2.0 Literature Review

2.1 Conventional Methods of Defect Identification

A good estimation of type of defect is very important in all NDT methods including ultrasonic testing since the defect type will adversely affects the service life of the component/product.

In conventional ultrasonic A-scan methods recognition of the defect type (porosity, slag, crack etc.) is ascertained by a series of movement of the probe as rotational, orbital, lateral and transverse to observe the echo pattern. Here the human eye perceives many facts simultaneously by moving a transducer in infinite increments in 3D to seek out additional information–the mind sorts and processes the accumulated real-time facts and combines them with empirical data from experience and case history before making final decision on the defect. According to this technique, moving the probe in an arc (orbital movement) about the location of an isolated pore produces little or no change in the echo in height and position. During other types of movement the echo rises and falls quickly and smoothly as the beam scans through the pore[6, 7, 8, 9].

Porosity gives rise to a lot of tiny echoes, depending on the number and distribution of the pores. There are a number of multiple echoes with small amplitudes[7].

In the case of slag inclusion swiveling the probe on the same spot causes the echo indication to vary randomly, some peaks rise and some falls and indication position shifts in either direction on the screen. Traversing the search unit in an arc causes the indication to vary randomly in height and to broaden slightly.When the probe is rotated around the slag, the echo does not disappear, or one can even see number of maxima [9].

Crack produces sharp echo when the beam is at right angle to the defect. In the case of large crack back echo is heavily attenuated, and it may disappear if the crack is large enough so that it cuts the entire section of the ultrasonic beam. The echo height falls off drastically when the probe is orbited around the defect or rotated about its own axis from its position of maximum echo signal [9, 10, 11].

In-complete penetration gives clear and sharp echo. The echo disappears when the probe is moved orbital.

In lack of fusion, echo trace remains in one position when the probe is moved over a given section of the weld in a direction at right angles to it, depending on the size of the defect.

Since cracks, in-complete penetration and lack of fusion are all planer defects, they cannot be differentiated from each other simply by the echo shape. To determine the nature of each defect with certainty, the location of the defect in the weld has to be established. In-complete penetration and lack of fusion have preferred location in the weld seam [7].

Under cutting gives a clear sharp signal. At the same time, the maximum amplitude occurs at a distance of either half or one skip distance between the probe and the weld.

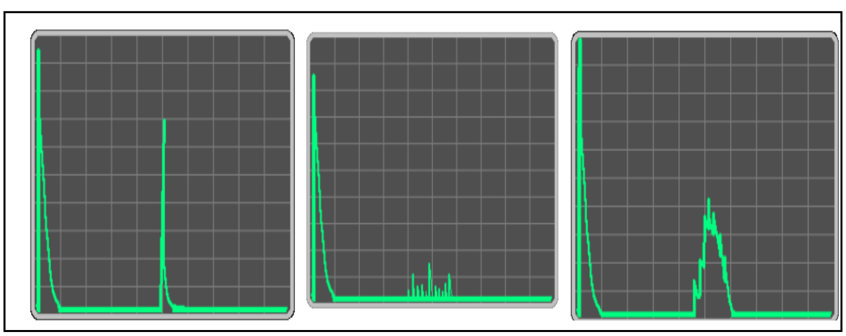


Figure 2: Echo patterns of various defects

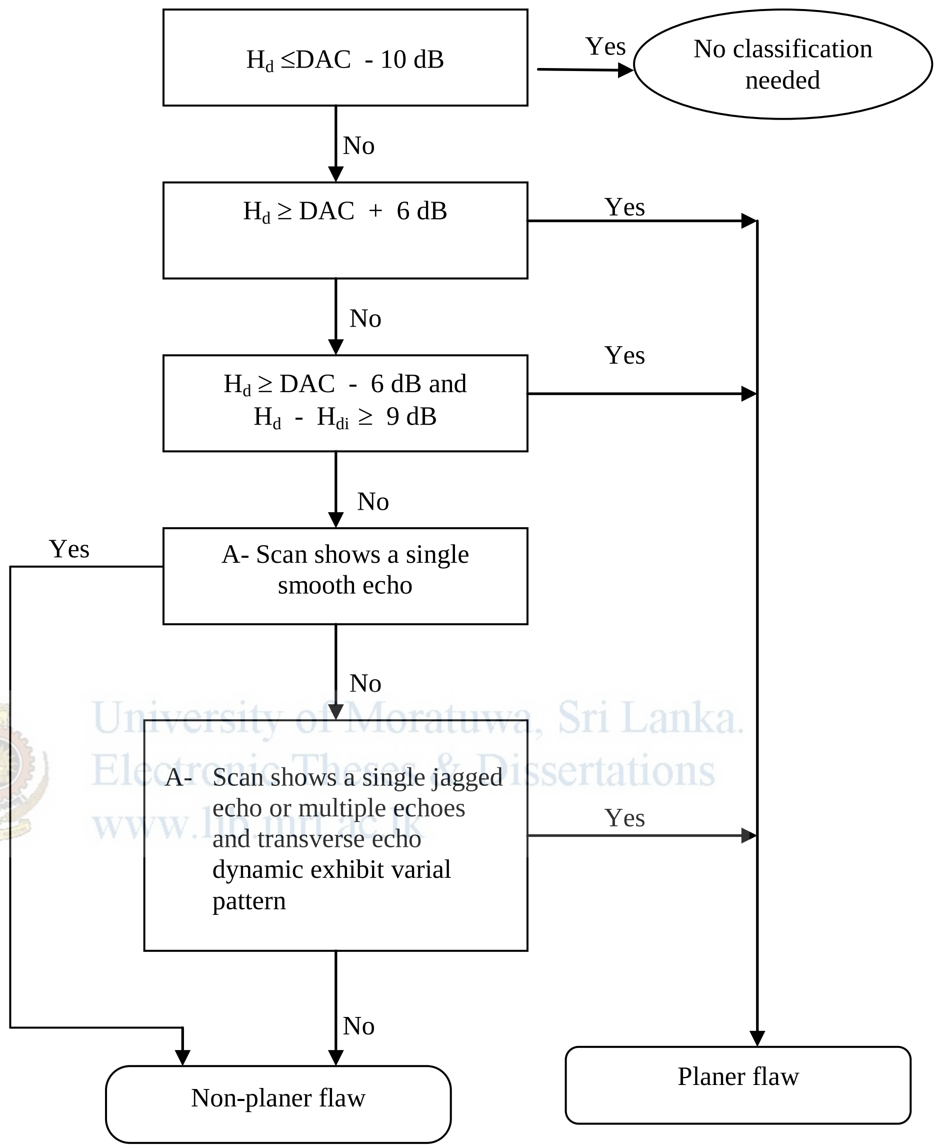
By considering these facts it is understood that the ultrasonic signals are quite complex since it may contain many signals other than defect echoes and the amplitude and shape of the signal may change due to slight movement of the testing probe. Therefore the estimation of defect type using this technique is totally depends on the experience of the operator who carries out the testing and only well-experienced NDT personnel can identify defect type using this technique [6, 10, 11].

2.2 Recent Development of Defect Identification Methods.

The rapid advances in computer hardware and software technology have made the incorporation of computer into NDT test systems, particularly for ultrasonic testing in defect classification, which will lessen the operator dependency on defect identification. Investigations have been done to develop software tools to classify welding defects in metallic plates into two classes the planar defects and volumetric defects.

N.Kopp, D. Chanveau, D. Flotte et.al. (1998), have classified defects as non-planer and planer based on the A-scan ultrasonic technique[12] . The flow chart connected with this work is shown in figure 3. In this flow chart, the maximum echo height has compared with the Distance Amplitude Curve (DAC). If the value of echo height was lower than the DAC level by 10dB then the defect was considered as harmless to the component. Otherwise, it was further classified as planer or non-planer defect.

The flow chart shown in figure 4 classifies the defects into planer and cubic[6]. This follows JIS Z3060 standards (JIS-Japanese Industrial Standards). According to this, if the defect length is equal or larger than 30mm, it is considered as planer defect. The defects having length less than 30mm are further classified by observing the echo pattern and defect location.



H_d :Flaw echo with the highest amptitude.
H_{di} :Flaw echo with the highest amplitude for an other angle of incidence.

Figure 3: Classification of defects based on the pulse echo technique[12]

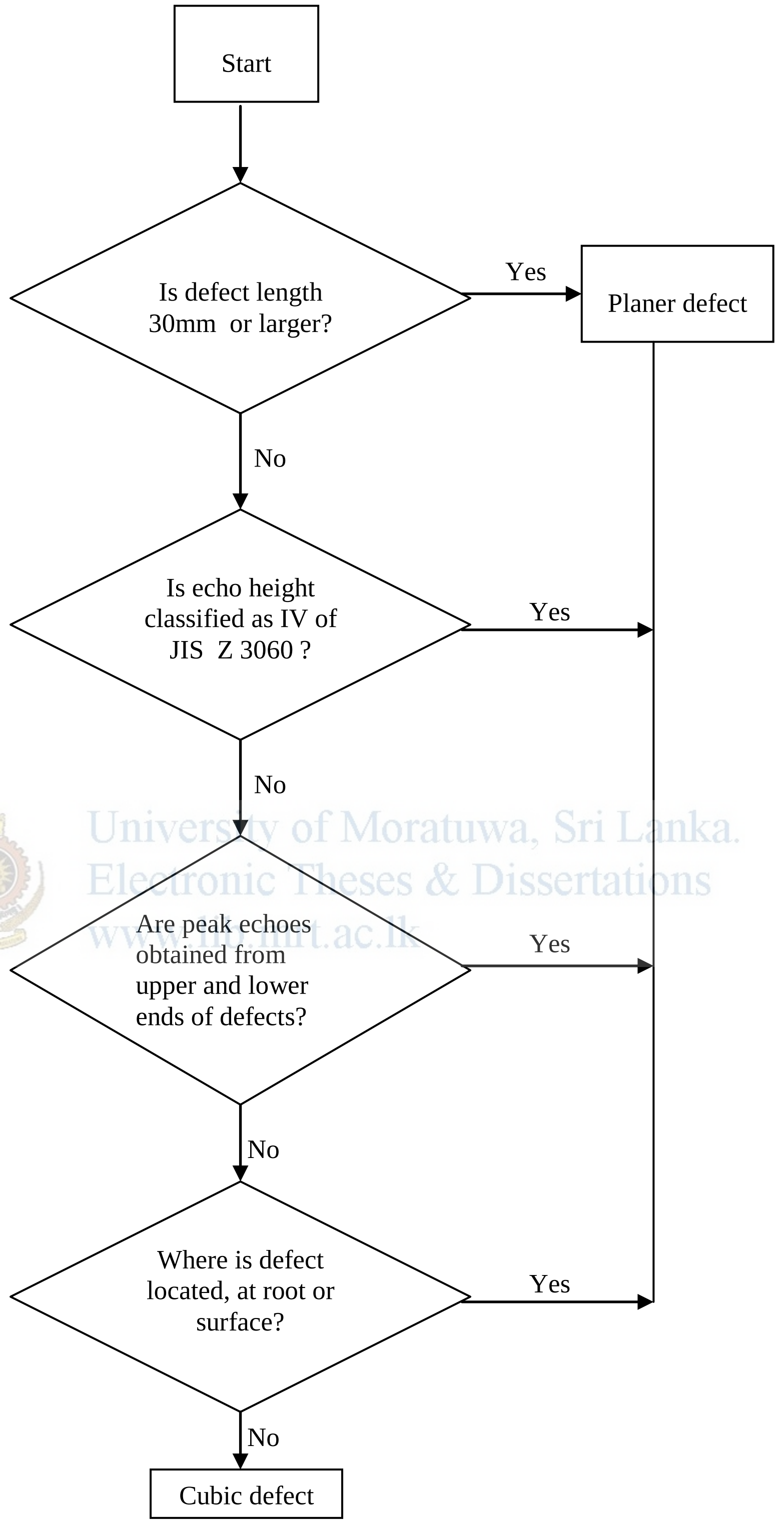


Figure 4: Flow chart to determine the type of defect as per JIS Z 3060 (Japanese Industrial Standard - Method for Ultrasonic Manual Testing and Classification of Test Results for Ferrite Steel Welds) [6].

R.Raillon, P.Calmon, L.Paradis and co-authors (1998) have suggested a model called "Mephisto" for predicting Ultrasonic images. It is based on the extraction of the maximum available information about the defect from ultrasonic images. Here they have compared measured image and the corresponding image computed with above model [13].

Classification and identification of faults in welding using digital signal processing; with emphasis to the neural network technique has been shown by Arlindo (1999). The results of this work have proved the efficiency of the proposed method in identifying the presence of faults [14].

T.Stepinski and F.Lingvall (2000) have reported the results of their research to develop a software tool to facilitate the interpretation of defect signatures obtained from pulse–echo ultrasonic measurements. A neural network processing outputs from specialized feature detectors was used for the characterization. The approach here consists in, first carefully analyzing the ultrasonic responses, using different transducers, and then examining if there are features which are unique for the individual classes of defects, and hence, could be used for defect characterization [15].

The purpose of study of Y.Shoef, G.Shoef et.al.(2000) was to develop calculated images by establishing mathematical models through 3-D Ultrasonic Imaging. These images will be obtained according to the Ultrasonic inspection parameters and will predict the image that is supposed to come as result of inspection. This can serve as a tool for evaluating the size of the defect and to distinguish between two different types of defects those has similar images[16].

Sung – Jin Song, Hak-Joon Kim and Won-Suk Sung have reported their effort to develop a new intelligent ultrasonic evaluation system using a multi-axis portable scanner and a control computer.

In this system, a human operator moves manually the multi-axis portable scanner around the defect, and then the information on defect geometry is determined automatically by a defect analysis software package[17].

2.3 Recognition of Defect Type using Echo Height

Investigations have been done by a Japanese research team to correlate the type of defect with echo height and probe angle[6]. Three probe angles with 45°, 60° and 70° have been used to measure the echo height with reference to primary reference level (echo height from 4mm-diameter hole). Height of echoes from different artificial defects of welded plates such as porosity, slag, incomplete penetration, lack of fusion, crack have been plotted against the shear wave probe angle[6].

Echoes have been classified by the type of defect and refraction angle of transducer used. Results are shown in figure 5.This figure shows that relatively harmless defects such as blowholes produce generally low echoes and harmful defects such as cracks give comparatively high echoes. That means the type of defect can be detected to some extent from the echo height depends of angle of the probe. This will provide good relationship between type of defect and echo height.

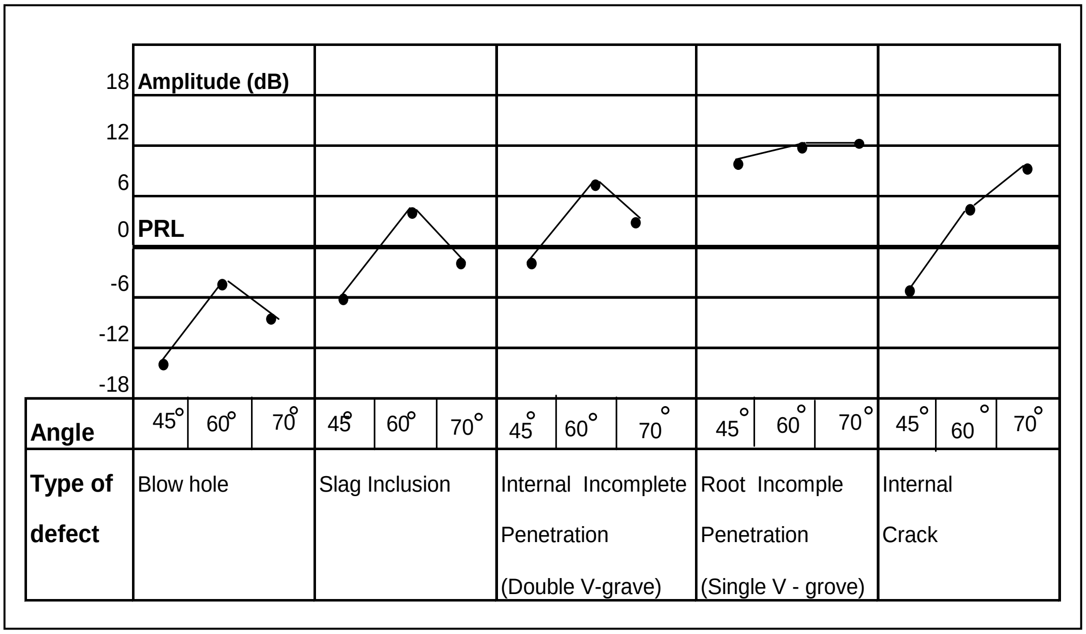


Figure 5: Graphical correlation between defect type,echo amplitude and angle of probe[6] (Thickness: 25 - 28 mm, Frequency: 4 - 5 MHz, PRL: Primary Reference Level (echo height from 4mm diameter hole))

By considering all the literatures above and considering the equipment available it was concluded that this technique is more suitable to further develop for using in field inspections, which will be cheep, portable and simple to understand by the operator in defect characterization.

As such the objective of this research is to further study this technique and to develop a relationship between defect type and echo amplitude. This relationship along with width and position of defect echo and change of sound beam direction is used to identify defect type. Finally it will develop a specialized procedure and a software programme based on above relationship[18].