PAUT as Tool for Corrosion Damage Monitoring

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Abstract

Corrosion assessment / monitoring is essential to know the service life of the pipeline / piping assets by estimating the extent of damage due to corrosion / erosion. The present trend of corrosion damage assessment / monitoring is to carry out screening of pipelines / piping and verifying its findings for defect sizing using Ultrasonic Thickness Gauge (UTG). Monitoring corrosion with UTG is not effective and cumbersome technique as one has to make grids to cover maximum area and due to time consumption.

The sensitivity of corrosion monitoring with UTG increases with maximizing the grids, which account for loss of time and money. This paper discusses the advantage of using Phased Array as a sizing tool for corrosion monitoring in pipeline and static equipment with various site results. A comparative study between PAUT and UTG as a corrosion monitoring tool with respect to accuracy, time of inspection, sensitivity, POD and reporting shows that PAUT as Corrosion Damage Monitoring tool yields the maximum safety of manpower, nature and equipments which indirectly helps to boost the growth of organization and country.

Keywords: UTG, Phased Array, Corrosion Monitoring, Pipeline / Piping

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1. INTRODUCTION

Developing stature of India is raising the demand for oil and gas which is leading the refineries to work at full efficiency. The rise in population and its uneven distribution is motivation behind laying the thousands of kilometers of cross country pipelines. The major problem faced by cross country pipelines/piping is wall loss due to corrosion and erosion. The reduction in wall thickness results in catastrophic failure, which claims the toll on population, environment and economic losses. To avoid such catastrophic failure it is mandatory to have a regular in-service inspection of cross country pipeline and the refinery piping for wall loss monitoring.

Monitoring wall loss for pipelines/piping is herculean task, which can't be carried out with one NDE technique. It is recommended to do screening of the pipelines/piping with NDE techniques like Internal Pigging (IP) or Long Range UT (LRUT). Screening of the pipelines results in few doubtful area which shall be cross verified and confirmed for wall loss using Phased Array UT (PAUT).

Introduction to Phased Array Ultrasonic Testing (PAUT)

Ultrasonic waves are mechanical vibrations induced in an elastic medium by piezocomposite probe excited by an electrical voltage. Typical frequencies of ultrasonic waves are in the range of 0.1 MHz to 50 MHz whereas most industrial applications require the frequencies in the range of 0.5 to 15 MHz.The major difference between PAUT and UT lies in its crystal arrangements and control of its excitation. Conventional UT probe ismonocrystal probe which is excited irrespective of time control. PAUT probe is multi crystal probe which are computer controlled for amplitude and delay. Delay control is necessary to improve steering capability, focal length and focal spot size of peizocomposite probe. The controlled beam is focused and can detect the disoriented defects. These defects are oriented away from the beam axis. A monocrystal probe with a limited movement and beam angle has a high probability to miss the disoriented defects. The controlled UT i.e. PAUT has a high probability of detecting disoriented defects due to sweeping movement of waves , which is as shown in below image.

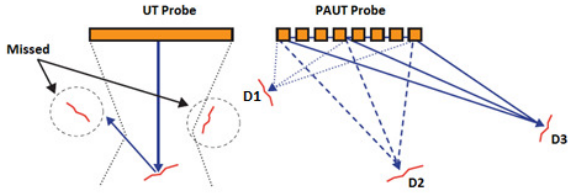

Image No. 1: UTG Vs PAUT

The main component required for scanning with PAUT contains Tomoview Software in collaboration with Omniscanwhich plays a major role in controlling the delay and amplitude of the peizocomposite probe. Probe tracking or length covered by probe is monitored with encoder setup in conjunction with Motion Control Drive Unit. Depending upon the job or client requirement the data can be displayed in A, B, C, D, S, and Polar scan

Data display plays major role in defect characterization and location identification. Group of displays is always recommended for better defect characterization. A, B, Cand S scan are recommended for corrosion mapping whereas A,B and S scan are considered for weld inspection.

A-scan is graphical representation of the received ultrasonic wave amplitude Vs the time of flight from the reflected area. It can be displayed as RF (Radio Frequency) or bipolar rectified signal as shown in image no. 2.

B- Scan is 2D view of recorded ultrasonic data, where horizontal axis is scan position and vertical axis is ultrasound path or time. B Scan is made up by stacking A-scan results. Generally it is referred as side view scan.It is shown in image no.2.

C – Scan is 2D view of ultrasonic data displayed as top or plan view. One axis is scan axis while another one is index axis. In C scan both axes being a measurement axis, the amplitude is displayed as color coding on pixel scale. Refer image no.2 for C-Scan display.

S – Scan (Sectorial or Azimuthal)is 2D view of all A-Scans from specific channel corrected for delay and refracted angle. The horizontal axis corresponds to the projected distance (test piece width) from the exit point for corrected image and the vertical axis corresponds to depth which is as shown in image no.2.

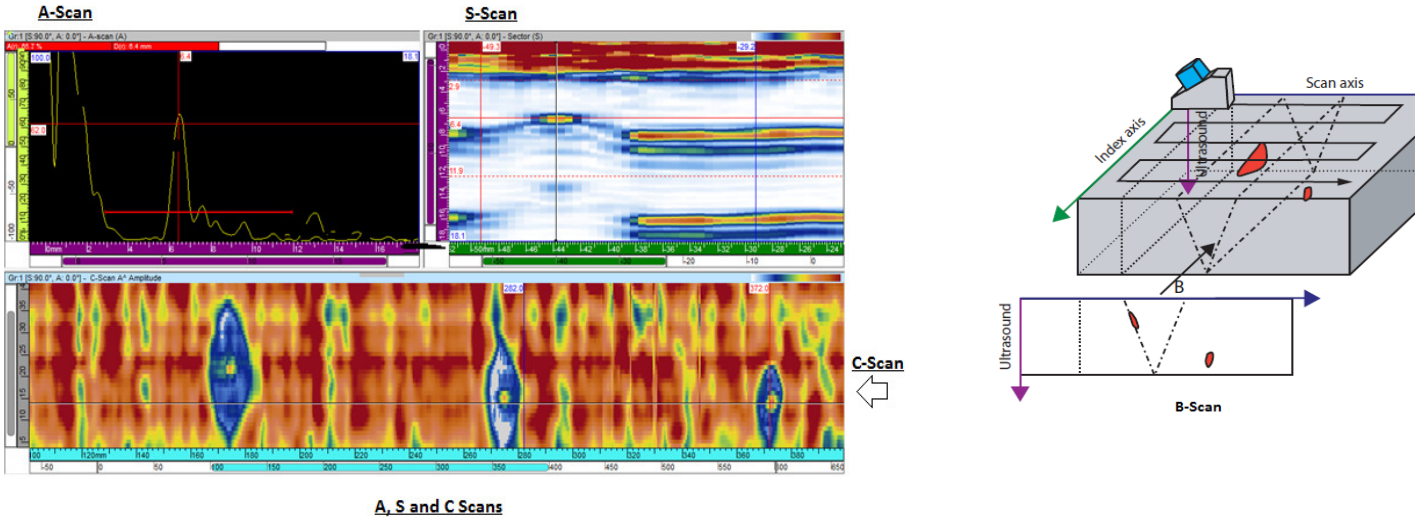

Image No.2: A, S & C Scan & B Scan Display

2. EQUIPMENT AND ACCESSORY DETAILS

a) Equipment make and model : Olympus OmniscanMx
b) Probe Details : 5L64
c) Wedge Details : SA2-0L-IHC (Flat Wedge)
d) Encoder Details : Mini Wheel Encoder with 12steps/mm resolution
e) UTG Equipment : Panametrics MG2-DL

Image No.3: OmniscanMx with Mini-wheel encoder

3. RESULTS AND DISCUSSION:

To get the good results and to carry out comparative study between PAUT and UTG with respect to Sensitivity, POD, Scanning required time and Reporting an 8 mm carbon steel plate is used.Curved bottom pits of wall loss 20%, 40% and 60% are made on bottom side of plate with drilling machine. Detail of curved bottom pits is given in table no.1 and 8mm Plate with three pits is shown in image 4.

Table No.1: Details of Curved Bottom Pits

Details of Curved Bottom Pits			
% Wall Loss	20%	40%	60%
Depth of Pit (mm)	6.4	4.8	3.2
Length of Pit in Scanning Direction (mm)	10	16	18

A) Bottom View B) Top View

Image No.4: Bottom& Top view of Carbon Steel Plate

To gather the good results and ease of scanning, the area covering the pits is covered by grid pattern on top side of plate. Each grid is of 30mm width. By making grid of 30mm it is insured that there will be overlap of 10mm in consecutive grid scanning. Plate with grids is shown in image no. 4B.The area ofinterest i.e., pits with wall loss were covered in grid number 5 in above mentioned test plate. Scanning was done with two means, i.e. PAUT and UTG. PAUT probe scanning did gird wise, total 9 grids where scanned with the help of Advanced NDT engineer. Encoder connected with PAUT probe gives the exact location of wall loss on C Scan display. UTG scanning is carried out as point scan where the complete rectangular area is scanned with the help of experienced UTG technician. Table No.2 shows results obtained for 60%, 40% and 20% pits with PAUT and UTG. Images 5 and 6 shows supporting PAUT scan and UTG readings respectively.

Table No.2: PAUT & UTG scanning results

Pit Characteristics	60% Pit		40% Pit		20% Pit	
	Depth	Length	Depth	Length	Depth	Length
Actual	3.2	18	4.8	16	6.4	10
PAUT Reading	3.2	17	4.8	14	6.4	10
UTG Reading	3.3	NA	4.8	NA	6.4	NA

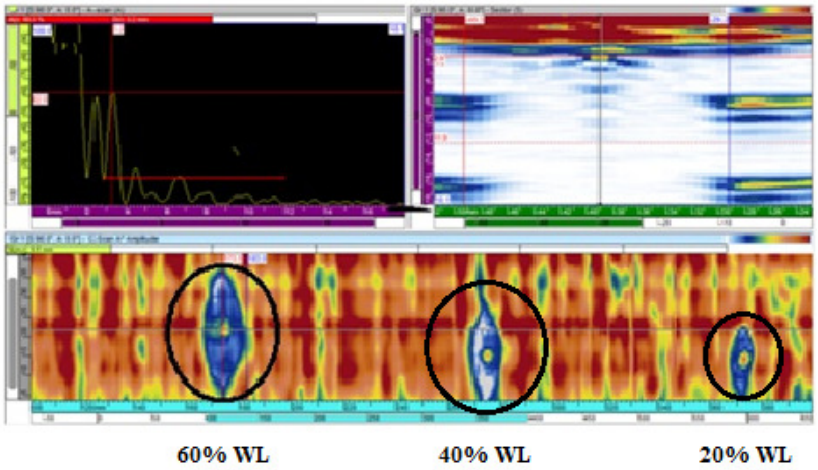

Image No.5: 60%, 40% & 20% Pit, A-S-C Display

A) UTG for 60% WL B) UTG for 40% WL C)UTG for 20% WL

Image No.6: 60%, 40% & 20% Pit, UTG Display

From above results it is evident that, it is not possible to find the pit length with UTG scanning, where as support of mini wheel encoder helps to determine the exact pit length in PAUT scanning. From table no.2it can be seen that accuracy of wall loss measurement&accuracy of pit length measurement with PAUT is 100% & in the range of 90-100% respectively. Sizing of pit plays a major role in determining the severity of corrosion, type of corrosion taking place and calculation of remaining life.

One of the major pros of PAUT Corrosion Mapping is the speed of scanning. At a time a grid width of 30 mm can be covered with SA2-0L wedge and 5L64 probe setup. With UTG, which works on point scanning principle requires more scanning time to cover the same 30 mm width when compared to PAUT. Again result of UTG scanning is technician dependent. Good experience and patience are the two major factors of technician which plays important roll while scanning with UTG. One of the major advantages where PAUT has a definite edge over UTG is the probability of covering 100% width of the grid (30 mm) with a very less time, which enables to save a major portion of time to accomplish post inspection activities. The probability of detection with UTG depends upon the skill of the person performing UTG, whereas in PAUT, which is semi-automated inspection has an innate advantage of 100% coverage and improved POD.

Data analysis in PAUT yields more information about the defect sizing and orientation which can be viewed in A, B, C and S scans. Multiple scan viewsplay a major role in getting complete picture about contour of the defect. From C-scan,it is possible to know the length of the defect in scanning direction along with its exact location. The corresponding B-scan at a section gives the cross sectional view of the defect, which helps to understand the wall thinning in particular area. Defect characterization can be made easier with X-Y scanner or manually scanning in X & Y direction. UTG with its single point scanning capability is helpful in determining remaining wall thickness whereas other information about the defect topography may not be possible. This advantage in terms of mapping overall view with advanced signal processing and image processing techniques allows one to research the probable cause of the defect formation and the same feedback can be constructively used as inputs for improvements in future designs.

One of the major advantages of PAUT where it stands far ahead of UTG is its reporting structure. Multiple views of scan (A, B, C & S scans) help to understand the defect and its formation thoroughly. PAUT reports gives complete information about defect characterization along with added advantage of

top and side views. A system generated report removes the chances of any forgery with actual readings which is unavoidable with UTG report generated by technician itself. PAUT provides the ease of reporting with its softcopy and hardcopy structure. Softcopy can be saved for years to come as one need to monitor the corrosion and study its pattern of growth.

Below are few site results of corrosion mapping on cross country pipeline during the year 2014-15. Every image is supported with A-B-C Scan,wall loss %& defect length in scanning direction.

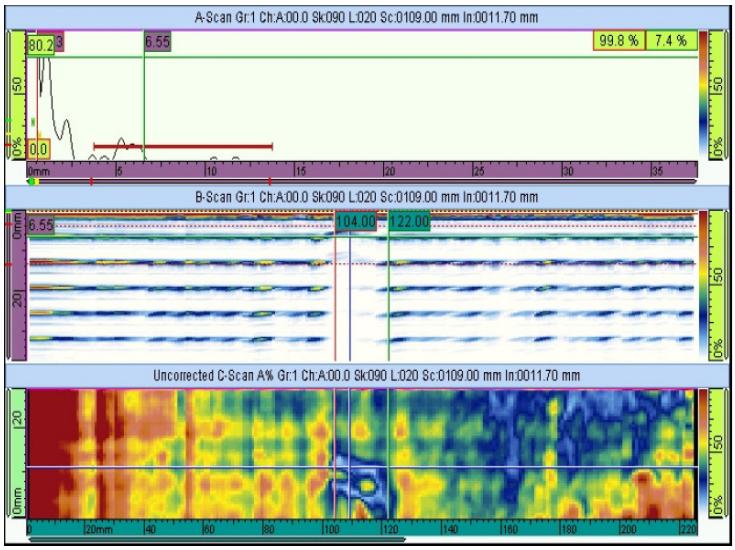

Image No. 7: Pit with Gradual Wall Thinning Wall Loss %: 22%, Defect Length: 18mm

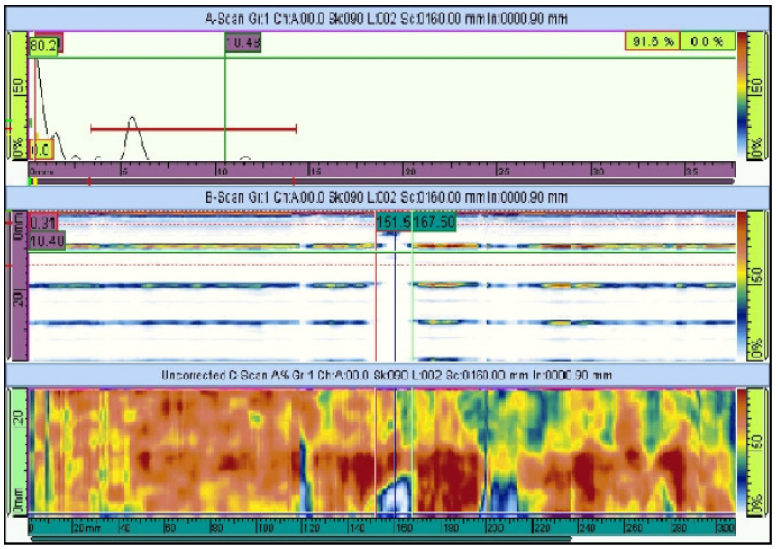

Image No. 8: Single Pit with sharp thinning Wall Loss %: 42 %, Defect Length: 16mm

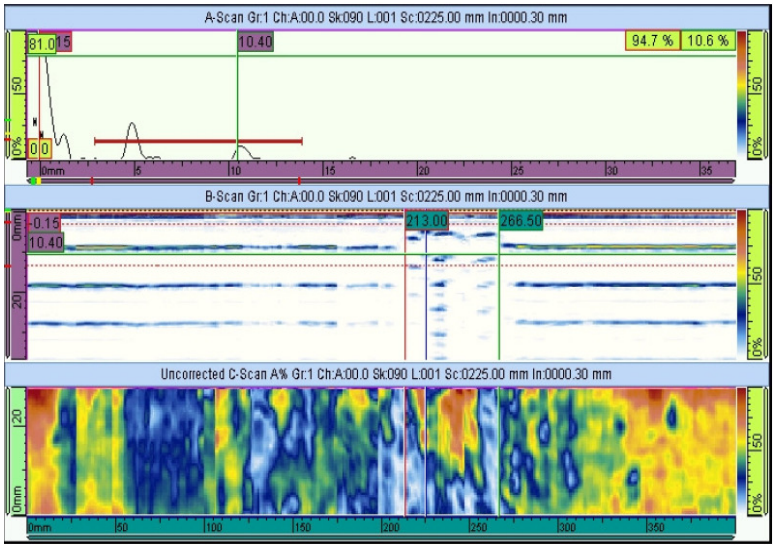

Image No. 9: Cluster of Pits Wall Loss %: 50 %, Defect Length: 53.50mm

4. CONCLUSION

PAUT with its advance beam controlling technique and display patterns make it a perfect tool for monitoring corrosion losses in pipeline and heavy equipments. Many backlogs of point scanning or line scanning with manual UTG or Automated UTG respectively is removed with grid scanning of PAUT. Multiple scan views like A, B, C and S scan improves the defect characterization which is good feed for remaining life calculation and in service monitoring.

Use of PAUT results in finding disoriented defects which can be a potential threat if gone undetected. Improved POD helps to avoid catastrophic disasters which in term help countries to prosper and grow.

5. ACKNOWLEDGEMENT

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6. REFERENCES

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