4.0 Equipment and Accessories Used

4.1 Ultrasonic Flaw Detector

Modern ultrasonic flaw detectors are small, portable, microprocessor-based instruments suitable for both shop and field use. They generate and display an ultrasonic waveform that is interpreted by a trained operator, often with the aid of analysis software, to locate and categorize flaws in test pieces. They will typically include an ultrasonic pulsar/receiver, hardware and software for signal capture and analysis, a waveform display, and a data logging module.

While some analog-based flaw detectors are still manufactured, most contemporary instruments use digital signal processing for improved stability and precision. The pulsar/receiver provides an excitation pulse to drive the transducer, and amplification and filtering for the returning echoes.

Pulse amplitude, shape, and damping can be controlled to optimize transducer performance, and receiver gain and bandwidth can be adjusted to optimize signal-to-noise ratios[41, 45].

Modern flaw detectors typically capture a waveform digitally and then perform various measurement and analysis function on it. A clock or timer will be used to synchronize transducer pulses and provide distance calibration. Signal processing may be as simple as generation of a waveform display that shows signal amplitude versus time on a calibrated scale, or as complex as sophisticated digital processing algorithms that incorporate distance/amplitude correction and trigonometric calculations for angled sound paths. Alarm gates are often employed to monitor signal levels at selected points in the wave train to flag echoes from defects.

The display may be a CRT, a liquid crystal, or an electroluminescent display. The screen will typically be calibrated in units of depth or distance.

Multicolor displays can be used to provide interpretive assistance. Internal data loggers can be used to record full waveform and setup information associated with each test, if required for documentation purposes, or selected information like echo amplitude, depth or distance readings, or presence or absence of alarm conditions[41, 45].

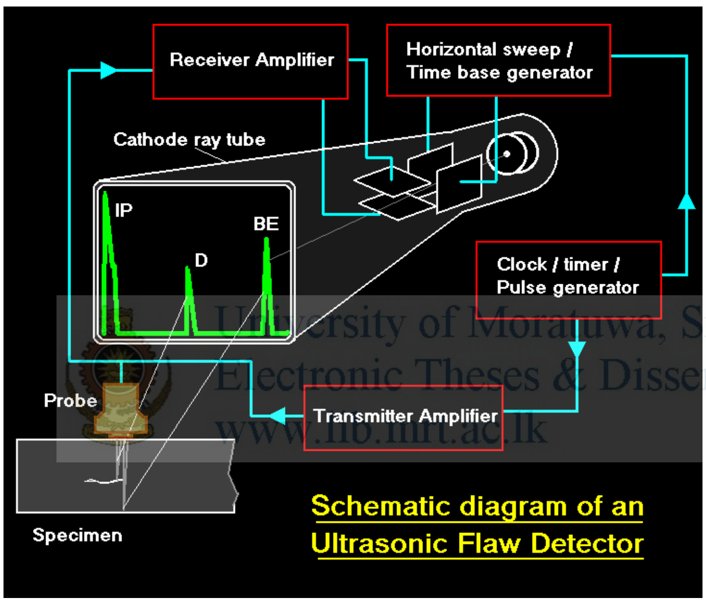

Figure 31: Schematic Diagram of an Ultrasonic Flaw Detector

4.2 Ultrasonic Probe

An ultrasonic probe (transducer, search unit) is a device that converts energy from one form to another. Ultrasonic transducers convert electrical energy into high frequency sound energy and vice versa.

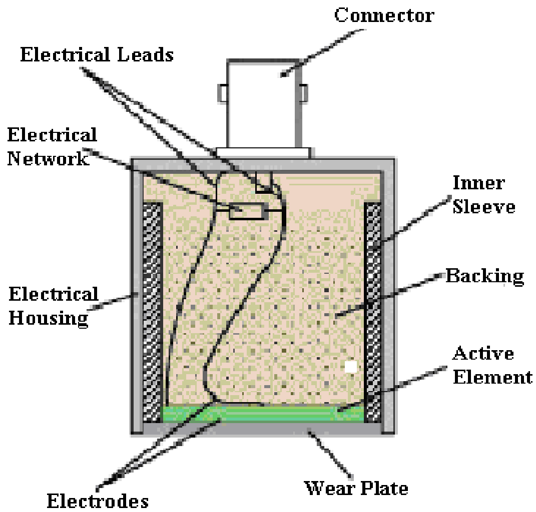

Figure 32: Cross section of typical contact transducer

Typical transducers for ultrasonic flaw detection utilize an active element made of a piezoelectric ceramic, composite, or polymer. When this element is excited by a high voltage electrical pulse, it vibrates across a specific spectrum of frequencies and generates a burst of sound waves. In the reverse transducer is vibrated by an incoming sound wave, it generates an electrical pulse[41, 45].

The front surface of the element is usually covered by a wear plate that protects it from damage, and the back surface is bonded to backing material that mechanically dampens vibrations once the sound generation process is complete. Because sound energy at ultrasonic frequencies does not travel efficiently through gasses, a thin layer of coupling liquid or gel is normally used between the transducer and the test piece.

There are three types of ultrasonic transducers commonly used in defect detection applications specially in weld testing.

4.2.1 Contact Probe

As the name implies, contact transducers are used in direct contact with the test piece. They introduce sound energy perpendicular to the surface, and are typically used for locating defects parallel to the outside surface of a part, as well as for measuring thickness[41, 45].

4.2.2 Duel Element Probe

Dual element transducers utilize separate transmitter and receiver elements in a single assembly. They are often used in applications involving rough surfaces, coarse grained materials, detection of pitting or porosity, and they offer good high temperature tolerance as well[41, 45].

4.2.3 Angle Beam Probe

Angle beam transducers are used in conjunction with plastic or epoxy wedges to introduce shear waves into a test piece at a designated angle with respect to the surface. The use of angle beam testing is especially common in weld inspection.

Typical angle beam assemblies make use of mode conversion and Snell's Law to generate a shear wave at a selected angle (most commonly 45, 60, or 70 degrees) in the test piece.

As the angle of an incident longitudinal wave with respect to a surface increases, an increasing portion of the sound energy is converted to a shear wave in the second material, and if the angle is high enough, all of the energy in the second material will be in the form of shear waves[41, 45].

There are two advantages to designing common angle beams to take advantage of this mode conversion phenomenon. First, energy transfer is more efficient at the incident angles that generate shear waves in steel and similar materials. Second, minimum flaw size resolution is improved through the use of shear waves, since at a given frequency; the wavelength of a shear wave is approximately 60% the wavelength of a comparable longitudinal wave.

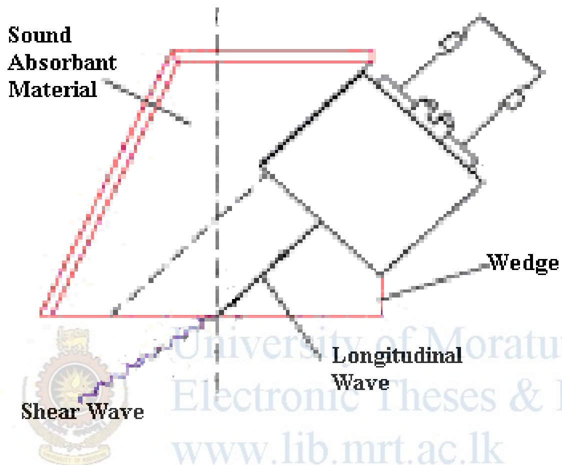

Figure 33: Cross section an angle beam probe[45]

5.0 Research Methodology

5.1 Fabrication of Test Specimens

The objective of this part of the work was to fabricate single-v butt welded steel specimens containing defects. The defects embedded were porosity, slag, lack of fusion, incomplete penetration and crack. The defects were identified using Radiography technique. These specimens containing known defects were then used in the proposed experiment to develop a new concept for interpretation of defects in. single-v butt welded steel plates.

5.1.1 Defects in Single-V Butt Welded Steel Plates

In welding, metal pieces are joined by establishing metallurgical atom- to – atom bonds between them by the application of heat and sometimes pressure[46]. Manual metal arc welding (MMAW) or shielded metal arc welding (SMAW) is an electric arc welding process where the heat for welding is generated by an electric arc between a flux covered electrode and the work piece. The filler metal is deposited from the electrode and the electrode covering provides the shielding.

A proper welding run is achieved by using optimized welding parameters and proper control of the arc by welder under on-line visual inspection[46, 47].During the welding process the defects such as slag, porosity, crack, lack of penetration, lack of fusion, etc. may occur due to various factors such as wrong design, improper manipulation of welding parameters, incorrect selection of electrode, human errors, etc. A short description of these defects is as follows.