Evaluation of the Signal to Noise in Different Radiographic Methods and in Standard Digitizer

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Abstract: Radiography is one of the methods to find volumetric defects in Non Destructive Technique (NDT). Radiographic film is digitized for the further assessment of the defects. The successful use of radiography depends on the source used being X-ray or Gamma rays and the digitizer. The effect of source and digitizer used should produce necessary contrast and quality of the image. This paper deals with the different radiographic technique applied on a stainless steel pipes .The resultant radiographic film is digitized in three different digitizers. The variations of image quality parameters such as Signal to Noise Ratio (SNR), Memory capacity, Resolution is analyzed for the film digitized in different resolutions and file formats. The results have been analyzed to find the suitable parameters for the digitization of radiographic weld metal. The results show that X_ray source is giving good Signal to Noise Ratio compared with the other two sources.

Key words:- Radiographic methods, Signal to Noise Ratio, Film digitizer.

1. Introduction

The successful use of radiography depends on the ability of the radiation source, be it x-ray or gamma, to provide sufficient radiation to penetrate the weld and to produce an image of acceptable contrast and definition on the processed radiographic film, using an acceptable and economic time[1]. The difference between x-ray and gamma-ray radiographs is that while x-rays and gamma-rays are fundamentally the same type of electromagnetic radiation, the quality of radiation produced is based on their origin and their differing energy spectra[2].

In the past few years, a substantial increase in the number of radiographic film digitizers being used in radiological research industries throughout the world have been reported [3]. Basically, a film digitizer converts optical density information present in the radiographic image into pixel values, density and contrast values, which are interpreted by the computer to create the digital image. Digital radiography consists of four major steps which include X-ray detection, digitization, image processing and display [4] – [7].

This paper concentrates on the quality of the radiographic weld image with one image quality parameters for different resolutions and file format. To investigate the effect of parameters on the image, a radiographic film of X-ray and gamma rays such as iridium 195, selenium 75 are digitized in three different digitizer is considered.

The paper is organized as follows the section 2 reviews with Gamma source Radiography, Section 3 deals with X-ray radiography. The Section 5 deals with the different film digitization. Section 6 discusses the experimental results on the data acquired, and Section 7 concludes the paper.

2. Gamma Source Radiography

Weld inspection of pipe can also be done using Gamma source. The Gamma ray sources have less weight equipment and low cost compared to X-ray radiography. Gamma equipment does not need a power supply and are very useful for mobile inspection and access in space restricted areas. The most commonly used gamma ray sources are Iridium 192(Ir 192) and Selenium 75 (Se 75)[2].

An 8NB stainless steel pipe of wall thickness Sch 40 is considered for test measurement is subjected to gamma radiography. The gamma sources considered for analysis are Ir-192 and Se-75.The specification of the radiographic technique is tabulated in the table 1. Test measurement on the weld pipes are conducted to study the effect of image quality parameters such as Signal to Noise Ratio ,resolution memory capacity and file format in radiographic images.

Table1. Specification for Gamma ray Radiography

Specification of the sources	**Ir-192**	**Se-75**
Radiographic technique	Double Wall Double Image(DWDI)	Double Wall Double Image(DWDI)
Source to film distance(SFD)	12 inch	12.5 inch
curies	3.5	3.5
Size	2 x2mm	2 x2mm
Exposure time	13 min	1 min 25 sec
Film type	D4	D4
Intensifying screen lead foil type	Front size 0.005 inch Back screen 0.005 inch	Front size 0.005 inch Back screen 0.005 inch
Film size used	6” x 3”	6” x 3”

3. X-Ray Radiography

X-ray is one of the powerful sources used for the evaluation of radiographic weld material. X-ray sources generate a continuous range of energies up to a maximum. And that is dependent on the operating kilo voltage (kV), while gamma-ray sources produce fixed line spectra at specific photon Energies[1].

The same 8NB stainless steel pipe of wall thickness Sch 40 is subjected to X-ray radiography. The specification of it is tabulated in table 2

Table 2.Specification for x-ray Radiography

Specification of the sources	**X-Ray**
Voltage	250 Kv
Focus size	2.6 mm
Current	5 mA
Source to film distance(SFD)	24 inches
Exposure time	1.0 min
Film type	D4
Intensifying screen lead foil type	Front size 0.005 inch Back screen 0.005 inch
Film size used	6” x 3”

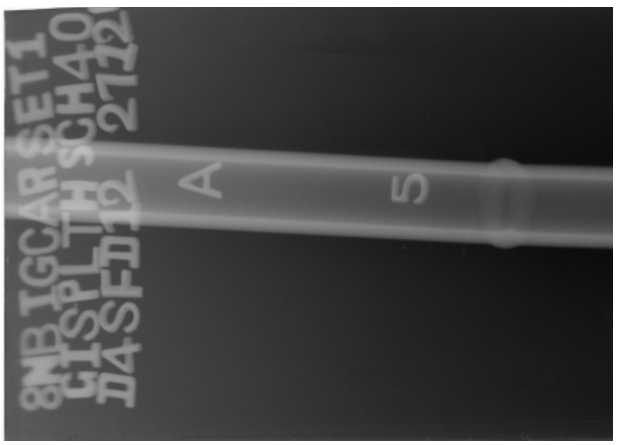

Fig.1.Digitized radiograph of an 8NB pipe

4. Film digitization

Radiography includes not only film, and due to recent technological advances, it is now possible to meet a wide range of NDT inspection applications with **digital solutions** i.e. the digitization of films. Fortunately, digital radiography systems (digitizers) are currently avail-able for digitizing radiographic film images without losing the useful information captured in the original radiograph.

It has been reported that digitized radiographic images not only enable more-efficient management of radiographic inspection data, but also make closed-loop process control and automatic inspection of welds possible. In order to validate the digital detector for measurement or assessment of weld image, physical image quality test needs to be performed. The assessment is a complicated multivariate quantity related to the contrast, resolution, and noise properties of imaging systems. It is a quantitative measurement and it is a requirement of ASME standards, EN (EN 14784-1) and IEC (62220-1).

For digitization of radiographic films three film digitizer are considered for analysis they are

1. *VIDAR's* diagnostic PRO Advantage film digitizer from Cynoptixs center, Chennai.
It is a CCD Digitizer. Radiographic film has been digitized in three different DPI (75,300,570) and in two file formats (BMP, TIFF).
2. Array Corporation's 2905 X-Ray film digitizer from Indira Gandhi Center for Atomic Research, Kalpakkam.
It is a Laser film digitizer. The radiographic film was digitized in two different DPI (75,300) and in two file format (BMP, TIFF).

3. *LUMISCAN 85LS* from Indian Space Research Organization, Bangalore, a Laser film digitizer. Radiographic film was digitized in 2048, 4096 LPS (Lines per Scan) Each LPS is stored in TIFF 8 bit and TIFF 12 bit format.

5. Data Analysis and Results

The film digitized in three digitizers is stored in two file format and in different DPI. The performance of this digitizer is analyzed in terms of image quality parameter Signal to Noise Ratio (SNR).The results obtained are tabulated in table 3. The figure (1) - (3) shows the graphical comparison of image quality parameters Signal to Noise Ratio vs Resolutions. From the results it was found that for the **ARRAY 2905 film digitizer** on considering resolution the film digitized in 400 µm is having higher value of Signal to Noise Ratio and less

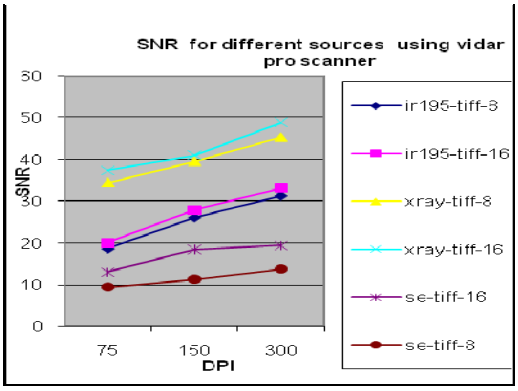

Fig.3.SNR Vs Resolution for different sources in Vidar

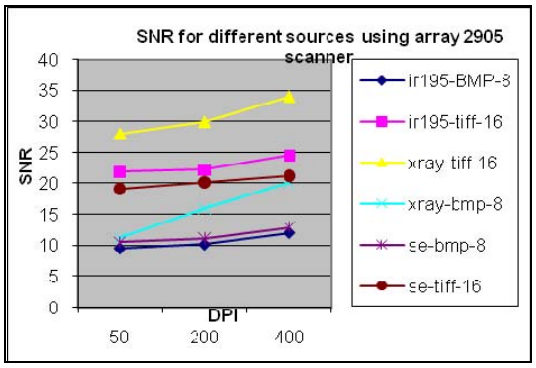

Fig.2.SNR Vs Resolution for different sources in Array 2905

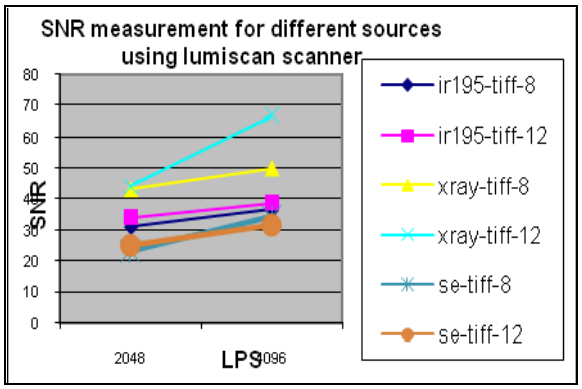

Fig.1.SNR Vs Resolution for different sources in LS-85

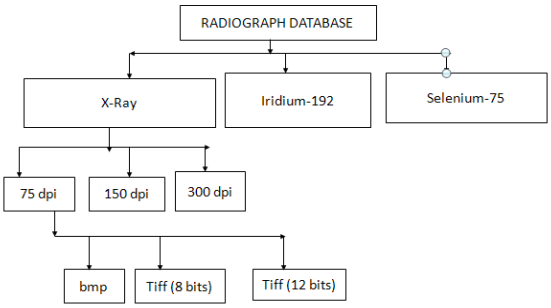

Fig.4.Data base for a single DPI, Similarly the database is acquired for all techniques and all dpi

memory capacity. In this 400 µm the file format TIFF with 16 bit is giving higher value of Signal to Noise Ratio and less memory capacity. In **Vidar film digitizer** in 300 DPI Resolution, Signal to Noise Ratio is high but with increase in memory capacity. When comparing the file format at this resolution TIFF with 16 bit is giving higher value of Signal to Noise Ratio and have high memory capacity. In case of LS 85 film digitizer the film digitized in 4096 LPS resolution is giving higher value of Signal to Noise Ratio and with high memory capacity. The file format with 12 bit TIFF gives good Signal to Noise Ratio compared to all other file format in the LS 85 film digitizer.

On comparing the sources X-ray is giving higher value of Signal to Noise Ratio with respect to Ir-192 and Se - 75 for all the film digitizers and there is not much of variation in memory capacity. With respect to film digitizers, **LS 85** film digitizer gives higher value of Signal to Noise Ratio. The film digitized at 400 µm is having higher value of Signal to Noise Ratio and less memory capacity. Thus one can conclude that film digitized with higher resolutions and with larger bit gives high value of Signal to Noise ratio.

Table3 .Image quality parameters values obtained from different sources and in different digitizer.

DIGITIZERS	RESOL -UTION	FILE FORMAT	BIT	SNR FOR DIFFERENT SOURCES			MEMORY		
				SE 75	IR-192	XRAY	SE 75	IR-192	XRAY
ARRAY-2905 (Laser Film Digitizer)	50 µm	BMP	8	10.55	9.486	11.25	11.4MB	11.4MB	11.4MB
		TIFF	16	19.19	21.93	28.13	22.8MB	22.8MB	22.8MB
	200 µm	BMP	8	11.12	10.12	15.91	733KB	733KB	733KB
		TIFF	16	20.21	22.2	30.06	1.4MB	1.4MB	1.4MB
	400 µm	BMP	8	12.93	12.02	20.15	188KB	188KB	188KB
		TIFF	16	21.28	24.55	34.03	366KB	366KB	366KB
VIDAR (CCD Film Digitizer)	75 DPI	TIFF	8	9.45	18.73	34.47	237KB	228KB	238KB
			16	13.11	20.09	37.44	353KB	340KB	355KB
	150 DPI	TIFF	8	11.3	26.14	39.6	898KB	898KB	928KB
			16	18.54	26.14	41.04	1.31MB	1.31MB	1.35MB
	300 DPI	TIFF	8	13.81	31.3	45.43	3.05MB	2.86MB	3.19MB
			16	19.47	33.15	48.85	4.58MB	4.29MB	4.79MB
LS 85(Laser Film Digitizer)	2048 LPS	TIFF	8	23.32	31.14	43.19	1.96MB	1.93MB	2.14MB
			12	25.14	34.19	44.15	3.62MB	3.83MB	4.32MB
	4096 LPS		8	34.74	36.67	50.01	2.67MB	2.15MB	2.56MB
			12	31.89	38.93	66.76	4.8MB	5.18MB	5.35MB

LPS-Lines Per Scan *DPI-Dots Per Inch* µm-Micro meter

Conclusion

From the results it was found that X-ray film has good Signal to Noise Ratio and high memory capacity compared to Gamma radiography. An “improvement” in one parameter can degrade another, resulting in decreased performance. In this context it is to be noted that , even a very impressive Signal to Noise Ratio (SNR) will not result in a good image. Hence unique quantitative image analysis cannot be achieved if the image format and the radiation sources are different. But above all, even though as the radiographer is well aware of analyzing the inequality still radiographic technique is perhaps the most critical component in attaining quality image output.

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