Comparisons between Ultrasonic Testing (UT) and Radiographic Testing (RT)

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Abstract:

The objectives of this paper is to discusses the Non destructive testing of metallic structures. Two of the most common non- destructive testing methods were studied, Ultrasonic Testing(UT) And Radiographic Testing (RT) and comparisons was made between them through the results obtained on the based on cost and accuracy, safety, time consumption. These tests provides a better understanding of flaws and defects existing in the equipment by clarifying the type, size, position and orientation of defects. This results in prevention of malfunctioning of the equipments and processes. The Samples are also selected and experiments are conducted on each of the two methods. The experimental results are discussed and comparisons are made based on cost, accuracy, safety, time consumption. Based on these comparisons are made conclusions. The results of the experiment two test methods Ultrasonic, X-ray Testing shows that: Ultrasonic test gives the best flaw detection result, this is because ultrasonic is sensitive to small flaws. X-ray gives better flaw detection result next to ultrasonic. X-rays are hazardous to human beings when absorbed above certain limit, hence great care should be made before, during and after conducting the test. Due to this safety case the operators and the testing room should be shielded and test should be conducted only in specially prepared test rooms. UT method has no health hazard during and after operation.

Keywords : Non-destructive testing - metal- Welding-Crack- ultrasound testing - radiography- Defect.

مقارنة بين اختبار الموجات فوق الصوتية(UT) واختبار التصوير الشعاعي(RT)

ملخص:

الهدف من هذه الورقة مناقشة الاختبارات غير المدمرة للهياكل المعدنية.

تمت دراسة طريقتين من أكثر طرق الاختبارات غير الهدَّامة شيوعًا، وهما الاختبار بالموجات فوق الصوتية (UT) والاختبار الشعاعي (RT) وتم إجراء مقارنة بينهما من خلال النتائج المتحصل عليها بناءً على التكلفة والدقة والسلامة واستهلاك الوقت. تقدم الاختبارات غير الهدَّامة (NDT) فهم أفضل للعيوب الموجودة في المعدات من خلال توضيح نوع وحجم ومكان واتجاه العيوب. وهذا يؤدي إلى الوقاية من الخلل في المعدات وأيضا خلال عمليات التصنيع. تم اختيار عينات الاختبار وأيضا إجراء التجارب على كل من الطرق السابق ذكرها. وتم مناقشة النتائج التجريبية وإجراء مقارنات على أساس التكلفة، والدقة والسلامة واستهلاك الوقت بين هذه الطرق، وبناءً على هذه المقارنات تم وضع استنتاجات نتائج اختبارات الموجات فوق الصوتية، والأشعة السينية، تبين أنَّ الاختبار بالموجات فوق الصوتية يعطي أفضل نتيجة، وذلك لأنَّ الموجات فوق الصوتية حسَّاسة للعيوب الصغيرة. تليهاالاختبارات بالأشعة السينية. ومن ناحية الخطورة على الصحة فالأشعة السينية خطرة على البشر عندما يمتص فوق حد معين، وبالتالي ينبغي بذل عناية كبيرة قبل وأثناء وبعد إجراء الاختبار، وعليه لسلامة المشغلين فأنَّ غرفة الاختبار يجب أنْ تكون محمية ويجب أنْ تجرى الاختبارات فقط في غرف اختبار أعدت خصيصاً لذلك. بينما الاختبارات بالموجات فوق الصوتية لا يوجد فيها خطر على الصحة أثناء وبعد العملية.

Introduction

Non-destructive testing (NDT) is a wide group of methods used in science and in industry to determine properties or quality of materials, objects or constructions without causing any damage to them. NDT is very popular because it allows saving time and production costs.The basic NDT methods include visual inspection, ultrasound testing , radiography, Liquid penetrant , eddy current testing and many more. These methods and techniques can be used to determine what variations or non-uniformities in properties can be tolerated in the anticipated service. Non-destructive Testing is one part of the function of Quality Control and is complementary to other long established methods. By definition non-destructive testing is the testing of materials, for surface or internal flaws or metallurgical condition, without interfering in any way with the integrity of the material or its suitability for service. A similar description of NDT defined by American Society for Nondestructive Testing (ASNT) is:("The determination of the physical condition of an object without affecting that object's ability to fulfill its intended function"[1]). The term NDT is often considered to be concerned only with the detection and location of flaws[2]. Any kind of defects and discontinuities within the material can affect its efficiency، maintainability and serviceability. A flaw is defined as discontinuity judging from the results obtained by NDT. A defect is defined as a flaw rejected because of exceeding the judging standard prescribed in the specification, the standard . Type of defect is another factor that should be considered by operators. Operators should be aware of the defect classification . Wear, corrosion , erosion , crack. The non-destructive testing (NDT) of metals worldwide experienced a significant Change in the last half of the twentieth century. NDT can save millions of dollars for industries by reducing the failure related costs. Those methods are mainly used in industry during production process for quality assessment and also for structural health monitoring of constructions. With the variety of NDT methods available, it is important to select the method that will provide the necessary results. A combination of different NDT tests may be applied to provide assurance that the material or component is fit for use. Materials are used under various conditions of stress, fatigue and corrosion, which may create additional defects or aggravate present ones. It has been established that most material failures occur because these defects reach dangerous proportions such that remaining parts of the materials could not withstand the stress they are subjected to, thus become ductile or brittle. Several studies based on ultrasonic non destructive testing has been carried out in different industrial field. In 1985,arakawa and his coworkers have reported that non destructive testing based on ultrasonic has explored superior tool in the detection of cracks in weldments eith particular reference to the directivity of the reflected waves from the crack surface , and to the relationship between crack size and height of the echo. In 1985, Wattenberg and his colleague have reported that ultrasonic inspection method has been used for the inspection of defects in the boiling reactor pressure vessels. A variety of test flaws (cracks under the cladding, surface notches and undecladnotches) in different clad test blocks is examined by just in 1994.He described the results and the methods used to quantify the reliability of NDT assessments. In 1989, van leeuwen reported that the ultrasonic testing of austenitic welds prepared by two different welding processes is used to evaluate the welding processes. The tested specimens were welded using two welding processes . In 1989, wessels reported that ultrasonic non destructive testing was also used for detection of defects. They have been used the ultrasonic to detect and characterize any defects formed during the process. The ultrasonic means indicated the presence of lack of fusion, inclusions, porosity and undercutting. In 2003, Sony baby and his colleage reported that non destructive testing techniques based on standard ultrasonic transducer were implemented for detection of defects located at the inner diameter of a girth weld and very close to the root of the weld. In 2010,experimental work was conduted to test the polymeric material using both ultrasonic testing using the pulse-echo technique [3].In performing NDT we should have the clear objective. After having the objective clear the following procedures have to be followed, We should select the proper NDT method and testing conditions to detect surely the flaws. In performing the inspection it is needless to say that inspectors who have sufficient knowledge and skill have to perform the inspection by using the proper inspection equipment and by following the proper inspection manual. It is also necessary to select the proper location for the inspection.It is necessary to make clear what kind of quality is demanded of the object to be examined. This is usually made clear by so called specification.We should investigate what kind of flaw is possible to be generated in the objects. According to past experiences, Purpose of use NDT in industries to:Prevent accident, Ensure Product Integrity, Avoid Failures, Improve Design/ Maintain Quality, Improve Production/ Control Processes, Lower Costs [4]

The Objective of This paper

This paper is expected to raise awareness on what NDT is and how to apply it and to clearly expose the necessity and importance of NDT.Comparisons between two different methods (Ultrasonic Testing (UT) , Radiographic Testing (RT), based on cost, accuracy, safety, time consumption.

Types of Defects

The type of defects that NDT is called up on to find can be classed in to three groups :

1. **Inherent defects:-** Introduced during the initial production of the base or raw material
2. **Processing defects**:**-** Introduced during processing of the material or part
3. **Service defects:-** Introduced during the operating cycle of the material of part.

Defects in metals

The term "defect" is just one of many terms used by industry to describe an imperfect material or component. In some texts and NDT standards, the term "defect" is taken to mean that the defect is out of specification with the manufacturing code and a repair is necessary. Other terms such as "imperfections" "discontinuitie" or "flaws" are often used as more generic terms to describe that something is present or missing that could compromise the integrity of the material or component. The importance of detecting even small defects at the manufacturing stage cannot be overstated. Such small defects can develop into fatigue or stress-corrosion cracks in service, which can be notoriously difficult to detect until it is too late and the component suffers catastrophic failure. The processes in castings, welds and coatings- there are many occasions where the same defect name is used in each of the manufacturing processes. but has occurred for quite different reasons and is peculiar to that process [5].

Welding Defect

Cracks are fracture which have sharp tips, and a small crack opening displacement compared with the length and width. They can be longitudinal or transverse to the weld.

Lack of fusion is when the fusion is incomplete on the wall and root of the weld preparation **Lack of penetration** is when the weld penetration is less than that specified.

Porosity(Isolated/linear / Wormhole / Cluster).

Liner inclusions are linearly distributed and can be nonmetallic and metallic.

Root undercut is when a groove is melted in the parent metal either side of the weld root and is not filled by the weld metal.

Excess penetration is when too much weld metal is produced at the root end of the weld.

Misalignment is when two parts of the parent material are not set or aligned properly before welding [6].

Defects in Parent Material

The term "parent material" is used here to represent the nature of the material. The types of defects considerd in the parent material are as follows:

1. Surface irreqularities comprise rust, weld spatter notches, and grooves. these may have arisen because of the casting process itself.
2. Surface roughness refers to the general surface condition.
3. Porosity ocurs when small bubbles of gas trapped in the hot metal as it cools and solidifies.
4. Inclusions, both metallic and nonmetallic, can occur because of impurities in the base metal , through additives to improve the machining properties the material.
5. Laminations can occur during the pouring process of the metal where splashes can become trapped in the material.
6. Pipe is a defect associatd with shrinkage in the upper portion of the ingot during cooling and solidification.
7. High hydrogen, content can arise when water vapor reacts with the molten metal to form hydrogen [5].

Non-Destructive Testing

There are many kinds of NDT methods and these are divided into the following two classes

* Methods for detecting surface and/or subsurface flaws.
* Methods for detecting internal flaws.

The reason why we divided into these two classes is that surface and/or sub-surface flaws are more harmful to the strength of materials when we consider the same kind of flaw whose shape and size are the same. Hence, we should first examine whether there is a flaw near surface or subsurface[2]. There are numerous methods of NDT, some are reasonably simple, but others require specialist operators and expensive equipment, such as X-ray testing. NDT is also interesting for those who are willing to improve their operations by decreasing downtime and final cost of product to be competitive in the global market [1]. Non-destructive testing (NDT) relates to the examination of materials for flaws without harming the object being tested. As an industrial test method, NDT provides a cost effective means of testing while protecting the object's usability for its designed purpose[3]. Methods of non-destructive testing have been in use for centuries, with the easiest form – visual inspection – being the oldest. NDT can be used to determine the physical and mechanical characteristics of the material. There are many NDT techniques/methods used, depending on four main criteria:

1. Material Type
2. Defect Type
3. Defect Size
4. Defect Location [7]

The ability to inspect castings, weldments , in an accurate and comprehensive manner is critical and even more important when the machine has been in use for several years, and operating conditions that are now placing more stress on the equipment than original design allowed [3]. The primary purpose of a non-destructive inspection is to determine the existing state or quality of a material [2]. This testing may be carried out at the time of production or when the component is in service. Each method is suited to detecting particular faults and may be suited to designing of a component or as a quality control measure[8]. Each NDT method has its strong point and weak point. Hence, it is necessary to select the proper NDT method which is just the method for its use. Recently، to use plural NDT methods. The more important point is that we sometimes cannot detect a flaw even if we apply a proper NDT method. Because of this NDT techniques are rapidly advancing and all inspectors are making their efforts not to miss a flaw as possible as they can [2]. NDT can save millions of dollars for industries by reducing the failure related costs. NDT covers the inspection of almost all equipments. Knowing when and how to apply NDT methodology is important.

NDT methods can be applied for:

1. Thickness measurements
2. Classification of materials
3. Assessment of the chemical composition (changes in chemical composition caused by corrosion can change the material response to the NDT test)
4. Evaluation of surface characteristics
5. Determining areas with high stress concentration
6. prediction of material behaviour [1].

NDT is used for inspection

1)Inspection in manufacturing: Inspection in manufacturing is performed to evaluate qualities of materials and welds. That is, the object of this inspection is to confirm whether the product is manufactured based on the standard and/or the specification.

2) Inspection during the operation

The objective of inspection performed regularly during the operation is to estimate whether we can safely use the objects during the period until the next inspection and to evaluate their expected lives[2]. classification of defects, there are three major categories:

a- Type of defect : consists of categories such as erosion, corrosion, material deformation, cracks, fractures and etc.

b- Shape of defects: round, linear and etc.

c- Size of defects: small, medium or big[1].

Selection of NDT Methods

The selection of a useful NDT method or a combination of NDT methods first necessitates a clear understanding of the problem to be solved. It is then necessary to single out from the various possibilities those NDT methods that are suitable for further consideration. Several different ways of comparing the selected NDT methods are presented, but there is no completely acceptable system of comparison, because the results are highly dependent on the application. Therefore, it is recommended that a comparison be developed specifically for each NDT area and application. Nondestructive evaluation can be conveniently divided into distinct areas:

1. Flaw detection and evaluation
2. Metrology (measurement of dimension) and evaluation
3. Location determination and evaluation
4. Structure or microstructure characterization
5. Estimation of mechanical and physical properties
6. Chemical composition determination

Benefits of Non-Destructive Testing

1. NDT plays an important role in the quality control of a product. It is used during all the stages of manufacturing of a product.
2. It is used to monitor the quality of the:
3. Use of NDT during all stages of manufacturing results in the following benefits:

(a) It increases the safety and reliability of the product during operation .

(b) It decreases the cost of the product by reducing scrap and conserving materials, labour
and energy.

(c) It enhances the reputation of the manufacturer as producer of quality goods.

4. The benefits which can be derived from nondestructive tests include the following :

a -Increased productivity and profits

- Lowered operating and production costs .

- Process control and improvement– monitor manufacturing processes .
- More efficient use of equipment.

b- Safety: Preventing accidents, Preventing loss of life, Preventing loss of property[1,2,9].

The advantages of using advanced NDT technologies include:

1. Better coverage.
2. Better documentation and storage.
3. Cost-effective operation.
4. Clearer and more precise interpretation of results.
5. Higher probability of detection of defects.
6. Better imaging and sizing of defects.
7. Ability of repeating the test [1].

Applications

- Dimensional Measurements.
- Estimation of Mechanical and Physical Properties.
- Flaw Detection and Evaluation.
- Location Determination.
- Material Sorting and Chemical Composition Determination.
- Stress (Strain) and Dynamic Response Measurements.
- Structure and Microstructure Characterization.
- Inspection of Raw Materials.
- Aircraft Inspection[4,6].

Experimental Work

1- X-ray Machine:the radiographic machine used for this study was X-ray CP 200D

The specification of the x ray machine: Industrial –x-ray generator, Type: CP 200D

2- Ultrasonic flaw detector : Digital sitescan USM 32 ultrasonic flaw detector designed and manufactured in Germany by GE inspection technologies krautkramer with serial number 3540 a is used in this study to carry the examination of the carbon steel specimens.

Selection of test specimens

The selected specimens are listed as follows:

1- Twoplate lamination

2- Two welded plate

3- Two welded pipe

Specification and preparation of sample material

The specimens used in this study are all manufactured from low carbon steel material. Carbon steel material was selected because of good weld ability.

Specification of plate :ASTM A283/A283M : Is standard specification for low and intermediate tensile strength carbon steel plate. **Plate of dimension :** 9 x 1.83 m with Thickness of 15.2 cm

Table (1) : Chemical composition

Chemical composition of A283Gr.C, %							
Grade	C	Mn	P	S	Si	Cu	V
A283Gr.C	≤0.24	≤0.90	≤0.035	≤0.04	≤0.40	-	-

Table (1) shows the Chemical composition of plate A283**Gr.C, %**.

Table (2) : Mechanical Property

Grade	Thickness	Yield Strength	Tensile Strength	Elongation
A283Gr.C	Mm	Min Mpa	Mpa	Min %
	5<t≤300	205	380-515	22

Table (2) shows the **Mechanical Property** :Yield Strength,Tensile Strength, Elongation, and Thickness of A283Gr.C

Specification of pipe :ASTM A106 Grade A:

Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

pipe dimension : 9 x 1.83 m with Thickness of 15.2 cm

Table (3) : Chemical Composition of ASTM A106 Grade A

Composition	Percentage %
Carbon max. %	0.25
Manganese %	0.27 to 0.93
Phosporous, max. %	0.025
Sulfur, max. %	0.025
Silicon, min. %	0.10

Table (3) shows the Chemical Composition of ASTM A106 Grade A

Table (4) : Mechanical Properties of ASTM A106 Grade A

Properties	**Value**
Tensile Strength, min (N/mm^2)	330
Yield Strength, min (N/mm^2)	205

Table (4) shows the Mechanical Properties of ASTM A106 Grade A ,Tensile Strength, Yield Strength.

Testing using Ultrasonic (UT)

Equipment

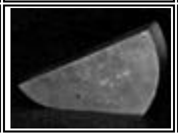
Digital sitescan USM 32 ultrasonic flaw detector designed and manufactured in Germany by GE inspection technologies krautkramer with serial number 3540 a is used in this study to carry the examination of the carbon steel specimens .

Table (5) : choice of probe angle

Parent metal thickness	Probe angle
6 to 15 mm	60 or 70
15 to 35 mm	60 or 45
Over 35 mm	45

Table(5) shows how to choose the angle of the probe according to parent metal thickness

Table (6):-Reference Blocks

TYPE / ORDER CODE	SHAPE	DESCRIPTION/ APPLICATION	STANDARD MADE TO	MATERIAL / SIZE
V1 (A2) / V1		System evaluation block. For range, sensitivity, resolution and angle checking calibrations.	ISI, BS2704 DIN 54120 IIW AWS	Steel 300 x 100 x 25 mm
V2 (A4) / V2		Miniature calibration block for angle beam with 5 mm target hole.	B.S 2704IOW	Steel 75 x 43.3 x10 mm

Table(6) shows Calibration and reference blokes of Ultrasound system**,** Ultrasonic pulse echo testing test using blocks containing notches, slots, or drilled holes to determine the operating characteristics of the flaw detector and probes and establish reproducible test condition. These blocks are termed standard calibration blocks and generally designed manufactured with very certain specification. Another block is used to compare the height or location of the echo from a flaw in the test specimen with artificial flaw in the test block and termed as reference block.

Testing using Radiographic

Equipment :- the radiographic machine used for this study was X-ray CP 200D

The specification of the x ray machine: Industrial –x-ray generator ,**Type: CP 200D**

S.N 122397103, TUBE 200/8 AEF, S.N 2736, Angle beam 60^0*40^0 , Focal spot size : 1.5*1.5 mm , Voltag : 10-200 KV, Current : 1-10 mA , Film type : D7, Max power 900 W

Results and Discussion

Testing of plate for laminations:

Plate No. 1

1- X –ray radiography: There were no defects appear.
2- U . Testing :There were lamination of dimension of 100*65 cm , depth 7 mm

Lamination :Produce a slot parallel to the surface of the material.

Table (7) Result plate lamination No. 1

Plate No. 1	Defect type
X –ray Testing	No defects appear
U .T Testing	Lamination with dimension of 1oox65 cm with depth of 7 mm

Plate No. 2

1- X –ray radiography :There were no defects appear
2- U .T Testing : There were lamination of dimension of 250*74 cm with depth of 5 mm

Table (8) Result plate lamination No. 2

Plate No. 2	Defect type
X –ray Testing	No defects appear
U .T Testing	Lamination with dimension of 250x 74cm with depth of 5 mm

Testing of welded plate:

Plate No. 3

1- X –ray radiography

The plate used had crack , under cut and Closter Porosity

2- U . Testing

The plate used had crack , under cut and Porosity

Porosity: Molten weld metal has a considerable capacity for dissolving gases that come into contact with it, such as hydrogen, oxygen and nitrogen. As the metal cools its ability to retain the gases diminishes. With the change from the liquid to the solid state, there is reduced solubility with falling temperature. This causes an additional volume of gas to be evolved at a time when the metal is becoming mushy and therefore incapable of permitting the gas to escape freely.

under cut : During the final or cover pass, the exposed upper edges of the beveled weld preparation tend to melt and to run down into the deposited metal in the weld groove. The result is a groove, which may be either intermittent or continuous, with more or less sharp edges along the weld reinforcement

Table (9) Result welded plate No . 3

Plate No . 3	Defect Type				
	Crack	Under cut	Porosity	Lack of penetration and Lack fusion	Slag inclusion
X –ray Testing	10.2mm	28 mm 3 mm 1 mm	Closter Porosity 6 mm	_	_
U .T Testing	10 mm	26 mm 2 mm 1 mm	6 mm	-	-

Testing of welded plate:

Plate No. 4

1- X –ray radiography

The plate used had Lack of penetration , Porosity and Slag inclusion

2- U .T Testing

The plate used had Lack of penetration , Porosity and Slag inclusion

Cracks are linear ruptures of metal under stress. Although sometimes wide, they are often very narrow separations in the weld or adjacent base metal. Cracks can occur in a wide variety of shapes and types and can be located in numerousCracks associated with welding may be categorized according to whether they originate in the weld itself or in the base metal. Four types commonly occur in the weld metal, i.e. transverse, longitudinal, crater and hat cracks .

Lack of fusion is when the fusion is incomplete on the wall and root of the weld preparation .

Lack of penetration is when the weld penetration is less than that specified .

Table (10) Result welded plate No . 4

Plate No . 4	Defect Type				
	Crack	Under cut	Porosity	Lack of penetration Lack fusion	Slag inclusion
X –ray Testing	-	-	5*4 mm	12 mm 20 mm	-
U .T Testing	-	-	5*4 mm	15 mm 28 mm	-

Testing of welded pipe:

Pipe No. 5

1- X –ray radiography

The pipe used had crack , Closter Porosity

2- U .T Testing

The pipe used had crack , Closter Porosity

Table (11) Result welded pipe No 5

Plate No. 5	Defect Type				
	Crack	Under cut	Porosity	Lack of penetration Lack fusion	Slag inclusion
X –ray Testing	-	-	Closter Porosity	-	-
U .T Testing	6 mm	-	Closter Porosity	-	-

Testing of welded pipe:

pipe No. 6

1- X –ray radiography

The pipe used had Lack fusion

2- U .T Testing

The pipe used had Lack fusion

lack of fusion : This is due to the lack of union in a weld between the weld metal and parent metal between parent metal and parent metal, or between weld metal and weld metal.The defect results mainly from the presence of slag, oxides, scale, or other non-metallic substances.

Table (12) Result welded pipe No. 6

Plate No.6	Type Defect				
	Crack	Under cut	Porosity	Lack of penetration Lack fusion	Slag inclusion
X –ray Testing	-	-	-	-	4mm
U .T Testing	-	-	-	-	3mm

The result of plate No. 1 AND 2

plate No.1

The plate as has limitations with of dimension of 100*65 cm with depth of 7 mm .

1- In X –ray Testing did not show any defect .
2- In U .T Testing showed the lamination of dimension of 100*65 cm and determine the depth of defect it was 7 mm from the surface .

plate No. 2

The plate was has limitations with of dimension of 250*74 cm with depth of 5 mm .

1- In X –ray Testing did not show any defect .
2- In U .T Testing showed the lamination of dimension of 250*74cm and determine the depth of defect it was 5 mm from the surface .

To detect lamination defect in plate we should do not use X – ray Testing. they did not showed any defect. the UT testing showed the perfect results. as shown above.

The result of plate No. 3 , 4 And pipe No 5 , 6

plate No.3

The plate was has some defect as shown in table (9)

1- The crack

was 10.2 mm length In X –ray Testing

was 10.0 mm length In U .T Testing

the crack was opened on the surface , we detect it with all methods with little different in the length .

2- The Under cut
were 28 , 3 and 1 mm in length on deferent places In X –ray Testing
were 26, 2 and 1 mm in length on deferent places In U .T Testing
theUnder cut detect it with all methods with little different in the length .

3- the Porosity
Was liner porosity 6 mm in length In X –ray Testing
Was liner porosity 6 mm in length In U .T Testing in 3 mm in depth .

plate No.4

The plate was has some defect as shown in table (10)

1- the Porosity
Was liner porosity 4*5 mm in length In X –ray Testing
Was liner porosity 4*5 mm in length In U .T Testing in 6 mm in depth .

2- Lack of penetration
was 12 and 20 mm length in different places In X –ray Testing
was 15 and 28 mm length in different places In U .T Testing
the Lack of penetration detected with UT and x ray methods with little different in the length .

Welded pipe No.5

The pipe was has some defect as shown in table (11)

1- The crack
no defect appear In X –ray Testing
was 7 mm length In U .T Testing
the crack was opened on the surface , we detect it with U .T Testing with little different in the length . but did not appear with X –ray Testing for that we repeat it with different angle beam the crack shown with 6 mm length, another shot taken with different angle beam the crack shown with 10 mm length. from result in X –ray Testing defect dimension depend on angle beam of radiography it did not give real dimension of defect.

2- the Porosity
Was Closter Porosity Spread on all pipe In X –ray Testing
Was Closter Porosity Spread on all pipe In U .T Testing
the Porosity it found by both X –ray Testing and U .T Testing that mean the porosity was located in the and did not opened on the surface.

welded pipe No.6

The pipe was has some defect as shown in table (12)

The Slag inclusion
was 4 mm length In X –ray Testing
was 3 mm length In U .T Testing.

Comparison of Ultrasonic and X-ray Testing

Each test will be compared based on time consumption, cost, defect detection ability, safety, portability and defect depth penetration capacity. Based on this comparison the appropriate method for testing of various components will be presented.

Table (13) :-Comparison of crack depth detection

NO	Specimen	Ultrasonic	X-ray
1	Welded plate	Excellent	Does not Show
2	Welded pipe	Excellent	Does not Show

In comparing the crack depth detection of the methods, methods which resulted in the indication of better crack depth are marked as “Excellent” in UT and others method did not show any thing in X-ray . As Table (13) shows only ultrasonic test can detect the depth of a defect. Due to the sensitiveness of ultrasonic test minor defects could be detected. Even if this sample is not tested by x-ray, the x-ray test cannot give as clear image as that of the ultrasonic because the crack has a different orientation at different positions. Due to the above reasons ultrasonic test could give us better result than the x-ray.

Table (14) Comparison of time consumption for conducting and interpreting tests

NO	Specimen	Ultrasonic	X-ray
1	Lamination	2 h &15 min	30 min
2	Welded plate	2 h	1h and 15 mints
3	Welded pipe	2h &37 min	1 min 22 mints

Table (14) shows that the time consumed by the ultrasound test is longer than the time taken by the X- ray test.

Table (15) Comparison of relative flaw detection

NO	Specimen	Ultrasonic	X-ray
1	lamination Plate	Excellent	Poor
2	Welded plate	Excellent	Good
3	Welded pipe	Excellent	Good

Table (15) shows comparing the relative flaw detection of the methods, method which resulted in the indication of better crack length are marked as “Excellent” and others marked “ Good”, and “Poor” are set relatively to the excellent method.

Table (16) :- Comparison of safety hazard

Ultrasonic	X-ray
NO	High

Table (16) shows The safety is concerned x-ray film needs a serious safety care. For ultrasonic tests have no A health risk .

Table (17) : Comparison of cost for testing

NO	Specimen	Ultrasonic	X-ray
1	Plate lamination	130 L.D / h	190/ L.D / h
2	Welded plate	130/ L.D / h	190/ L.D / h
3	Welded pipe	130/ L.D / h	150/ L.D / h

Table (17) shows x-ray is the most expensive method. Cost of x-ray test is mainly due to material cost (x-ray film). Each method is also compared based on costs spent to implement the tests. The cost elements are material, labor and machine costs.

Table (18) : Comparison of equipment portability

Ultrasonic	X-ray
Yes	**No**

Table (18) shows portability of test equipment is considered ultrasonic test portable type equipments and hence on site test is possible, whereas due to safety case x ray cannot be conducted anywhere except in a specially designed room.

CONCLUSIONS

1. The results ofmethods (Ultrasonic Testing, and X-ray Testing).Ultrasonic test gives the best flaw detection result, this is because ultrasonic is sensitive to small flaws.
2. X-ray gives better flaw detection result next to ultrasonic. But this method did notgive clear image of the x-ray film for the surface crack .
3. x-rays are hazardous to human beings when absorbed above certain limit, hence great care should be made before, during and after conducting the test. Due to this safety case the operators and the testing room should be shielded and test should be conducted only in specially prepared test rooms .
4. UT method has no health hazard during and after operation. Ultrasonic test portable type instruments which helps on site testing
5. The results can be very useful for the companies looking for the factors and parameters that can affect their inspection plans and programs. These factors have a high effect on the frequency of the NDT methods applied for inspection purposes.

Recommendation:

1 - The UT is highly dependent on the level that the operator is trained. Basically all NDT methods require skilled and experienced operators, but this requirement is amplified in UT. Use qualified person .

2- Use Ultrasonic testing to detection of flaws deep in the part and in extremely small flaw

3- Use Ultrasonic testing to achieve greater accuracy than other nondestructive methods in determining the depth of internal flaws and the thickness of parts with parallel surfaces.

4- Next to ultrasonic X-ray gives better flaw detection result. But do not use this method to detect planar cracks because it is difficult to detect .

5- Use X-ray for the surface crack and internal crack which is oriented at an anglex-rays .

7- some methods are better on paper, but when it comes to real practical experiments some other factors influence the applicability of the method.

8- x-rays are hazardous to human beings when absorbed above certain limit, hence great care should be made before, during and after conducting the test. Due to this safety case the operators and the testing room should be shielded and test should be conducted only in specially prepared test rooms .

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