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Review on Investigation of Shear Lags Effect for EMI and PZT Technique by using Analytical Approach

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Abstract: ***The emergence of clever materials including piezoelectric (PZT) transducers At gift, the impact of adhesive layer thickness (shear log effect) is considered minimum in the sensible utility of EMI generation. The notably new NDT approach called electronics (EMI) era has been beneath investigation for over decades, and there are nevertheless many troubles that want to be addressed earlier than it may be implemented to real systems. The method, which has vast capacity to create one of the handiest SHM structures, involves the use of a PZT for exciting and sensing the host shape. This paper opinions applied studies of EMI technology over the last decade to understand its trend. in addition, new ideas and thoughts proposed with the aid of diverse authors were surveyed and ends with the dialogue of possible instructions for destiny work of this paper.***
Keywords: Structure health monitoring; Electro-Mechanical impedance technique; PZT patches; Shear lag effect.

I. INTRODUCTION

SHM involves checking the response of any structure subjected to current loading, considering environmental conditions. It assesses irregularities, deterioration affecting the safety or serviceability of any structural element [1]. Continuous monitoring, procuring feedback, analysis of test data to facilitate decisions are key aspects of SHM [2]. Recognizing local or early damage at an early stage prevents serious damage. The severity of damage ranges from localized damage to severe damage. Moderate to severe damage is easily visible and this type of damage substantially alters the vibration response of the structure. Variations in vibrational response i.e. changes in mode shape, modal frequencies are identified through global techniques.

It is difficult to identify local damage with global techniques because the frequency or mode shape change is not so significant for local damage. Thus, for local loss detection, local techniques are more relied upon. Local class techniques are Ultrasonic Pulse Velocity Techniques which detects the strength of the structure, Acoustic Emissions, Impact Echo Testing etc. These are usually immense techniques and lead to the extraction of some information, which is the history of the applied load and strain formation, which does not give much information about the initial or local damage.

The investigation of the shear gap effect for PZT sensors bonded or embedded in the structure is a complex task because the bonding layer thickness of the PZT sensor bonded to the actual structure cannot be changed. This paper focuses on investigating the effect of bonding layer thickness using numerical approach. Therefore, a model of the coupled system and the binding layer was developed using the FEM based numerical model at ANSYS. The signature of the coupled system was extracted numerically and further analysis of the change in signature was carried out to study the effect of the bond layer thickness to accurately predict the health of the structure.

II. PROBLEM FORMULATION

Many researchers have investigated the effect of the bonding layer and observed that the effect of the adhesive layer is significant. Therefore, it is necessary to calculate the error in the signature of the coupled system due to the bonding layer. Monitoring a structure after its construction is as important as it is during its designing or construction. Proper monitoring structure can avoid a lot of catastrophic accidents. Structural health monitoring (SHM) plays an important role. Earlier systems were analyzed blindly by professional experts.

Various Non-Destructive Tests (NDT) like Rebound Hammer, Ultrasonic Pulse Velocity Test etc. are used for inspection. Another way to evaluate the structures of these piezoelectric transducers as well has been proven. Electromechanical impedance (EMI) techniques through piezoelectric materials have been widely used for structural reaction at various stages. EMI has the ability to detect damage, corrosion and even strength of any structural member.

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III. OBJECTIVES

The primary objectives of this project can be summarized as follows:

1) To study the various new concepts and ideas that have evolved over the past decade related to EMI.
2) To study structural health monitoring is to identify the location and severity of damage and to estimate the remaining life of the host structure.
3) To study the thickness of the bonding layer.
4) To analyze the effect of bonding layer thickness numerically using Finite Element Method (FEM) based software.

IV. LITERATURE REVIEW

Smart content has become a new way for SHM and NDT. Smart materials have a tendency to detect changes. One smart material is the piezoelectric material. The word piezo is a Greek word which means pressure. Pierre and Paul Jacques Curie discovered the piezoelectric effect in 1880. Lead zirconate titanate (PZT), is a kind of piezoelectric material.

Structure Health Monitoring (SHM) has been used to assess the health of structures such as bridges, high-rise buildings, cable bridges, trusses, and other infrastructure.

There are several techniques that are used to predict the health of the structure for SHM (Spencer, Nagayama and Rice, 2008; Moreno-Gomez et al., 2018; Maura et al. 2020). EMI technology is one of the SHM techniques which has been used by various researchers. Piezoelectric properties are used in EMI technology to assess the health of the structure. A number of experimental and analytical studies have been reported in the field of application of PZT sensors for SHM.

PZT sensors are used to assess the health of structures (Kaur et al., 2017; Maurya et al., 2019; Maurya et al., 2020). In EMI techniques PZT sensors are bonded to the structure using adhesive materials. These patches are used as sensors or actuators in structures.

The materials used in the bonding layer of the PZT sensor have different shear modulus, inertia, geometry and dynamic properties, etc. (Han et al. 2008). Because of these inherent properties of the adhesive material, the signature of the coupled system differs from the actual signature.

This difference of the recorded value of the signature from the actual signature (i.e. on the surface of the host structure) is due to the shear lag effect (Han et al. 2008). In recent times, many researchers have studied the effect of the bonding layer on the signature of the coupled system based on different properties of the bonding layer.

It was observed that the adhesive layer properties significantly affect the signature of the coupled system (Bhalla and Gupt, 2010; Islam and Huang, 2014; Moharana and Bhalla, 2014, 2015).

V. PROJECT METHODOLOGY

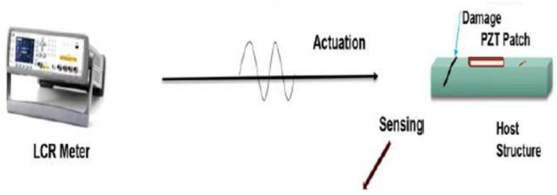


Fig. 1 EMI technique

The surface waves in EMI are generated through the vibration or excitation of the PZT patch. These waves travel radially outwards. Waves Play detects any defect or damage that hinders its course. The technique uses PZTs either bonded or embedded on the host structure. Alternatively the patch is excited.

1) The patch is excited by using the alternating electric field through the impedance analyzer or LCR meter. The analyzer then measures the patch's electro-mechanical response as it penetrates. The analyzer plots the real and imaginary parts of the penetration against the frequency range and is referred to as the signature.
2) Figure 1 shows the mechanism of EMI technology through LCR meter. Ancient signatures are considered to be fundamental indicators. Damage to the structure changes the signature and the damage is detected.
3) The project focuses on EMI technology and its various features. Various studies are mentioned that have been conducted over the years to help readers see how the technology has evolved so far.

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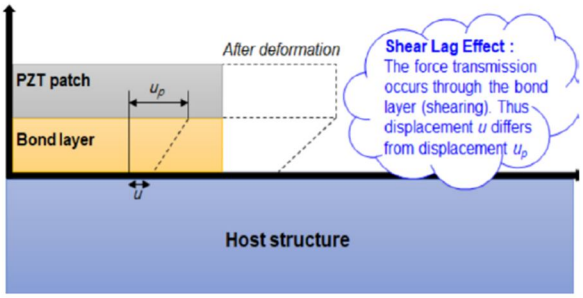


Fig.2. Shear Lag Phenomena

4) Analytically taking into account the shear lag phenomena, some precise analytical solutions were designed. Fig. 2 shows the shear interval phenomenon. The earlier model ignored the inertial effect of the PZT but was taken into account here to build the shear interval model.

5) The new model considered both the shear gap and the inertia effect simultaneously. The predictions of the new model coincide more precisely with the experiment.

VI. CONCLUSIONS

Every nation spends a lot of money in building. All civic structures play an important role in the life and development of the residents living in a country. Any damage to such structures and systems affects the GDP of the country, loss of many human lives and stunts the growing development of the country as well as its inhabitants. Structural strength decreases with constant loading and environmental impacts. Therefore, the performance of the structure should be evaluated to check whether the performance is satisfactory or not. Failure of structures can be prevented by proper monitoring.

This review engaged on the EMI technique and concentrated on the latest research in this field. There are still numerous problems in the implementation that need to be addressed like PZT's restricted sensing range, proper selection of the frequency interval, the need to account for temperature fluctuations, accurate statistical metrics, etc., must be overcome to monitor the damage.

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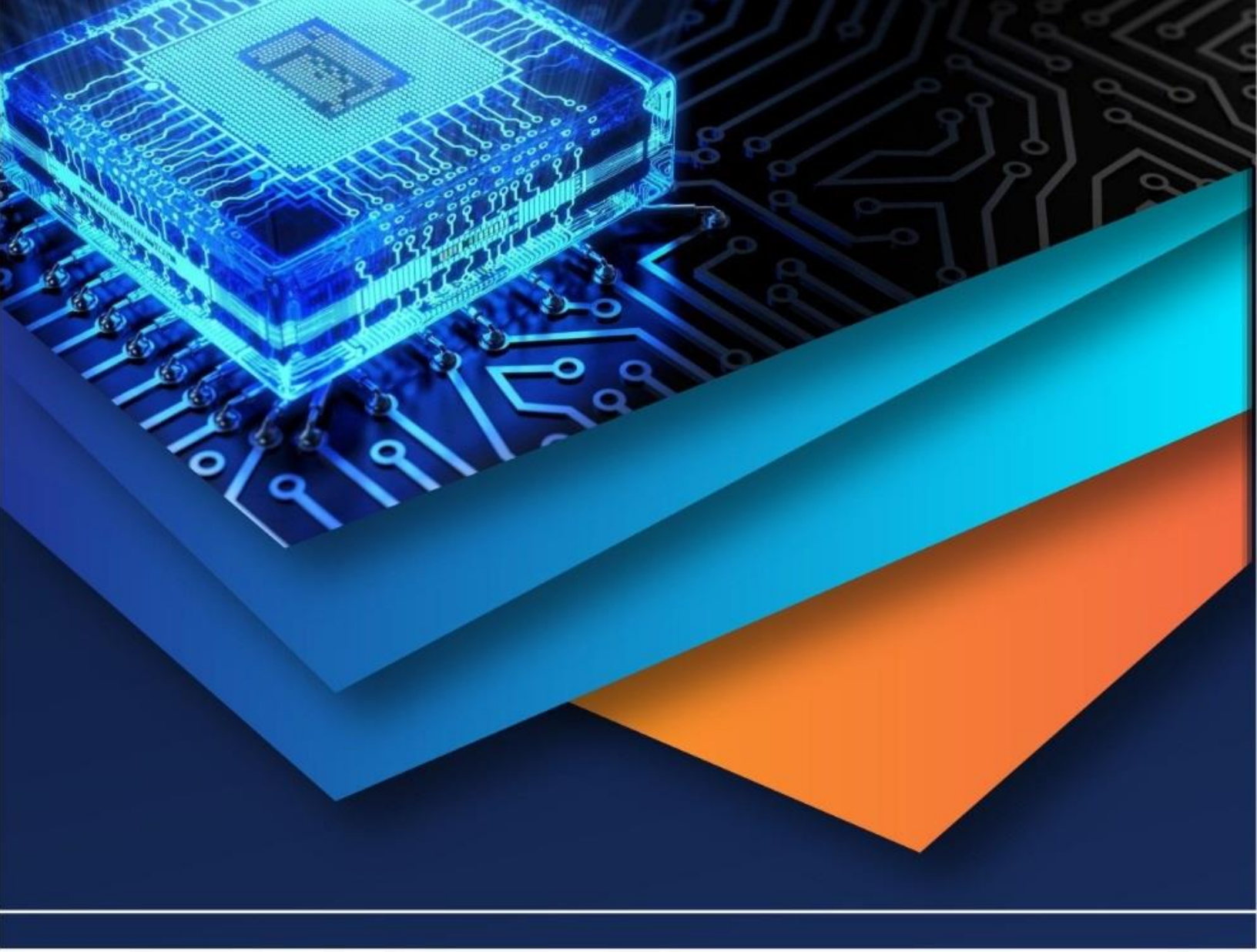
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