Basic Technique, Limitation And Application of Guided Waves, Phased Array And Electro-Magnetic Acoustic Transducer (EMAT).

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ABSTRACT

In recent years advancement in NDT Technology has taken place in a very great pace. Among all NDT methods, Ultrasonic testing have undergone many developments and is evolving with more methodologies using sophisticated equipments. However it is deadly felt and observed that the inspection technocrats involved in NDT fail to understand the exact and appropriate application of these technologies to fulfill their inspection objectives and benefits. More often the wrong selection and application of Hi-tech NDT technique is concluded with failure in technology.

Thus the basic understanding of technique, limitation and application of these hi-tech technologies are very vital for technocrats, enabling them to select appropriate technique to obtain and optimize inspection reliability with economy.

(a) - Guided Waves.

(b) - Electro-Magnetic Acoustic Transducer (EMAT.)

(c) - Phased Array.

Guided Waves

Guided wave inspection named by many end users is technically a,"long range inspection". The guided wave inspection is a volumetric inspection used mainly to determine the pipe integrity as a rapid screening tool for corrosion. "Guided Waves" are ultrasonic waves guided by the geometry of the object in which they propagate. Due to very less attenuation loss these waves transmit along the whole circumferential of the pipe propagating in the planer direction. These wave travel across the straight stretches of pipe to several meters. Bends supports, welds, type of insulation and coating adds to attenuation loss.

The guided wave is generated by placing the probe ring or can term as an array of probes generating sound on both side of the pipe. Usually it is placed by removing the heavy coating or insulation on that particular location. These transmitted waves reflect back from the anomalies thereby generating signals and giving information about the distance from the ring and as well the loss of energy.

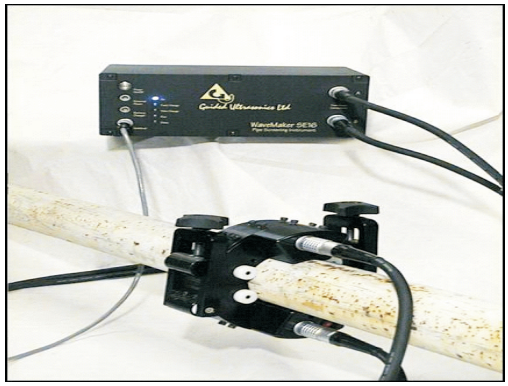

Fig.1: Guided Wave Ring on the pipe.

Various wave modes are used in inspection for full coverage and reliability requirements. Among many waves torsional and longitudinal waves have found to have more adaptability basically using two mode of operation i.e. Symmetric Mode or Ant symmetric Mode.

Many guided wave mode exists in a particular component. Certain modes are sensitive to particular flaws. It is very important to select the mode to fulfill the inspection objectives. In many cases multi modes are used to cover the full thickness coverage and for identification of particular flaws.

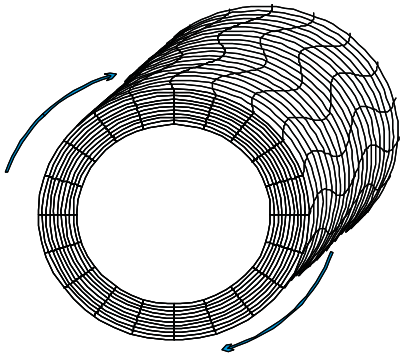

Fig.2: Torsional Waves.

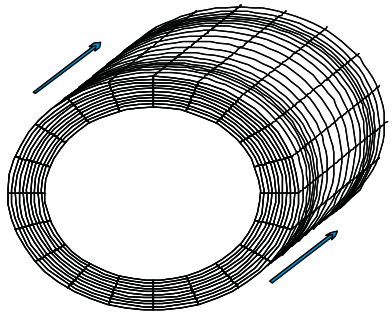

Fig.3: longitudinal Wave.

Guided Wave Application

Guided wave inspection is employed basically as a fast screening tool for volumetric inspection.

The major application are:

- Pipe under insulation.
- Under Ground Piping.
- Road Crossing Piping.
- Internal tube piping.
- Adhesive Bond inspection.

A reliable Guided wave inspection can be applied for pipes above 2inch in diameter.

Fig. 4: Guided Wave Inspection On a pipeline.

Fig.5: Guided Wave inspection on a road crossing piping.

Advantages of Guided Wave Inspection

The major advantages are:

- It's a fast screening tool
- Covers a large length of inspection. About 40Meters of coverage is possible under favourable conditions.
- Defects of more than 5 % volumetric size of the pipe can be detected.
- Portable and battery operated Equipment which makes easy for field application.
- Fast result.

Limitation of Guided Waves

The major disadvantages or limitations are:

- Small volume defects, like localized pitting cannot be detected.
- Poor on heavly corroded pipes.
- Dead zone of nearly 1 meter near by the rings.
- Sizing is limited.
- Poor on Bitumen and concert coated piping.
- Need UT and VT to follow up and pinpoint.
- Requires very experienced technicians.

Electro-Magnetic Acoustic Transducer

EMAT- Known as " Electro-Magnetic Acoustic Transducer" is considered to be a transducer that uses the interaction of a magnetic wave and eddy current to transmit ultrasound in the test pieces.

Unlike piezo-electric transducers which generate the ultrasonic waves in a crystal, an EMAT actually generates the ultrasound in the body of the test piece.

The EMAT does not touch the test piece and maintains a lift of approximately 2mm form the test surface.Thus it also does not require couplant for transmission of sound waves.Usage of no couplants provides an immense advantage in inspecting of high temperature test objects as well as provides a very fast inspection result.

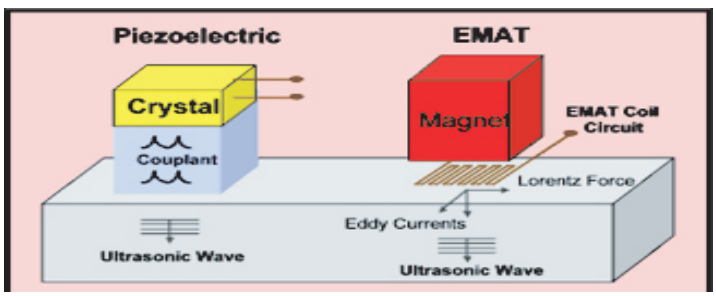

Fig.6: Illustration of the comparison between generation of conventional ultrasonic waves and EMAT bulk waves.

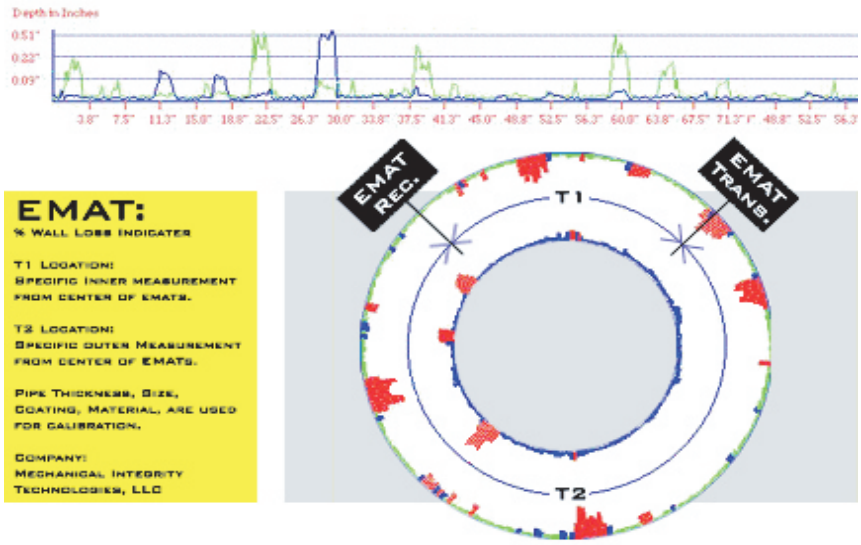

Fig.7: Showing the transducer position and a typical set up.

EMAT is considered to be a volumetric inspection responding to the volumetric loss of energy or sound waves reflected from anomalies along the pipe cross section. It uses two Sets of Transducers to emit and receive the ultrasound. More often the frequency selection is critical to adjust the ultrasound waves to fully cover the thickness along the cross section of the pipe and as well response to anomalies. Usage of multi frequency also finds more adaptability.

Fig.8: EMAT on a pipeline.

Application of EMAT.

- Process Piping Straight Runs
- Heater Tube Straight Run piping
- Inlet and Outlet piping to Fin fan coolers
- Heat Exchanger Shells
- Pressure Vessel Shells
- Tank Shells (Liquid Vapor Interface)

Advantages of EMAT.

- Accurately Detects cracks, pitting, and wall loss.
- 360º Inspection of process piping
- Hard Copy Reporting
- Determine remaining wall at pipe supports
- Capable of inspecting pipes from 5" to 42" volumetric
- 100% wall thickness inspection and repeatability

By using EMAT Technology, surface preparation of furnace tubes require minimal amount of labor as compared to other traditional methods of pipe scanning.

Heater tubes can be scanned with the EMAT system in horizontal or vertical applications.

Also EMAT inspections are couplant free.

Limitation of EMAT.

- It's a volumetric inspection.
- Initially requires long set up and calibration time.
- Require technicians with high experience.
- Usually a large set up on a moving trailer.
- requires UT and VT for locating exact location of the anomalies.
- Requires conventional UT for exact Sizing.

Phased Array.

In recent years Ultrasonic Phased Array systems are finding a high demand in application in various fields due to its capability of providing a high level of inspection information and visualization to ultrasonic tests that includes weld inspection, bond testing, Crack sizing, flanges inspection etc.

By the word "phase" it means in stage and "array" a set in an arrangement. The probe in a phased array ultrasonic Testing technique uses a set crystals or elements arranged in an array all being pulsed separately and independently. Normally linear array has found more common application due to its convenient adaptability, less expensive and easy calibration setup. Each element operates as an individual probe encased in a single mounting or case sending back the data through the micro coaxial cables.

The operator gets the full control over the beam to be focused, beam steering in many sequences, changing in depth of focusing in order to achieve a precise and accurate inspection.

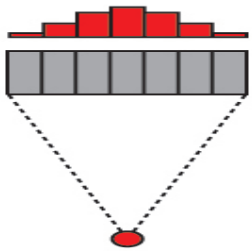

Fig.9: Showing beam focusing.

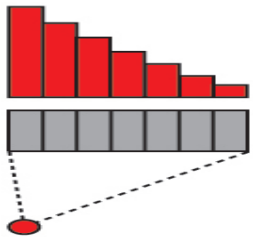

Fig.10: Beam Steering.

The phased array equipments available now are backed and supported by A scan, B Scan, scan and Sectorial Scan.It gives the operator more of the options for evaluation and determining the test results. More importantly the manufacturers aiming at the portability and ruggedness of the equipment has also contributed to an immense advantage.

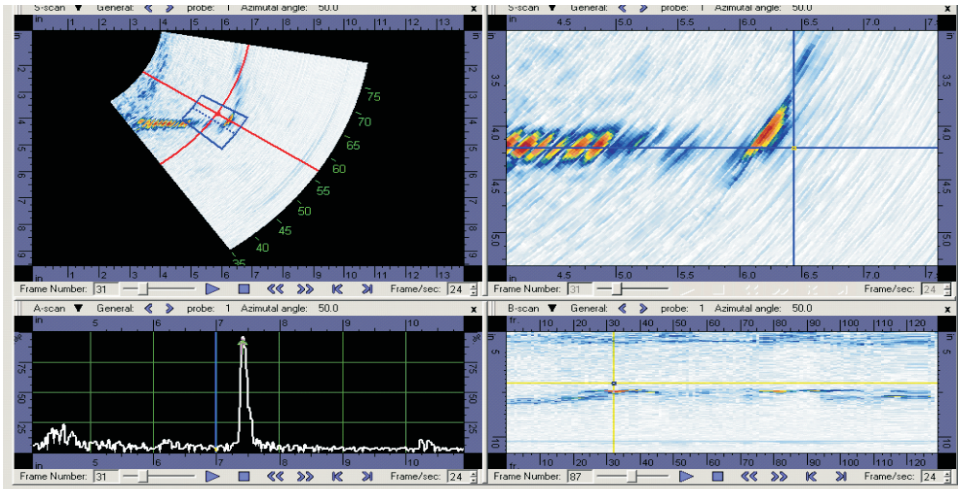

Fig. 11: Representing "A" Scan, "B"Scan, "C" Scan and Sector Scan.

Application.

In actual Phased Array has got no specific or typical application. It can be used to inspect varity of products which typically includes but not limited to the inspection of structural metals, pipelines weld, flanges, shafts, pressure vessels, aerospace etc.In other words phased array finds the application where additional information to ultrasonic testing is required.

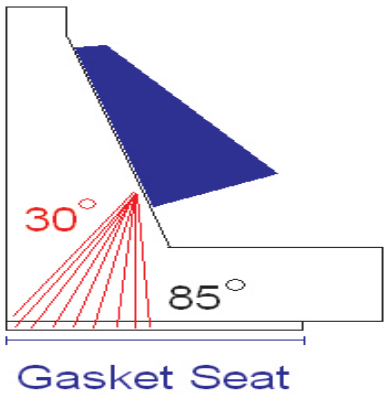

Fig.12: Flange Inspection covering the critical area.

Advantages of Phased Array.

Phased Array has got lot of advantages and special features in comparison to conventional Ultrasonic.

The man advantages and silent features are:

- Improved inspection coverage.
- Very high resolution
- Reduced inspection timing.
- Simultaneous multi angle inspection with single transducer.
- Beam focusing and beam steering.
- Decrease in energy loss can be achieved on coarse materials by beam focusing.
- Smaller diameter pipe with heavy wall thickness can be easily inspected with sufficient number of inspection depth zone.
- Fast data acquisition.
- Easy interpretation and analysis.

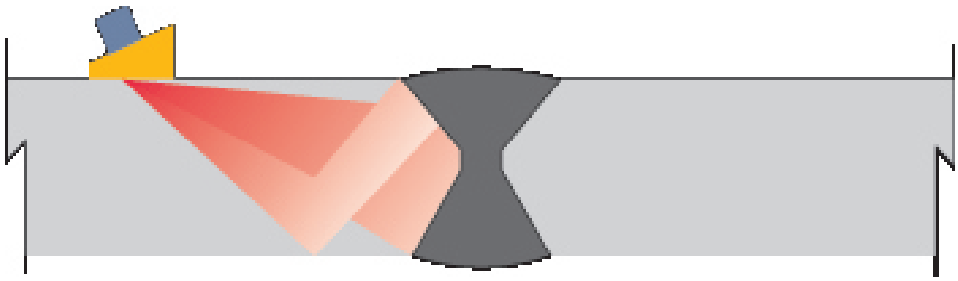

Fig.13: Coverage of complete weld section from one transducer

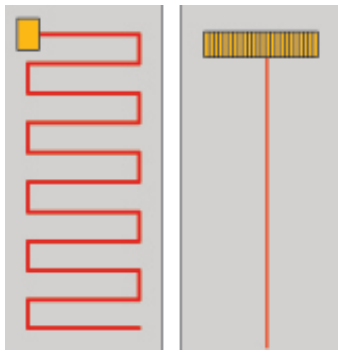

Fig.14: Phased Array operates on linear scan rather than raster scan.

Limitation.

Phased array technician requires more experience and training than the conventional ultrasonic testing technician. The system uses a sophisticated software which requires a high knowledge of set up and configuration. But now this is being over come with much user friendly software from manufacturers.

Phase array is a great up gradation to conventional ultrasonic. Therefore its high cost is limiting the usage and adaptation.

Conclusion.

Guided Waves, EMAT and Phase array are all ultrasonic testing methods greatly varying in there application. In general these are addressed as Hi-Tech NDT inspection. It is very necessary to understand there scope of application, advantages and limitations in order to select the exact technique for inspection optimization.

All the techniques are capable for specific findings and test objectives. Selecting the right technique for achieving inspection objectives or findings will definitely prove these technologies, "worth it."

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