some materials are subjected to a mechanical pressure in a certain direction, charges of opposite sign developed to their faces, normal to the direction of the applied pressure.

The phenomenon is known as the piezoelectric effect. It is a reversible process means, electrical signals can be converted into the mechanical vibrations. Simple, so we are having some kind of crystals, some crystals are naturally available, some crystals generally we are synthesizing in our lab itself. So these kind of crystals is having certain properties, that in a particular certain side or certain positions, if we give them the electrical energy, it will generate the mechanical vibrations or maybe if we give the mechanical vibrations, it will generate the electrical intensity or maybe the current.

What causes the piezoelectric effect? This effect works because of the movement of the atoms in the crystal molecules. Simple, the atoms will vibrate within its lattice parameter. Piezoelectric crystals are composed of positive and negative ions in an alternating fashion. Tensions and compressions push and pull these positive and negative away from either other, creating an energy gradient across the crystal and allowing an electric current to flow.
So in this particular case you can see this is very, very compactly bonded so there is no tress, stress. So, when we are giving the tension over there, so we are giving the current so, and then that time its atom is changing its place. So automatically it is generating the current at the time of tension and as well as the in the case of compression also.

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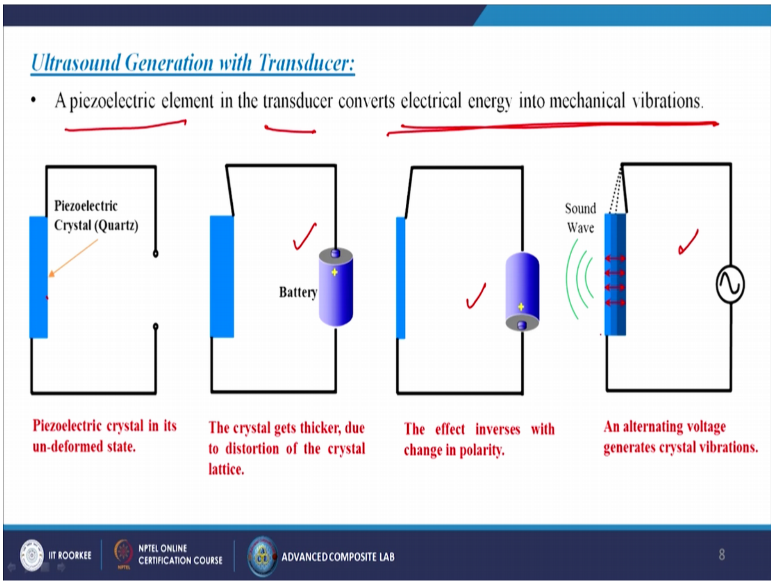

Now how we are generating the ultrasound with transducers a piezoelectric element in the transducers convert the electrical energy into the mechanical vibrations, that already I have described. So piezoelectric crystals it is like quartz, so now I am connecting with this one, with the battery, and then the effect of the inverse with the charging the polarity, and you can see an alternating voltage generates the crystal vibrations. So when we are giving the current, so automatically the vibration is taking place inside the crystal.

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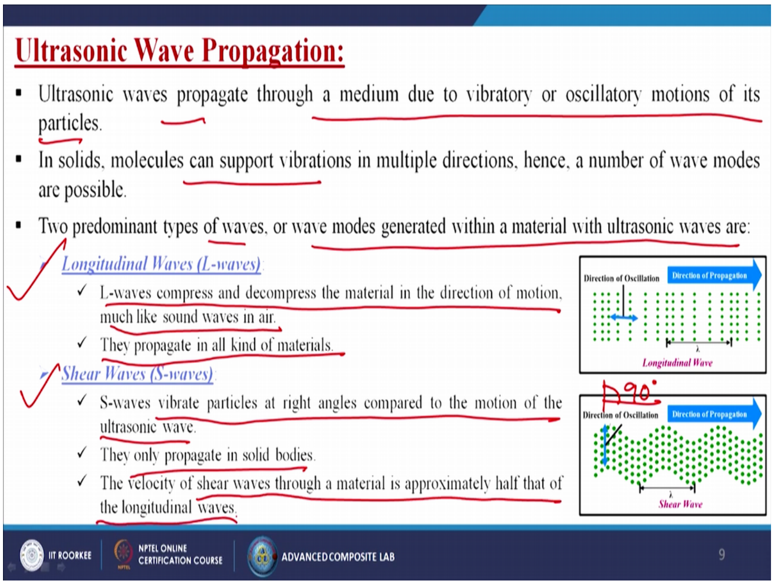

Now come to the ultrasonic wave propagation. Ultrasonic wave propagate through a medium due to vibratory or oscillating motions of its particles. In solids, molecules can support vibrations in multiple directions; hence a number of wave modes are possible, as I told already. When the atom or maybe the molecules will try to vibrate, so it will vibrate either maybe the longitudinal directions or maybe the horizontal directions or maybe in any other directions two predominant types of waves or wave modes generated within a material with ultrasonic waves are, longitudinal waves generally in short we are calling it as L waves and another one is called the Shear waves, in short, general you are calling it as a S waves.

So, L waves compress and decompress the material, in the direction of motion, much like sound waves in air. They propagate in all kind of materials. So this is known as the longitudinal wave. So this is the direct up propagation, direction of propagation, and here is the direction of oscillations. So you can see, that it is going, say suppose, I am giving the current over there and then it is deflecting in this particular manner, okay.

And one is the Shear waves, S waves vibrate particles at right angles compared to the motions of the ultrasonic wave. So simple, if I give the current the atoms will vibrate in two horizontal directions over there. So direction of propagation is in this way, and the direction of oscillations is in this way. So automatically it is create the 90-degree or maybe the perpendicular to each other. The only propagate in solid bodies, the velocity of shear waves, through a material, is approximately half that of the longitudinal waves. So that means the efficiency in the terms of longitudinal waves are more than the shear waves.

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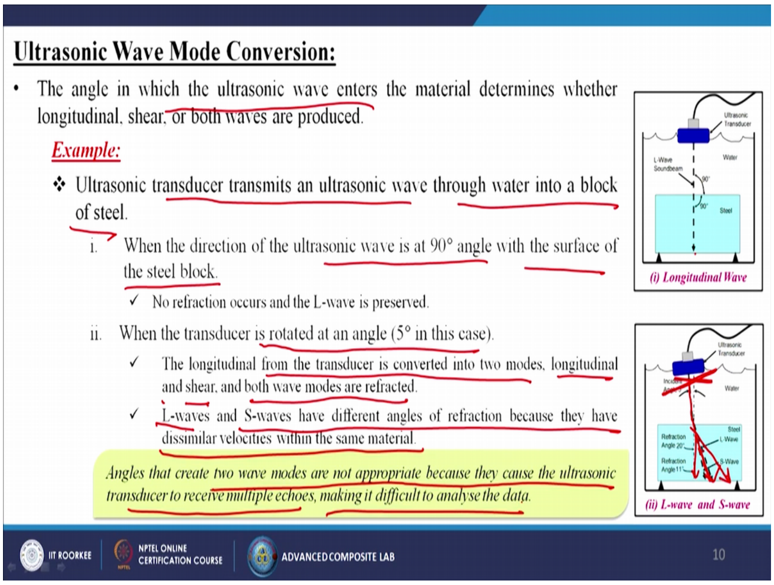

Now ultrasonic wave mode conversion: The angle in which the ultrasonic wave enters the material, determines whether the longitudinal, shear or both waves are produced. Example ultrasonic transducer transmits an ultrasonic wave through water into a block of steel. So when the direction of the ultrasonic wave is at 90 degree angle with the surface of the steel block, no reflection occurs, and the L wave is preserved.

So in this particular case you can see that from top, simple, the longitudinal waves are coming, and then up to the bottom and then it is reflecting back and again it is coming to the transducer itself or maybe that detector itself. When the transducer is rotated at an angle 5 degree in this case, so what is happening, the longitudinal form of the transducers is converted into two modes, one is the longitudinal, another one is the shear, both wave modes are refracted. So one it will come straight, another it will come into some angle, so one is the L and other one is the S wave over there.

So if it is become no angle over there, but when we are giving a angle over there. So automatically that this will also be deflected, so one will come in these directions and other will come into the these directions so one is called the L wave and other one is called the S wave, L waves and S waves have different angles of refraction because they have dissimilar velocities within the same material.

Angles that create two wave modes are not appropriate because they cause the ultrasonic transducer to receive multiple echoes, making it difficult to analyze the data, means there is a chance of the cross sensitivity or maybe the overlapping of the signals. So that time it is really difficult to segregate too.

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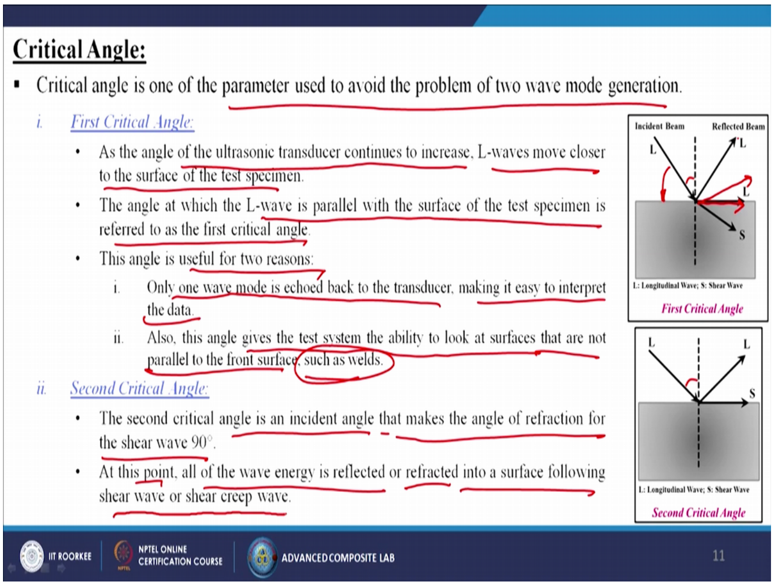

Now come to the critical angle. Critical angle is one of the parameter that used to avoid the problem of two wave mode generation. First is called the first critical angle, as the angle of the ultrasonic transducer continues to increases, L waves move closer to the surface of the test specimen. The angle at which the L wave is parallel with the surface of the test specimen is referred to as the first critical angle.

So you see, when we are giving that incident beam over there, now it is reflecting in this way, and some waves are passing at that just the surface of your particular materials. So that is known as the first critical angle, so if again we are going to increase/decrease this particular angle, so automatically these will come up to these positions. This angle is useful for two reasons. Only one wave mode is echoed back to the transducer, make it, easy making it easy to interpret the data, also these angles gives the test specimen system, the ability to look at surfaces that are not parallel to the front surface such as welds.

Now come to the second critical angle, the second critical angle is an incident angle that makes the angle of refraction for the shear wave 90 degree. At this point all the wave energy is reflected or maybe the refracted into a surface following shear wave or shear creep wave. So you see that L is coming in this particular case L wave but shear wave is passing through the system itself.

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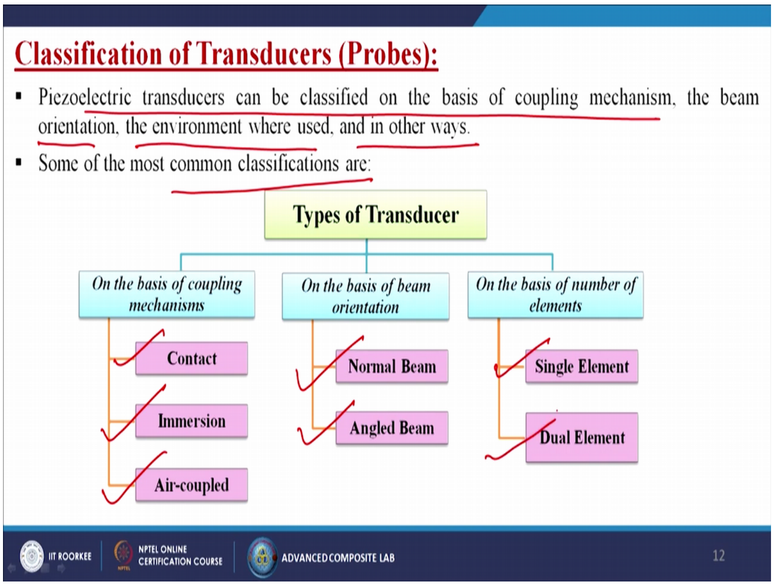

Now classification of the transducers or maybe the probe or as I told may be the horn. Piezoelectric transducers can be classified on the basis of coupling mechanism, the beam orientations, the environment where used and in other ways. Some of the most common classification types are, first one is called on the basis of coupling mechanisms, like contact, immersion or maybe the air coupled. On the basis of beam orientations either it may be the normal beam or may be the angled beam on the basis of number of elements, like single element and the dual element.

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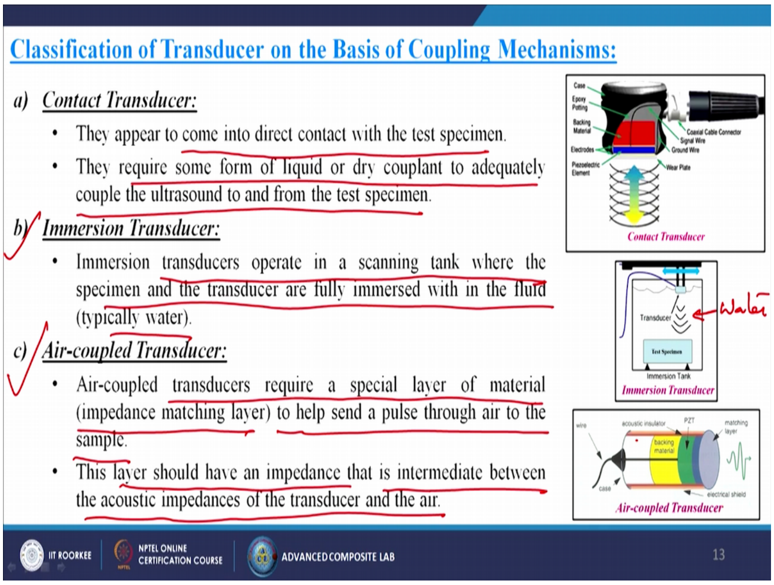

Classification of transducers on the basis of coupling mechanisms: So first is called the Contact Transducers. They appear to come into direct contact with the test specimens so in this case you are having the transducers and you are directly touching with your test surface or maybe the test specimen. They require some form of liquid or dry couplant to adequately couple the ultrasound to and from the test specimen itself.

Next one is called the immersion transducers, immersion transducers operate in a scanning tank where the specimen and the transducers are fully immersed with into the fluid typically into the water. So in this particular case, it is filled with the water itself. So now what is happening? So, your ultra sonic motion is coming, it is passing through the water, and then it is going inside your test specimen.

Next one is called the air coupled transducers. Air coupled transducers require a special layer of material that is impedance matching layer to help send a pulse through air to the sample itself. This layer should have an impedance that is intermediate between the acoustic impedance of the transducers and the air itself. So in this particular case, you can see, that we are having that where we are having that case, with the acoustic insulator, we are having the piezoelectric crystals, we are having the backing materials and this is the matching layer over there, and whole thing is called the electrical sealed. So this is called the air coupled transducers.

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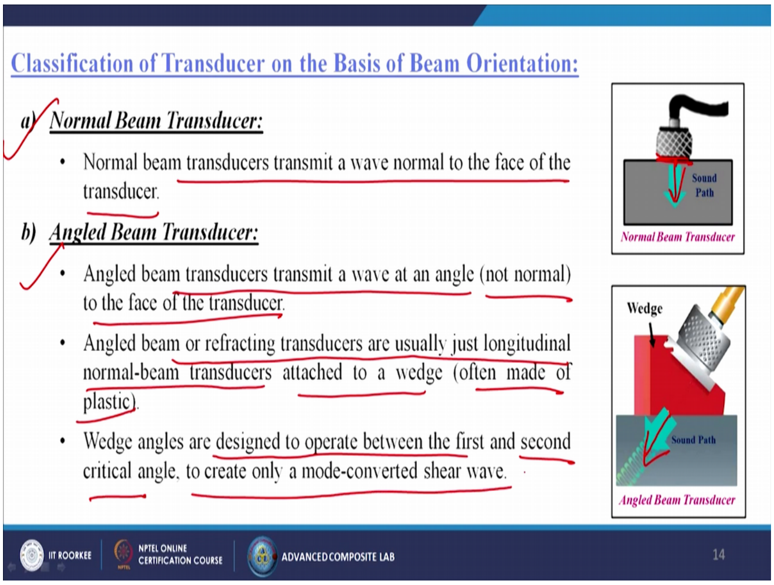

Classification of transducers on the basis of beam orientations: First one is called the Normal beam transducers. Normal beam transducers transmit a wave normal to the face of the transducer itself. So in this particular case, you can see that beams are coming in to these directions. So this is the face of the transducers. Next one is called the Angled beam transducers. So angled beam transducers transmit a wave at an angle not normal to the face of the transducers itself. So now we are having one wedge and the sound path it is coming in to these directions not like that normal, so it is creating certain angle, over there.

Angle beam of or refracting transducers are usually just longitudinal normal beam transducers attached to a wedge, often made of plastic. Wedge angles are designed to operate between the first and second critical angle, to create only a mode converted the shear wave.

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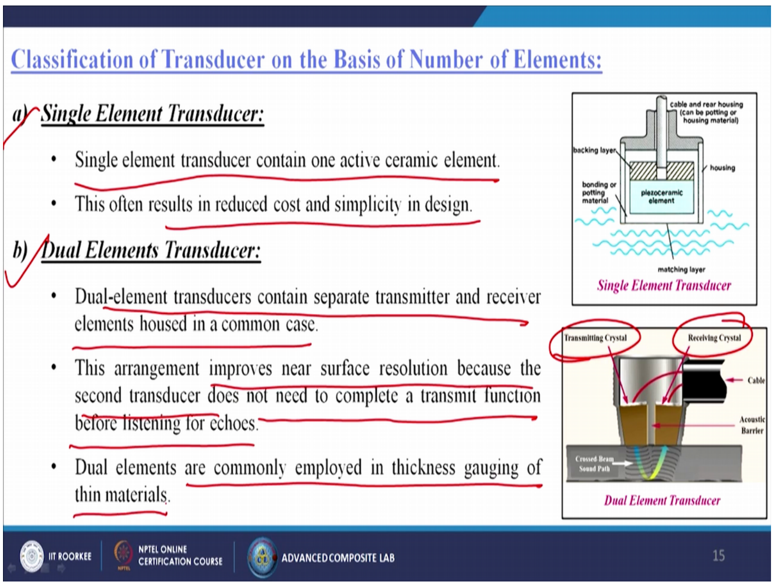

Next one is called the classification of transducers on the basis of number of elements. First one is called the Single Element Transducers. What is that? Single element transducers contain one active ceramic element. These often results in reduced cost and simplicity in design. Yes of course, if you want to increase the crystals number, so automatically the cost will increase and not only that the machine will not be or maybe the probe will not be the simple one. It will become that complex.

Next one is called the dual elements transducers. Dual element transducers contain separate transmitter and receiver elements housed in a common case. So in this case we are having two crystals, so one will be the transmitting crystals, another one is called the receiving crystals. So automatically in this particular case, your chance of getting the results more accurately is high. This arrangement improves near surface resolutions, because the second transducer, does not need to complete a transmit functions before listening for echoes. Dual elements are commonly employed in thickness gauging of thin materials.

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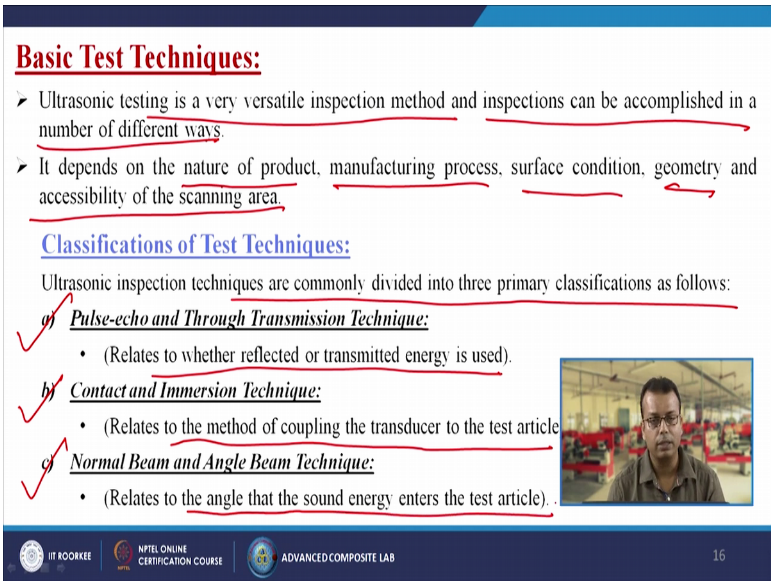

Next basic test techniques. Ultrasonic testing is a very versatile inspection method and inspections can be accomplished in a number of different ways. It depends on the nature of product, manufacturing process, surface conditions, geometry and accessibility of the scanning area. Classification of test techniques: Ultrasonic inspection techniques are commonly divided into three primary classifications as follows: Pulse Eco and Through Transmission Technique relates to whether reflected or transmitted energy is used.

Contact and Immersion technique relates to the method of coupling the transducer to the test articles, and the third one Normal beam and the Angle beam technique relates to the angle that the sound energy enters the test article or maybe the specimen.

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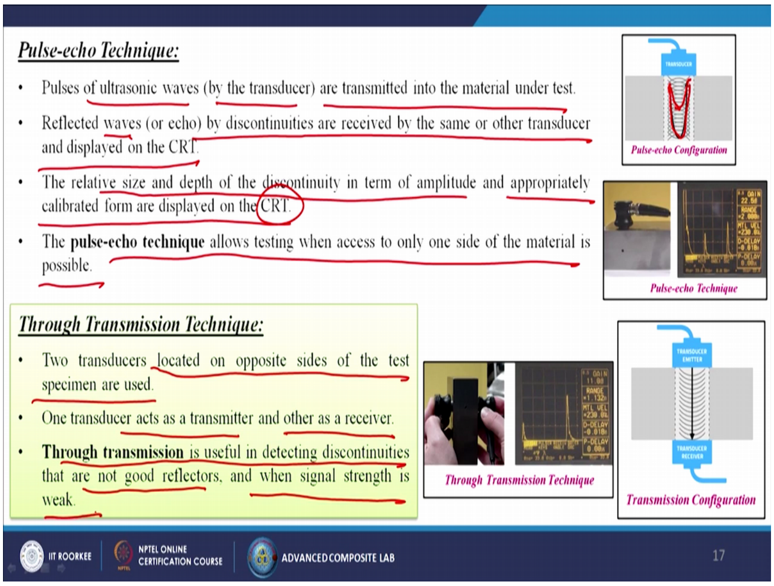

First one is called the Pulse Echo technique. So, Pulses of Ultrasonic waves by the transducers are transmitted into the material under test. Reflected waves or echo by discontinuities are received by the same or other transducers and displayed on the CRT screen. So in this case, you can see, that pulse are coming, and then it is reflecting from the bottom if there is no crack, if there is certain cracks so automatically it will be reflecting from that particular crack point.

The relative size and depth of the discontinuity in terms of amplitude and approximate appropriately calibrated forms are displaced on the CRT screen. The pulse echo technique allows testing when access to only one side of the material is possible. Through transmission technique, two transducers located on the opposite sides of the test specimens are used. One, transducers acts as transmitter and others as receiver. Through transmissions is useful in detecting discontinuities that are not good reflectors and when signal strength is very very weak.

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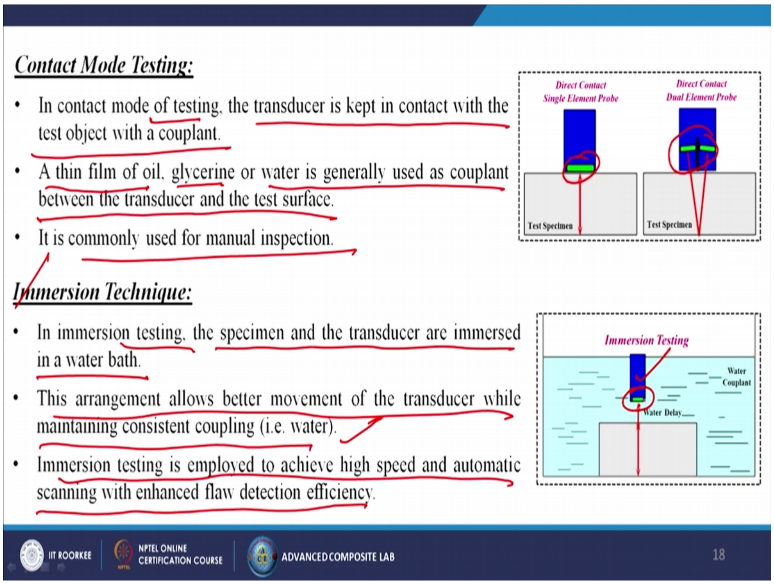

Next Contact Mode Testing: In contact mode of testing, the transducers has kept in contact with the test object with a couplant. A thin film of oil, glycerine or water is generally used as couplant between the transducers and the test surface. It is commonly used for the manual inspection. So in this particular case, you can see, that we are having that direct contact single element probe over there, we are having that test specimen, so it is a single crystal. In this case, we are using the dual crystal. One is the transmitter another one is the receiver.

Next one is called the immersion technique. In immersion testing, the specimen and the transducers are immersed in a water bath. This arrangement allows better movement of the transducer while maintaining consistent coupling that is water. Immersion testing is employed to achieve high-speed and automatic scanning with enhanced flaw detection efficiency.

So you see, this is our probe having the single crystals, now the whole systems we have dipped into the water, and there is no direct contact in between your transducers and your materials or maybe the specimen, so simple, you are generating the ultrasonic wave from here and through the water it is coming inside the materials and reflecting back.

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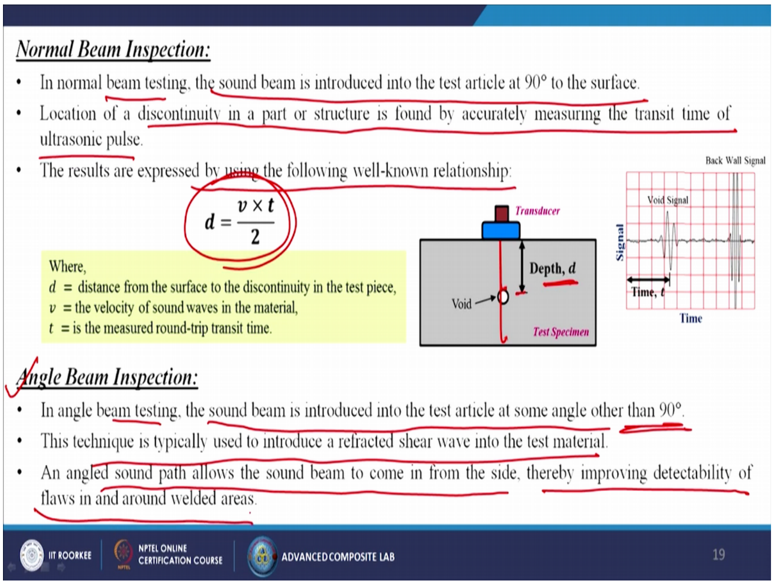

Now come to the normal beam inspections. In normal beam testing, the sound beam is introduced into the test article at 90 degrees to the surface itself. Location of a discontinuity in a part or structure is found by accurately measuring the transit time of the ultrasonic pulses, as I told already, the results are expressed by using the following well-known relationship, what is that, that is the famous relationship, that is called the small d is equal to small v into t by 2, where d is the distance from the surface of the discontinuity in the test piece.

So here you can see this is the d. v is the velocity of the sound waves in the material itself, t is the measured round-trip transit time. So what time? It is required to go back. Angle beam inspections: In angle beam testing, the sound beam is introduced into the test article at some angles other than 90 degrees. This technique is typically used to introduce a refracted shear wave into the test material. An angled sound path allows the sound beam to come in from the side, thereby improving detectability of flaws in and around the welded parts.

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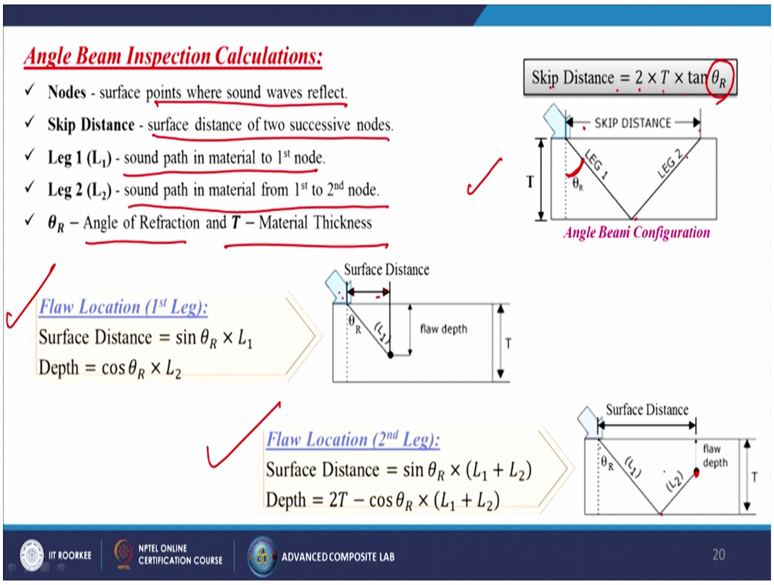

Now come to the angle beam inspection calculations. So this is the case over there. So first let us know about the nodes. Surface points where sound waves reflects, that is called the nodes. Skip distance, surface distance of two successive nodes leg1 or maybe the L1, sound path in material to first node leg2 or maybe the L2, sound path in material from first to second node Theta R, angle of refraction and T is the material thickness.

So, now in this case, we are having one leg one, so when it is coming and then deflecting it is the leg2, so this is the skip distance over there. So what is the skip distance, that is equal to 2 into capital T into Tan theta R. So this is the angle, is the theta R, that is the incident angle over there. And what is that capital T that is the thickness of your particular material.

Now flaw locations for the first leg surface distance sine theta R into L1, Depth cos theta R into L2. So this is the surface distance over there. So you can by trigonometric calculations you can easily calculate that what is the distance and how much is the depth flaw detection for the second leg. So in this particular case, it is coming over there, and then there is certain crack is generated over there. So, sine theta R into L1 + L2, depth 2T - cos theta R into L1 + L2 so by this case also, you can easily calculate the actual point.

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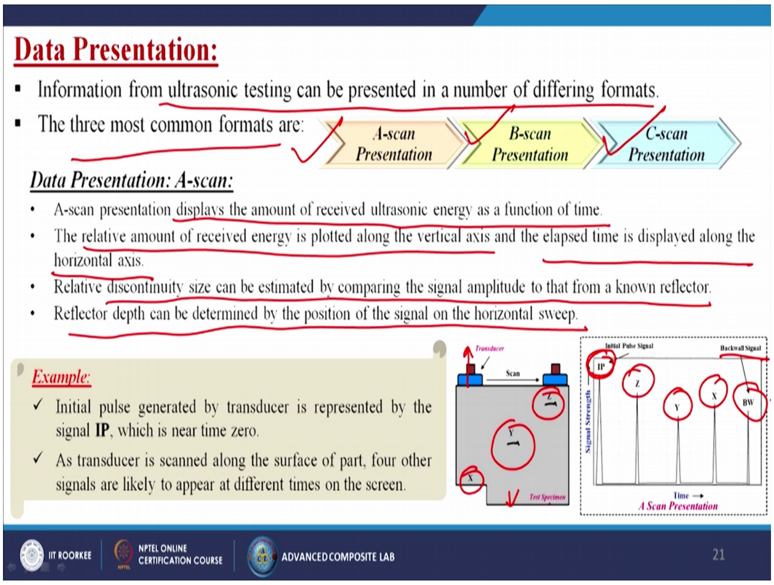

Now Data Presentations: Information from ultrasonic testing can be presented in a number of defracting or maybe the differing formats. The three most common formats are A-scan presentations, B-scan presentations and the C-scan presentations. Data presentations for A-scan: A-scan presentation displays the amount of received ultrasonic energy as a function of time. The relative amount of received energy is plotted along the vertical axis and the elapsed time is displayed along the horizontal axis.

Relative discontinuity size can be estimated by comparing the signal amplitude to that from a known reflector. Reflector depth can be determined by the position of the signal on the horizontal sweep. Examples: So now we are having on transducers, here that is transmitter, another one we are having the receiver. An initial pulse generated by the transducers is represented by the signal IP which is near time zero. As transducer is scanned along the surface of part, four other signals are likely to appear at different times on the screen itself.

So that is for the IP when it is directly coming at the bottom then Z Y X and the BW, that is nothing but called the back wall signal. So one it will come, and then back wall signal, and then it is about the Y, it is about the Z, it is about the X, and another one is coming to the back wall signal. So one will be reflected from here that is known as the IP, one will be reflected from here that is known as the BW.

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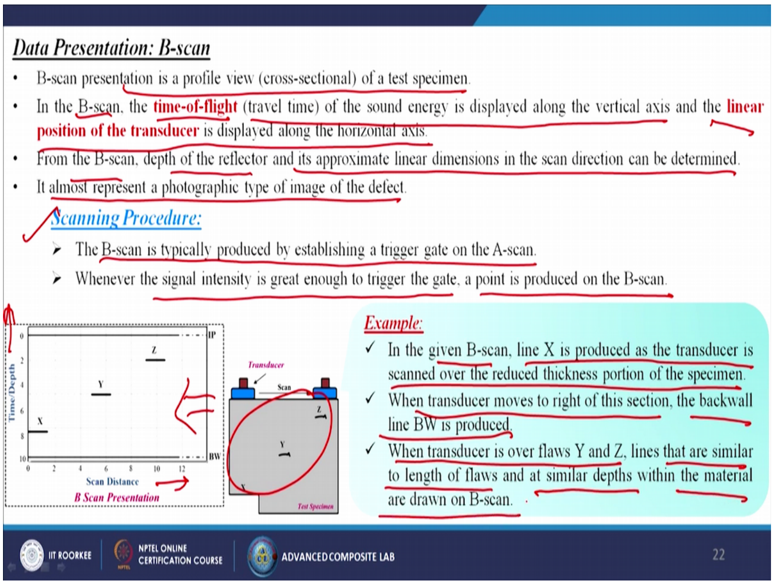

Data presentations B-scan: B scan presentations are a profile view cross-sectional of a test specimen. So in the B-scan, the time of flight travel time of the sound energy is displayed along the vertical axis and the linear position of the transducers is displayed along the horizontal axis. From the B-scan, depth of the reflector and its approved summate linear dimensions in the scan deflection direction can be determined. It almost represents a photographic type of image of the defect.

Scanning Procedure: The B-scan is typically produced by establishing a trigger gate on the A-scan. Whenever the signal intensity is great enough to trigger the gate a point is produced on the B scan itself. So now, you can see, in the x-axis we are giving the scan distance and in the y-axis we are giving the time by depth. So now we are having that XY and Z and the IP point and this one is the back wall. So here the situation is looks like this and you are getting the information in this way.

Example: In the given B scan, line X is produced as the transducer is scanned over the reduced thickness portions of the specimen. When transducer moves to the right of this section, the back wall line BW is produced. When transducers is over flows Y and Z lines that are similar to length of flaws and at similar depths within the material are drawn on B-scan.

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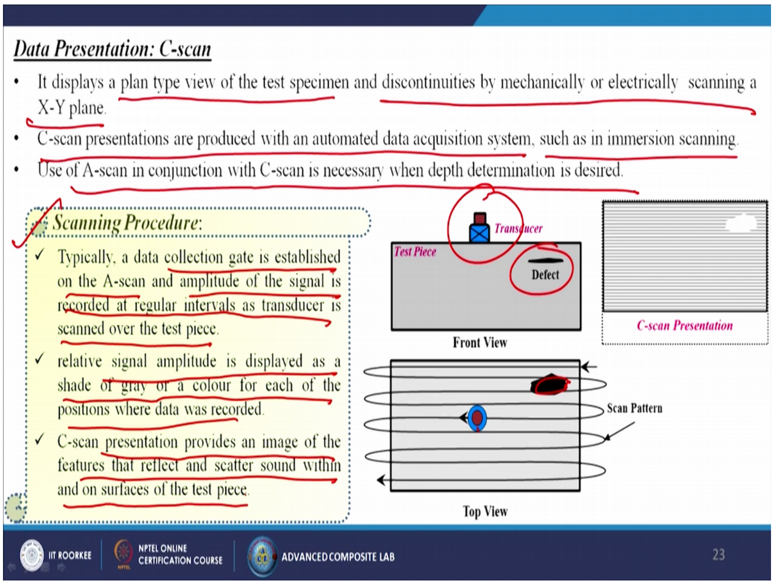

Data presentations C-scan: It displays a plan type view of the test specimens and discontinuities by mechanically or electrically scanning a XY plane. C-scan presentations are produced with an automated data acquisition system, such as an in immersion scanning. Use of A-scan in conjunction with C scan is necessary when depth determination is desired. Scanning Procedure: Typically a data collection gate is established on the A-scan and amplitude of the signal is recorded at angular regular intervals as transducer is scanned over the test pieces.

So now this is your transducer, this is your test piece, and defects are present over there. So now from the top B we are seeing that this is the transducer and this is your crack or maybe the defects. Relative signal amplitude is displayed as a shade of gray or a color for each of the positions where the data was recorded. C-scan presentation provides an image of the features that reflect and scatter sound within and on surface of that test piece.

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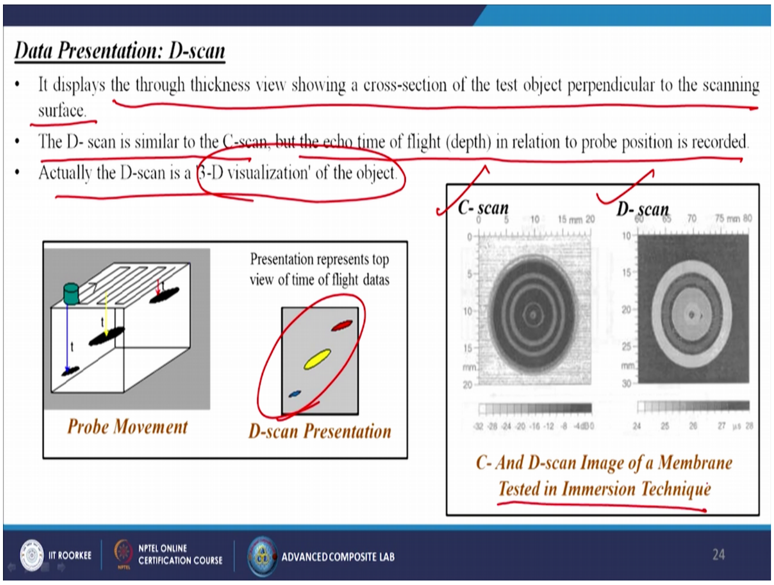

Next come to the Data presentations D-scan: It displays the through thickness view showing a cross-section of the test object perpendicular to the scanning surface. The D-scan is similar to the C-scan, but the echo time of the flight in relation to the probe positions is recorded. Actually the D-scan is a 3D visualization of the object. So by this, can type, you can get the more accurate, your result. So probe movement is taking place, in these directions and the disc and presentation the result will come in this manner. So this is the difference of the C-scan and the D-scan. C and D scan image of the membrane tested in a immersion techniques.

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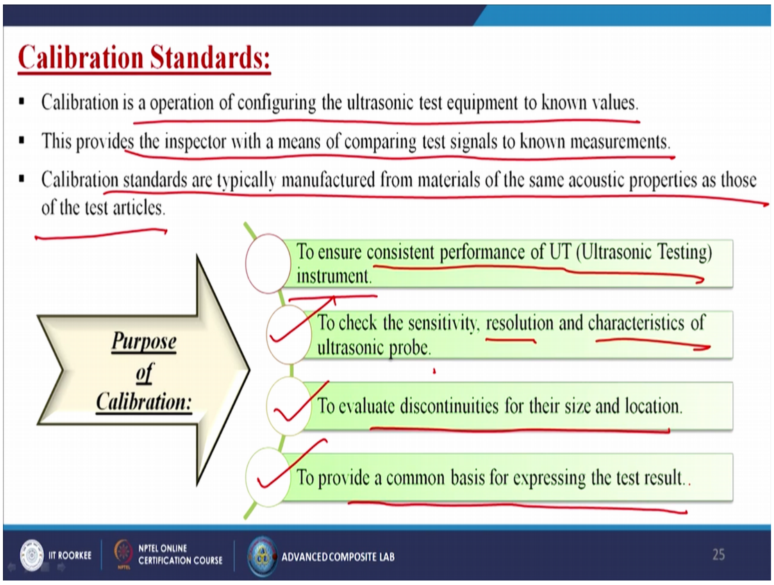

Next Calibration Standards: Calibration is the operation of configuring the ultrasonic test equipment to the known values. This provides the inspector with a means of comparing test signals to known measurements. Calibration standards are typically manufactured from materials of the same acoustic properties as those of the test articles. Purpose of the Calibrations: To ensure consistent performance of ultrasonic testing instrument to check the sensitivity resolution and characteristics of the ultrasonic probe. To evaluate the discontinuities for their size and locations to provide a common basis for expressing the test result.

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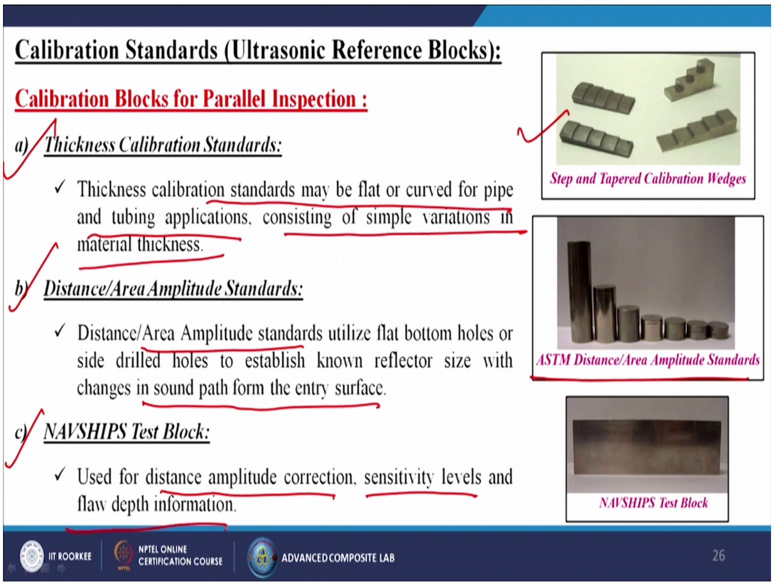

Next Calibration Standards Ultrasonic Reference Blocks: Calibration blocks are parallel for parallel inspection. First one is called the, Thickness Calibration Standards. Thickness calibration standards may be flat or curved for pipe and tubing applications consisting of simple variations in the material thickness. Here you can see Step and Tapered calibration wedges. So simple, we are having that known time for that particular materials, so when you are using that probe after certain time, we need to recalibrate it or check that whether it is giving the exact result or not.

So that is why after a certain time, regular basis, or maybe the regular interval, we need the calibration testing. Second, Distance and Area Amplitude standards: Distance or area amplitude standards utilize flat bottom holes or side drilled holes to establish known reflector size which changes in sound path from the entry surface over there. Here you can see ASTM distance and area amplitude standards, so many. Third one is called that NavShips Test Block, used for distance amplitude correction, sensitivity levels, and the flaw depth information. So this is known as the navships test block.

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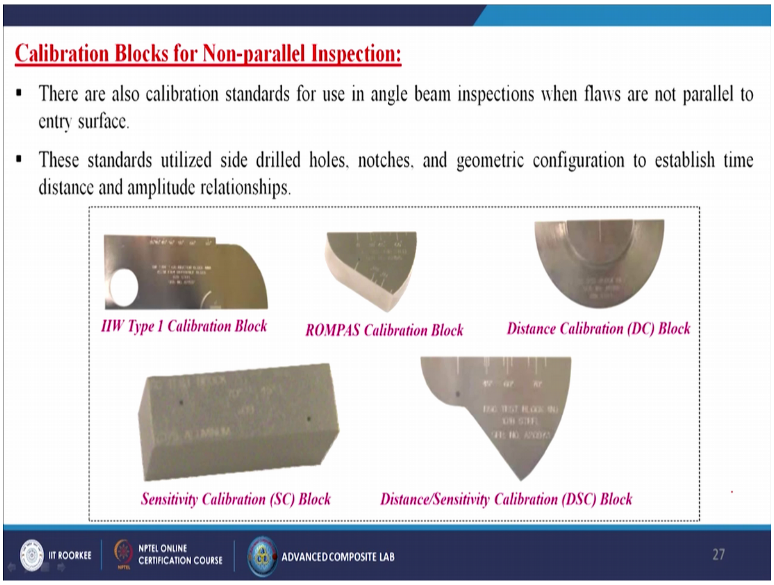

Calibration blocks for the Non parallel Inspections: There are also calibration standards for using angle beam inspections when flaws are not parallel to the entry surface. These standards utilize side drilled holes, notches, and the geometric configuration to establish time distance and amplitude relationships. Here you can see that, we have given so many examples of different calibration blocks for some kind of abnormal surfaces or maybe the irregular surfaces.

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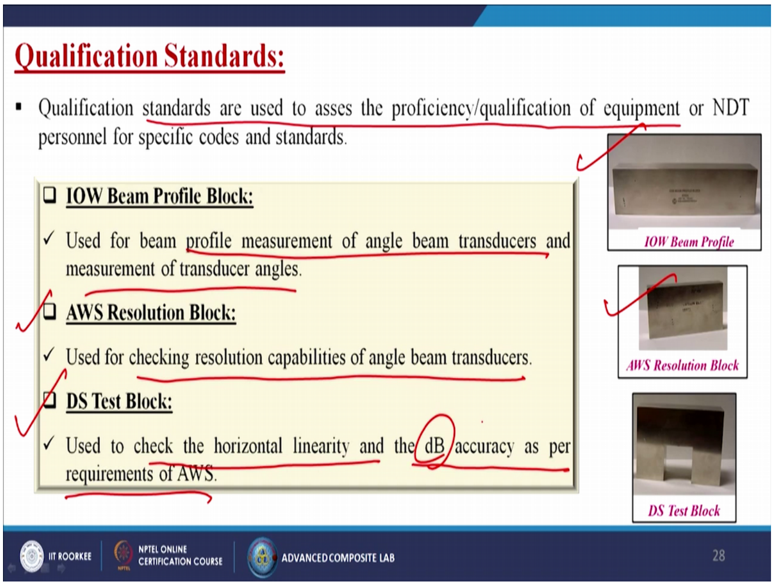

Now come to the qualification standards. Qualification standards are used to assess the proficiency or maybe the qualification of equipment or NDT personnel for specific codes or standards. Specific codes and standards: First one is called the IOW beam profile block. So this is the IOW beam profile used for beam profile measurement of angle beam transducers and measurement of transducer angles. Second one is called the AWS Resolution block. So this is the AWS resolution block, used for checking resolution capabilities of angle beam transducers. Third one is called the DS test block, used to check the horizontal linearity and that dB frequency as per requirements of the AWS. dB is nothing but the unit of the sound, that is the boon.

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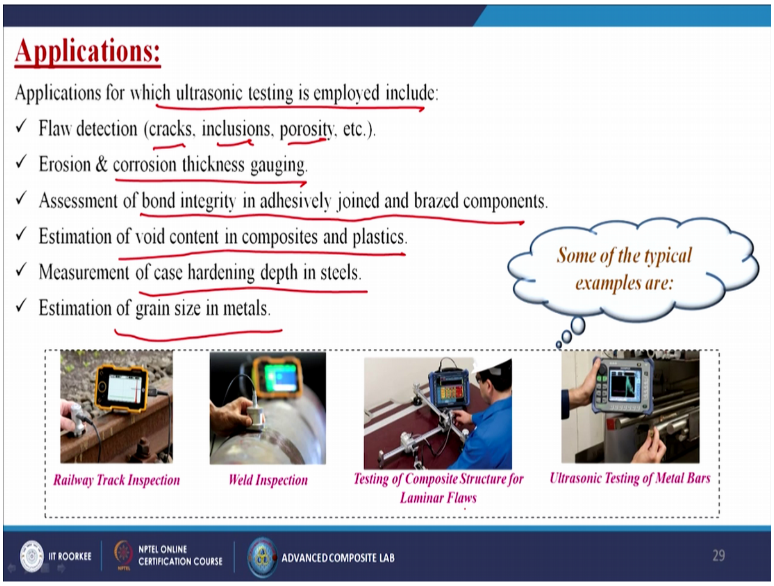

Applications: Applications for which ultrasonic testing is employed include, Flaw detections like cracks, inclusions, porosity, erosion, or maybe the corrosion thickness gauging. Assessment of bond integrating in adhesively joined and brazed components, say suppose, I am doing the coating or maybe I am sticking on materials and top of that. So what is the position of the interface, if there is any bubble formation or cracks are present or maybe there is some kind of denominations. So this kind of loss, generally, we can measure by these particular techniques.

Estimations of void content in composites and the plastics: Measurement of case hardening depth in steels, estimation of grain size in metals so like this way, we are doing the railway track inspections, if inside that path, if there is any cracks has been generated or not, weld inspections we are doing, testing of composite structures for laminar flaws, we are doing ultrasonic testing of the metal bars and nowadays widely we are using it for the medical purposes.

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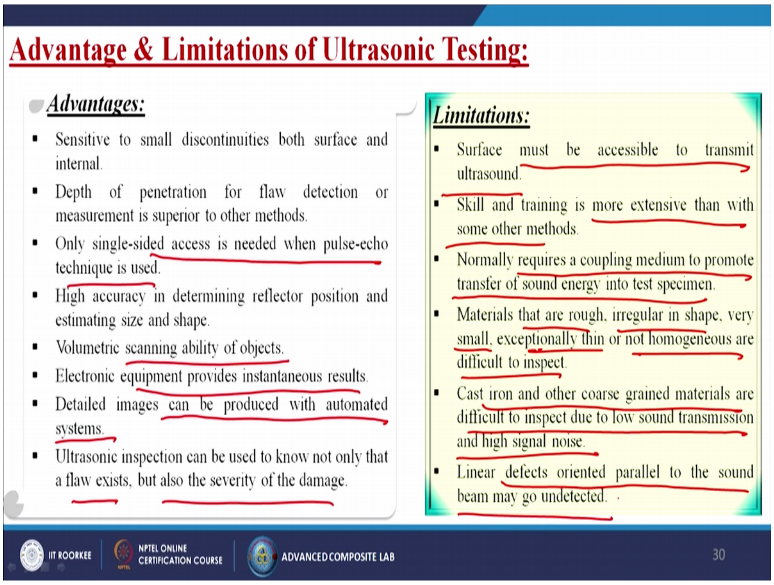

Now what are the advantages and limitations of ultrasonic testing? Advantages are, Sensitive to small discontinuities both surface and the internal. Depth of penetration for flaw detection or measurement is superior to other methods. Only single sided access is needed when pulse echo techniques is used. High accuracy, in determining reflector positions and estimating size and shape, volumetric scanning ability of objects, electronic equipment provides instantaneous results. Detailed images can be produced with automated systems.

Ultrasonic inspection can be caused to know not only that a flaw exists, but also the severity of the damage itself. But of course there is certain limitation. What are those? Surface must be accessible to transmit ultrasound, transmit ultrasound. Skill and training is more extensive than the or maybe than with some other methods. Normally requires a coupling medium to promote transfer of sound energy into test specimen.

Materials that are rough, irregular in shape, very small, exceptional thin, or not homogeneous are difficult to inspect. Cast iron and other coarse grain materials are difficult to inspect due to low sound transmission and high signal noise. Linear defects oriented parallel to the sound beam may go undetected.

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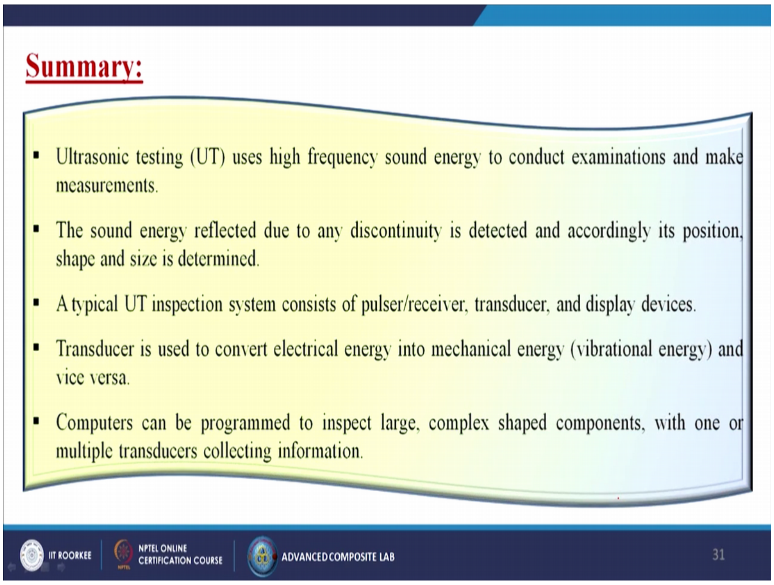

So now we have come to the last light of this particular lecture. So in summary, we can say that Ultrasonic testing uses the high frequency sound energy to conduct the examinations and make measurements. That already we have gone through. The sound energy reflected due to any discontinuity is detected and accordingly its position shape and size is determined. That also we have taken into consideration, that how we can calculate, how you can get the information.

A typical ultrasonic testing inspection system consists of pulser oblique receiver, transducers and the display device CRT screen. Transducer is used to convert electrical energy into mechanical energy, vibrational energy, and vice versa. Computers can be programmed to inspect large complex shaped components with one or more multiple transducers collecting information. Thank you.