Use of X-Ray Radiography in the Field of Non-Destructive Testing: Analytical Approach

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Abstract— *Non-Destructive Testing tests different types of materials which includes various types of techniques in NDT. X-ray Radiography testing one major type which is applicable to most materials and gives best and effective results. In radiography X-ray and gamma radiation the famous "penetrating radiation" is used. Variations in thickness and density modify the passage of radiation through the test material specimen. This variation in the intensity of the transmitted radiation can be detected in a different variety of ways, by use of film, semiconductors, photoconductors, and scintillation crystals. The information on radiography has been divided into two sections, one dealing primarily with X-ray radiography and the other dealing with gamma-ray radiography.*

Keywords— NDT, Non-destructive Testing, Analytical Paper, Radiography, X-Ray, Gamma Rays, Radiation

I. Introduction

Radiography is method of non-destructive testing which uses X-ray radiation. X-ray is referred in this thesis as "penetrating radiation." Radiography is one of the oldest nondestructive tests, having been used since the early 1920s [3]. Today it is one of the most widely used nondestructive tests. The intensity of the penetrating radiation is modified by passage through material and by defects in the material. The phenomenon of differential absorption illustrated in Fig. 4.1 [3] serves as the basis for the use of radiography in NDT. The contrast (difference in density) on the developed film between the image of an area containing a defect and the image of a defect-free area of the specimen permits the observer to distinguish the flaw.

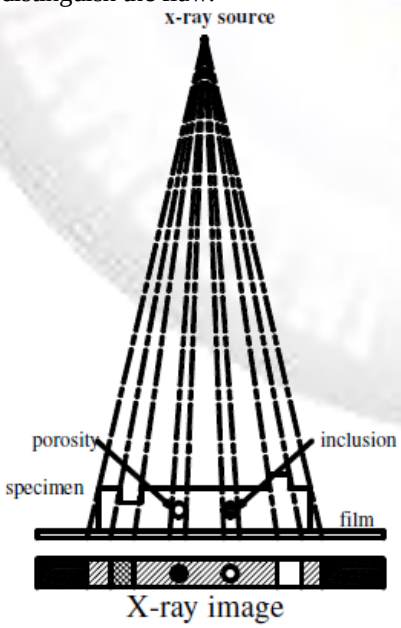

Fig. 1: Differential Absorption

X-rays and gamma rays comprise part of the electromagnetic spectrum. This spectrum may be roughly divided, on the basis of wavelength, in to the following categories:

Gamma rays	0.1-0.005A
X-rays	5-0.0004 A
Ultraviolet	10-4,000 A
Visible	4,000-7,500 A
Infrared	7,500-4 x 10^6 A
Radio waves	10^6-10^{13} A

Table 1: Electromagnetic Spectrum

The wavelengths are expressed in angstroms, an angstrom being equal to10-8cm. X-rays and gamma rays have the following properties:

1) Are invisible electromagnetic radiation
2) Can penetrate matter
3) Are differentially absorbed
4) Travel in straight lines
5) Produce photochemical effects in photographic emulsions
6) Ionize gases through which they pass
7) Are not affected by electric or magnetic fields
8) Travel with a velocity of 3 x 1010 cm/sec or 186,000 miles/sec
9) Are capable of liberating photoelectrons
10) Cause some substances to fluoresce

The usual method of detecting X-rays and gamma rays in the field of radiography is by means of a photographic emulsion. However, other means such as Geiger counters, semiconductors, photoconductors, and scintillation crystals are sometimes used.[5]

II. Steps followed in X-Ray Radiography:

1) X-ray Radiation Sources
2) Electromagnetic Radiation
3) Absorption
4) Half value thickness
5) Scattering of X-ray
6) X-ray Film Processing
7) Film Graininess
8) Types of Films
9) Geometric Factors
10) Filters
11) Screens
12) Inverse Square Law
13) Film Illuminator
14) Scintillation Counters
15) Detection of X-rays
16) Industrial Radiographic practice
17) Technique Chart
18) Penetrameter

III. TYPES OF RADIOGRAPHY

1) Weld Radiography: Flaws which may be found by radiography in welds include the following: porosity, slag inclusions, inadequate penetration, incomplete fusion, undercutting, cracking, and pinholes
2) Pipe Radiography: Radiography on pipe can be done in three ways, as shown in Fig. 2 [4]. There is the single-wall technique, in which the source is inserted inside the pipe and film is placed around the welded seam. The practicability of this technique depends not only upon the wall thickness but also on the possibility of introducing the source into the pipe itself.

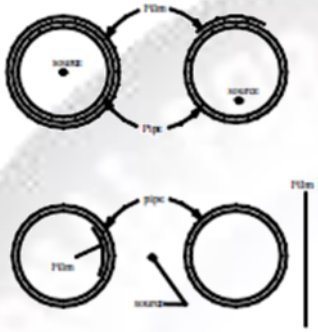

Fig. 2: Radiography of Pipe

3) Radiography codes: There are many existing codes that go into detail on X-ray and gamma-ray radiography. These codes may specify such items as source-to-film distance, penetrameters, and other pertinent information. Some of the existing radiographic codes include those of the 113 American Societies of Mechanical Engineers, Power Boiler and Pressure Vessel Code, United States defense establishment, American Welding Society American Petroleum Institute, and boiler codes of various states. In addition, many company specifications are written to cover specific items produced or procured by the individual company [3]. Example of standard for radiography test is shown in Table 2 [6].

[1] JIS. Japanese Industrial Standards

Standard No.	Designation of standard	Publisher
JIS Z 3104-1968	Method of Radiographic Test and Classification of Radiographs for Steel Welds	Japanese Industrial Standards
JIS Z 3105-1984	Methods of Radiographic Test and Classification of Radiographs for Aluminium Welds	>>
JIS Z 3108 -1978	Methods of Radiographic Test for Circumferential Butt Welds of Aluminium Pipes and Tubes	>>
JIS G 0581- 1984	Methods of Radiographic Test and Classification of Radiographs for Castings	>>
JIS Z 3861- 1979	Standard Qualification Procedure for Radiographic Testing Technique of Welds	>>

Table 2: Standards pertaining to radiographic test

IV. SAFETY CONTROL FOR RADIOGRAPHY

The technology of the safety control of radiations must be applied not only to the radiation operators but also to the public habitants around the radiation facilities so as to reduce the radiation hazards to the minimum by controlling the radiation exposure to be as small as possible. For that purpose, we must be well acquainted with the properties of radiations and radioactive materials, apply effectively the adequate facilities and monitoring instruments, and handle reasonably the radiations and radioactive materials. There are three ways for the protection of external radiation protection [6].

1) Increase the distance between radiation source and human body,
2) Place the shielding material between radiation source and human body,
3) Shorten the time of exposure.

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