Utilization and Validation of Tangential Radiographic Technique in Wall Thickness Measurement of Insulated Pipes in Moulovi Bazar Gas Processing Plant

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Abstract

In industrial sectors (in power plants, petroleum, petrochemical industries etc.), the reduction of wall thickness of fluid carrying pipes is a common phenomenon caused due to corrosion. Accurate measurement of remaining wall thickness is a challenging task as the operation life and safety of the industry depend on it. Industrial radiographic method has opened a new horizon through the development of Tangential Radiographic Technique (TRT) to overcome this problem.

In the present work, the remaining wall thickness of the gas carrying pipes of Moulovi Bazar Gas Processing Plant has been measured through glass fibre insulation using Phosphor Imaging Plate (IP) based Computed Radiography and Ir-192 isotope as a source of radiation. The radiographic images captured were digitized & further processed respectively by the Durr NDT 35 IP Scanner & image processing software ISee!. The result shows that the measurement becomes accurate with the use of higher thickness of lead shielding and with the use of higher radiographic exposures. This is because of the fact that the IPs are very sensitive to scattered radiation which is responsible for the poor quality of image generation and higher is the exposure lower is the noise resulting in the generation of good quality image for satisfactory measurement.

Keywords: Tangential radiographic technique (TRT), imaging plate (IP), digital industrial radiography (DIR), computed radiography (CR), corrosion

1. Introduction

In the sectors of industry, reduction of wall thickness of fluid carrying pipes is a common phenomenon caused due to corrosion/erosion. Determination of the extent and progress rates of the corrosion and the deposit provide useful information about the operation life and safety. Wall thickness measurements by other conventional methods have a number of limitations; particularly they need removal of insulation from the metal part which is costly & health hazardous during periodic inspection. For instance, Ultrasonic Testing (UT) method is widely used to measure the wall thickness of pipes. The UT covers only a small portion of object and this technique is not convenient for the detection of pitting like defects. Besides, to perform UT of insulated pipes it is required to remove hazardous insulation [1] and after completion of inspection the insulation should be reinstalled over pipe which introduces plants down-time [2]. Moreover, wall thickness measurement of pipes by UT Method is influenced by surface condition and can vary by as much as 40–50 per cent [2]. This limitation has been overcome by the application of tangential radiography technique.

Industrial Radiography is one of the most reliable and effective NDT techniques to determine the internal defects and assess the quality and integrity of objects. In the past, various types of radiation sources and radiographic films were used for conventional Industrial Radiography Technique. Now-a-days different types of energy dependent detectors have been developed for Digital Industrial Radiography for image capture. Digital Industrial Radiography provides wide advantage and opportunity compared to the traditional film radiography. Currently, the most common type of digital industrial radiography is the computed radiography (CR). The CR system consists of ionizing radiation source (X-ray tube or radio- isotope), computer unit, scanner and phosphor imaging plate (IP)[3].

The sole characteristics of IPs, like wide dynamic range, linearity, greater radiation dose sensitivity allow a greater range of thicknesses to be measured [3-4]. Besides, IPs is reusable for more than 1000 times [5] and no need for a chemical darkroom for IP processing. Their main disadvantage is the higher sensitivity to scattered radiation [4].

The features like Digital Radiographic Image processing and analysing software made CR suitable for erosion/corrosion mapping and monitoring of pipes in petrochemical Industries [3]. Digital Industrial Radiography along with the Tangential Radiography Technique made it possible to avoid problem of side wall "burn off" and influence of the examiner [3].Various advantages and included features of software for Radiographic Image processing can lead this technique to be adopted by industries for inspection of corrosion monitoring and analysing of insulated pipes. Up to now, Radiography was used as qualitative method but this technique results are quantitative [6]. With these consideartions, in the present work, the remaining wall thickness of the gas carrying pipes of Moulovi Bazar Gas Processing Plant has been measured through glass fibre insulation using Phosphor Imaging Plate (IP) based Computed Radiography and Ir-192 isotope as a source of radiation.

2. Materials and Methods

Generally, X and Gamma radiation sources are used for industrial radiography. In this work Tangential Radiographic Technique (TRT) (Fig. 1) comprising 48Ci Ir-192 isotope, Imaging Plate (white) and Image Plate Scanner of DurrCR 35NDT, Image Processing Software ISee! &

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Dtect were used to measure the wall thickness of insulated pipe (Fig. 2) of Gas Processing Plant. The used radio isotope Ir-192 emits the following major gamma rays: 0.31 MeV, 0.47 MeV and 0.64 MeV. The radiographic image of the wall thickness only along the tangential beam is interpreted [7].

TRT is an indirect method for wall thickness measurement and in this technique calibration is required to measure the wall thickness accurately. For this purpose, reference block of known dimension is attached on the surface of the test object during exposure and processed radiographic image is calibrated according to its dimension. The wall thickness of pipe is then determined from the same radiographic image following the calibration [3]. The wall thickness of pipe at tangential location (Fig. 3) is higher than the double wall thickness of pipe and can be calculated from equation (1) [8].

$$W_{max} = 2\sqrt{t(D_e - t)} \quad (1)$$

where,

W_{max}=Maximum penetrated thickness

t= Nominal thickness of the pipe

D_e=Outside diameter of the pipe

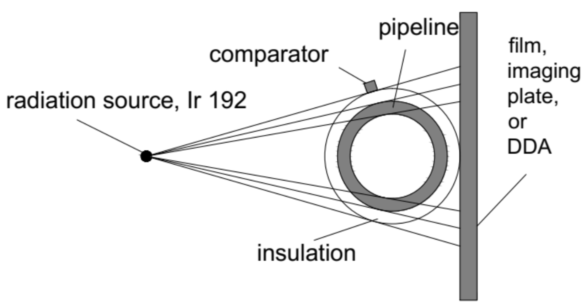

Fig. 1: Tangential radiographic inspection set-up

Schedule Diameter × Thickness of the test components Impact Tee and Elbow Line was 60 × 5.54 mm, CUI Elbow-1, CUI Elbow-2 and CUI Elbow-3 was 88.9 × 5.49 mm. Source to Film Distances (SFD) were set at distances about ten times of the Outer Diameter (OD) of the pipes and exposure times were determined as per Maximum Penetrated thickness $W_{max.}$ Multiple numbers of lead screens of thickness 0.125 mm were used at the front and back side of IP to reduce the scattering.

The contrast of radiographic image decreases with the increase in radiation energy. Higher contrast will display low density region prominently but it will make it difficult to measure the wall thickness. Lower contrast radiographs obtained at higher radiation energy delineate better ID (inner diameter) profile [7].

Phosphor IPs used for industrial radiography contains BaBr: Eu2+ active layer in which, after radiographic exposure, latent image is formed. Scanning pre exposed IP in CR scanner with laser beam enables photo luminance effect and thus transforming latent image into visible light. emitted visible light is collected by light guides, amplified in photomultiplier tube and transferred into digital image by A/D converter [1].

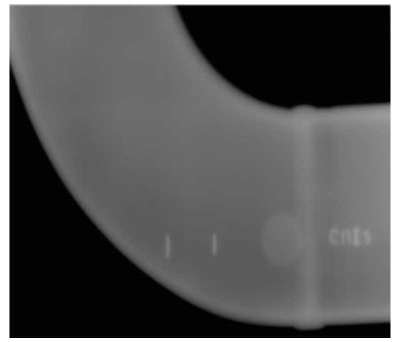

Fig. 2: Radiographic image of insulated pipe

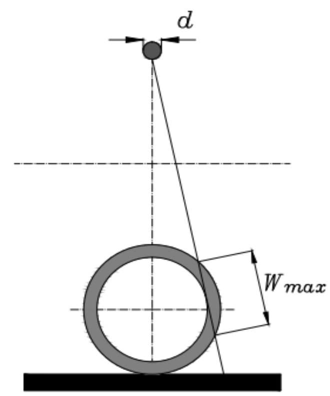

Fig. 3: Maximum penetrated thickness, Wmax, for the tangential radiography technique

3. Results and Discussion

The first and second radiographic images of a certain pipe were taken at exposures of 20.16 and 48Ci-min and with a lead screen of 0.125 and 0.25 mm thick respectively. The measurement accuracy of these processed images was found reduce due to scattering effect by the neighboring structures which were improved later by insertion of lead screen. The measurement accuracy of third radiographic image increased and reached above 90% with the increase in thickness of lead screen to 0.375 mm and exposure to 72 Ci-min. The rest of the three radiographic images were taken each with 0.375 mm thick lead screen but increasing exposures to 120, 192 and 336 Ci-min respectively. The result is shown in the graph (Fig. 4). It is observed from the curve of Fig. 4 that the accuracy of wall thickness measurement of insulated pipes in Computed Radiography reaches the satisfactory value (>99.6%) with the increase in thickness of lead screens inserted and with the increase of exposures. This is due to the fact that lead screens stop the scattered radiation to reach the film through Photoelectric absorption & Compton scattering, thus contribute in the production of sharp images in one hand and increase in exposure increases Grey value, Normalized Signal to Noise Ratio, Contrast to Noise Ratio and Reduces Noise of the outlined on the other [9]. Combination of proper lead screen and exposure time improves detect ability and hence yields the satisfactory result for accurate measurement. Moreover, the definition of the radiographic images reduced due to scattering of radiation beam from the walls. This may be reduced by positioning the source alternatively directly over the pipe wall (Fig. 5) [4].

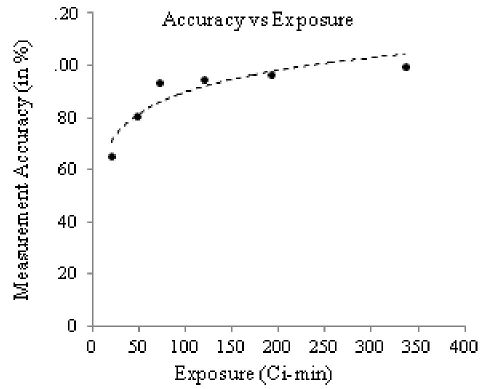

Fig. 4: Graph of measurement accuracy vs exposure

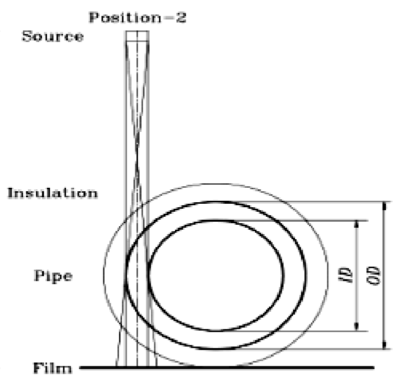

Fig. 5: Alternative tangential radiographic set-up for reduction of scattering

4. Conclusion

TRT Technique was validated in the laboratory of NDT Division of Atomic Energy Centre, Dhaka and verified the test result of this technique through another NDT Method Ultrasonic Testing (UT) and revealed satisfactory result. The current work was an approach to implement the technique successfully in local industries to measure the remaining wall thickness of insulated pipes. The image quality can be improved by using lead screen with appropriate thickness. Corrosion monitoring and remaining wall thickness of insulated pipes of local industries can be performed without removing costly and hazardous insulation.

References

1. M. Rakvin, D. Markučič and B. Hižman, Evaluation of Pipe Wall Thickness Based on Contrast Measurement Using Computed Radiography (CR), Science Direct, Proc. Engin., **69**, 1216 (2014).
2. T. Wawrzinek, U. Zscherpel and C. Bellon, Wall Thickness Determination in Digital Radiography, NDT net, **2**(10), (1997).
3. Imaging Plates for Computed Radiography,https://www. duerr-ndt.com/downloads/imaging-plates.html
4. W. Harara, Critical Comments on the Optimum Determination of Remaining Wall Thickness in Insulated Pipes by Tangential Radiography, Insight, **3**, 679 (2001).
5. IAEA-TECDOC, Development of Protocols for Corrosion and Deposits Evaluation in Pipes by Radiography, **1445** (2005).
6. S. Sönmez and H. Jahangiri, Wall Thickness Measurement of Carbon Steel Pipes by Using Digital Radiography, Engin. Sci. (NWSAENS), **12** (4), 256 (2017).
7. U. Zscherpel, U. Ewert, S.Infanzon, Aendur, Montevideo, N. Rastkhan, P. R. Vaidya, I. Einav and S. Ekinci, Radiographic Evaluation of Corrosion and Deposits in Pipelines: Results of An IAEA Co-ordinated Research Programme, ECNDT, Mo.2.4.1 (2006).
8. N. Azaman, K. A. M. Salleh, A. A. Abas, A. Yassin and S. Ahmad, Validation and Application of Computed Radiography (CR) Tangential Technique for Wall Thickness Measurement of 10 Inch Carbon Steel Pipe, https://inis.iaea.org/ collection/NCLCollection tore/_Public/48/050/48050427.pdf
9. Training Manual ISO 9712 Radiography Level 2 Welds CR/DR, IAEA/RCA Training Course on Radiographic Testing RT-D Level 2 for Personnel Certified to Radiographic Testing RT-F Level 2 (2019).