International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

NDE 4.0 Automation of Digital X-Ray (DR System) with AI - For Crude and Gas Transportation Pipes

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Abstract: ***Non - Destructive Testing (NDT) plays a vital role in the manufacturing of oil and crude oil transportation pipes. The primary goal of NDT is to identify any potential defects in pipes that may cause accidents or damage to in - service pipelines. Oil and crude oil transportation pipes are subjected to various forms of stress during their lifespan. These include internal pressure, external loads, and mechanical stresses caused by handling, transportation, and installation. If there are any defects or flaws present in the pipes, they could compromise the pipe's structural integrity, leading to leaks, ruptures, or other failures. NDT techniques such as ultrasonic testing, radiography, and magnetic particle inspection are used to inspect the pipes for flaws such as cracks, porosity, inclusions, and other defects. By using NDT techniques, manufacturers can detect any potential issues early, allowing them to take corrective actions to prevent failures. Ultrasonic and radiography are the two main NDT methods to check the quality of pipe welds used oil and gas transportation. Phased array ultrasonic test development and automation (PAUT) has emerged as the preferred NDT alternative for many industries and is gradually replacing radiography as the primary inspection technique. But PAUT also has a limitation in the detection of volumetric weld defects for which radiography is still the best method. So the time has come when we think about developing digital radiography in automation mode. The Aim of this work is to find out Introduction, Automation of Digital Radiography with AI, challenges, acceptance and consensus of Digital Radiography (DR system) for pipes used in crude and gas transportation. To find out if we can do automated digital radiography similar to automated ultrasonic testing used in crude and gas pipe inspection.***

Keywords: PAUT, Digital Radiography, NDT, NDE 4.0, Ultrasonic Testing

1. Introduction

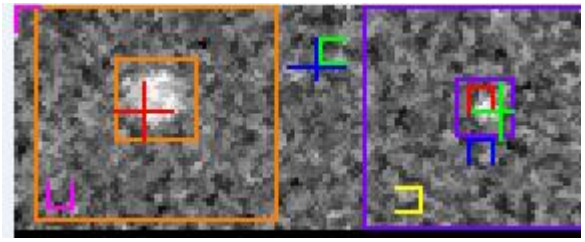
Industrial radiography is a major NDT method of inspecting steel pipes to detect hidden volumetric defects, using the ability of short X - rays, gamma rays and neutrons to penetrate various grades steel pipes. We used film radiograph for many years which was slow and had many limitations but now industry is shifting to digital radiography and the process of shifting is fast in last 10 years. Digital X - ray is faster and comes with many advantages but still the interpretation process of digital radiographs is human based.

With respect to physical principles, there is not much difference between digital and film radiography. Instead of using film to both detect and store image data, digital radiography uses digital detectors to produce a digital image, which is then stored separately on a digital medium

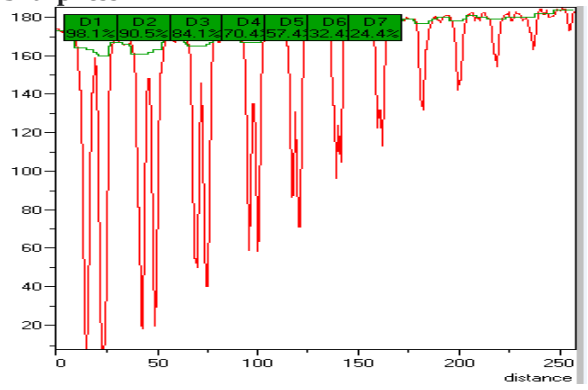
Digital radiography using radiation - sensitive plate - and panel detectors, including digitization of traditional film. Several other computer - assisted methods such as the CT technique.

Digital radiography gives the same shades of black and white images, but viewing and interpretation is done on a computer screen. The quality of the image on the film can be assessed by three factors, namely:

1) Contrast



2) Sharpness



3) Graininess

Digital radiography, the factors contrast, sharpness and noise are a measure for the image quality; pixel size and noise being the (electronic) equivalent of graininess. The major parameters to compare film to digital radiography are spatial resolution, contrast sensitivity and optical density range.

The major merits of digital radiography compared to conventional film are:

- Shorter exposure times and thus potentially safer
- Faster processing and Reviewer can view live or integrated images
- No chemicals, thus no environmental pollution
- No consumables, thus low operational costs
- Plates, panels and flat beds can be used repeatedly
- Digital images can be saved in the cloud and experts can review the digital image in real time from anywhere.
- A very wide dynamic exposure range/latitude thus fewer retakes
- Easy to store date without any special arrangement.
- Possibility of assisted defect recognition (ADR)
- Easy to analysis any defects with different measuring tools.

Digital radiography using panel or line array detectors this process of digitization with assigned grey levels is done at once, at the detector itself. In case of imaging plates the digitization and grey level assignment is done in the so - called "reader". The mapping process allows data to be measured and stored from a much wider dynamic range than the eye can normally perceive. After an image has been stored, different maps can later be applied to show different thickness ranges, without affecting the original measurements. These maps can be linear or non - linear: for example, a logarithmic map is sometimes used to more closely mimic the response of conventional films.

Why need to automation of digital X - ray

- Ultrasonic testing and Phased Array is very effectively used for the detection of defects in oil and gas transportation pipes welding in an automated mode, but ultrasonic testing has some other limitations for the detection of volumetric defects. Radiography testing is more reliable for detecting volumetric defects (Porosity, slag etc.) than ultrasonic testing. After the automation of phased array system, the industry is adopting phased array system and it is gradually replacing radiography in pipe manufacturing.
- For best quality pipe we cannot bypass radiography as radiography is still the best NDT method to detect volumetric defects. Now the time has come when we need to develop Auto Digital Radiography in parallel with Auto Ultrasonic testing and combine the results of both the NDT methods to get extremely high quality pipes for gas and oil transportation.

Roadmap to achieve Automation

- With the combination of plate panels (with extremely small pixel sizes) and AI, we can capture defects that are not visible to the naked eye in digital images. By comparing the data with data from other NDT methods we can get high quality with zero allergens.
- With AI we can easily transfer digital images to color images and pixel contrast variation will be the basis of color combination.
- Steel pipe manufacturers typically use a trolley/wagon or similar type of arrangement to test pipe with digital radiography.

Figure: An example of a boom (for installation base of flat panel or X - ray tube) with wagon for pipe transport

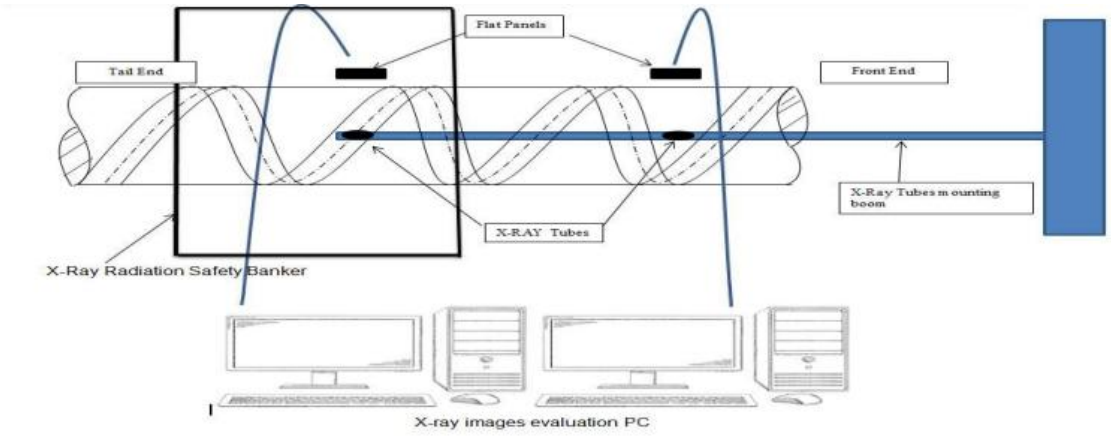
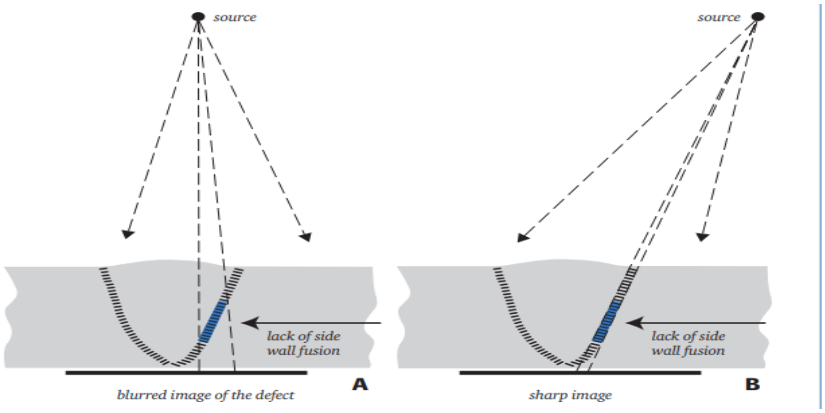


Figure: An example of multi plate panels mounted at different angles to improve flaw detection capability with different outputs that will be combined by AI software for the final visualization.

- Industries generally use single wall single image or double wall single image technology but after automation we can use both the technologies together.
- The time has come for the pipeline industry to introduce auto digital systems with features such as automatic weld tracking, smaller pixel multiple flat panels for better sensitivity, and advance software where we can convert all flat panel outputs to get the final X - ray image view.



- By adding different X - ray sources and digital flat panels, we can easily detect defects that are not possible to detect with a single X - ray source and panel. Like ultrasonic testing where we use series of transducers to cover all types of defects.
- Create an AI base database where test results of all NDT methods are stored to be helpful in case of a problem in the service pipeline.

Benefits

Get high quality pipe that is free from all kinds of defects to make oil and gas pipeline safe and help the environment with zero accidents.

2. Conclusions

Digital X - ray Live Image Interpretation with AI software is more effective without human intervention and we have got fully automated digital X - ray system.

Effective comparison of test results of two or more NDT methods for accurate decision making with AI software.

Achieving full automation of digital radiography testing with AI is the future. AI can easily detect defects in live mode of digital radiography testing which are not acceptable by the standard. We can integrate and store digital radiographs of weld part identified by AI based software for more accurate result.

AI based software can easily differentiate the contrast difference in X - ray images. Auto alarm can alert the reviewer if any defect is larger than the acceptable limit. In an advanced version we can arrange a series of flat panels at different angles to obtain a 3D view of the defect.

AI software can compare an alarming images with data images to make accurate decisions.

In digital radiography live testing it is very difficult for the NDT specialist to continuously monitor the live images. But automation software can continuously monitor.

So if AI software already has ultrasonic inspection data and followed by digital radiography data we can easily insure the quality of weld and ensure that weld is free from all types of defects (volumetric as well as linear) is free.

References

[1] GE Inspection Technologies Industrial Radiography Image forming techniques Issued by GE Inspection Technologies ©2006 General Electric Company.