ADVANCED NDE TECHNIQUES FOR INDUSTRIAL APPLICATIONS

I. Maria Michael Raj [1, a] and R.D.Patel [2, b]
[1]Head, Quality Assurance, Heavy Water Plant, Baroda
[2] Associate Director (O), Heavy Water Board, Mumbai
[a]michaelrajim@gmail.com, [b]rdpatel@mum.hwb.gov.in

Abstract

The world where we live today is fast changing in technology and development. New innovations everyday are forcing products of yesterday obsolete. Success, survival or failure of any organization depends on the ability to sustain uninterrupted operation at minimum cost of production and eliminate unplanned outages.

Any System, Structure and Component (SSC) is likely to face degradation over a period due to service induced stresses and environmental factors. Non Destructive Evaluation (NDE) is a tool for assessment of health of any System, Structure and Component (SSC) without harming its characteristics and end use. Several NDE techniques are available for an assessment of the integrity of SSC. They play a crucial role in industries during pre-service inspection in selection and installation of components. NDT techniques also contribute in regular condition monitoring & in service inspection, identification of the origin and propagation or growth of any harmful defect and evaluation of the residual life.

Advancement in science & technology has brought forth several NDE techniques with enhanced capabilities for scanning, characterization and sizing of discontinuities. Many of these advanced techniques have been adopted commercially by industries worldwide. It is a great feat that plants which had been designed only for twenty years of service life have seen life extension over two decades without any reportable degradation.

Heavy Water Board is the largest producer of Heavy Water in the world with five decades of excellence in operation and earned distinction as a credible global supplier of heavy water to several countries. This paper presents some widely used advanced NDT techniques in Heavy Water Plants for Condition Monitoring, In Service Inspection and Ageing Management. We have salvaged many service aged Inconel components, qualifying them with these techniques and saved several millions in foreign currency.

Introduction:

The world where we live today is fast changing in technology and development. Success, survival or failure of any organization depends on the ability to sustain uninterrupted operation and eliminate unplanned outages. With the ever growing competition accelerated with the globalization and squeezing pressure on margin of profit, each industry is focusing on lower cost of production by adopting cost effective, innovative measures for assessing the health of the plant and ensuring uninterrupted operation.

Non Destructive Evaluation technique as the name itself implies is a technique for assessment of health of any System, Structure and Component (SSC) without harming its characteristics and end use. Several NDE techniques such as Visual Inspection, Penetrant

Examination, Magnetic Particle Examination, Ultrasonic Inspection, Acoustic Emission Measurement, Eddy Current Testing, Radiography and Thermography are available for an effective assessment of the integrity of any SSC. NDT techniques play a crucial role in industries. During pre service inspection, they help in selection and installation of components whichare free from defects and meet our stringent specifications. During the operational phase, NDT techniques play an important part in regular condition monitoring & in service inspection, in identification of the origin and propagation or growth of any harmful defect and evaluation of the residual life.

Advancement in science & technology has brought forth several NDE techniques with enhanced capabilities for identification, characterization and sizing of discontinuities. This paper discusses a few of the advanced NDT techniques adopted forin service inspection and condition monitoring in Heavy water Plants.

Infrared thermography:

Infrared thermography is a technique for non contact measurement or mapping of spatial distribution of temperature over the surface of any component. It is based on the principle that any object above absolute zero temperature emits electromagnetic radiations. Infrared thermography is a qualitative, complementary technique to other NDT techniques.
It has got two approaches viz. passive approach and active approach. Passive approach involves inspection of materials without any external stimulus while active approach involves provision of external stimulus or thermal energy to induce relevant thermal contrasts.
IR thermography has got the unique distinction among NDT techniques because of its fast results, adaptability to inspect hostile/ inaccessible areas, free from any unsafe radiations, and ability to provide both qualitative and quantitative information on the inspection.
The wide application of Infrared thermography includes:

- Infrared thermal mapping and imaging of high temperature surfaces such as boilers, furnace walls and steam net work
- Condition monitoring of bearings, casings, gear boxes and other components of High pressure pumps, compressors, turbines, Induced Draft fans and exhaust blowers.
- Health assessment of SSC of Electrical distribution network including motors, circuit breakers, panels, switch gears, connectors, switches, bushings, buses, insulators of switchyard etc.
- Identification of loss of thermal energy through the discontinuities in hot/ cold insulation medium

Phased Array Ultrasonic Technique (PAUT)

Ultrasonic testing implies the transmission of sonic waves inside a material and assessment of the material properties or healthiness with the help of reflected or transmitted waves. Conventional ultrasonic instruments employ single or dual transducers to transmit and/or receive sound waves. Hence, they suffer the constraints of fixed angle scanning, longer inspection periods due to multiple angle scans and a risk of missing defect signals.
Phased array ultrasonic testing technique works on the same principle and a single frequency, but contains an array of transducers which can be pulsed in groups for phased transmission of sound waves and propagation of sound waves in a range of angles covering a

wider path. Since each element in the transducer is individually wired, we shall be able to control the interactions of waves for desired interference. The elements can be scanned, swept and focused at a particular depth due to electronic beam shaping and steering.
Scan time is considerably reduced; probability for detection of defect improves and is extensively used in rail, aerospace and chemical/petrochemical industries.

Ultrasonic Time of Flight Diffraction Technique (TOFD)

Conventional ultrasonic testing technique is versatile in detection of defects and their orientation but is inadequate in precise characterization and sizing of defects. The orientation of defect, scanning surface condition etc. may influence the sizing and realistic sizing may be difficult and time consuming. An advanced technique known as Time of Flight Diffraction (TOFD) technique derived on the same ultrasonic principle is more appropriate for precise measurement of dimensions of defects for repair/ remedial actions. When an ultrasonic pulse encounters a defect, the pulse is diffracted at the edges of defect. The difference in time of flight of initial pulse and echoes diffracted from the edges of defects is measured for location and precise sizing of defects and this technique is known as time of flight diffraction technique. By measuring the transit time between diffracted echoes from the top and bottom of defect, we can assess the depth and size of defects.

Both Phased Array Ultrasonic Testing andTime of Flight Diffraction techniques provide real time image with precise location and are non hazardous .Hence many industries substitute radiography which is hazardous, with PAUT and TOFD techniques.

Impact Echo Testing Technique

Impact Echo is a method for nondestructive evaluation of concrete and masonry. As against the ultrasonic pulse velocity technique which uses sound waves , this technique is based on the use of mechanical impact-generated compression waves that travel through the structure and are reflected by internal flaws and external surfaces. Impact Echo can be used to measure the thickness of slabs, plates, columns and beams, and hollow cylinders. It can also be used to determine the location and extent of flaws such as cracks, de-laminations, and voids, honeycombing and de-bonding in concrete structures.

Impact Echo testing consists of measuring both the time record and frequency spectrum associated with a mechanical impact on the surface of a structure. As stress waves propagate through the structure, they are reflected from internal and external boundaries and cause periodic displacements on the surface. The waveform is transformed into the frequency domain, so that the periodicity of stress-wave arrivals can be accurately determined.

The Impact Echo method has several applications in evaluation of the integrity of masonry and concrete structures. It is non-destructive and requires only one surface of the structure to be exposed.

Remote Visual Inspection (RVI)

Visual Testing (VT) is the first choice of any inspection as it offers an immediate, less costly technique which guides us in identification of other appropriate techniques for quality

assessment. While conventional visual testing quality can be enhanced with additional tools, it has its inherent limitations. Remote Visual Inspection is a Non-Destructive Testing technique used to detect and examine a variety of visible flaws; such as cracks, corrosion, contamination, structural integrity, and other discontinuities in inaccessible, remote locations. This minimally invasive inspection technique is ideally suited for hostile environments unsafe for human intervention or inspection of narrow, longer and confined locations.

Remote visual inspection technique has made extensive advancements fromsimple bore scope, endoscope to video scope. We have miniature cameras and optical lens which can be used to access even very small bore locations such as heat exchangers, drain headers and stacks. Provisions are available to rotate the lens, enlarge and analyze the images collected from a long distance inside the pipes and equipment.
The benefits of RVI include inspection at confined spaces, lesser operational& safety risks, enhanced image resolution and permanent documentation.

Acoustic Emission Technique

Acoustic emission (AE) is a phenomenon where transient elastic waves are generated by rapid release of energy from localized sources within a material due to the redistribution of energy in the system .The energy thus released travels as spherical waves and can be picked up by highly sensitive peizo electric transducers located on the surface of the inspected material. The wave is converted into electrical signals, processed and analyzed for identification of source and cause of energy release. Metallic corrosion involving chemical reactions leads to redistribution of energy. Any corrosion phenomenon is thus a source of acoustic emission.

This technique has got wide applications in detection of corrosion pitting, stress corrosion cracking, crevice corrosion, Hydrogen embrittlement etc. The unique characteristic of AE technique is that it is a dynamic technique and emits signals in each stage when the previous threshold limit is exceeded, called Kaiser effect and has shown wide potential in corrosion detection.

Conclusion

The above advanced NDT techniques have been successfully utilized in Heavy Water Plants for effective Condition Monitoring, In Service Inspection and successful Ageing Management& Residual Life Assessment.

The field of Non Destructive testing has been growing by leaps and bounds. Feed back from the application of different techniques has helped in development of more precise measuring and imaging tools. With faster and more accurate methods of quantification of signals established and cost competitive devices in the market today, industries can aim for safer, cost effective operation with zero break downs and life extension over design life.