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# Structural health monitoring using ultrasonic techniques

**Madhusudanan A, Prabhakaran S, Ruba P H and Elizabeth Rufus**

School of Electronics Engineering, VIT University, Vellore 632014, Tamil Nadu, India

E-mail: elizabethrufus@vit.ac.in

**Abstract.** Structural health monitoring is the method of detecting damage and performance for mechanical structures found in wide variety of application in various fields. Ultrasonic examine is a regime for detection of defects in engineering structures. Here the block is used as a specimen under test. Two ultrasonic transducers are used as transmitter and receiver. The Signal obtained from the receiver will be further processed. Here the block undergoes two significant methods such as pulse echo and through transmission testing. From the data corresponding inference comparison methods is analysed.

## 1. Introduction

This paper is about detection of flaw occurs in the mechanical structures using Non Destructive Testing (NDT) method. Ultrasonic transducer is used as sensing element to perform operations. Peripherals are constructed with sufficient strength to withstand stress in service and endure at abnormal conditions. Failure happens in component because of flaw, like cracks reduces strength of component. This flaw is due to fault manufacturing or service in degraded environment [4]. To protect them after manufacturing various techniques used. Non-destructive testing (NDT) is an evaluation performed on object of any type, size, shape or material to detect the present of discontinuities [1].

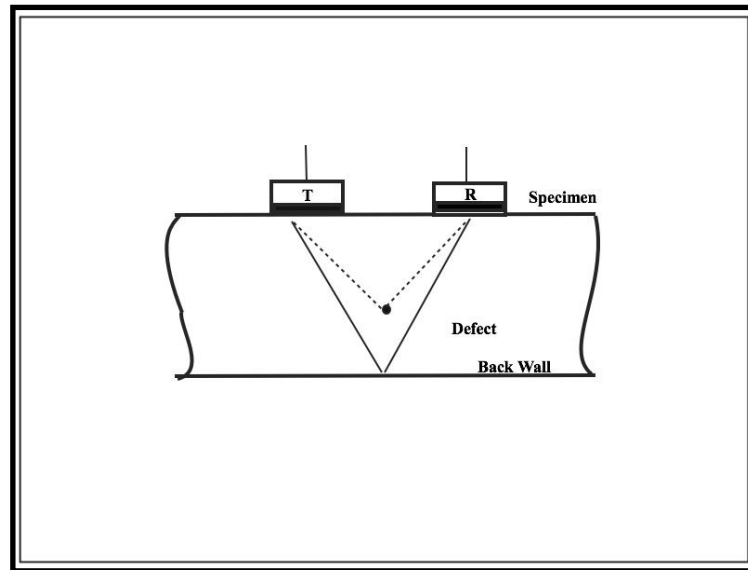
In that, ultrasonic evaluation is widely applicable, having capacity for detection and allocation of cracks in outspread of locations and surface depth of material. Ultrasonic evaluation make use low amplitude waves to discover, characterize and size flaws in objects [2]. The transmitters and receptors of ultrasonic waves are transducers i.e., piezoelectric material which twists when voltage is applied. Applying voltage produces mechanical distortion which travel through object as wave. Signal arrive at receptor, piezoelectric convert to voltage that rely on orientation and magnitude of deformity. Mechanical structures become fatal by durable fracture if defects present above threshold size for load. The strength of solid, depend on cohesive bond between components, it is not achieved in bulk solids however in thin filaments. In general, resistance is distinguished by cracks on surface. At the point when a material is extended, energy is stored in elastic displacement [3]. The material is relaxed and the strain energy is discharged.

## 2. Proposed system

### 2.1. Pulse Echo Testing

The ultrasonic pulse-echo method, or pulse-echo method, is a non-destructive testing technique using ultrasonic waves to find defects in materials. The transmitter (T) generates an ultrasonic pulsed wave which is reflected by an inhomogeneity like a defect or the back wall of the specimen, and obtained by the receiver(R) [5].





**Figure 1.** Pulse echo method.

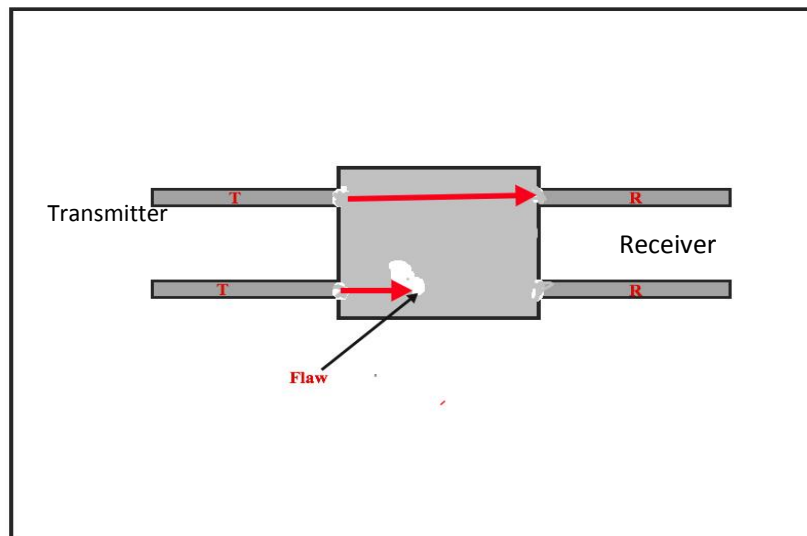
In pulse-echo testing a transducer emits out a pulse of energy and the same or a second transducer receive for reflected energy, also known as an echo. Pulse echo method is effectual when either side of the material can be used. A piezoelectric transducer with longitudinal axis situated perpendicular to and set up on or near the surface of the test material is used for transmit and receive ultrasonic energy. The ultrasonic waves are sent back by the opposite face of the material or by disconnected, layers, voids, or inclusions in the material, and received by the same transducer where the reflected energy is transformed into an electrical signal. The electrical signal is analyzed and display it on a video monitor or TV screen. Hence the thickness of the material can be found in which the flaws are present. The pulse-echo uses an ultrasonic pulsed wave. Ultrasonic waves are mechanical vibrations and have a frequency greater than 20,000 Hz. The time-of-flight between the transmitted and back-reflected waves was measured using a 5073PR transmitter and receiver with 1MHz transducer with a diameter of 15 mm. With acoustic velocity 'v' and the time't' between two peaks, the distance 'd' in the material can be calculated [6]:

$$\text{Distance Calculation:} \quad d = v t / 2 \quad (1)$$

### 2.2. Through Transmission Testing

In the through-transmission method, a ultrasonic transmitter is utilized on one side of the material while a detector is set on the opposite side. Checking of the material utilizing this method will bring about the location of deformities, defects, and inclusions in the X-Y plane. This method is utilized for non destructive testing of multi-layered and multicomponent materials.

Through-transmission ultrasonic testing (UT) is utilized for detection, verification, measuring, and growth rate monitoring of breaks in channeling, vessels, round and hollow shapes, and some-times non barrel shaped shapes. Through-transmission UT is a two transducer strategy in a pitch-get game plan. While there are many sorts of UT methods, on the grounds that of the wide assortment of component shapes, sizes, and orientations it is sometimes capable to have an option strategy for verification, for example, through-transmission. Through transmission is performed utilizing two transducers on opposing sides of the example. One goes about as a transmitter and the other as a beneficiary. Through transmission is helpful in identifying discontinuities that are not good reflectors and when signal strength is feeble.



**Figure 2.** Through transmission method.

The time-of-flight between the transmitted and back-reflected waves was measured using a 5073PR transceiver with 1MHz transducer with a diameter of 15 mm. With acoustic velocity 'v' and the time 't' between two peaks, the distance 'd' in the material can be calculated [6] :

Distance Calculation: 
$$d = v.t \quad (2)$$

### 3. Results and discussion

The ultrasonic wave was passed through the specimen and flaw characteristics was analysed below. In pulse echo method, position of the transducer was placed at four faces (TR) of the specimen. The time of flight of the reflected wave is analysed and distance of the flaw from transducer is calculated.

#### 3.1. Analysis I

Position	Velocity (m/s)	Distance (mm)	Time ( $\mu$ s)
TR1	2730	52.4	38.46
TR2	2730	49.9	38.56
TR3	2730	50.0	36.72
TR4	2730	50.0	36.64

**Table 1.** Transducer Frequency for 1 MHz-Without Flaw

#### 3.2. Analysis II

Position	Velocity (m/s)	Distance (mm)	Time ( $\mu$ s)
TR1	2730	26	19.38
TR2	2730	25.8	18.96
TR3	2730	27	19.80
TR4	2730	26.9	19.74

**Table 2.** Transducer Frequency for 1 MHz-With Single Flaw

### 3.3. Analysis III

Position	Velocity (m/s)	Distance (mm)	Time ( $\mu$ s)
TR1	2730	10.8	7.96
TR2	2730	10.5	7.72
TR3	2730	36.2	26.58
TR4	2730	37.1	27.2

**Table 3.** Transducer Frequency for 1 MHz-With Double Flaw

From the tabulations given above, we inferred that the distance optimization was made using pulse echo technique.

### 4. Conclusion

In this paper two strategies are utilized for examining in time domain, the results of both the strategies are found important because they demonstrate effective damage identification, localization and characterization as spread to both complex signals and varying environmental conditions. The quadrant in which the flaw is present is determined by calculating the maximum power level of time signal with through transmission method. Simulation results show that ultrasonic NDE technique can be used as a powerful tool for structural health monitoring.

### 5. Future scope

Results from this experiment can be further improved. Further research is required for interpretation of echoes will provide better results through more precise methods. As the experiment of ultrasonic flaw detection has come to a conclusion, various opportunities for expansion have been identified. This experiment paves way into many applications of aerospace and structural engineering. The flaws in the oil pipelines, structural mechanics, and radiography of medicine can be overcome in the near future. Future work incorporates about acoustic signature of imperfection with material being anisotropic. The shape, size and position of various blemishes in the structure require to be considered.

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