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A PRACTICAL STUDY OF NON DESRTUCTIVE TESTING TECHNIQUES ON STEEL MATERIAL

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Abstract — *This research work presents a practical study on Non Destructive testing (**NDT**) techniques like Ultrasonic Testing and Radiographic inspection and application of the same on steel structures. Non Destructive testing techniques are the inspection, Testing & Evaluation of materials parts of the elements assembly of the parts for identifying the Discontinuities, differences in characteristics without disturbing the functioning of the structure or part of it. After the testing was competed the part can be used without any discrepancy. Sometime all other methods of testing were with some difficulties that limit true assessment of the NDT performance. This paper describes developments of NDT technology, Ultrasonic Testing and Radiographic Testing methods to detect problems in railway lines, water pipe leakages, gas pipe leakages and bridges whose service cannot be disturbed during the evaluation time. Most of the overcomes that are due to conventional method of testing should be overcome with NDT Technology usage. Again in NDT Ultrasonic Testing and Radiographic inspections are the advanced tests over Liquid penetration and Electromagnetic method.*

Keywords **:** *Non-destructive testing ,Ultrasonic Testing ,Radiographic Testing, water pipes ,Gas pipes railway lines, bridges.*

I. INTRODUCTION

The main constructions of civil infrastructure systems are road ways, road bridges, railways water supply systems, drainage systems and these are the main contribution from a Civil Engineer to the society. The usage of steel and iron in bridge works is mainly due to the advantages of steel over the conventional material like concrete and wood. The bridge failures due to small defects make the researchers to concentrate more to research on steel bridges. The assessment of the structural integrity of infrastructure after extreme events is an important application of non -destructive technology to an Engineer it is easy to reduce bridge failures by avoiding error in design and by increasing the quality of material. But human and economic losses are the remainders which move towards the study of causes for the failures. In the production of products, single or more than one different material will be used in combination. The material used are of good quality for production, the product also will be a good quality one. Quality checking in any industry is very important to get good quality output particularly in construction industry. Quality maintenance checking is also very important in the case of Railway lines, Water pipes, gas pipes defects without service break of the functioning during the evaluation time In any Industry we can check the quality and evaluation in two ways. IN this paper I am discussing about Ultrasonic pulse velocity method and Radiography methods of NDT Tests.

1. Destructive test Methods.
2. Non Destructive test Methods.

Destructive test method: The specimen is subjected to fracture under load and mechanical properties are measured by this testing. Eg. Tensile test, Impact test, Hardness test and Fatigue test and Compressive strength test etc.

Non Destructive test method: Both strength and Quality of material like homogeneity of the composite material etc., Can be found under this category without disturbing the service of the element. The production inspection and in service inspection for controlling the integrity and quality of the product can be done with Non Destructive testing techniques. There by to reduce the production cost as well as maintenance cost and to have a uniform quality control. At the time of construction NDT are used to ensure the quality of the material and joining process.

NDT tests:
1. Visual and optical
2. Liquid penetration
3. Magnetic field induction
4. Ultra sonic pulse velocity testing method
5. Radiographic testing

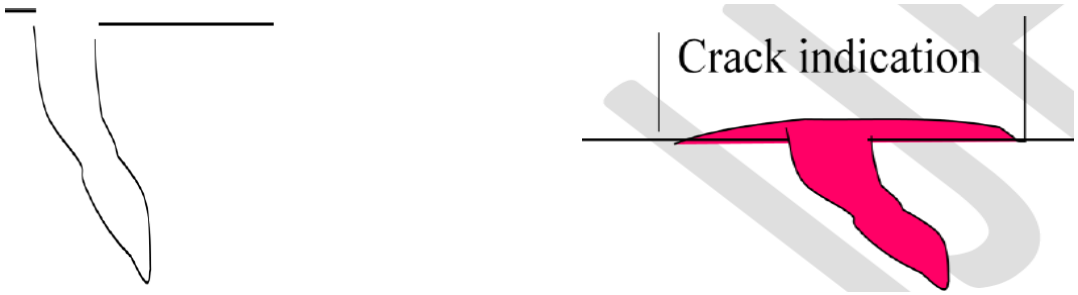
Visual inspection: Visual inspection involves using an inspector's eyes to look for defects. The inspector also uses special tools such as magnifying glasses, mirrors to gain access and more closely inspect the subject area. Surface defects, dimensional accuracy and penetration in the welded joints any colour change any crack formation are inspected

by this method. Most basic and common inspection method**.** Tools include fibre scopes, bore scopes, magnifying glasses and mirrors are used to inspect.

Liquid Penetrant Inspection: It is applicable to discontinuities that are open to the surface or surface connected. As surface opening is required, it cannot detect anomalies like inclusion, segregation etc. Liquid Penetrant Inspection detects only those discontinuities that are present on or open to the surface part. The principle of the technique is that a liquid is drawn by capillary action in to the defect and, after subsequent development; any surface breaking defects may be rendered visible to the human eye. This method of examination involves the use of a solvent soluble coloured dye, which penetrates in to surface discontinuities by capillary attraction. After an interval or penetrant dwell time, the excess dye is removed and the exact position of any discontinuities present is detrained by the use of a non-aqueous wet developer, which gives a white background against the coloured penetrant in the discontinuity.

The materials used in this procedure are Penetrant: P-Met Company PP 110/NDT-19 or equivalent Remover : P-Met Company PC 120/NDT-17 or equivalent Developer: P-Met Company PD 130/NDT-18 or equivalent Pre-cleaner Remover may be used for this purpose.

Crack Indication: A liquid with high surface wetting characteristics is applied to the surface of the part and allowed time to seep into surface breaking defects. The excess liquid is removed from the surface of the part, developer (powder) is applied to pull the trapped penetrant out the defect and spread it on the surface where it can be seen. Visual inspection is the final step in the process. The penetrant used is often loaded with a fluorescent dye and the inspection is done under UV light to increase test sensitivity. It is most preferred to check the gas lines.



Human eye acuity Actual discontinuity (Liquid penetration)

Figure: 1 Liquid penetration Test

Ultrasonic Testing (UT): Human ears can respond to sound vibrations which have frequencies in the range of 20Hz to 20000 Hz .The frequencies above 20000 Hz are known as Ultrasonic Frequencies. Ultrasonic Testing uses high frequency sound energy to conduct examinations and make measurements. Ultrasonic inspection can be used for flaw detection and evaluation, dimensional measurements, material characterization, and more. To illustrate the general inspection principle, a typical pulse/echo inspection configuration will be used.

Methods for Ultrasonic Testing are
1. Resonance Method.
2. Trough Transmission Method.
3. Pulse Echo Method

A typical UT inspection system consists of several functional units, such as the pulsar/receiver, transducer, and display devices. A pulsar/receiver is an electronic device that can produce high voltage electrical pulse. Driven by the pulsar, the transducer generates high frequency ultrasonic energy. The sound energy is introduced and propagates through the materials in the form of waves. When there is a discontinuity (such as a crack) in the wave path, part of the energy will be reflected back from the flaw surface. The reflected wave signal is transformed into electrical signal by the transducer and is displayed on a screen. In the applet below, the reflected signal strength is displayed versus the time from signal generation to when an echo was received. Signal travel time can be directly related to the distance that the signal travelled. From the signal, information about the reflector location, size, orientation and other features can sometimes be gained. Ultrasonic Inspection is a very useful and versatile NDT method. If the echo is a sharp edged one indicates that it touches the defect.Sherical defects like porosity reflects only a small amount of sound. It can be used very effectively in submarines with 100GHZ. The basic formula, to which reference is made throughout the whole study of ultrasonic examination is

$$C = f X \lambda$$

Where C =Velocity in mm/s
F =frequency in Hz
λ = wavelength in mm

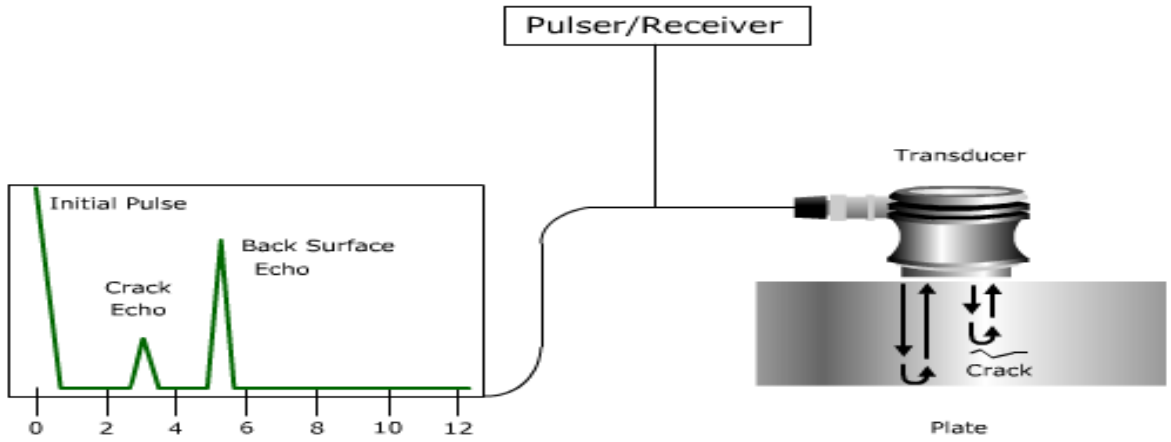


Figure: 2 Schematic Representation of Ultrasonic Pulse Velocity Testing Equipment

In this research a block of size 34 mm of steel was considered for practical study. As shown in the figure3.The equipment consists of a thickness scale on Y-axis and Time scale on X-axis. First of all we need to apply oil over the surface of metal block, to remove the air gap between metal and probe. The vertical difference between the two probes will give the depth of defect. For this 34mm size block we took as specimen for testing the defect depth is found as 15mm.

Figure: 3 Ultrasonic Pulse Velocity Testing

Advantages of Ultrasonic Inspection are:

1. It is sensitive to both surface and subsurface discontinuities.
2. The depth of penetration for flaw detection or measurement is superior to other NDT methods.
3. Only single-sided access is sufficient when the pulse-echo technique is used.
4. Minimal part preparation required.
5. Ultrasonic Method is faster than Liquid Penetration method.
6. Electronic equipment provides instantaneous results.
7. Detailed images can be produced with automated systems
8. It has other uses such as thickness measurements, in addition to flaw detection.
9. The ultra-sonic Technique widely used for welds crack detection and the measurement of steel element (measurement of section loss due to corrosion.

Limitations of ultrasonic inspection:

1. Surface must be accessible to transmit ultrasound.
2. Skill and training is more expensive than with some other methods.
3. It normally requires a coupling medium to promote transfer of sound energy in to test specimen.
4 .Materials that are rough, irregular in shape, very small, exceptionally thin or not homogeneous are difficult to inspect.

5. Cast iron and other coarse grained materials are difficult to inspect due to low sound transmission and high signal noise.
6. Linear defects oriented parallel to the sound beam may go undetected.

Radiographic Inspection:

Radiographic inspection is performed using a radioactive isotope or an x-ray tube in order to create an image on a film or in a digital format.X-rays are produced by high voltage x ray machines whereas gamma rays are produced from radioactive isotopes such as Iridium 192 .The x-ray or gamma rays are placed close to the material to be inspected and they pass through the material and are then captured on film. This film is then processed and the image is obtained as a series of gray shades between black and white. This method can be performed in lab or in the field. This method is a volumetric inspection in which defects that are not open to the surface can be detected that may not otherwise be detectable. The choice of which type of radiation is used (x ray or gamma) depends on the thickness of the material to be tested. Gamma sources have the advantage of portability which makes them ideal for use in construction site working. Two types of penetrometers or image quality indicators are mainly used to determine the quality of the radiographic image. Penetrometer material and the specimen need be one and the same. These are placed on the specimen and radiographed; Radiograph gives the image of the specimen super imposed with the image of penetrometer. The image of penetrometer gives an indication about the quality of the image. Penetrometer sensitivity is indicative of only the quality of the image and it shall not be related to the size of the defect that can be detected.

A vast array of material can be examined by this method which is an efficient and reliable way-ranging from tiny electronic components to large vessels. Element has the capabilities to perform conventional film radiography to Computed and Digital radiography. Computed and Digital radiography is a highly sensitive method of radiography that produces an image in a digital format that can be viewed on any laptop or computer.The part to be tested is is placed between the radiation source and a piece of film. If any defect occurs rays will not pass through the object.. Thicker and denser area will stop more of the radiation. The film darkness (density) will vary with the amount of radiation reaching the film through the test object. The failure of a pressure vessel can result in the rapid release of a large amount of energy. To protect against this dangerous event, the tanks are inspected using radiography and ultrasonic testing.

The radiographic method is more traditional method of NDE. It is used to inspect the quality of butt welds in the fabrication of steel plates for bridge girders. It works similar to an X-ray. Penetrating radiation is absorbed to produce a high contrast image. Indications of cracks and discontinuities in the welds will show up as darker areas on the high contrast image. Fig. shows an example of a radiograph, with the locations of known cracks shown as dark horizontal lines. We need to take care that Penetrometer should always be kept opposite to the film.For important jobs wire type Penetrometers are preferred. Linear defects are not measurable with Radiography Technique. Usage of Led screens reduces the film development time.

When fast moving electrons are suddenly decelerated, X-rays are produced. The kinetic energy acquired is converted into X-ray photon energy as shown in figure. The spectrum of X-rays generated in X-ray tube is continuous or white X-rays superimposed with characteristic X-rays, K_α , K_β etc. Conventional X-ray tubes can produce X-rays energy up to 600 KV (100KV). There are applications for very much higher energy and penetrating power in the range of 1 Mev –25 Mev in industrial radiography. Basically they consists a source of electrons and a means of producing high electric field to accelerate the electrons. As in the case of X-ray tubes, they strike the target and high energy X-rays are produced. Betatron, linear accelerators and Van de Graff generators are some of high energy sources.

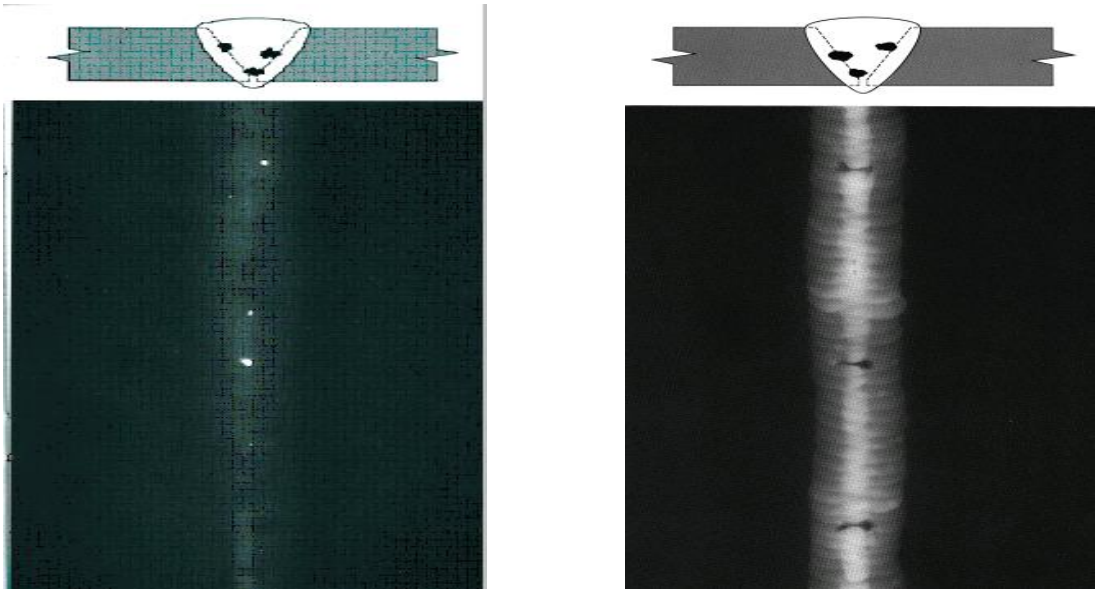


Figure :4 Appearance of inclusions in film radiography

New advances in radiography have made it possible for some applications to generate real-time X-ray continuous images video that can be stored digitally.

Figure: 5 Welded steel pipe (GAMMA Radiography Technics-HYD)

Figure: 6 Testing of Welded Steel Pipe Joints with Radiographic Methods ((GAMMA Radiography Technics-HYD)

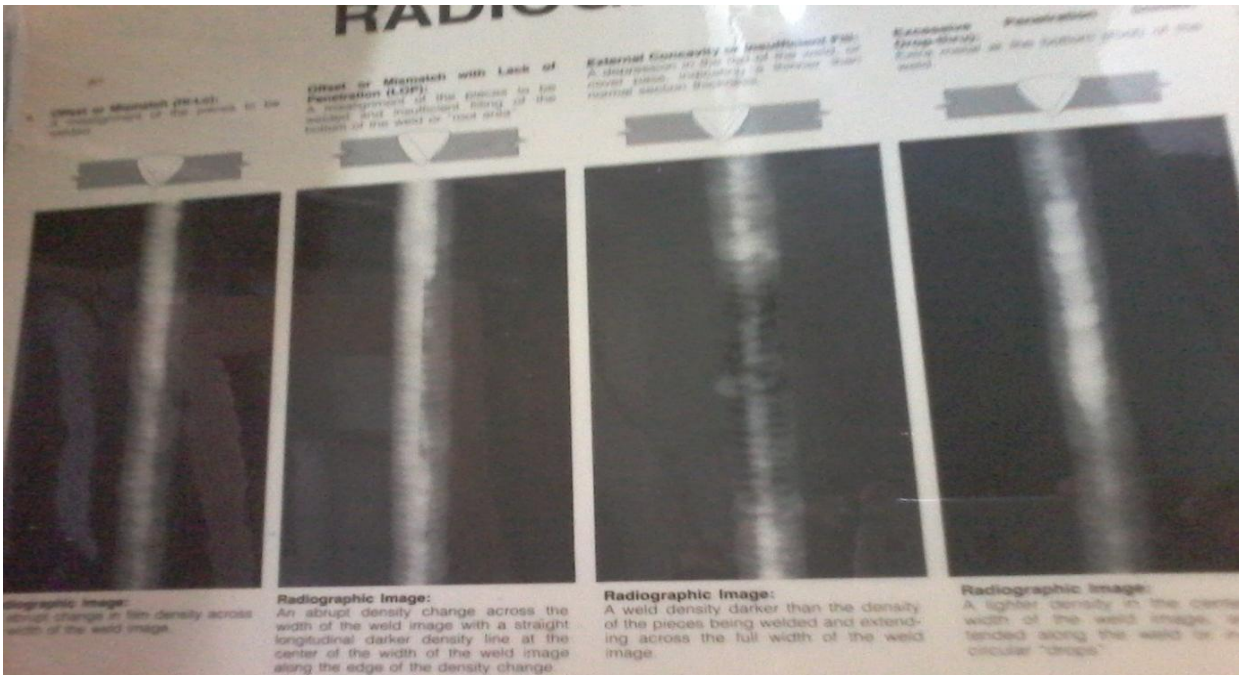


Figure: 7 Steel Pipe Welded Joints In X-Ray Films(Radiographic images)

Advantages of Radiographic method:

1. The method of detection of defects in welding lines is effective.
2. This method can reduce the working effort of human being and increase the defect detection efficiency.
3. Defects in pressure vessels can be identified.

Disadvantages of Radiographic method:

1. Highly trained and qualified persons required to do the testing.
2. The emission of high energy x rays is harmful to human bodies working with.
3. The site safety must be followed very strictly while handling x-ray equipment.
4. Frequent health check-ups should be done to the people working with Radiographic methods.

Applications of NDT:

1. Ultrasonic thickness gauging is routinely utilized in the petrochemical and utility industries to determine various degrees of corrosion/erosion.
2. For processing plants, and offshore structures.
3. Estimation of void content in composites and plastics Measurement of case hardening depth in steels.
4. Non Destructive testing (NDT) is the preferred technique to evaluate the integrity of pressure vessels, pipelines, tubular joints, underwater welds.
5. It is well known that water has a detrimental effect on the performance of adhesive joints, and is amongst the most common elements for a bond to encounter in service.
6. Surface analysis has subsequently been performed on the failure surfaces of these specimens, which has helped to explain the variations seen in the mechanical performance after exposure to moisture. It is well known that introduction of a crack-like defect into a structure reduces its stiffness .Even government sector they are preferring NDT tests for detection of water leakage of water pipes.
7. For diagnostic testing of strength, quality, durability of structural materials for the assessment of reliability of limit states of modern civil structures, the non-destructive acoustic, ultrasonic and sclerometric methods are mainly applied in connection with the testing of samples (bore-holes) as well as other special scientific methods justified and adjusted to the construction practice under specific conditions. With the help of ultrasonic, rotary current and radiographic methods strength properties of steel and connections in the as well as testing on cut-off samples – to test structure– non-destructive special methods and tests on models or cut-off samples – to test elements, steel plates and connections– acoustic, ultrasonic, electrical thermo vision, electromagnetic and other methods to test corrosion and protective layers of Steel elements of building structures are tested with the use of NDT methods and stands enabling a complex assessment of steel elements.
8. To reduce in-service accidents in the case of railway lines and all by checking the joints.

CONCLUSIONS

1. Productivity could be increased by NDT..
2. Digital image processing techniques simulate the functions of human visions.
3. Radiographic method and which can derive useful information from images.
4. In some aspects such as enhancement, digital image processing out performs human visions by improving the quality of images.
5. Linear defects cannot be measured with Ultrasonic Pulse velocity method.
6. Among all the methods Ultrasonic Pulse velocity method is the most accurate method.

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