iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** II **Month of publication:** February 2020

DOI: http://doi.org/10.22214/ijraset.2020.2018

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 8 Issue II Feb 2020- Available at www.ijraset.com

Review of Active Vibration Control using Piezoelectric Patch

MD Saqulain M Khan[1], Siddique Aamir Sohail[2], Mansoori Himayatullah[3], MD Zishan Khan[4]
[1, 2, 3, 4]Department of Mechanical Engineering, Anjuman-I-Islam's Kalsekar Technical Campus, New Panvel, Maharashtra, India

Abstract: Active vibration control is a need of the decade because of microscopic deflection in structural and machine components. Smart materials like piezoelectric materials are used for such active vibration control using optimized location of piezoelectric patch on the vibration component. Different authors done researches on application of piezoelectric material for vibration control using different approaches. In this literature reviews authors had focused on vibration control using different control methods, by optimal location of piezoelectric batch, and by changing the composition of the composite plate. The objective of this literature review paper is to understand the type of approaches and methods used for active vibration control using piezoelectric material and also to find the research gap which existing in this research.
Keywords: Active vibration, Piezoelectric material, UDL, UVL, Patch, Cantilever Beam.

I. INTRODUCTION

The developments in piezoelectric materials have motivated many researchers to work in the field of smart structures. A smart structure is a system containing multifunctional parts that can perform sensing, control, and actuation for the required mission, this is done using smart material like piezoelectric material. Smart or composite structures in the form of plates and shells are used in almost all structural components of aircraft structures and launch vehicles, in addition to the specific use in wings, fuselages, artillery rocket nose cone, thermal shielding of space vehicles, reactor vessels, turbines, heat exchanger tubes, heat-engine components, electronic goods. The uncontrolled vibration in these structures can cause severe distortion to the structure and therefore leading to failure of structure.

The contribution of this paper is to provide an analysis of the available literature on Active vibration control of last 15 years which have dealt with the use different type of piezoelectric material, different controllers.

II. REVIEW

ShravanKumar B. Kerur & Anup Ghosh [1] used Simply Supported Beam made of Graphite Epoxy laminate is used & is tested for Thermal Loading (Pyro electric Effect), Beam Composition is 0/90/0/90. Beam is tested for Mechanical & Thermal Load. MFA Layer at the Top of Beam acting as actuator is used with 0 degree fiber Orientation and is tested for Mechanical, Electrical conditioned with and without Hygrothermal effect. Fiber Orientation of MFC is altered from 0 to 90 Degree and Tested for damping effect. Beam is also tested for different Voltage input. For 90/0/90/0/MFC, results are Reversing. Temperature ranging from 0 to 100 degree and Moisture Content 0 to 1% is considered. As the fiber orientation changes from 0 to Positive or Negative angle (+-90 Degree), Deflection increases. As the Voltage changes from 0 to +500, Deflection Decreases, for - Voltages, Deflection increases. In plane Stresses in x and Y direction are Studied for different fiber orientation of MFC. Introduction of temperature and Moisture results in Lateral Deflection which can be controlled by External Voltage. ShravanKumar B. Kerur & Anup Ghosh [2] use simply supported plate (PVDF/0/90/0/90/AFC) subject to time invariant UDL and transverse harmonic load. Active vibration control reaches maximum when fiber orientation angle in AFC layer is 0 degree. The actuation capability of actuator is maximum when difference between piezoelectric fiber orientation angle in AFC layer and fiber orientation angle in top substrate layer is 90 degree.

ShravanKumar B. Kerur & Anup Ghosh [3] analyzed Response for cross ply (0/90/0/90) substrate with collocated and N on collocated arrangement. Active controlled response of both 0/90/0/90 and 90/0/90/0 cross ply arrangement for different piezoelectric fiber orientation angle in AFC layer are taken. The maximum damping control for collocated arrangement is better than that of non-collocated arrangement. The active control of decreases as piezoelectric fiber orientation angle in AFC varies from 0 to 90 degree. Result also show that the sign of piezoelectric fiber orientation angle in AFC layer has no effect on Actuation capability of AFC actuator for cross ply laminate. It is observed that actuation capability of actuator reaches maximum when difference between piezoelectric fiber orientation angle in AFC layer and fiber orientation angle in top substrate layer is 90 degree. K Khorshidi [5] used a flat piezoelectric coupled circular plate with one plate host layer in middle and two identical piezoelectric layer bonded to upper and lower surface of host layer is used. LQR and FLC are both are applied to the system and dynamic equations are obtained.

The piezoelectric patch is placed on actuator. For open circuit configuration, total surface charge is assumed to be 0, the sensor voltage is obtained by integrating electric field over thickness of sensor. The results indicate that output of system is reduced with LQR controller LQR method has better performance compared to FLC method Maximum voltage applied to system is less than or equal to 2.5 volt and for this voltage LQR performs better and system is more stable.

In Zhiyuan Gao [6] the experimental aircraft frame is made by aluminum alloy. The aircraft wing is made by epoxy resin board. The length of the experimental model is 1500 mm, the height is 160 mm, while the aircraft nose width is 500 mm, and aircraft tail width is 350 mm. Four FBG cables each contains sixteen surface-bonded FBG sensors are fixed in the aircraft frame and another 16 FBG sensors are bonded on the surface of the airfoil. Meanwhile eight groups of PZT sensors and actuators are bonded on the aircraft surface. The PZT actuator type is PZT-5H, the PZT sensor type is P51, and they are manufactured by Zibo Yuhai Electronic Ceramic Company. JZK-10 exciter is used to excite vibration. While the FBG sensors are used to obtain the vibration information.

Sharavari Heganna [7] used a smart structure which is finite and flat beam like fiber cantilever structure with PZT patches attached to surface. A simple function generator is employed to generate forced vibration. PZT patches used as vibration sensor which is subjected near a vibrator to sense vibration of structure. Output of inverter circuit is directly fed to PZT patch that is working as actuator. When PZT actuator is excited through exactly opposite waveform of that of the vibration sensor waveform, two signals, one because of forced vibrations and other from the actuators get added. If both the waveforms have same magnitude but are 180 degree out of phase their vector addition results into waveform of zero amplitude and frequency. Hence, basic mechanical vibrations present within the smart structure system are suppressed. For large structures vibration suppression within the system is very influenced by location of the PZT patches, i.e. sensors and actuators. This is observed by changing positions of the PZT vibrator and PZT actuator patch on the structure. It shows that distance between vibrator and actuator patch is directly proportional to the amplitude of structural vibrations, i.e. as distance decreases amplitude of structural vibrations decreases.

In A.P. Parameswaram [8] System parameter of the smart cantilever beam was obtained by subjecting the system to free vibration test. This was done to obtain critical parameter values like that of systems natural freq. stiffness, damping etc. The smart cantilever was subject to harmonic excitation at natural frequency. The piezo exciter excited the beam at its natural frequency as a results of which maximum displacement of the beam tip was observed at its free end. The maximum induced strain was developed at the fixed end and it was sensed as a voltage by the piezo sensor. Through software means, the smart beam was subjected to forced vibrations at its first natural frequency (27.05 Hz) through the PZT Exciter patch mounted at the bottom of the beam. The harmonic excitation at the systems first natural frequency ensured maximum tip deflection as well as maximum strain development at the fixed end. The model result for both experimental and simulated (LAB VIEW) were tested and validated. It is seen that when the control was initiated (at time (t)=7 s and controller gain =10), by employing strain feedback based control logic, the strain developed at the fixed end of the beam reduced from 1.5 mm to around 0.5 mm. This meant that nearly 67% reduction within the strain when active vibration control is applied. Similarly, when displacement feedback based control was applied, for an equivalent controller gain (at t = 9 s), it had been observed that displacement of the free tip of the smart cantilever beam decreases from about 0.35 cm to around 0.15 cm. this shows depletion within the vibration by about 57%.

S M Khot and Yusuf khan [9] made model of a cantilever beam with the single sensor/actuator in ANSYS software. And through modal analysis 10 ranks of modal frequencies and mode shapes are extracted. The beam having size of 508 x 25.4 x 0.8 mm3 and sensor/actuator of dimensions 76.2 x 25.4 x 0.305 mm3 are selected for analysis. Single pair of actuator/sensor is placed in collocated form at nearer to the root of the beam, with the sensor at the bottom surface of the beam. The element type chosen for beam is solid 45 and for piezoelectric patch is solid. Mesh size of 70 x 4 x 1, is arrived by mesh conversance study. The mathematical model of cantilever beam is made in MATLAB, with an impulse force as input at the tip, and therefore the tip deflection is output of the system. The state space matrices are constructed by using Eigen values and Eigen vectors obtained from modal analysis using ANSYS. The transient and frequency response for all 3 controllers are tested by output and state feedback. For transient response, the H-∞ controller contains a good close loop dynamic performance than LQR and LQG controller. It has been seen that in frequency response of three controllers, the amplitudes of LQR controller follow the pattern of the amplitudes of uncontrolled frequency response, the amplitude of LQG controller have considerably died down, while in case of H-∞ controller amplitude get constant at higher frequencies. The settling time for both state and output feedback is much less in H-∞ controller than LQR and LQG controller.

Giovanni ferrari and marco ambaili [10] used One type of Macro Fiber Composite piezoelectric patch, produced by Smart Materials Corp., was chosen as actuator. Model M-8557-P1 has an active area 85 mm long, 57 mm wide and a unidirectional blocking force of 923 N. As sensors, Dura Act P-876.A15 patch transducers are used. They are 61 mm long, 35 mm wide and 0.8 mm thick, with a capacitance of 45 nF. Both sensors and actuators were glued to the carbon/epoxy surface by means of Loctite Hysol E-120HP epoxy resin. Both transducers contain as a piezoelectric element Lead Zirconium Titanate (PZT), a ceramic compound with a marked piezoelectric effect, and can be used as actuators or sensors interchangeably in a wide frequency band. The non-collocated configuration increases the effectiveness with respect to the previous collocated configuration. It is possible to approach, for the primary four resonances, reductions near to the values of 20 dB, both for the Multi SISO and MIMO configuration. The Multi SISO configuration proves effective without any modification, while in the MIMO case it is essential to introduce delays, in order to correct the detected phase lags.

Vidur V. Gundage and Prof. P. R. Sonawane [11] controlled the Vibrations of cantilever beam by using PZT patches. To find-out the appropriate controller for effective vibration control of cantilever beam with minimum control input. To find out the effectiveness of system when sensor placed at top and actuator at bottom and vice versa. The active vibration control of cantilever beam is done by using PZT patches in this paper. It is concluded that the SRF control method is more effective than the PID control method. The sensors placed at top and sensors placed at bottom are tested for optimized position. The sensor at top and actuators at bottom gives better performance. The main advantages: The reduction of the required space to install actuator and sensor (mechanical design). The possible use of simple control laws, such as positive position feedback. The main conclusion of this study is that the necessity to manage several sensors and actuators so as to ensure global quality of vibration rejection along the beam. More precisely, in keeping with the variability of measurements and actions, it'll be more or less easy to create the corresponding control scheme. Another aspect of this study concerns the extent of the attainable vibration reduction. Indeed, if disturbances come from the basis, it's impossible to eliminate its influence at the clamped end of the beam. In this case, the utilization of several actuators may cause a suitable compensation of their effect along an outsized section of the beam.

Jacques Lottin, Fabien Formosa, Mihai Virtosu, Laurent Brunetti [12] their work deals with the matter of efficient location of sensors and actuators encountered within the domain of active control of the flexible structure. The main conclusion of this study is that the necessity to manage several sensors and actuators so as to ensure the global quality of vibration rejection along the beam. More strictly, according to the variety of measurements and actions, it will be more or less easy to build the corresponding control scheme. Another aspect of this study concerns the level of attainable vibration reduction. Also, if disturbances come from the basis, it is not possible to eliminate its influence at the clamped end of the beam. In this case, the use of several actuators may lead to an acceptable compensation of their effect along a large section of the beam.

Fabio Botta, Daniele Dini, Christoph Schwingshackl, Luca di Mare,and Giovanni Cerri [13] reported that the multimode damping will be obtained by applying a counter phase load, by PZTs plates, to the external excitation. The effectiveness of the piezoelectric elements are going to be measured by the amplitude of the vertical displacement of the free end, in order that the most effective (optimal) position are going to be the location which maximizes this amplitude. A steel beam of 30 cm of length has been taken into account; with bimodal control in mind and that specialize in combinations of the primary five modes, the wavelength of the highest mode has been divided into 50 subintervals of length 3 mm, so that $\Delta a = \Delta h = 3$ mm and 5000 different combinations for a and h have been considered. For each of these, the amplitude of the response of the tip, to a periodic load, with the frequency corresponding to one of the first five Eigen frequencies has been calculated. Moreover the amplitude response to a linear combination of the previous loads has been obtained by superposition of the response to two of the Eigen frequencies. The optimal position has been chosen to be the one which corresponds to the maximum amplitude. In this work a replacement theoretical model for the optimal placement of piezoelectric plates to regulate the multimode vibrations of a cantilever beam is proposed. After an in depth description of the theoretical model, bi-modal excitation is taken into account.

Suresh Venna, Yueh-Jaw Lin [14] made a finite element model of the plate with these actuators and sensor was built and modal analysis was performed to obtain the natural frequencies, mode shapes and strain energy distributions for various modes. The mass and stiffness of the piezoelectric materials is also considered. However, the piezoelectric effect was not taken into account, as it is not required. Then, five locations are chosen randomly for the placement of the passive piezoelectric vibration absorber. Passive damping piezoelectric transducer locations are considered on the surface of the plate on which there is no sensor. This surface is chosen, as it gives more options and the transducer locations can be chosen at a place closer to the actuator, where the strain energy concentration is high in the first mode. The properties of the piezoelectric materials are obtained from the manufacturer of the piezoelectric actuators from where the actuators, sensors and vibration absorber are acquired. In addition to the mass and stiffness of the vibration absorber, the piezoelectric properties of the vibration absorber are also defined, to perform the piezoelectric modal analysis. The results obtained from electric modal analysis serve as a very good tool in determining the location of the passive vibration absorber without much effort. This method, compared to others, is more effective which enables us to predict the electrical potential that might be generated within the vibration absorber on which the quantity of damping depends directly. This method also can be utilized in optimizing not only the location, but also the dimensions and shape of the passive vibration absorber to get maximum amount of damping. This can be achieved by simply changing the size and shape of the piezoelectric vibration absorber within the finite element model on an iterative basis to seek out the configuration that gives maximum electric potential. Piezoelectric modal analysis also can be utilized in optimization of the location of the actuators and sensors for various applications to attenuate the actuation effort and to maximise the sensing capability, respectively.

Jinhua Xie, Rui Huo, Yanfeng Guan, and Zhen Zhou [15] In this paper, based on the transmission and equilibrium relationship of vibration energy in beam-like structures, the Galerkin weighted residual method was applied to equation discretization. An equivalent transformation of feedback element is suggested to develop the Energy Finite Element model of a composite piezoelectric cantilever beam driven by harmonic excitation on lateral direction, both systems with and without time delay are being studied. And the power input estimation of harmonic excitation is discussed for the resolution of the Energy Finite Element function and then the energy density solutions of the piezoelectric coupling beam through Energy Finite Element Method (EFEM) and classical wave theory were compared to verify the EFEM model, which presented a good accordance. Further investigation was done about the influence of control parameters including the feedback gain and arrangement of piezoelectric patches on characteristics of system energy density distribution. The EFEM gives a time-averaged and space-averaged value of energy density at the conjunction node between discredited beam elements. In modeling the piezoelectric intelligent beam, the feedback gain might be like an additional increase of the flexural rigidity of the composite beam segment; that's, greater feedback gain would offer greater reduction of system vibration level, whereas the introduction of time delay would cause complicated situations. In general, both rigidity modification and damping modification should be taken into consideration, and attention should be paid to potential problems on negative rigidity and damping numerical analysis indicates that proper design of system configuration parameters would be essential in order to achieve the best control efficiency, and how to find the optimal system parameters would be of significant value to be explored further. For the piezoelectric cantilever beam as studied by their paper, the control efficiency would be raised by arranging the piezoelectric patches near-clamped-end in position, a touch longer in size and multiplied in number.

Jinqiang Lia, Yu Xuea, Fengming Lia, Yoshihiro Naritac [16] In the study reported here, the active vibration control of the FGPM plate with four simple support edges under uniform and non-uniform electric field will be studied. The active damping is obtained by a velocity feedback control strategy. And the effects of the distribution type, volume fraction index and the total volume fraction of piezoelectric material on the vibration control of the FGPM plate are discussed. To obtain better control effect, different distributed types of piezoelectric material are considered and the control voltage is applied on different parts of the FGPM plate for evaluation of numerical results. It shows that the piezoelectric material component in the FGPM plate can be used as an efficient active actuator with an active strategy for suppressing excessive vibrations of system. The numerical results show that the volume fraction of piezoelectric material plays an important role in the vibration control. When the piezoelectric material density increases from inside to outside of the plate one can obtain a good control result. That's because in the bending of laminate the outer layer plays a more decisive role than the inner layer in influencing on the active damping and stiffness. For the same reason, the outside control voltage applying on the upper parts of the FGPM plate is more efficient than applying on the other parts for vibration active suppression.

Hui-Shen Shen [17] Developed a mathematical model for laminated plates with integrated piezoelectric actuators and sensor accounting for geometric nonlinear in the von Karman sense. A perturbation technique is to determine the load deflection and load bending moment curves. The simple higher order shear deformation plate theory in which the transverse shear strain are assumed to be parabolically distributed across the plate thickness. The dimensionless deflation of the plate with aspect ratio and width to thickness ratio is compared with the first order shear deformation plate theory which is seen that the discrepancy is attributed to the difference of in-plate boundary condition (movable and immovable). The effect of temperature and electric field on the nonlinear behavior of the plate with the help of this several numerical were solve for unsymmetrical cross ply plate with fully curved piezoelectric actuators. It can be seen that both deflection and bending moment are increased with increase in temperature. The three electric loading cases in which seen that plate with an embedded piezoelectric layer has lower bending moments. The bending moments are significantly but deflections are hardly influenced by lamination scheme and location of the layers.

Feng Chen, Ming Hong, Meiting Song and Hongyu Cui [18] used an 8 node quadrilateral isoperimetric element with a laminated plate being governed by distributed piezoelectric sensor and actuator was put forward based on a negative velocity feedback control method. Vibration of a cantilever under transient excitation was controlled using non-conforming single layer triangular plate element based on Kirchhoff laminated theory. Vibrations of a beam were suppressed using a constant gain feedback control theory. AVC of piezoelectric composite cantilever is simulated through the corresponding FORTRAN finite element programs and modeling based on a linear approach. Linear quadratic regulator output feedback control use to determine control gain. The finite element is 4 node and bilinear displacement element with 24 generalized displacement degree of freedom and one electric degree of freedom per piezoelectric layer expressed in terms of nodal variable through the shape function. The FORTRAN computer program was programmed and then high precise direct (HPD) integration method was proven for solving dynamic response.

Javad Alamatian and Jalil Rezaeepazhand [19] two types of boundary conditions are used for analyzing the laminated plates with variable cross section i.e. simply and clamped supports. By applying the essentials of the simply supports, a system of simultaneous equations is obtained which is solved by an independent DR (Dynamic Relaxation) algorithm. The composite plates with variable crossection has been analyzed for this purpose, the CPT theory in combination with the DR approach is utilized for analyzing the laminated plates. For the first numerical study, the angle ply laminated plates i.e. (±θ) n, are analyzed in which θ varies between 0 and 90. The boundary condition is considered as SCSC. Two types of cross ply laminated plates i.e. (0/90)n and (0n /90n), are nonlinearly analyzed for different boundary conditions i.e. SSSS, CCCC and SCSC.A quasi-isotropic ply laminated compos- its plate i.e. (0/45/-45/90) n is nonlinearly analyzed for different boundary conditions. The analysis results of the laminate plates with variable cross section show that in the angle ply plates, the maximum displacement of the nonlinear analysis has low sensitivity to the cross section variation however; linear analyses results are more sensitive to the variation of cross section. In the case of cross ply laminated plates, for all types of boundary conditions, the plate's displacement in the case of (0n/90n) is higher than the case of (0/90)n if cross section varies. Moreover, the plate's deflection increases by reducing the cross section of the quasi-isotropic laminated plate.

Fujun Peng, Alfred Ng and Yan-Ru Hu [20] used a performance criterion to proposed the optimization of piezoelectric patch actuator locations on flexible plate structures based on maximizing the controllability grammian. After this the determination of parameters required for actuator location optimization through Structuring Analysis in ANSYS Finite Element Analysis Package. Genetic Algorithm is then utilized to implement the optimization. The actuators are bonded on optimized locations, a filtered-x LMS-based multichannel adaptive control is applied for suppressing vibration response of the plate. Numerical simulations are done for suppressing tri-sinusoidal response at three points of the plates. K Ramesh Kumar and S Narayanan [21] showed from the results it can be concluded that the sensor–actuator pairs are optimally located in the regions of high modal strain energy. From the results it can be noted that the control effectiveness offered by direct proportional feedback, which is a displacement feedback, is insignificant when compared to the constant gain negative velocity feedback. The study also revealed that the LQR optimal control offers an effective control with lower peak actuator voltages when compared to classical control methods.

J. Fei [22] One model using singularity approach considering two moment case is derived. The dynamic modeling and the feasibility of active vibration control scheme SRF (strain rate feedback) and PPF (positive position feedback) control for the vibration suppression of steel cantilever beam are investigated and compared. Two vibration suppression methods are used, proportional-integral-derivative (PID) compensator and strain rate feedback. Suppression of the only dominant mode vibration was administered and then the best result was obtained using SRF control. The PPF control was also effective in suppressing the vibration. Both SRF and PPF control have better vibration suppression result for the beam compared to PID controller. In Juntao Fei [23] One model using singularity approach considering two moment case is derived. The dynamic modeling and the feasibility of active vibration control scheme such as PID control and SRF control for the vibration suppression of steel cantilever beam are investigated. PID controller is the type of controller of which proportional gain and derivative gain are often determined based on desired specifications and dynamics of a plant. Strain rate feedback (SRF) control is employed for active damping of a flexible space structure. The SRF controller and optimized parameter PID compensator are employed to actively suppress vibration of a flexible steel cantilever beam. Suppression of the single dominant mode vibration was carried out and the best result was obtained using SRF control. The optimized parameter PID compensator was also effective in suppressing the vibrations. SRF controller results were little better than those with the PID compensator.

In K. B. Waghulde, Dr. Bimleshkumar Sinha, M. M. Patil, Dr. S. Mishra [24] A smart beam was constructed using a Lucite beam, PZT actuator, and PVDF sensor. A dSPACE controller card was installed and integrated with related electronics to make an active control setup. First, signal was sent to the beam without the controller and data was taken and saved in dSPACE controller. Then, with the controller added in the system, the signal was sent to the beam, the actuator implemented the response from the controller due to displacement detected by the sensor, and the data was taken and saved in dSPACE controller. Both of these data sets were loaded into MATLAB and imported to MATLAB's identification toolbox. The same procedure from above was used to obtain a model closest to the original data set and these were sent to the command window where a Bode plot showed the reduction in vibration amplitude after the controller was implemented. Experiments were conducted to control the Vibration response to broadband disturbance. A 30% reduction in 1st-mode vibration response was achieved.

S. Gluhihs, A. Kovalovs [25] studied the behavior of the aluminum plate with the top surface bonded to piezoelectric actuators is studied in detail. The plate parameters are studied by varying the placement of the piezoelectric actuators. The plate is discredited using 10 equal coupling areas. The length of each piezoelectric actuator is the same as that of one area. The reduction of vibration in an aluminum plate under variable harmonic pressure loading with surface bonded piezoelectric actuators was studied numerically by using the commercially available ANSYS packages. A thermal load according to the thermal analogy modeled the applied voltage. By using this method, it is found that the form of torsion modes determines the optimum placement of actuators. It is also found that the length of piezoelectric actuators affects the active control of plates. J Shivakumar and M C Ray [26] used an antisymmetric angle- ply smart composite plate integrated with a PFRC layer is used. PFRC is placed on the top of the plate which acts a distributed actuator. Various mechanical loads are applied on the plate to determine the variation of piezoelectric fiber orientation in the PFRC layer and nonlinear deformation. For optimum performance, fiber orientation in the PFRC layer also varies with the no of layers and stacking sequence in the substrate antisymmetric angle -ply composite plates. If the fiber orientation (θ) in the topmost layer of the substrate being integrated with the PFRC layer is positive then the fiber orientation (ψ) in the PFRC layer should be negative and vice versa for achieving maximum actuating capability of the PFRC layer.

A. *Research Gap*

Different MFC Layer Thickness can be tested. Different Mode Shapes Analysis. Can be tested for Sinusoidal Loading or Harmonic Loading. MFC Composition is Changes. Experimental Testing for Validation. FEA element type can be changed for better performance. Better Control system can be implemented for better vibration control. Testing in hygrothermal environment. Testing for different position of actuator and sensor.

III.CONCLUSIONS

The review of different research papers shows that active vibration control is done using piezoelectric material by focusing on three concepts of analysis i.e. by different control methods of Electrical engineering approach, Material composition approach. We found from the research that lots of work can be done on active vibration control by implementing the different new approaches. 1st approach is by varying the composition of Piezoelectric Material, by changing the thickness of piezoelectric Patch and by changing the cross section of patch. 2nd approach is by finding the different mode shapes of vibration more than 2 mode shapes max to 6modes. This approach will help us to find the critical natural frequency in one frequency range.3rd approach is by imparting the real working conditions i.e. by considering the actual working loads means UDL, UVL and load varying with temperature impact. It was also found the research is restricted to maxi mum of standard case like cantilever and SSB beams. These research can be extended to actual real time problems like aero plane wings, turbine blades, super-fast bullet train tracks, assembly conveyor of robotics assembly bed.

REFERENCES

[1] Shravankumar B. Kerur & Anup Ghosh (2013) Geometrically Non-Linear Bending Analysis of Piezoelectric Fiber-Reinforced Composite (MFC/AFC) Cross-Ply Plate Under Hygrothermal Environment, Journal of Thermal Stresses, 36:12, 1255-1282.

[2] SB kerur and Anup Ghosh, Active vibration control of composite plate using AFC actuator & PVDF sensor, International Journal of Structural Stability and Dynamics Vol. 11, No. 2 (2011) 237255.

[3] SB kerur and Anup Ghosh, Active control of geometrically Non-linear transient response of smart laminated plate integrated with AFC actuator & PVDF sensor, JOURNAL OF INTELLIGENT MATERIAL SYSTEMS AND STRUCTURES, Vol. 22—July 2011.

[4] SB kerur and Anup Ghosh, Active vibration control of composite plate using AFC actuator and PVDF sensor, 2011.

[5] K Khordishi,Active vibration control of circular plate coupled with piezoelectric layers excited by plane sound wave,2014.

[6] Zhiyuan Gao,Active Monitoring and vibration control of smart structure aircraft base on FBG sensor and PZT actuator,2016.

[7] Sharavari Heganna,Active Vibration control of smart structure using PZT patches,2013.

[8] A.P. Parameswaram, Active Vibration Control of a Smart Cantilever Beam on General Purpose Operating System, 2015.

[9] SM Khot and Yusuf khan, Simulation of Active Vibration Control of a Cantilever Beam using LQR, LQG and H-∞ Optimal Controllers,2014.

[10] Giovanni Ferrari and marco ambaili, Active vibration control of a sandwich plate by non-collocated positive position feedback,2016.

[11] Vidur V. Gundage and P. R. Sonawane, Active Vibration Control of Cantilever Beam Using Piezoelectric Patches,2006.

[12] Jacques lottin and Fabian Farmosa, Optimal location of sensors and actuator for control of flexible structure, 2013.

[13] Fabio Botta, Daniele Dini, Christoph Schwingshackl, Luca di Mare, and Giovanni Cerri,Optimal Placement of Piezoelectric Plates to Control Multimode Vibrations of a Beam,2013.

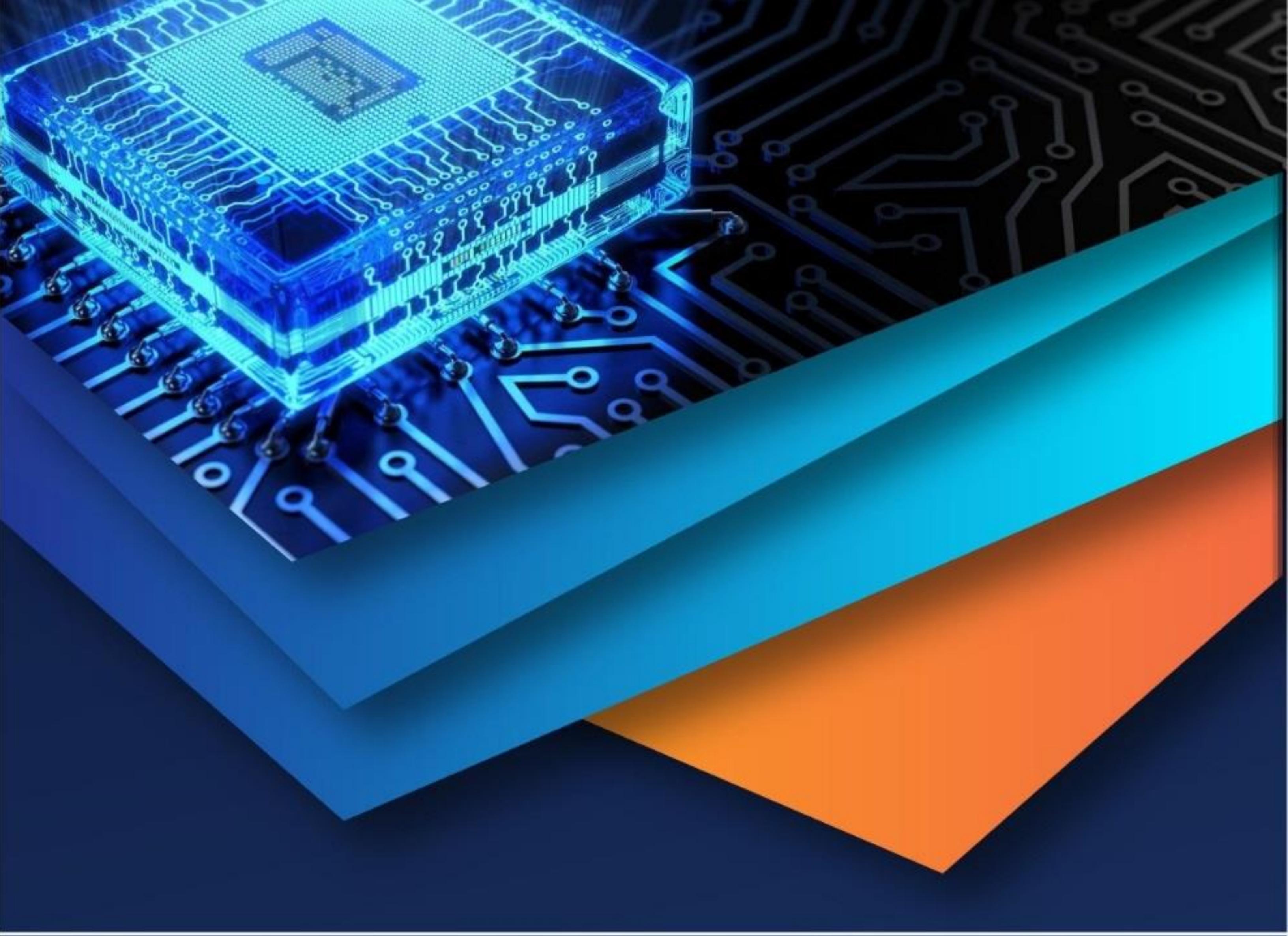
[14] Suresh Venna, Yueh-Jaw Lin, an Effective Approach for Optimal PZT Vibration Absorber Placement on Composite Structures, 2013.

[15] Jinhua Xie, Rui Huo, Yanfeng Guan, and Zhen Zhou, Application of Energy Finite Element Method in Active Vibration Control of Piezoelectric Intelligent Beam,2012.

[16] Jinqiang Lia, Yu Xuea, Fengming Lia, Yoshihiro Naritac, Active vibration control of functionally graded piezoelectric material plate, 2018.

[17] Hui-Shen Shen, Nonlinear bending analysis of unsymmetric cross-ply laminated plates with piezoelectric actuators in thermal environments, Composite Structures 63 (2004) 167–177.

[18] Feng Chen, Ming Hong, Meiting Song, Optimal Control of a Beam with Discontinuously Distributed Piezoelectric Sensors and Actuators, J. Marine Sci. Appl. (2012) 11: 44-51.
[19] Javad Alamatian and Jalil Rezaeepazhand,Nonlinear bending analysis of variable cross-section laminated plates using the dynamic relaxation method, Journal of Mechanical Science and Technology 30 (2) (2016) 783~788.
[20] Fujun Peng, Alfred Ng and Yan-Ru Hu, Actuator Placement Optimization and Adaptive Vibration Control of Plate Smart Structures, JOURNAL OF INTELLIGENT MATERIAL SYSTEMS AND STRUCTURES, Vol. 16—March 2005
[21] K Ramesh Kumar and S Narayanan, The optimal location of piezoelectric actuators and sensors for vibration control of plates, 2007 Smart Mater. Struct. 16 2680.
[22] J. Fei, Active Vibration Control of a Flexible Structure Using Piezoceramic Actuators, Sensors & Transducers Journal, Vol. 89, Issue 3, March 2008, pp. 52-60.
[23] Juntao Fei, Active Vibration Control of Flexible Steel Cantilever Beam Using Piezoelectric Actuators, 0-7803-8808-9/05/$20.00 02005 IEEE.
[24] K. B. Waghulde ,Dr. Bimleshkumar Sinha ,M. M. Patil ,Dr. S. Mishra, Vibration Control of Cantilever Smart Beam by using Piezoelectric Actuators and Sensors, International Journal of Engineering and Technology Vol.2(4), 2010, 259-262.
[25] S. Gluhihs & A. Kovalovs (2006) Reduction of the vibration in a helicopter blade using piezoelectric actuators, Aviation, 10:2, 3-6.
[26] J Shivakumar and M C Ray, Geometrically nonlinear analysis of antisymmetric angle-ply smart composite plates integrated with a layer of piezoelectric fiber reinforced composite, 2007 Smart Mater. Struct. 16 754.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY