Ultrasound Test

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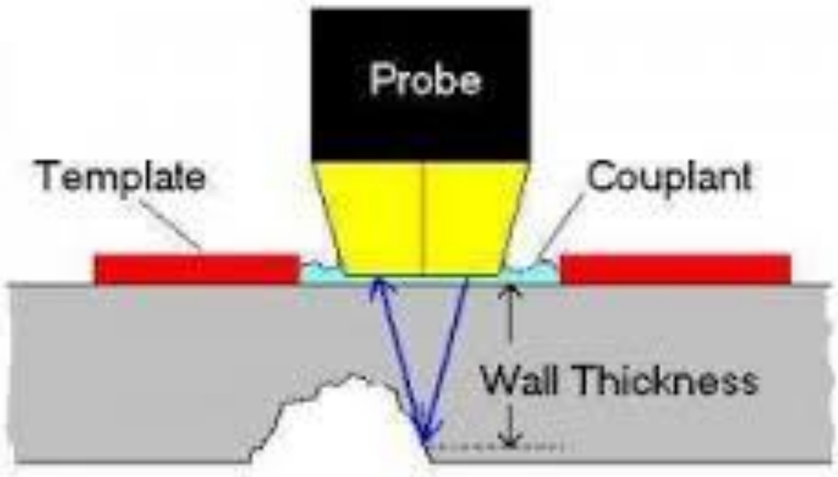
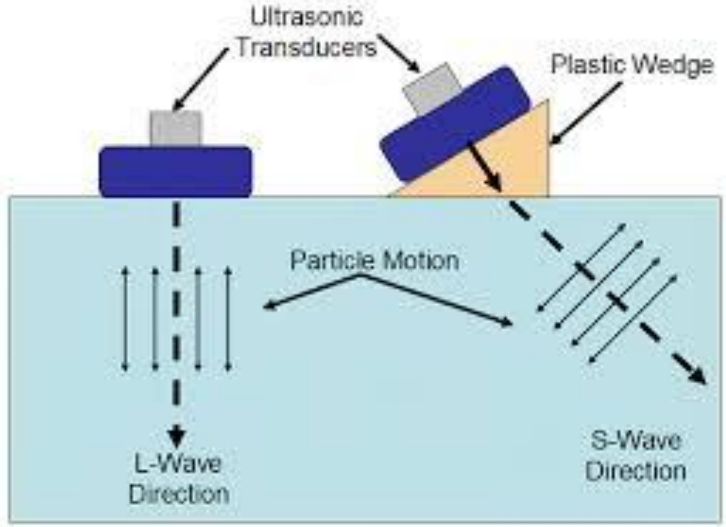
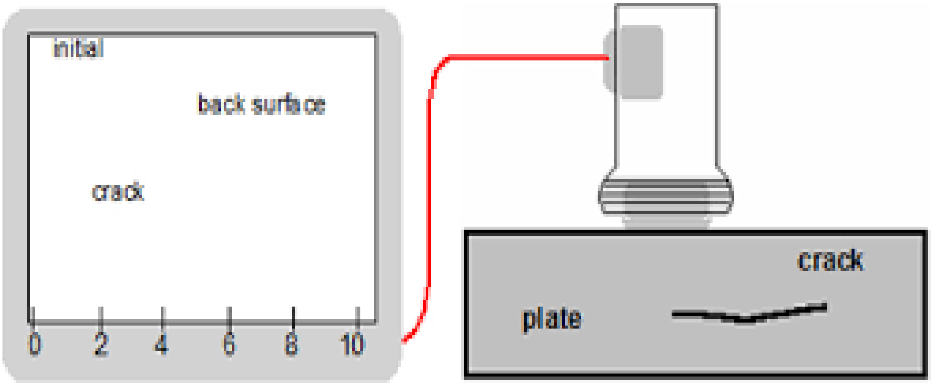
Ultrasonic testing

- Ultrasonic testing (UT) is a family of non-destructive testing techniques based on the propagation of ultrasonic waves in the object or material tested. In most common UT applications, very short ultrasonic pulse-waves with center frequencies ranging from 0.1-15 MHz, and occasionally up to 50 MHz, are transmitted into materials to detect internal flaws or to characterize materials. A common example is ultrasonic thickness measurement, which tests the thickness of the test object, for example, to monitor pipework corrosion.
- Ultrasonic testing is often performed on steel and other metals and alloys, though it can also be used on concrete, wood and composites,


Probe
Template
Couplant
Wall Thickness

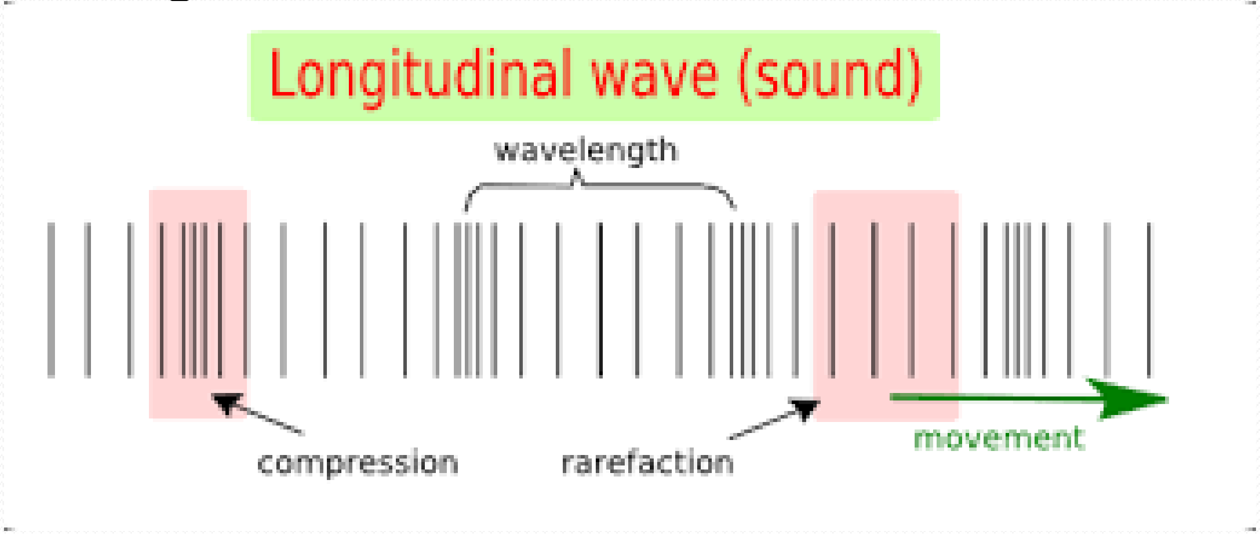

Ultrasonic Transducers
Plastic Wedge
Particle Motion
L-Wave Direction
S-Wave Direction


initial
back surface
crack
0
2
4
6
8
10
crack
plate

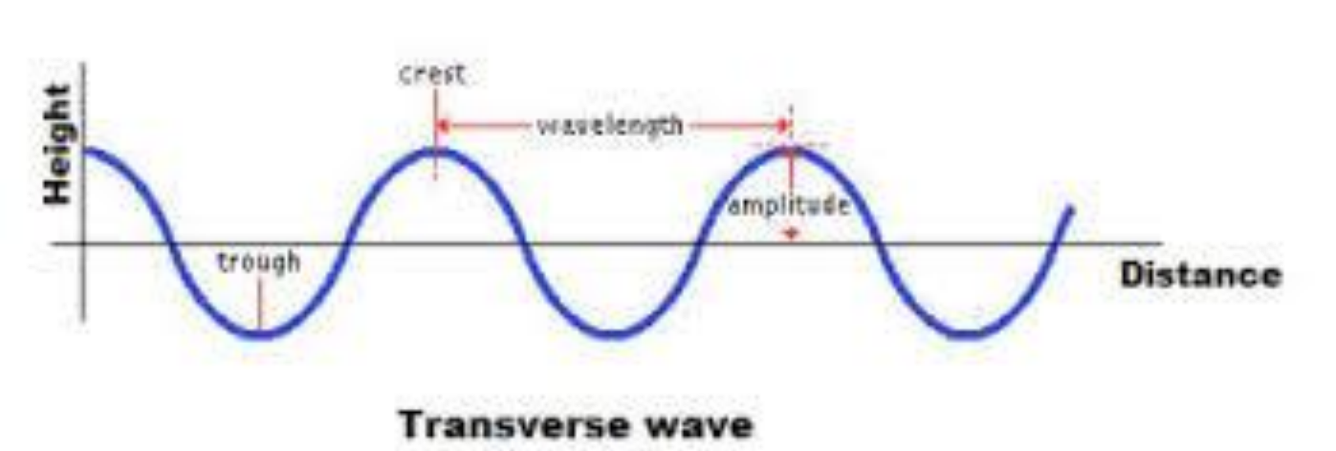
- Types of waves

There are three types of waves:

- **1)The longitudinal wave:** is a wave in which the center molecules fluctuate around their equilibrium positions in the direction of the propagation of the waveform and consist of compressions and indentations. The longitudinal waves are divided into two main parts: electromagnetic waves and mechanical waves. The majority are mechanical waves, since electromagnetic waves are essentially transverse waves, but in rare cases and under special conditions (such as in a plasma wave) electromagnetic waves can propagate in the form of longitudinal waves.

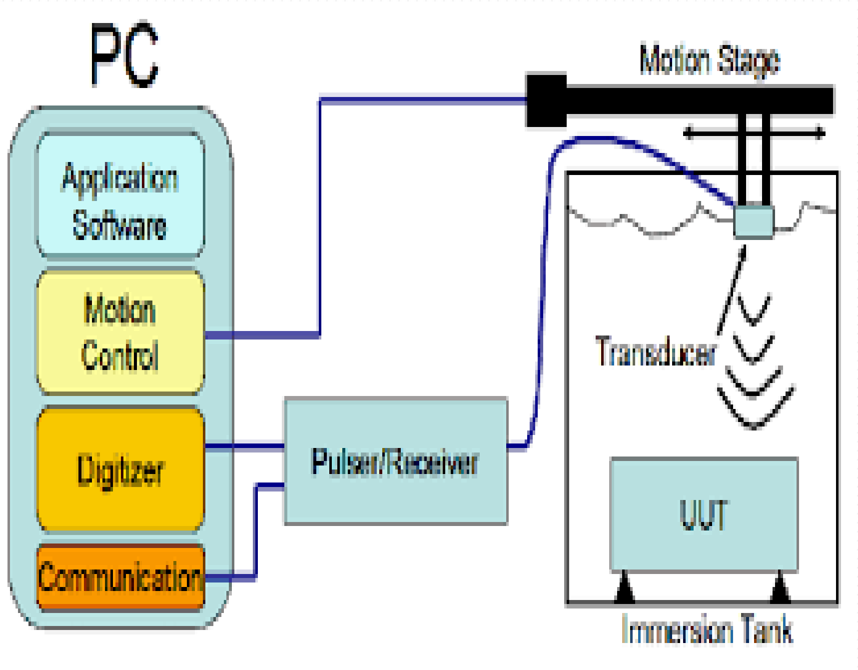


- **2)The transverse wave**: is a moving wave consisting of vertical frequencies on the wave propagation direction. The transverse wave consists of peaks and bottoms. The most frequent waves are water waves and electromagnetic waves. The wavelength of the transverse wave is the distance between two successive peaks or two consecutive floors or between any two consecutive points of the same phase (same speed, same capacity and same direction)



- **3)Surface wave**: is a mechanical wave that is spread among different circles. A common example of this is the wave of gravity on the surfaces of liquids such as ocean waves. The gravitational wave can also propagate in the interstellar medium of different density fluids. The flexible surface wave can be spread on surfaces of solids such as Rayleigh waves. Electromagnetic waves can also propagate as surface waves in the interstitial surfaces of materials that have a different electrostatic insulation constant. When the radio is transmitted, a ground wave propagates near the earth's surface.

- **Components of the ultrasonic device**
- **Ultrasonic devices consist of the following main parts:**
- 1. The probe.
- 2. Central control unit.
- 3. Pulse control unit.
- 4. Display Screen.
- 5. Keyboard and mouse.
- 6. Volume.
- 7. Printer



Ultrasonic thickness measurement

- In the field of industrial ultrasonic testing, **ultrasonic thickness measurement (UTM)** is a method of performing non-destructive measurement (gauging) of the local thickness of a solid element (typically made of metal, if using ultrasound testing for industrial purposes) basing on the time taken by the ultrasound wave to return to the surface. This type of measurement is typically performed with an ultrasonic thickness gauge.
- Ultrasonic waves have been observed to travel through metals at a constant speed characteristic to a given alloy with minor variations due to other factors like temperature. Thus, given this information, called celerity, one can calculate the length of the path traversed by the wave using this simple formula:
- $l_m = c\,t / 2$

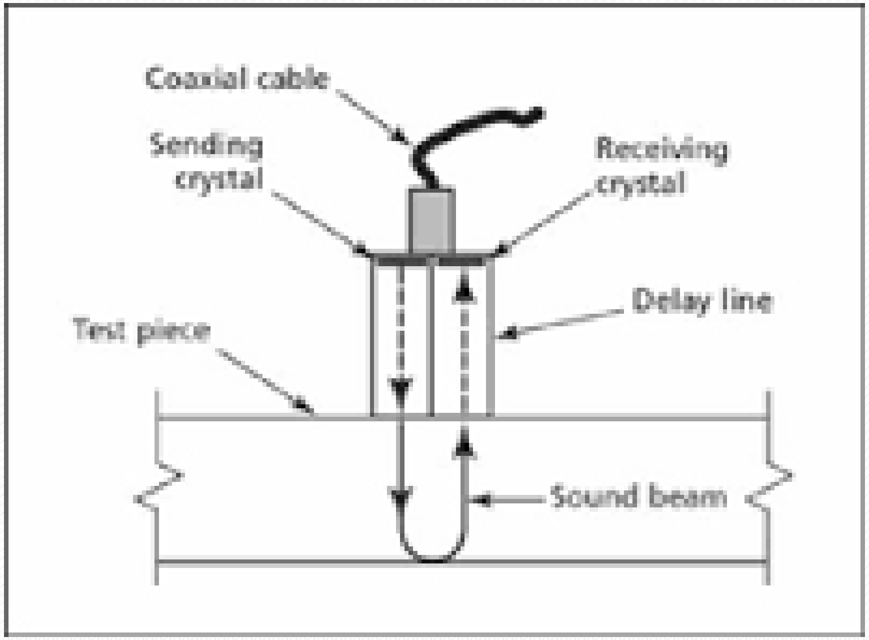
  where

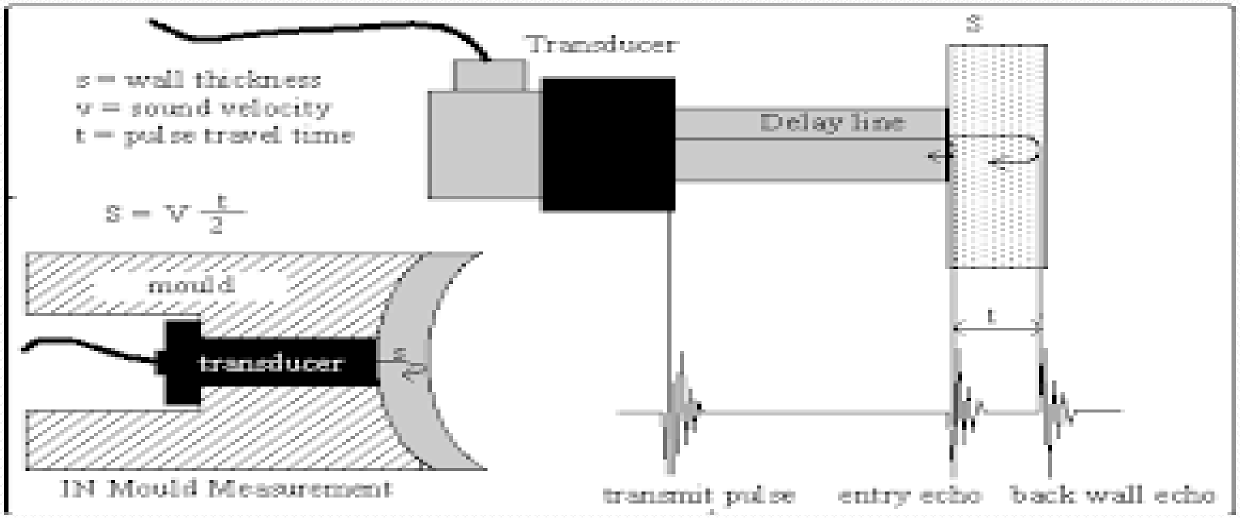
  l_m is the thickness of the sample

  c is the celerity of sound in the given sample

  t is the traverse time


0.287


Coaxial cable
Sending crystal
Receiving crystal
Delay line
Test piece
Sound beam

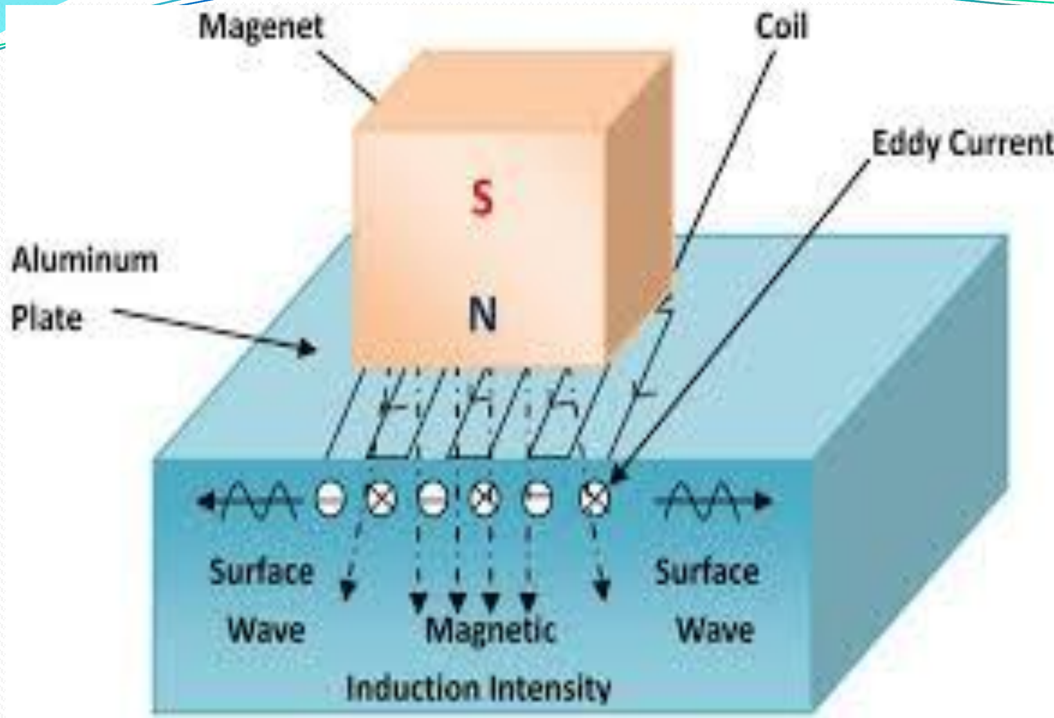

Transducer
s = wall thickness
v = sound velocity
t = pulse travel time
S = V t/2
S
Delay line
t
mould
transducer
IN Mould Measurement
transmit pulse
entry echo
back wall echo

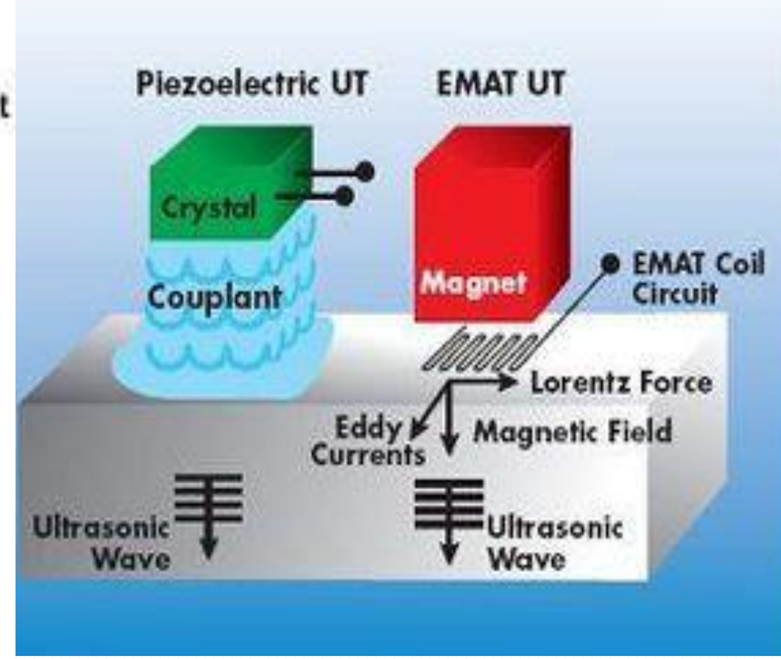
- **Advantages:**
- Non-destructive technique
- Does not require access to both sides of the sample
- Can be engineered to cope with coatings, linings, etc.
- Good accuracy (0.1 mm and less) can be achieved using standard timing techniques
- Can be easily deployed, does not require laboratory conditions
- Relatively cheap equipment
- rosion and other surface coatings on metals
- No need to remove the coating of the metal.
- **Disadvantages:**
- Usually requires calibration for each material
- Requires good contact with the material
- Interpretation needs experience

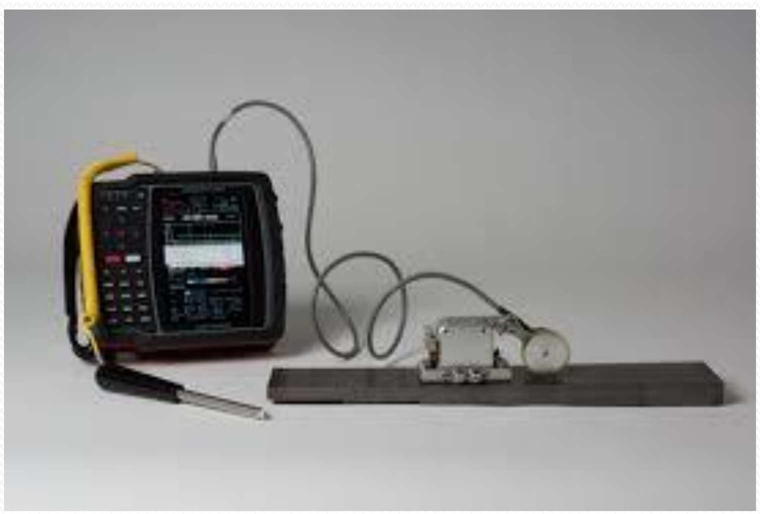
Electromagnetic Acoustic Transducer (EMAT)

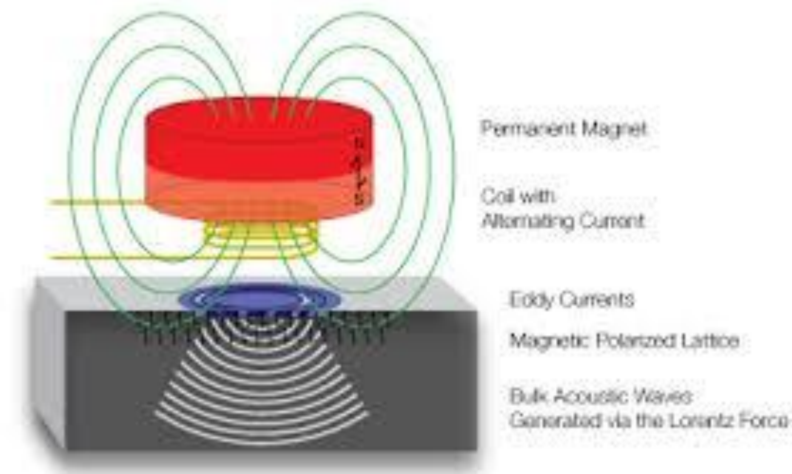
is a transducer for non-contact sound generation and reception using electromagnetic mechanisms. EMAT is an ultrasonic nondestructive testing (NDT) method which does not require contact or couplant, because the sound is directly generated within the material adjacent to the transducer. Due to this couplant-free feature, EMAT is particularly useful for automated inspection, and hot, cold, clean, or dry environments. EMAT is an ideal transducer to generate Shear Horizontal (SH) bulk wave mode, Surface Wave,

As an emerging ultrasonic testing (UT) technique, EMAT can be used for thickness measurement, flaw detection, and material property characterization. After decades of research and development, EMAT has found its applications in many industries such as primary metal manufacturing and processing, automotive, railroad, pipeline, boiler and pressure vessel industries.


Magenet
Coil
Eddy Current
Aluminum
Plate
S
N
Surface
Wave
Magnetic
Induction Intensity
Surface
Wave


Piezoelectric UT
EMAT UT
Crystal
Couplant
Magnet
EMAT Coil
Circuit
Lorentz Force
Eddy
Currents
Magnetic Field
Ultrasonic
Wave
Ultrasonic
Wave




Permanent Magnet
Coil with
Alternating Current
Eddy Currents
Magnetic Polarized Lattice
Bulk Acoustic Waves
Generated via the Lorentz Force

- **Basic Components in EMAT Transducer**

There are two basic components in an EMAT transducer.

One is a magnet and the other is an electric coil. The magnet can be a permanent magnet or an electromagnet, which produces a static or a quasi-static magnetic field. In EMAT terminology, this field is called bias magnetic field. The electric coil is driven with an alternating current (AC) electric signal at ultrasonic frequency, typically in the range from 20 kHz to 10 MHz. Based on the application needs, the signal can be a continuous wave, a spike pulse, or a tone-burst signal.

The electric coil with AC current also generates an AC magnetic field. When the test material is close to the EMAT, ultrasonic waves are generated in the test material through the interaction of the two magnetic fields.

Applications of EMATs

- Thickness measurement for various applications
- Flaw detection in steel products
- Laser weld inspection for automotive components
- Various weld inspection for coil join, tubes and pipes.
- Pipeline in-service inspection.
- Railroad and wheel inspection
- Material characterization