Ultrasonic Flaw Detection

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I. INTRODUCTION

Ultrasonic testing (UT) uses high frequency sound waves (typically in range between 0.5 and 15 MHz) to conduct examinations and make measurements. Besides its wide use in engineering application (such as flaw detection, dimensional measurements, material characterization, etc.) ultrasonics are also used in medical field (such as sonography, therapeutic ultrasound, etc.)

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1.2 BASIC PRINCIPLE:

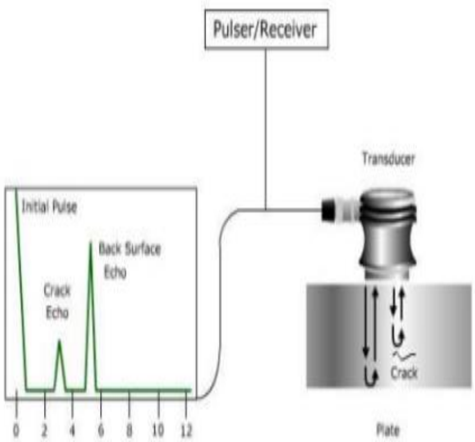

Fig. 1.1: Principle of ultrasonic flaw detection

A typical pulse-echo UT inspection system consists of several functional units, such as the pulser/receiver, transducer, and a display device. A pulser/receiver is an electronic device that can produce high voltage electrical pulses. Driven by the pulser, the transducer generates high frequency ultrasonic energy. The sound energy is introduced and propagates through the materials in form of waves. When there is discontinuity (such as crack) in the wave path, part of energy will be reflected back from the flaw surface. The reflected wave signal is transformed into an electrical signal by the transducer and is displayed on a screen. Knowing the velocity of the waves, travel time can be directly related to the distance that the signal travelled. From the signal, information about the reflector location, size, orientation and other features can sometimes be gained.

1.3 PROCEDURE:

Ultrasonic flaw detection is basically a comparative technique. Using appropriate reference standards along with a knowledge of sound wave propagation and generally accepted test procedures, a trained operator identifies specific echo patterns corresponding to the echo response from good parts and from representative flaws. The echo pattern from an test piece may then be compared to the patterns from these calibration standards to determine its condition.
- Straight Beam Testing -- Straight beam testing utilizing contact, delay line, dual element, or immersion transducers is generally employed to find cracks or delaminations parallel to the surface of the test piece, as well as voids and porosity. It utilizes the basic principle that sound energy traveling through a medium will continue to propagate until it either disperses or reflects off a boundary with another material, such as the air surrounding a far wall or found inside a crack. In this type of test, the operator couples the transducer to the test piece and locates the echo returning from the far wall of the test piece, and then looks for any echoes that arrive ahead of that backwall echo, discounting grain scatter noise if present. An acoustically significant echo that precedes the backwall echo implies the presence of a laminar crack or void. Through further analysis, the depth, size, and shape of the structure producing the reflection can be determined.

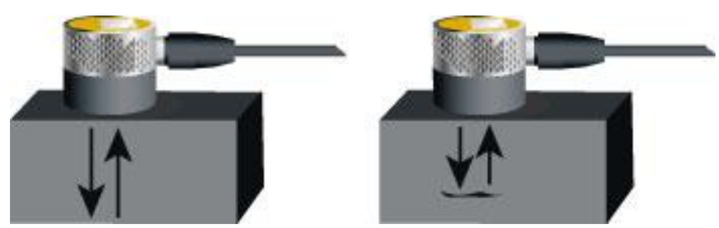

Fig.1. 2: Procedure of ultrasonic flaw detection

Sound energy will travel to the far side of a part, but reflect earlier if a laminar crack or similar discontinuity is presented.

In some specialized cases, testing is performed in a through transmission mode, where sound energy travels between two transducers placed on opposite sides of the test piece. If a large flaw is present in the sound path, the beam will be obstructed and the sound pulse will not reach the receiver.

- Angle Beam Testing - Cracks or other discontinuities perpendicular to the surface of a test piece, or tilted with respect to that surface, are usually invisible with straight beam test techniques because of their orientation with respect to the sound beam. Such defects can occur in welds, in structural metal parts, and many other critical components. To find them, angle beam techniques are used, employing either common angle beam (wedge) transducer assemblies or immersion transducers aligned so as to direct sound energy into the test piece at a selected angle. 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 30, 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. 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.

1.4 BLOCK DIAGRAM

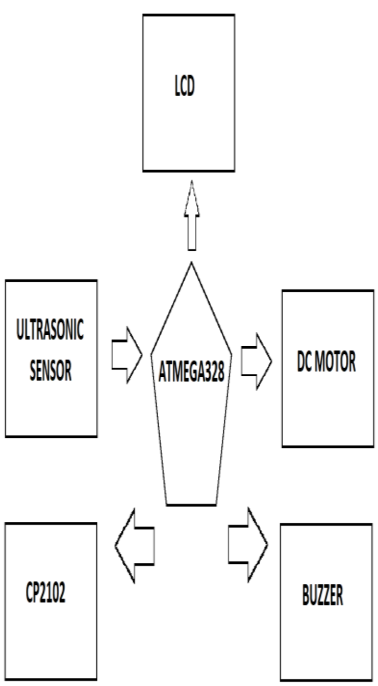

Fig. 3.1: Block diagram

The value of ultrasonic sensor has been fixed to a predetermined value. As soon as the value of ultrasonic sensor falls below a particular level, motors stops, buzzer is turned ON which indicates that any flaw is present and it is displayed on the LCD as "Crack Present". Whenever the value of the sensor is above the predetermined value, motors rotates, buzzer is turned OFF which indicated that flaws are absent and it is displayed on LCD as "Crack Absent". Data from both the condition is collected and it is given to CP2102 which analyses the data and plots a graph.

1.5 FLOWCHART

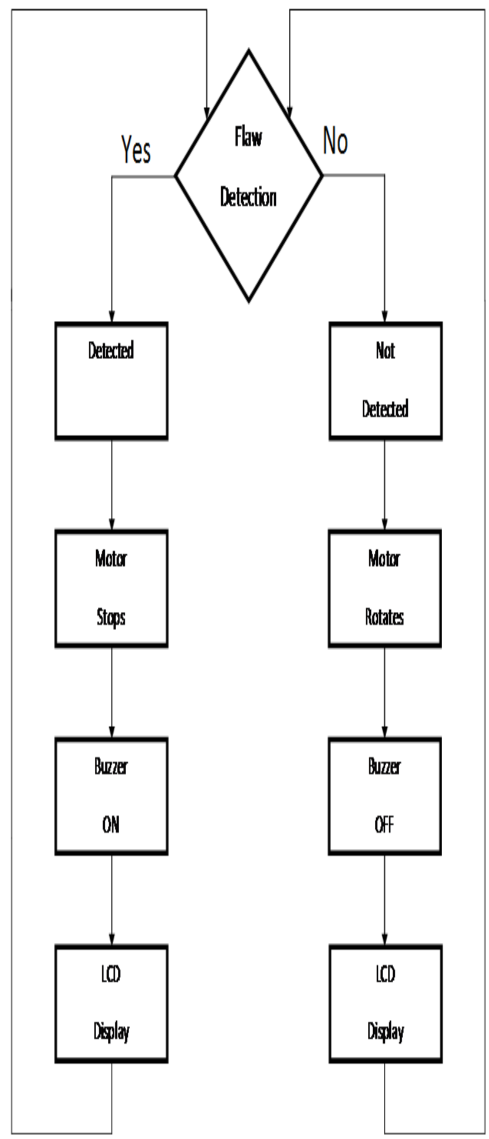

Fig. 3.2: Flowchart

1.6 OPERATION

The main objective of this project is to design and develop an automatic detection system to identify any flaw or deformation present on the metal rod based on ultrasonic technology. A typical ultrasonic sensor consists of a transmitter and a receiver. The sound energy generated by the transducer propogates in the form of waves. Sound waves are mechanical vibrations that pass through a medium such as liquid, solid or gas. These waves pass through a medium at a particular velocity in an expected direction. When these waves bump into a boundary having a different medium, they are transmitted back. This is the principle behind ultrasonic flaw detection. When there is a discontinuity (such as crack) in the wavepath , part of the wave will be reflected back from the flaw surface unlike normal wave . So we can differentiate between the areas with no flaw and flaw present condition as the readings at the output if ultrasonic sensor will be different in both the cases. The reflected signal is transformed into electrical signal by the transducer. The readings are noted and compared. As soon as there is a change in reading , the microcontroller will give command to the motor to stop working. A statement will be displayed on LCD screen notifying that a flaw has been detected. After some time delay, command will be given to the motor to start rotating again and thus the system will move in forward direction and the ultrasonic sensor will keep sending the reading to the microcontroller. Again the procedure will be repeated and if a flaw is present the motor will stop and LCD will display the crack detected statement. When a crack is detected , a buzzer pin will be set high and buzzer will be turned on. The values of the reflected waves are recorded on an excel sheet using CP2102 (USB to UART converter) to plot a graph. CP2102 fetches data from microcontroller and converts into a graph representation using PLXDAQ software. Thus we get a real time plot of the readings of ultrasonic sensor versus time.

Whenever ultrasonic sensor detects any flaw on the metal surface, it increments the counter by one. So after inspecting the metal rod we get the total number of flaws present on the metal rod and it is displayed on LCD.

1.7 CONCLUSION:

- Ultrasonic guided waves in adhesive layers are strongly affected by bond quality. Accordingly, this method for bond strength measurement, utilizing guided ultrasonic waves, is introduced.
- The analysis indicated that measurement of the propagation velocity may provide information about the strength of the bond.
- The advantage of this technique is that it interacts directly with the adhesive layer.
- The results indicate that there is a good correlation between the velocity of the guided wave and the bond strength and therefore can be used to classify the interface imperfection**.**

1.8 FUTURE SCOPE:

Ultrasonic testing is already essential in constructing and operating modern engineering plant, where it is used to detect and measure metallurgical defects which could undermine plant integrity. Safety requirements and the costs of component failure are powerful incentives to apply ultrasonics more widely, and to improve its reliability and efficiency. In particular, ultrasonics is needed to detect planar defects and to measure the defect dimensions which fracture mechanics shows to be structurally significant. The future of ultrasonics will, therefore, be linked closely with the growing use of fracture mechanics to assess defects. The unacceptable defects in a component must be at least as large as those which ultrasonics can detect and measure. At present, however, the performance of ultrasonics is poorly quantified. Consequently, further research is required into the interpretation of echoes, into the inherent limitations of ultrasonic techniques, and into the consequences of non-ideal testing conditions. Fundamental research will also improve ultrasonics for inspecting Inconel and austenitic steel welds, which present special difficulties. Improvements in equipment and procedures will extend the scope of both manual and automatic inspections. Automatic tests will increase the reliability and speed of testing, and will operate in hostile environments. In addition, holographic and other signal processing methods will aid defect diagnosis.

1.10 ADVANTAGES:

- In general, ultrasonic testing is based on the capture and quantification of either the reflected waves (pulse echo) or the transmitted waves (through-transmission). Each of the two types is used in certain applications, but generally, pulse echo systems are more useful since they require one-sided across to the object being inspected. It is sensitive to both surface and subsurface discontinuities.
- The depth of penetration for flaw detection or measurement is superior to other NDT methods.
- Only single-sided access is needed when the pulse-echo technique is used.
- It is highly accurate in determining reflector position and estimating size and shape.
- Minimal part preparation is required.
- Electronic equipment provides instantaneous results.

- Detailed images can be produced with automated systems.
- It has other uses, such as thickness measurement, in addition to flaw detection

1.11 APPLICATIONS:

- Conventional and imaging flaw detector
- Hydraulic cylinder production process
- Forging testing

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