1.0 Introduction

1.1 Background

1.1.1 Non-Destructive Testing of Materials

Non Destructive Testing (NDT) is a process of physical inspection of materials without causing any damage or harmful consequence to the material. It is widely used in Industry for checking quality of the production and also as part of routine inspection and maintenance in services. Therefore NDT is a tool to assure that engineered goods, assemblies and structures are free from dangerous defects.

Hence the obvious and clear benefits of using NDT is the identification of defects , which if they remained unchanged could result in a catastrophic failure which would be very costly in money and possibly in lives and machinery.

Five basic NDT methods are commonly used to examine materials. Those are Ultrasonic Testing (UT), Liquid Penetrant Testing (PT), Magnetic Particle Testing (MT), Eddy Current Testing (ET) and Radiographic Testing (RT).

NDT has been practiced for many decades, with initial rapid developments in instrumentation followed by the technological advances that occurred during World War II and the subsequent defense efforts. During the earlier days, the primary purpose was the detection of defects.

As a part of "safe life" design, it was intended that a structure should not develop macroscopic defects during its life, with the detection of such defects being a cause for removal of the component from service. The continued improvement of the NDT technology, in particular its ability to detect small defects, led to the unsatisfactory situation that more and more parts had to be rejected, even though the probability of failure had not changed.

However, the discipline of fracture mechanics emerged, which enabled one to predict whether a crack of a given size would fail under a particular load if a material property, fracture toughness, were known. Other laws were developed to predict the rate of growth of cracks under cyclic loading (fatigue).

With the advent of these tools, it became possible to accept structures containing defects if the type and size of those defects were known. Components having known defects could continue in service as long as it could be established that those defects would not grow to a critical, failure producing size. Detection was not enough. One needed to also obtain defects type and quantitative information about flaw size to serve as an input to fracture mechanics based predictions of remaining life[1, 2, 3, 4].

1.1.2 Ultrasonic Testing of Materials

Out of the five common NDT methods i.e., UT,PT, MT, ET and RT, Ultrasonic Testing plays an important role in detecting defects in materials.Ultrasonic Non-destructive Testing is the use of ultrasonic waves, for finding external and internal defects in materials, without destroying them.

In this technique an ultrasonic transducer, which is excited by a high frequency voltage (0.5 – 5.0 MHz), sends ultrasonic waves in the form of mechanical vibrations in to the test specimen through a couplant layer.These vibrations transmit through the test specimen and part is reflected back to the probe if it encounters a sudden change of homogeneity (e.g. a defect). The received signals are amplified, further processed and displayed on the CRT Screen.

The displayed signals are then analyzed to define presence and location of defects[5]. The horizontal axis on the CRT screen indicates the beam path length and vertical axis shows the echo amplitude. This is shown in figure1.

By observing the defect echo on the CRT screen depth, length, size and type of the defect can be estimated.

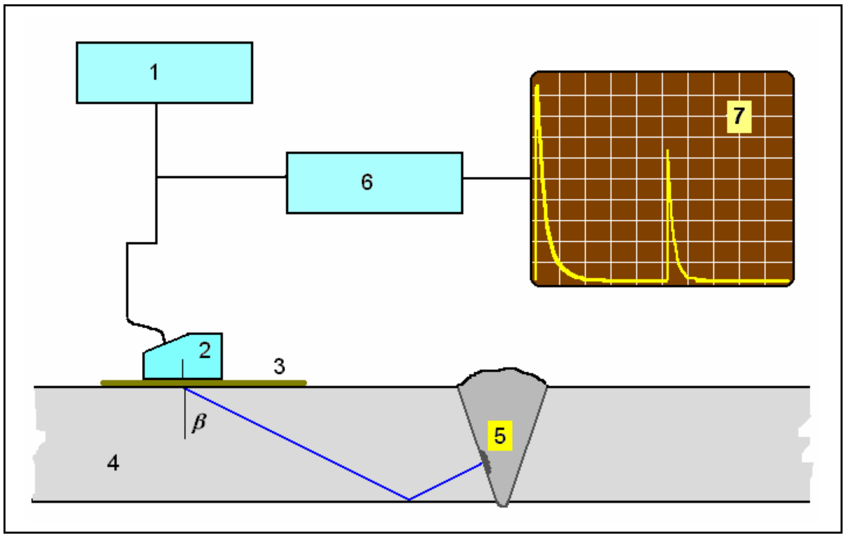

Figure 1: Ultrasonic A-scan presentation.

{1-Exciting Signal (Transmitter), 2-Transducer (Probe), 3-Couplant, 4-Test Piece, 5- Reflector (defect), 6-Amplifier, 7-Cathode Ray Tube (CRT)}

1.1.3 Advantages and Limitations of UT

Compared to other NDT techniques, the ultrasound method has some advantagesas described bellow[4, 5].

- High sensitivity, allowing the detection of 0.5 mm defects
- High precision for internal defects;
- For the testing it is only necessary to have access to one surface of the work piece.
- Deep penetration, which allows the detection of defects in depth.
- The equipment provides immediate indication of the signals;
- The equipment is portable, making the method ideal for field testing;
- It does not have any harmful effects on people around the tests.

However, it also presents some limitations. One of the main such limitation of UT is interpretation of echo signals on the CRT screen. The UT echo signals are typically quite complex to interpret since it may contain many signals other than originates due to defects within the material. These echoes may be due to irregularly shaped pieces, rough or non-homogeneous surfaces.

The echo pattern may change with small movement of detecting probe. Different defects may give similar echo patterns and same defect produces different echo patterns. Therefore accurate interpretation of defects in UT depends on the operator's ability to recognize the defect echo signal from signals other than originates due to defects.

The operator shall be capable of identifying the type of defect from echo shape and access the quality of material by correlating the scan data with the appropriate code or standard.

Today only very experienced operators are able to perform full evaluation of results. Therefore, a considerable demand has been observed for tools that can support operators in such tasks as defect interpretation. Considerable amount of work has been done to develop computer based software programmes to classify welding defects in metallic materials. Primarily they are designed to be used in laboratory work and not for field inspection. Most of the above-proposed methods needs many accessories required for neural network processing, digital signal processing, multi-axis portable scanning, 3-D Ultrasonic Imaging, etc. which have been limited its use in field inspection and more expensive.

Therefore, it is required to further develop the UT defect characterization methods to be used in field inspection, which are law expensive, portable and simpler to understand by the operators.

1.2 Objectives of the Research

Considering the background of the subject it can be concluded that the main aim of the research is to achieve the following objectives.

i) To study the various methods used in UT to identify the defect type.

ii) To identify the factors which affect on defect echo amplitude.

iii) To develop a relationship between defect type and echo amplitude.

iv) To use the above relationship along with width and position of defect echo and change of probe angle to identify the defect type.

v) To develop a specialized procedure and a computer programme based on above relationship.

1.3 Methodology

The objectives stated in section 1.2 were achieved using the standard techniques mentioned below.

- Literature Review
- Theoretical Approach
- Experimental Approach
    - Fabrication of test specimens
    - Affect of couplant thickness on defect echo amplitude
    - Affect of test surface roughness on defect echo amplitude
    - Affect of depth of defect on echo amplitude
    - Affect of impurities within the defect on echo amplitude
    - Affect of defect area on echo amplitude
    - Identification of lack of penetration by change of probe angle.
    - Identification of lack of sidewall fusion
- Development of a correlation between defect type, amplitude and width of defect echo, defect position and probe angle.
- Development of the software.
- Verification of test results.