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RESEARCH ARTICLE

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APPLICATION OF PIEZODISC AS A SENSOR FOR STRUCTURAL HEALTH MONITORING

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ABSTRACT

This paper mainly focuses on the development of piezo electric material as a sensor for crack detection for different materials. Now a days the field of smart material is introduced in the market. Major applicationsof piezoelectric sensors are in aircraft structure monitoringsystems, Ship structures and maintenance, civil structures, non-destructivetesting for heavy machines and in manufacturing processes. Smart material is the new technology which having the capability of both sensing and actuation, and to achieve this at lower cost, integrating the system with compact design, with less complexity and having good reliability.Piezoelectric materials is the most attractive functional materials for sensors and actuators because they can directly convert mechanical energy into electrical energy and vice versa.The application of transmitter-sensor pair of piezoelectric material for crack detection. The work of manual coin tap technique is modified to transmit the sound wave for application to a structural health monitoring system for large structures, which uses piezoelectric disc as asensor.

Key Words: Piezoelectric disc, buzzer, power amplifier, Structural health monitoring

INTRODUCTION

Previous day's people used a visual inspection to crack or damage detection. New and advanced structures cannot detect only by visualinspection, so there a need inventing new technologies i.e. Structural Health Monitoring as an damage or crack detection and Non Destructive testing(NDT) tools.SHM systems either work by detecting the presence of damage using online sensors, or by recording the impactof high risk damages.In this paper we are using a pair of transmitter-sensor, i.e. Piezobuzzer and piezoelectric disc microphone. The test was carried out on various materials by using low frequency techniques, to examine possible new methodology on structural materials like brick, paver block, tiles, wood, and metal bar.

Structural health monitoring (SHM):Structural health monitoring (SHM) is technology which can be used to detect damage or cracks, occurrence and the severity of damage in a structural member or system

before failure occurs. Different type of sensor is linked with computer system along with special equipments and software from which gives the indications and helps to find out the risk area of failure or damage.

A. ***Experimental Setup***

A basic circuit consists of piezoelectricdisc (sensor), power amplifier, Piezobuzzer (Transmitter), battery, and PCisdesigned for signal amplification and signal processing.Piezodisc Connect wires, one soldered to the middle of the piezodisc and other the metal plate on the edge of the piezodisc,these wires are connected respectively the analog input and ground, which then connected ahigh power amplifier which is shown in figure 1.

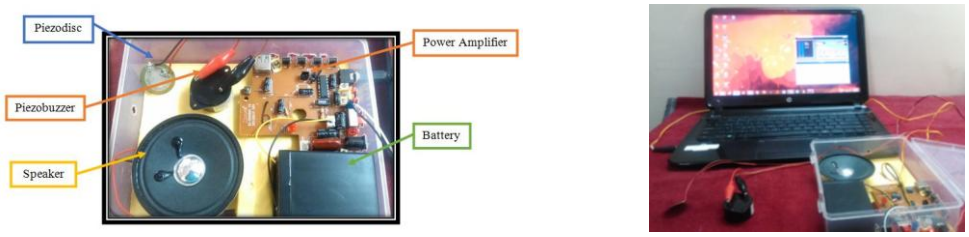


Figure 1: Experimental setup of power amplifier with sensor and laptop

Piezo buzzer which consist of piezoelectric disc encased a plastic cover and offer the advantages of directional actuation/sensing. The piezoelectric discs pick up the reflected waves from directions, resulting in a stronger signal. The amplifier consists of preamplifier, noise and band pass filter, power amplifier and output signal. The microphone is the piezoelectric disc, which allows for very low frequency operation but having very good sensitivity.The piezoelectric disc absorbing the signals which are received by piezobuzzer from different materials and analyzed in Matlab programme. The overall manufacturing cost is Rs. 700.

a) ***Application of Piezoelectric sensor on building material for SHM:***

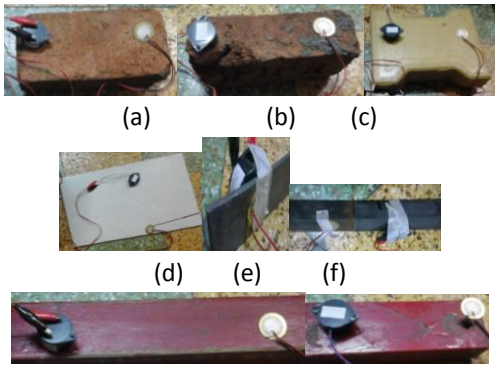
In this paper testing is carried out on different materials like brick, tile, paver block, wood, and metal bar. On these material, piezobuzzer is used as the transmitter in order to transmit sound wave signal (like beeper). The frequency of the wave energy will decrease due to the existence of cracks or damages. The change in the frequency of the normal structure and damaged structure is analyzed. Two types of Piezobuzzer used are continuous as well as Beeper. Piezoelectric materials based transducers are used as an active sensor for structural damage detection. The piezo disc as a sensor placedon materials at 15cm distance to receive the excitation signal from the piezo buzzer. When piezoelectric materials are subjected either to a stress or strain, they will generate an electric charge, in reversible effect alsotrue when applying an electric charge it produces stress or strain. Due to this special effect, PZT transducer can be used as an actuator as well as a sensor.Piezoelectric buzzer and piezoelectric discs were used as transducers to actuate and receive signal waves. The signals received by sensors are different from the same wave signal transmitted through different materialsand for analysis we are using Matlab. The recorded sound signals are analyzed in Time domain analysis, but we cannot identify the actual data. The actual frequency obtained from different materials are analyzed in Frequency domain analysis,which shows the overall frequency of the signalwhich is absorbed by the sensor. There are many tests are carried on different materials with the help of piezobuzzer and a piezodisc sensor pair for Structural health monitoring.

Figure2: Piezobuzzer and piezodisc are (a) kept in air (b) placed on each other

Initially the piezo buzzer -piezodisc are placed in the air then recording the signal come out from it, and again the pair is placed on each other which is shown in figure2. Again pair Piezobuzzer (Continuous) and

piezodisc were placed symmetrically on only the front side as well as bonded on opposite side (front and back) of the specimen so that same signal would propagate through the different materials.Same Procedure is carried out for piezoelectric buzzer (beeper) and piezoelectric discs were used.

To evaluate the response from the different materials, place the piezo buzzer and piezoelectric disc at a distance 15cm from each other. Switch on the system the sound signals transmitted from piezo buzzer are absorbed by the piezoelectric sensor. The signal from Piezo disc is transferred to the power amplifier. The amplified signals are recordedin .wav file format a computer.This procedure is repeated for all sample materials like brick, paver block, tiles, rubber, glass, wood, metal plate. Analysis of all recorded signals is processed in Matlab.This methodology has been introduced and tested on these materials like brick, paver block, tiles, wood and metal bar which is shown in figure 3:



(a) (b) (c)

(d) (e) (f)

(g)(h)

Figure 3: Experiments carried out on different materials like (a) sample Brick, (b) Damaged Brick , (c) Paver Block, (d) Tiles, (e) Metal bar, (f) two separate metal bar (g) Normal Wood, (h) wood with a hole and

B. ***Result and Analysis***

Signal amplification provides electrical signal which are proportional to output which can be used for display and further analysis. Basically Time domain analysis, Frequency analysis (FFT) is commonly used for data analysis in Matlab.There is analysis of frequency response from the piezobuzzer-piezodisc sensor for different materials.The results are plotted in frequency domain analysis for different materials as follows:

i) For pair Piezobuzzer -piezodisc sensor placed and **theair vs. placed on each other** as shown in figure 4.

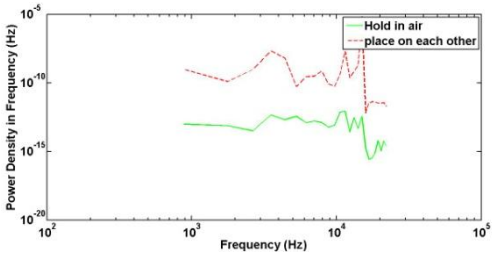
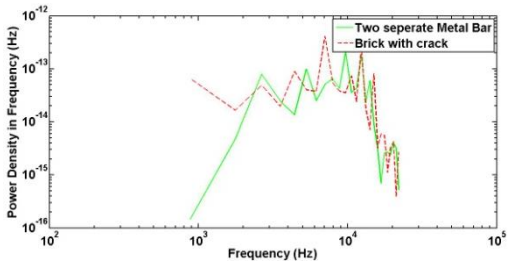
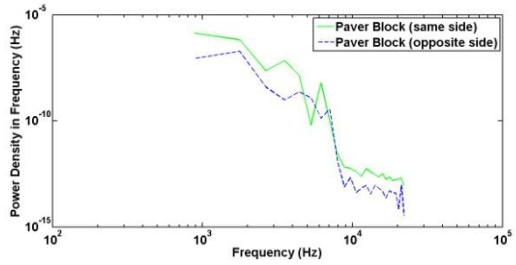


Figure 4: Analysis of Piezobuzzer and sensor are placed the Air and Place on each other

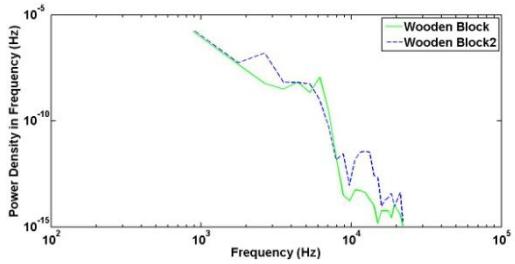
ii)Pair of Piezobuzzer -piezodisc sensor placed on(a)two separate metal bar vs. placed on opposite to each other (b) Paver Block placed on the same side each other vs. Paver block opposite to each other, (c) wood vs. wood with a hole placed on the same side each otheras shown in figure 5.



(a)



(b)



(c)

Figure 5: Analysis of Piezobuzzer and sensor are placed on (a) two different metal bar vs. opposite to each other, (b) paver block on the same side vs. opposite side, (c) wood vs. wood with a hole placed on the same side each other

iii) Pair of Piezobuzzer -piezodisc sensor placed on comparison of tiles, with small cracks and with large crack placed on the same side each other as shown in figure 6.

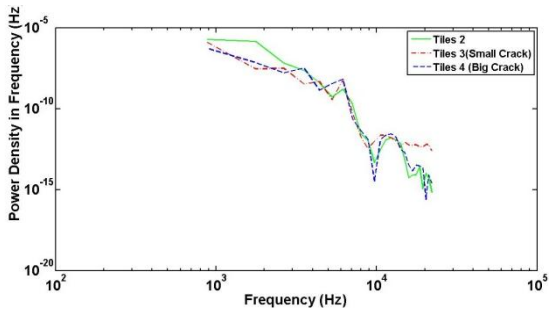
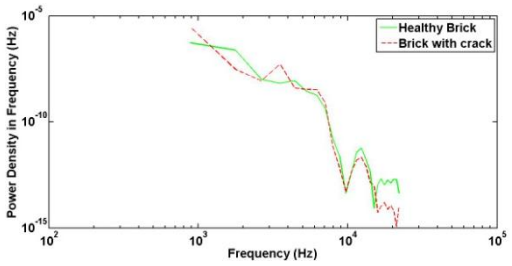
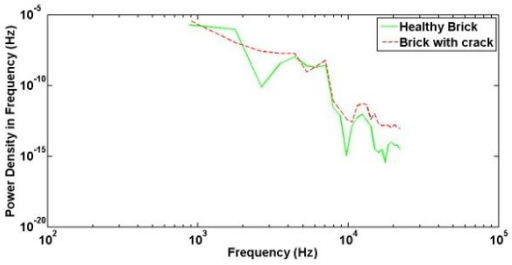


Figure 6: Analysis of comparison of tiles, with small cracks and with large crack

iv) Pair of Piezobuzzer -piezodisc sensor placed on healthy Brick vs. Damaged Brickplaced on the same side each other as shown in figure 7.



(a)



(b)

Figure7: (a)Analysis Healthy brick vs. Crack Brickby continuous buzzer(b) Analysis Healthy brick vs. Crack Brick by beeper

vi) Pair of Piezobuzzer -piezodisc sensor placed on different materials and comparison of it which is shown in figure 8.

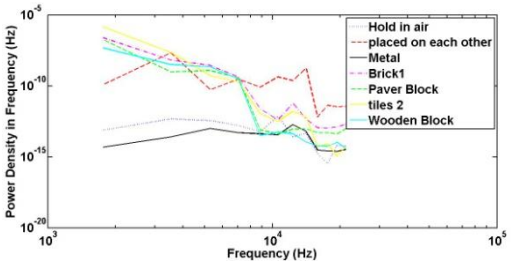


Figure 8:Analysis for different Materials

We were not able to show any significant difference in the frequency of the results obtained from the above analysis whatever we tried.

C. ***Summary and Conclusion***

The goal of this experiment is to identify the use of Pair of Piezobuzzer -piezodisc sensor for different materials for SHM. Analysis is carried out in MATLAB through signal processingtechniques which include frequency domain analysis.The experiment carried found with the high tolerance because the low frequency range was used as signal transmission carrier. Depth of penetration of the low frequency is less. Piezo disc operates in low frequency and need to change for high frequency as well as experimental setup.To improve the result of this system need to increase the frequency range as well as different inputs have to use instead of piezo buzzer.

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