

# Application Of Non-Destructive Testing (NDT) In Oil And Gas Industries And Recent Technology Advances

## ABSTRACT:

Corrosion and erosion over time can cause formation of debris in the walls of pipes, pressure vessels, and other equipment used in the oil and gas industry. Non-Destructive Testing, NDT is a clinical means of routine inspection in wall thickness of metal infrastructure and nature of fault in pipeline. Non-Destructive Testing (NDT) is a diverse methods of detection and inspection techniques employed to investigate pipelines, storage tanks, pressure vessels and other facilities in terms of their mechanical and structural integrity. It aids the detection of material defects or faults and the possible safety issues without causing any damage to the material. The field of Non-Destructive Testing and Non-Destructive Evaluation of materials is constantly evolving. This paper provides the different methods of NDT and recent advancements of NDT methods for defect inspection and faults/flaws detection. There are quite a number of methods used for NDT which includes Visual Inspection, Radiography Testing, Ultrasonic Current Testing, Eddy Current Testing, Magnetic Flux Testing, Magnetic Particle Inspection, Liquid Penetrant Testing, Thermal/infrared Testing and use of drones and robots to perform reliable testing tasks especially in offshore.

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**Keywords:** Corrosion, Faults, Materials, Non Destructive Testing, Oil & Gas industry, Pipeline.

## INTRODUCTION:

Over the last 5 year, Nigeria has experienced a total of 180 Pipeline rupture according to NNPC 2020 Annual Report [1]. Recently, Fire guts Shebah Exploration & Production Company Ltd (SEPCOL) Niger Delta with claims leading to explosion of production vessels. In Nigeria and the rest of world, several dangers occur due to the corrosion in pipelines throughout the year, and its life saving to prevent such fatal occurrence that can result to death and damage to equipment. To this cause, NDT in pipelines play a critical role in the early detection of corrosion in pipelines before they can do any harm. NDTs are done to ensure product reliability, lower manufacturing costs, maintain a uniform quality level of vessel, and for other safety measures [2]. Also, the increasing technologies in NDT are due to the disadvantages of various mechanical tests (tensile, impact, fatigue, creep, and others) which involves the ultimate destruction or

deformation of the part being tested. Even in hardness test the dents or impressions left on the specimen could initiate stress – concentration and lead to failure in highly stressed components like gas filled drums and aircraft parts. These tests are not very convenient for a regular quality control in such case and hence, reasons why Non Destructive Testing is very important as it has no negative impact on the system. NDT over the years have been proven to be a faster and more effective method of inspecting pipelines and providing consistent solutions to most faults in the oil and gas industry. NDTs are also economical. Unlike destructive testing, which involves the destruction of materials tested, NDT is cost effective as it prevents the need to replace an item before faults occurs without destruction of the material. NDT testing technique ensures that the company operation is fully functional and some peace as their equipment are fully functional preventing any future accidents and if fault detected, to determine any measures that can be taken for life extension. These testing methods are also beneficial to fittings and welded materials and their procedures to ensure that the process is without blemish and with good quality. NDT plays important usage in not only the Oil and Gas industry, but also Aerospace, Mining, Automotive, Power, Chemicals, etc.

Non-Destructive Testing plays an essential role in most industries especially in the Oil and Gas industry, where it is critical to test and inspect equipment used for refining, processing, and extraction. This test helps in keeping potentially hazardous chemicals and fluids in pipelines and pressure vessels safely without leakage or explosion.

NDT plays a role in many part of the oil and gas industry. The operation of a safe, efficient, reliable, and profitable extraction of crude oil requires effective NDT methods usually Ultrasonic and eddy current testing. NDT is relevant in all sectors of the Oil and gas industry. In the upstream industry, it is required for an efficient and reliable extraction of crude oil. In the Midstream, the equipment used for processing the crude into various fuels requires NDT as well. In the downstream, transportation through pipelines pose the largest application of NDT. NDT are used for inspection of pipelines, improving pipeline weld inspection efficiency, pipeline integrity assessment, and pipeline crack inspection. Another very important usage of NDT in the oil and gas industry is to mitigate corrosion. Corrosion can overtime cause defects and blockages of the pressure vessels or pipelines. NDT provides an effective and efficient means of inspecting wall thickness without the stoppage of production or rendering the equipment inactive. Also, hydrocarbons are highly rich in hydrogen and this can cause embrittlement when the hydrogen present react with iron in these materials, this could cause cracking in the steels. This problem is more intense due to the high temperatures and pressures which these infrastructure operates under.

The question, whether Oil and Gas company need to do NDT testing is not arguable, given the intense scrutiny the oil and gas industry operate under, it is of paramount benefits that the

safety and the reliability of pipelines, pressure vessels and other infrastructure is guaranteed. For this course, Ultrasonic and eddy current testing has a very wide range of application. [3]There are several methods of carrying out NDT, of which some of the methods and the recent development will be discussed more in this paper.

## Methods of Carrying Out NDT

There are several methods of carrying out Non-Destructive Testing, that is applicable to the Oil and Gas Industry. Some of these methods include Visual Inspection, Radiography Testing, Ultrasonic Current Testing, Eddy Current Testing, Magnetic Flux Testing, Magnetic Particle Inspection, Vacuum Box Testing, Liquid Penetrant Testing, Thermal/infrared Testing, Laser Testing, Thermography, Acoustic emissions, etc.

### 1. VISUAL INSPECTION

Visual inspection is the most used NDT method in maintenance of facilities and the inspection of equipment and structures. Visual inspection involves the use of either or all raw human senses such as vision, smell, etc. and/or any simple inspection equipment to detect faults and cracks in materials. Visual inspection requires specialized training and it implement specialized range of NDT Visual Testing equipment. Visual Inspection involves the use of simple equipment including the eye and various magnifying and measurement devices.

#### Microscope:

This instrument contains different lenses which are used to magnify the image of a small object. The material is placed close to the microscope to obtain higher magnification.



#### Borescope:

This instrument is designed to enable an observer carry out inspection of the inside of a narrow tube, a hole or interior of equipment. Borescope consists of lenses with digital signals and records signals when light is passed through it. As length increases, the image becomes less

bright. The diameter of a Borescope depends on the diameter of hole or bore to be inspected [13].



### **Endoscope:**

This device has a higher optical system and provides a more intense magnification than the Borescope. Various viewing angles can be used when carrying out inspection through this device. [13].



### **Fiberscope**

This device is used across corners and passages as it permits directional changes. It is designed to provide sharp and clear images of parts normally impossible to inspect. The working lengths are 60 to 365cm, with diameters from 3 to 12.5mm[13].



### **Applications of Visual Inspection**

1. Inspection of Plants systems / component for any leakage, abnormal operation etc.
2. Misalignment of parts in equipment.
3. Corrosion, erosion, cracks, fractures, etc.
4. Defects in weldments: surface cracks, lack of penetration, tear cracks, excess reinforcements, porosity etc.
5. Minute discontinuities with the help of optical aids in pumps, compressors, turbo-generator parts, etc. [13]

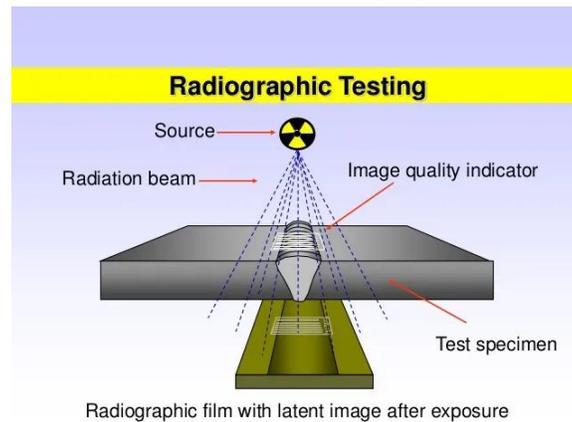
### **2. RADIOGRAPHY TESTING**

Radiography is a very useful NDT method in the Oil and Gas industry. This method can be used to inspect pipelines and pressure vessels. Radiography involves the use of either Gamma rays or X-ray to inspect the internal structure of the equipment being tested. Since these rays have short wavelength, they have the ability to penetrate and travel through structural materials, such as metals and metallic alloys.

Radiography can also be applied to testing of welds with the purpose of ensuring the weld quality in the industry. This method of testing welds can be used to detect weld defects like cracks, inclusions, Porosity, lack of fusion, voids, etc. in weld interiors [17].

Radiography Testing requires the use of radioactive source, this could be gamma ray or x-ray or any radioactive source. When carrying out Radiography Testing, as seen from the image below, the test specimen is placed between the radioactive source and radiographic film. The section being tested will stop some of the radiation when exposed to the radioactive source while the thicker and denser sections will stop more of the radiation. The radiation that passes through the part being tested will expose the film and forms a radiograph (X-ray Photography) of the part. The radiation causes a variation in density of the test specimen. The part being exposed to the radioactive source will have a higher intensity while the darker part will have lower

radiation intensity. With this variation, we can determine the thickness of the material and detect the presence of faults or flaws in the material. [14]



### **Radiographic Testing Procedure:**

The following provides the basic procedures for radiographic testing.

#### **Step 1:** Surface Preparation:

This is done by removing the surface irregularities and for butt welded joints, the prepared surface must be flushed with the test specimen.

#### **Step 2:** Selection of radioactive source and film:

The radioactive source (Gamma or X-ray) will then be selected based on the sensitivity of the radiation and the material being tested.

**Step 3:** Penetrometer Selection: This involves the selection of a suitable Penetrometer for the testing.

#### **Step 4:** Radiographic testing technique:

This involves carrying out the radiography testing. We can either use a single or a double wall exposure technique.

#### **Step 5:** Defect Inspection and removal:

The shadowgraph will then be studied for proper detection of defects.

**Step 6:** Recording: The final step is to record all the data that have been collected and examine the data to detect flaws. [4]

### **Advantages of Radiography Testing:**

1. It can be used to automatically detect faults and measure internal flaws
2. It reduces the surface penetration of the material.
3. It can be used to detect flaws in both surface and subsurface.
4. When the structure is complex, Radiography can be used to verify the internal defects of such structure.
5. It easily enables inspection of assembled components. **[15]**

**DISADVANTAGES:**

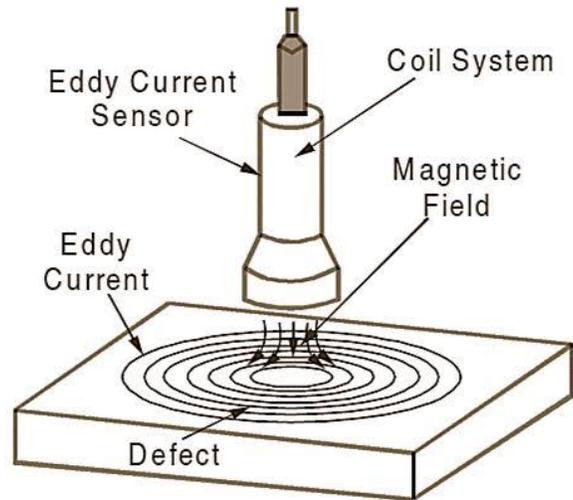
1. Radiography testing is highly hazardous due to the radioactive sources.
2. It requires high degree of skills and competency.
3. It is quite expensive and a slow process.
4. It involves access to the two sides of the component being tested.

**3. EDDY CURRENT**

Eddy current testing is a NDT technique used for inspecting flaws across the various types of tubes and the surface of materials. Therefore, eddy current testing could be divided into tubing inspections and surface inspection.

An eddy current is one that opposes the probe current introduced in a conductive material. Using eddy current testing, we can detect small defects and flaws that we can see with our eyes. The data being collected from eddy current testing is usually passed through critical analysis using software and others **[16]**.

This testing is the most widely used NDT testing for inspection of surfaces and tubes. Some of the types of flaws eddy current testing is used for include: Cracks, corrosion, wear (in tubes, often due to erosion), pitting, and wall/thickness loss.



In Eddy current testing, the inspector introduces a probe, which uses an alternating current. The eddy current test probe consists of a coiled conductive piece of wire; a magnetic field is then created on the probe by electrification. Once this field has been created, the field is then introduced to the object, when such is done; it will create opposite currents to the currents in the probe. These currents are called eddy currents. In the presence of a defect in this material, it will create changes or fluctuations in the eddy current and this data can be collected and evaluated to detect the type of faults. [19]

#### **Eddy Current Array:**

In other to create sensitivity profile, an array of electrically charged coils can be used to detect flaws in the materials.

Extra care need to be taken to avoid mutual inductance between the individual coils.

#### **Heat Exchanger Testing**

In this stage, a different differential probe could be passed into the heat exchanger. The inspectors can then detect flaws in the tubes after a single pass through the eddy current testing probes.

#### **Lorentz Force ETC**

This is a newer NDT method that uses multiple combinations of electric and magnetic force on the body to create eddy currents. In addition to the use of multiple magnets, the Lorentz force eddy-current testing uses relative motion to help prepare fast and effective eddy current tests [20].

#### **Surface Array Testing**

With the use of surface array probes, this testing method can be used in the oil and gas industry as well as aerospace to inspect small defects and can measure wall thickness with extremely high degree of accuracy.

#### 4. ULTRASONIC TESTING

Ultrasonic inspection involves the use of sound, usually sound waves for testing. Ultrasonic frequencies are usually from 20 kHz and such frequencies are above our hearing. Ultrasonic waves, that is being sent to the material behaves like sound waves as they will propagate through the given medium. The flaws are detected when the vibrations between the discontinuous materials are reflected in predictable manners.

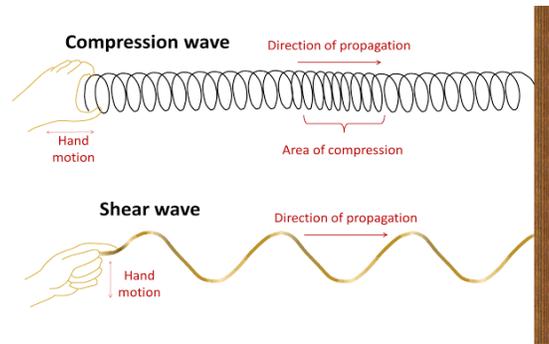
Ultrasonic testing is very relevant in the Oil and gas industry as it provides efficient inspection of pipelines, welds and detection of corrosion and defects. Ultrasonic testing helps in inspection of major equipment in the facilities and ensuring the quality of welds and forgings in the equipment before they are put into place.

**Ultrasonic Flaw Detection:** An echo sounding technique is used. Elastic waves are sent out by a probe transducer and are reflected by discontinuities. Results are recorded on an oscilloscope by the transmission pulse giving flaw and back echo.  $\frac{1}{2}$  to 20MH, frequency elastic waves are used.

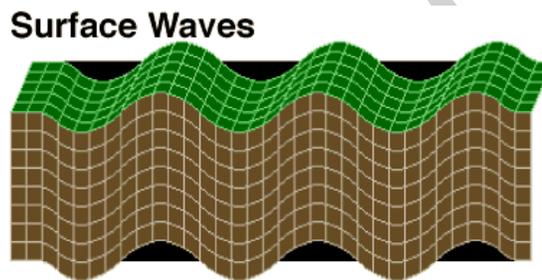
If a crack is filled with materials of same acoustic impedance, there will be no echoes reflected. If the crack is covered with air, the reflection is higher than the transmission, but if vacuum, everything will be reflected. Flaws smaller than the wavelength of sound will not be picked. To detect smaller flaws, much higher frequencies should be used, but the frequency that can be attainable is limited by the grain boundaries, such high frequencies detect grain boundaries as flaws and cause noise in the instrument. [2]

##### Types of waves used:

1. **Longitudinal or compressive waves:** Longitudinal waves are used for testing of both ends of a pipe body and for testing the strength and the integrity of plates before they are made into pipes. The longitudinal waves vibrate in the same propagation and push the tested materials in same direction of the waves.
2. **Shear waves or transverse waves:** This wave vibrate in a perpendicular direction and this pushes the tested material into a right angle direction hence why this is usually used for angle beam to detect irregularity in inner and outer diameters of pipelines.



3. **Rayleigh or surface waves:** They are used to penetrate the materials along the surface areas. They are used to detect flaws in the surface of the material. They are also used for testing pipes with intricate rounded surface structures.



Ultrasonic testing involves the following: Angle Beam, Automated Ultrasonic Backscatter Technique, Internal Rotary Inspection system, Electromagnetic Acoustic Transducer (EMAT), Immersion Testing, Long range ultrasonic testing and Phased Array Ultrasonic Testing [21].

Ultrasonic testing has a lot of advantages. It is a consistent method of testing and very portable. It can also be used to detect surface and sub-surface defects and it gives an instant result of the detection of faults. However, it is very expensive, requires professional training to carry out inspection and it pose difficulty when used for thin materials.

## 5. LIQUID PENETRANT INSPECTION

This method is also known as dye-penetrant. It is widely used because it is cheap and used to locate surface flaws such as cracks, folds, bump, scratches, mesh crack, hairline, and other surface defects in pipeline. It is not very good if greasy cracks (full of oxide) exist – always degrease the surface. [2]

### Basic Principle:

The item to be tested is cleaned first and then dipped into a penetrant. The penetrant is then allowed to soak into any faults. Afterward, the excess penetrant is then removed and the

component is dried. With the aid of a developer applied to the penetrant, it helps to draw the penetrant out of any defects and takes it into the surface for visual inspection. Depending on the type of penetrant used, a visual inspection is then performed either on ultraviolet or white light [11].

This method is highly useful for oil and gas industries as the test reveals the surface flaws on parts and equipment such as pressure vessels, clad vessel linings, valves and their component, machined parts, castings, and forgings which might not otherwise be visible. Its drawback however it can only detect flaws on the surface [12].

## 6. MAGNETIC PARTICLE INSPECTION

This is a non-destructive testing method used to detect surface and shallow subsurface flaws in most ferromagnetic materials which includes iron and its alloys, cobalts, nickels and their alloys.



Magnetic inspection can be classified into two; Dry and Wet Magnetic particle inspection testing. With wet magnetic particle testing, illuminated magnetic particles suspended in water are applied. In dry magnetic particle testing, it doesn't need water. In either case the process commence by running a magnetic current through the material. The first step used for detecting flaws is to create a magnetic current and if defects are present, it will intercept the magnetic current. This will create a flux leakage at the part with defects. Then, metal particles are placed on the materials and if defects are present, the flux leakage field will drag the particles to the part that has defects.

There are enormous benefits of Magnetic Particle Testing. It is cheap unlike others; it is also very portable to use and implement and can be used to detect shallow or sub-surface defects. Its major disadvantages are that the material must be of either iron, nickel, cobalt (must be

ferromagnetic) and it poses difficulty in demagnification of the material after fault has been detected.

## **7. ACOUSTIC EMISSION TESTING**

Acoustic emission is predicated on the formation of acoustic waves that causes vital changes within the structure of the equipment. This might involve subjecting some instrumentation to elastic waves that would cause cracks formation particularly with air mass and temperature, with aim of detective work flaws by the utilization of sensors. These emissions tend to occur from natural sources, and it happens typically once the equipment is subjected to extraordinarily high pressure and elevated temperatures. Acoustic testing is typically tired a dynamic science laboratory, wherever the equipment is analyzed for crack detection sometimes once there is a rise in stress of the instrumentation. Acoustic Emission Testing sometimes involves the utilization of sensors, Amplifiers and Preamplifiers, a visible show, filters, etc. Acoustic emission has transducer which converts mechanical to electrical signals and this helps in detection of flaws. The range of inaudible sound usually used for acoustic emission testing is twenty kHz (KHZ) and one MHz (MHZ) [22].

Acoustic emission due to its versatility has many applications especially in the oil and gas industry, where it can detect the presence of cracks or leaks, especially in vessels. It can also be used for structural integrity of welds and inspection of pressure vessels, etc.

### **Acoustic Emission Testing vs. Ultrasonic Testing:**

In acoustic emission, NDT inspectors listen for acoustic emissions that will occur from cracks or defects in the given material. This method can be used to easily detect if a structure is loaded beyond its carrying capacity.

In ultrasonic testing on the other hand, Ultrasonic waves such as Gamma or X- ray are sent to the material and the interruption of such waves can be used to detect the presence of defects in the material.

## **8. INFRARED TESTING**

Infrared Thermography testing is based on radiation of emission in some part of electromagnetic spectrum. Referring to the black body radiation law, as the temperature of a body tends to decrease, the intensity of the body also decreases and the peak moves to a longer wavelength. Also, objects with temperatures greater than zero emit infrared radiation. A thermographic camera is used for detecting the imaging of the IR radiation. With the help of the infrared cameras, a recording is done; the recording corresponds to the intensity of the thermal radiation. The recording made by the thermograph is called a thermogram. IR

thermography is therefore the process by which thermal cameras are used for recording the radiation emitted from the material in a thermograph [5].

Infrared Testing can be classified into active and passive infrared thermography. In passive thermography, the camera is pointed directly to the equipment and from here; the sensor gives a thermal imaging of the equipment. In active thermography, the object is heated using external source to energetically excite the object [18]. Flaws in the material are shown in the thermograph and given by the variations in the temperature decay rate.



The oil and gas company equipment usually consist of tanks, fittings, valves, piping, tanks, pumps, filter, separators, heat exchangers, steel structures, electrical cabling, instrumentation, etc. Majority of failure or accidents in oil facilities have been reported due to damage or failure of these equipment in oil facilities can only be prevented through regular oil and gas asset inspection. Thermographic imaging provides good detection of the conditions of the equipment.

It is well-known that when every other method fails, infrared testing can still spot the flaws. Some of these are few instances of thermal imaging:

1. Infrared testing can be used to provide effective and time saving inspections of electrical cabinets.
2. Infrared testing is capable of detecting electrical faults, conditions on transformers, and inspection of substation.
3. Infrared testing helps in determining the condition of heat exchangers. It could also be used to spots poor heating condition of heat exchangers, and for improving the process operations efficiency.
4. Infrared testing is a valuable tool used to detect heat loss from leaks and stream traps.
5. Infrared testing can be used for detecting solids buildup in pipes and tanks.
6. IR imaging is essential for maintenance of storage tanks by detecting leaks that occurs from ageing or corroding tanks.

7. Infrared testing can be used to detect efficiently hazardous gases emitted from various equipment in oil facilities.

## 8. USE OF DRONES

Drones can be used to provide a wide range of commercial and industrial applications on detection of faults and defects in major equipment. Drones are used for various purposes, from aerial photography, to surveys, shooting of videos, inspection of structures etc. Drone designed with sensors are becoming relevant in the oil and gas industry, and they play a key application for detecting and inspection of equipment safely and cheaply to monitor the quality of products. The drone technologies can be used to gather useful information such as leakages on gas pipelines, etc.

A fast-rising application of drones is the detection of methane gas leaks which occurs quite often and a disturbing challenge in the most gas handling facilities. This methane gas leakage presents a lot of harmful effect to the community and therefore it is essential in ensuring the detection and prevention of the leakages of these gases [7].



### Methane Gas Detection

The detection of methane gases can be done using drones for detecting leaks by means of a light reflection or the sensor. The sensors are used for emitting lasers which are visibly, and are reflected in certain ways upon contact with certain gases. The reflected beams are analyzed to detect leakages in the equipment. The sensors identify and inspect the methane spectral based on the light reflected, and this helps in determining the presence or absence of methane.

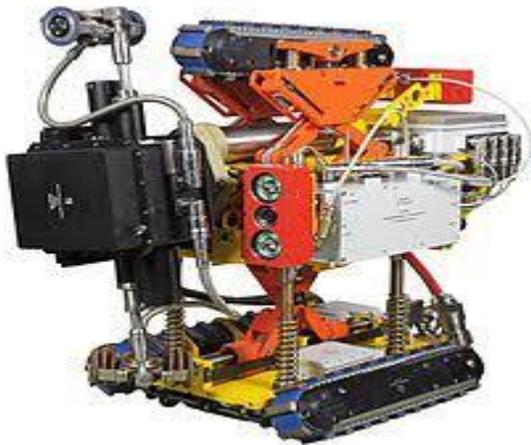
In a typical inspection, drones are equipped with lighting sensors; these sensors as a result of reflection can identify the weakened areas or the defects on the material [6]. The presence of methane gas will make the sensor absorb some part of the light and this part can be seen in the reflection of the light.

## 10. ROBOTIC INSPECTION

Like drones, Robots or Robotic inspection is a recent NDT technology that is gaining quite a number of usages in the oil and gas industry. This is a method that uses robots for inspecting the structural integrity of petroleum products, natural gas, pipelines, various refineries and

facilities equipment, water installations, etc. Robotic inspection could involve the automation of several NDT methods such as eddy current testing, magnetic inspection testing. Also, crawler type of robots can be used to inspect areas that are difficult and impossible to inspect using other methods. A good example is in In-line Pipeline inspection. Robotic NDT can also be used for areas that are inhospitable such as interiors of pressure equipment, inside of tanks, etc. [8]. Robots are used in order to limit dangers to human inspectors, when carrying out critical NDT testing that can pose threats to inspectors.

Application of Robotic NDT tools in pipelines and others for structural integrity tests includes Pipe wall thickness, interior or plates of storage tanks, heat exchangers, pressure vessels and Pipelines that are incapable of running intelligent pigs on, due to their fittings, curves, tees, etc. In inhospitable areas, Robotic Inspection find application in the use of robots for climbing tanks to inspect the tank shell or tank floor. Also in submerged areas covered with water, robots play very good application here. The use of robots is to eliminate the dangers pose on individuals in carrying out such inspection. It is also time saving, provides accuracy measurement of inspection however, It takes quite a lot of initial investment to automate NDT methods [8].



### **MY PERSONAL EXPERIENCE WITH NON-DESTRUCTIVE TESTING**

I had the opportunity of doing my 6 Months Internship in the Oil and gas industry and this was my first experience and knowledge about Non Destructive Testing and Non Destructive Examination. I did my internship (January to June 2022) with the Nigerian Petroleum Development Company, NPDC, a subsidiary of NNPC. I was deployed to Facility Maintenance, and had the opportunity to visit the OREDO FLOWSTATION, OML111 several times. From this visits and experience gathered from the IT, I got to understand the various flow process of the flow-station, the Oil and gas sectors and how it works, working principles of various mechanical devices such as separators, heat exchangers, storage tanks, fuel gas scrubber and others. Also

carried out some maintenance on the wellhead, various valves, export pump, foot valve and others.

During my experience in the flow station, I got to know about NDT and Pigging Operation and how they can be used to inspect Vessels and remove corrosion, respectively.

I also had the opportunity to witness NDT testing, although, I could not get all the experience from the various steps and others because the job was done by a contracting company, but I also got to ask questions and saw some few things. The thermographic testing method was used. Infrared camera was used to take imaging of the vessel. With that when the pointed camera is positioned to any equipment surface it can tell the temperature and when such equipment has crack on it, then the temperature gradients will differ from the expected. The cameras are used when the equipment you are working with deals with temperature and since most Oil and gas vessel deals with temperature and pressure, infrared was the best choice. This paper already has description of how infrared testing works. Also I witnessed how infrared testing is used to detect temperatures losses as a result of the issues while installing or constructing the equipment. In the case for pipeline, an intelligent Pig was run from the Pig launcher to receiver. A PIG (Pipeline Inspection Gauge) is a device used for monitoring corrosion in pipelines. In the case of longer pipelines, ultrasonic testing and magnetic flux testing were the recommended tests for such.

After thorough examinations on the equipment, I decided to carry out research on the various NDT methods and looked at how recent technology can be used to make the process easier. With this research, it will serve as a guide to anyone interested in learning about NDT method and its recent advances. The uses of robots, drones are some of the recent technologies and with time, many companies would start using them to carry out operations.

## CONCLUSION

Non-Destructive Testing plays a very critical role and relevance in the oil and gas industry to prevent damages to equipment, prevents deaths and other occurrence and the smooth operation of the facilities. NDT also helps in reduction of downtime, increase product reliability and even reduction of waste. Therefore, every sane society must look towards the recent advancements in NDT and how to ensure that simpler and more effective methods in ensuring safety and continuity of their operations.

This paper has described the various methods of Non Destructive Testing and Examination in the Oil and Gas industry. It also explains some of the advantages of the different methods. The use of drones, robots and newer technological methods are some of the advancement that most companies should look at to in carrying out their NDT.

Also, some recent Non Destructive Testing advancements such as digital radiography, Automated Ultrasonic Testing, Long range ultrasonic testing and others not discussed in this paper can also be useful to oil and gas industry.

With the use of NDT methods for detection of faults before they occur, this will go a long way in preventing most of the accidents that occurs in the Oil and Gas industry and increase the life span of the various equipment.

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#### **CODES AND STANDARDS**

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**ASTM E165:** Standard practice for liquid penetrant Examination for General industry, 2012.

**ASTM E1444:** Standard practice for Magnetic Particle Testing, 2012.

**ASTM EE1742:** Practice for Radiographic Examination, 2012.

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Etc.

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