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Application of Piezo-Electric Material in the Vibration Reduction: A Review

Pravin Uttam Mane[1], Suresh Laxman Chittewar[2], Santosh Tanaji Ghutukade[3]
[1,2,3]*Department of Mechanical Engineering, Annasaheb Dange College of Engineering & Technology, Ashta, Sangli, India.*

Abstract: This paper gives on overview of the vibration reduction techniques using piezoelectric material. Piezoelectric elements are commonly used in smart structural systems as both sensors and actuators. A key characteristic of these materials is the utilization of the converse piezoelectric effect to actuate the structure in addition to the direct effect to sense structural deformation. Typically, piezoceramic are used as actuators and polymer piezo films are used as sensing materials. It is also possible to use piezoceramic for both sensing and actuation, as in the case of self-sensing actuators In addition to the possibility of performing collocated control, such actuators/sensors have other advantages such as compactness, sensitivity over a large strain bandwidth.

Keywords: piezoceramic, shape memory alloy, vibration, bandwidth, damping, actuation etc.

I. INTRODUCTION

Vibration in simple term is to & fro motion of body about is means position. Everybody or structure has some natural frequency of vibration when external applied force or motion matches with this natural frequency of body there is resonance in the structure at which body vibrates with larger amplitude & causes the failure of the same. So the vibration levels in the structure or body has to be reduced to do so isolators, mounts or vibration absorbers can be used. The vibration absorbers used can be classified as passive dynamic vibration absorber which consists of only spring –mass system where the frequency of secondary system i.e. absorber system is tuned with the main system or primary system i.e. only mechanical elements. In active vibration or semi active vibration absorber little difference is there as the mechanical element and electric element & use of smart materials. The problems faced in passive dynamic vibration absorber is the secondary spring –mass system has only single frequency to which the frequency tuning can be done but if in any application if the applied frequency is changing with respect to time then natural frequency of secondary system must be changed to match with the applied frequency. This problem can be solved by using active type of materials generally called as smart materials. Smart materials like piezo electric material, Magnetostrictive materials, magneto-rheological fluid, electro-rheological fluids, and shape memory alloy etc. these all mentioned materials have properties such that it can be used in the application of vibration reduction. This paper discusses the application of piezoelectric material in the vibration reduction

A. Piezoelectric Materials

The word piezo electric consists of piezo + electric means when this material squeezed or pressed, it produces charge or voltage across the section where it is squeezed this effect is called as direct effect where as its reverse is also possible i.e. when an electric supply or voltage is given there is elongation in the material it is called as reverse effect. So this reverse effect is very much useful in developing a piezo electric based vibration absorber.

A smart structure which can be used for vibration control is in the form of a structure or structural component which has bonded or embedded sensors and actuators and a control mechanism for controlling the voltage & its deflection. The voltage applied is very much important as it enables the structure to give response simultaneously to external stimuli exerted on it and then suppresses or reduces the undesired effects or enhances required effects. The use of piezo electric material for vibration control requires multi-discipline knowledge, such as mechanics, mechanical engineering, modern control theory, and computer science. Piezoelectric elements are commonly used in smart structural systems as both sensors and actuators.

A key characteristic of these materials is the utilization of the converse piezoelectric effect to actuate the structure in addition to the direct effect to sense structural deformation. Typically, piezo-ceramics can be used as actuators whereas the polymer piezo films can be used as sensor. It is also possible to use piezoceramic for both sensing and actuation, as in the case of self-sensing actuators. So by the use of actuator & sensor of piezoelectric material better performance can be achieved, again due to good compactness & very good sensitivity over the larger bandwidth. Piezoelectric material can be easily embedded in the host structure due to this ability PZT is used in health monitoring & vibration control of structures.

There is lot more research has done in the field of vibration, health monitoring using piezoelectric material; we will see some of them. Dongmei Xu, et.al, developed a novel piezo-electric actuator to work under 2 working mode when alternating current (AC) & Direct current signals (DC) are provided. Alternating current (AC) mode is resonance mode while, Direct current signals (DC) mode is non-resonance mode respectively. [1]

Xavier Mininger, et. al, have shown experimentally that stator vibration of switched reluctance motor (SRM) can be reduced by piezo electric actuator, it is noted that due to electromagnetic forces there is decrease in the vibration level of SRM motor at a low voltage. [2]

Li Sui et.al, Used the piezoelectric material in active engine mount. Which has shown very well isolation from vibration which is reduced by 80% with very good performance at higher & lower frequency. [3]

Eric T. Falangas, have done the experiment on the rectangular plate where the vibration damping is done by using the piezoelectric actuator. Piezoelectric actuator & accelerometers are mounted on the structure.

The accelerometers used only for sensing while piezoelectric actuator is used for active damping. An active damping controller is used for control design to obtain the data, feedbac to provide the simultaneous response. [4] N. Fallah, et.al, have investigated the performance of piezoelectric actuators for the three degree of freedom which is the model of a building. The active control using piezoelectric actuator is checked by seismic response of the model. The displacements of the model are observed, two are in horizontal directions and one rotation about its vertical axis. [5]

Magdalene Marinaki et.al, in this paper the vibrations of beam are controlled using the piezoelectric sensors & actuators bonded to the beam .the theoretical analysis, numerical simulation has proved the vibration suppression in beam can be achieved by this technique also. [6]

H. P. Monner have worked on the piezoelectric stack actuators which are in the form of thin sheets or stripes attached to the composite beam or embedded in the composite structures in the discrete form. The actuator performance checked and their advantages & disadvantages also explained.[7]

Jung Woo Sohn, et.al , the vibration performance of a hull structure is tested by the optimal configurations of MFC Actuators. Tests performed showed that vibration levels are reduced by 17 %. Control input voltage is also tested with & without optimization.

It has been found that there is a 20% less control input voltage required for optimized configurations than without configurations.

[8]

C.M.A.Vasques, J.DiasRodrigues Have studied the use of piezoelectric materials for the vibration control. Polymers & ceramics are used; piezopolymers are used mostly as sensors which require more voltage while the piezoceramic can be used as both sensors as well as actuator which require less voltage. The feedback control is used to reduce the resonance peaks i.e. active damping.

[9]

Hadi Ghashochi et. al. Have studied & experiments performed on composite plates which is subjected to step by stop load. The optimization of power & vertical displacement is done, piezoelectric patches are used & multiobjective algorithm is used for optimization. The performance of E-ABC was compared with th PSO algorithm which shows the good efficiency of E-ABC algorithm. [10]

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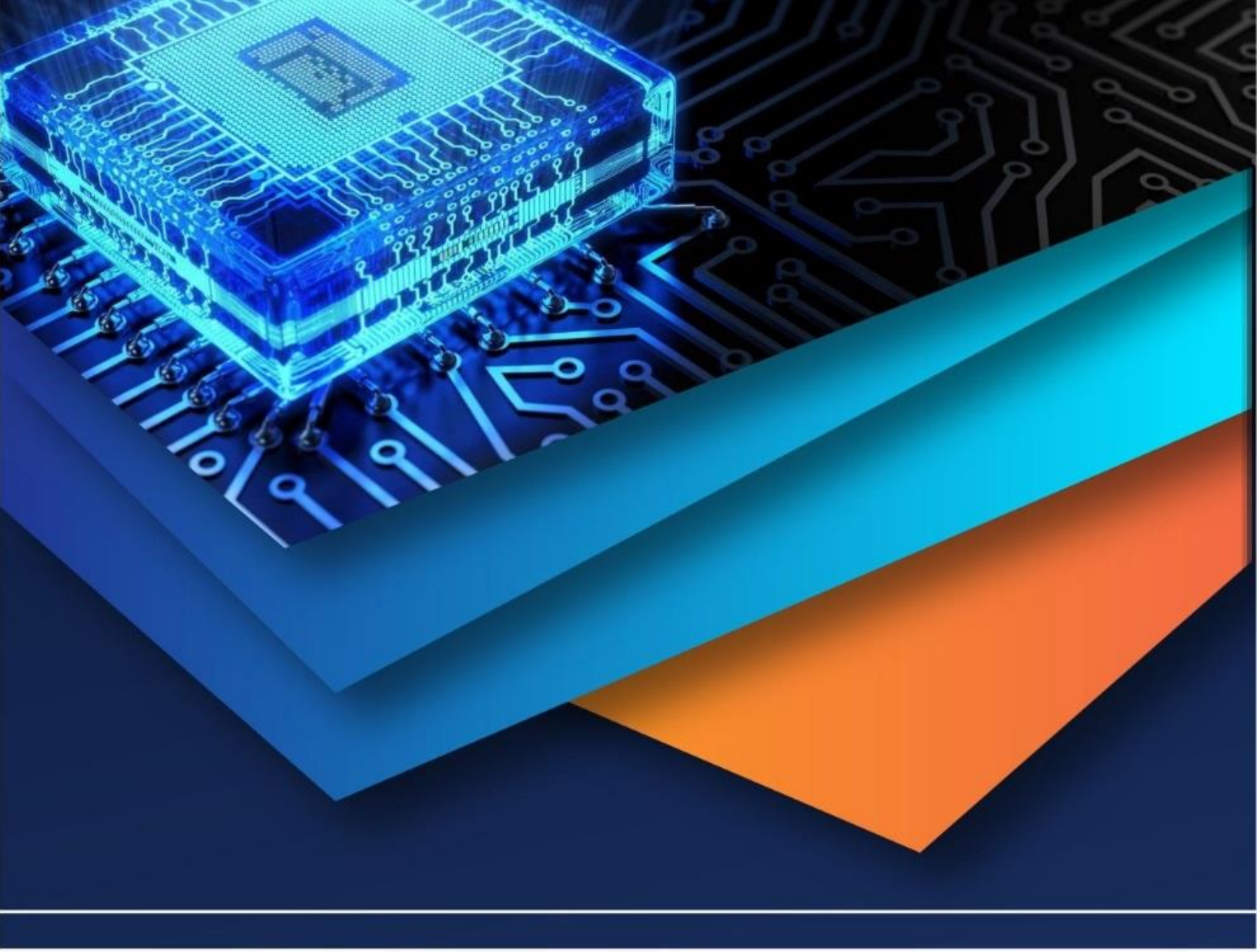

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