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A note on NDT Technology for Detection of Defects in Oil and Gas Pipes

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Abstract

This paper provides a general note on the state of the art in the application of nondestructive testing techniques (NDT) for the detection of defects or deteriorations in metallic and nonmetallic oil and gas pipes. The advantages and disadvantages of each technique will be pointed out.

Keywords: *NDT, Nonmetallic, Microwave*

I. Introduction

Non Destructive Testing techniques (NDT) have been widely used to detect corrosion or other types of failure in metallic and nonmetallic pipes [1-4]. Examples of these techniques include Penetrant Testing, Magnetic Particle Testing, Ultrasonic Testing, Eddy Current Testing, Radiographic Testing, and Microwave Testing. A brief explanation of each method showing its potential advantages and disadvantages follows.

II. Penetrant Testing Technique

In Penetrant Testing, a penetrant solution is applied to the surface of a pre-cleaned component. The liquid is pulled into surface-breaking defects by capillary action. Excess penetrant material is carefully cleaned from the surface. A developer is applied to pull the trapped penetrant back to the surface where it is spread out and forms an indication. The indication is much easier to see than the actual defect. The disadvantage with this method is that it detects only surface breaking defects, surface preparation and cleaning is critical, and chemical handling precautions are necessary [5].

III. Magnetic Particle Testing

In Magnetic Particle Testing, a magnetic field is established in a component made from ferromagnetic material. The magnetic lines travel through the material, and exit then reenter the material at the poles. Defects such as crack or voids cannot support as much flux and force some of the flux outside of the part. Magnetic particles distributed over the component will be attracted to areas of flux leakage and produce a visible indication. One of the limitations with this technique is that only ferromagnetic materials can be inspected whereas paint or other nonmagnetic coverings adversely affect sensitivity. In addition, demagnetization and post cleaning is usually necessary [6].

IV. Ultrasonic Testing

In Ultrasonic Testing, high frequency sound waves are sent into a material by use of a transducer. The sound waves travel through the material and are received by the same transducer or a second transducer. The amount of energy transmitted or received and the time for the energy to be received are analyzed to determine the presence and location of flaws. Changes in material thickness or material properties can also be measured.

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The disadvantages with this method are that the surface must be accessible to probe and couplant, surface finish and roughness can interfere with inspection, thin parts may be difficult to inspect, linear defects oriented parallel to the sound beam can go undetected, and reference standards are often needed [7].

V. Eddy Current Testing

In Eddy current testing, alternating electrical current is passed through a coil producing a magnetic field. When the coil is placed near a conductive material, the changing magnetic field induces current flow in the material. These currents travel in closed loops and are called eddy currents. Eddy currents produce their own magnetic field that can be measured and used to find flaws and characterize conductivity, permeability, and dimensional features. The disadvantages with this method are that only conductive materials can be inspected, ferromagnetic materials require special treatment to address magnetic permeability, depth of penetration is limited, flaws that lie parallel to the inspection probe coil winding direction can go undetected, surface finish and roughness may interfere, and reference standards are needed for setup [8].

VI. Radiographic Testing

In Radiographic Testing, X-rays are used to produce images of objects using film or other detector that is sensitive to radiation. The test object is placed between the radiation source and detector. The thickness and the density of the material that X-rays must penetrate affect the amount of radiation reaching the detector. This variation in radiation produces an image on the detector that often shows internal features of the test object. The disadvantages with this method is that extensive operator training and skill are required, access to both sides of the structure is usually required, orientation of the radiation beam to non-volumetric defects is critical, field inspection of thick section can be time consuming, relatively expensive equipment investment is required, and radiation hazard is possible for personnel [9].

VII. Microwave Testing

In Microwave Testing, the ability of electromagnetic waves to penetrate most dielectric materials, and their relatively short wavelengths at radio, microwave and millimeter wave frequencies, facilitate for potential nondestructive applications in this region of the electromagnetic spectrum [10]. Microwave Nondestructive Testing (MNDT) techniques have advantages over other NDT methods (such as radiography, ultrasonics, and eddy current) regarding low cost, good penetration in nonmetallic materials, good resolution and contactless feature of the microwave sensor (antenna). For MNDT techniques, the measured parameters are reflection coefficients, transmission coefficients, dielectric constants, loss factors, and complex permeabilities as functions of microwave frequency and temperature. These measured parameters can be related to material parameters of interest (e.g., flaws, binder content, moisture content, etc.) by suitable modeling and calibration.

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