International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

A Comprehensive Review on Applicability of Shape Memory Alloy Hybrid Composite Beam in Vibration Control

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Received 05 Dec 2019, Accepted 08 Feb 2020, Available online 10 Feb 2020, **Vol.10, No.1 (Jan/Feb 2020)**

Abstract

Smart materials are used to construct smart structures, which can perform both sensing and actuation functions. Shape Memory Alloys are a kind of smart materials which can undergo solid-to-solid phase transformation and can recover completely when heated to a specific temperature. The Hybrid Composites that embedded with SMAs showing better results in vibration control. The trend in the aeronautical, mechanical and civil design requires lighter, stronger, and more flexible structures. However, light weight structures can be more easily influenced by unwanted vibrations, which may lead to the performance reduction, sometimes the system may even fail due to resonance, etc. This paper focuses on research work carried till now in the area of SMA hybrid composites and its applicability in vibration control.

Keywords: *Shape memory alloys, Smart materials, Hybrid composites, vibration control*

Introduction

A Smart structure is a system containing multifunctional parts that can perform sensing, control, and actuation. Smart materials are used to construct these smart structures, which can perform both sensing and actuation functions. Smart materials are the materials that can significantly alter one or more of their inherent properties owing to the application of an external stimulus in a controlled fashion. The several external stimulus to which the Smart Materials are sensitive are: Stress, Temperature, Moisture, pH, Electric Fields, Magnetic Fields. (Bhattacharya, 2018; Wikipedia; Kelly, 2000)

Shape Memory Alloys are metal alloys which can undergo solid-to-solid phase transformation and can recover completely when heated to a specific temperature. These materials have two stable phases: Austenite - high temperature phase; Martensite - low temperature phase. Materials commonly used are: Cu-Al-Ni, Fe-Mn-Si, Cu-Zn-Al, Ni-Ti (50 % Nickel 50 % Titanium, Nitinol, which stands for Nickel Titanium Naval Ordinance Laboratory).SMAs also displays Super elasticity, which is characterized by the recovery of relatively large strains with some, however, dissipation. In addition to temperature-induced phase transformations, Martensite and austenite phases can be induced in response to mechanical stress. (Bhattacharya, 2018; Georges Akhras, 2000; Susmita Kamila, 2013)

The hybrid composites that embedded with SMAs show some unique properties or functions such as self-strengthening, active modal modification, high damping, damage resistance, control and self-healing so they can provide tremendous potential in many engineering applications. (Bhattacharya, 2013)

The trend in the aeronautical, mechanical and civil design requires lighter, stronger, and more flexible structures. However, light weight structures can be more easily influenced by unwanted vibrations, which may lead to the problems such as fatigue, instability, acoustic disturbances, performance reduction, sometimes the system may even fail due to resonance, etc. Though the composite structures of lesser weight offer same strength when compared to the conventional structures, it tends to exhibit higher levels of vibration due to its flexibility in nature. The numerous features of composite materials have led to widespread adoption and use in different industries like automotive, air craft, shipping and marine, wind mills, body armor and construction. However, it is essential to control the vibration of the composite structures which would improve the overall efficiency of the system. (Bhattacharya, 2013)

Damages like matrix cracking, delamination, debonding or fiber breakage in composite structures are unavoidable during service life time due to impact or continual load, chemical corrosion and aging, change

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DOI: https://doi.org/10.14741/ijcet/v.10.1.10

of ambient conditions, etc. Many times, it is not feasible to take the structure out of use. Real time damage detection and health monitoring in such cases have become one of the main areas of focus today.

In the past few decades various control techniques like use of springs, pads and dampers have been used to eliminate the unnecessary vibrations. These techniques are known as passive control of vibration. They have limitations of versatility and can control the frequencies only within a particular range of bandwidth. (Bhattacharya, 2013)

Passive control methods generally use mechanical vibration absorbers to achieve vibration reduction. Mechanical vibration absorbers are very effective for high range of frequencies. Mechanical vibration absorber requires the bulky/heavy installations. In many applications, such as aeronautical industries where minimizing the structural weight are the paramount design, the large and heavy passive control appendages are impossible. For light weight structures adaptive or active vibration control is desired one. (Bhattacharya, 2013)

Active vibration control methods combine the benefits of mechanical vibration absorbers with the flexibility of active control systems. Active vibration control uses external power to perform its function. It is the active application of force in an equal and opposite manner to the forces imposed by external vibration. Accelerometers and electromagnetic drivers are used in the active vibration control system to achieve high degree of isolation. (Bhattacharya, 2013)
Hybrid Vibration control combines the characteristics of Active and Passive control systems i.e. it uses sensors and actuators as in Active control and a passive energy dissipation device like dampers, isolators or absorbers.

Literature Review

Rogers, 1990, shows experimentally active dynamic tuning by a method called active strain energy tuning (ASET), active control of sound radiation from a clamped-baffled beam, and transient vibration control of a cantilevered beam. (Rogers, 1990)

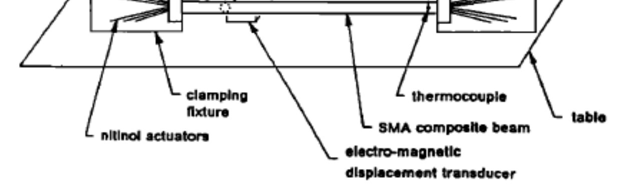

Fig.1 Experimental apparatus for active strain energy tuning (Rogers, 1990)

Saunders *et al*., 1991, demonstrated Active control of sound radiation from a clamped, baffled, composite beam with embedded Shape Memory Alloy (SMA) fibers using two different control strategies, minimization control and Peak radiation frequency placement control. (Sanders *et al*, 1991)

Baz. *et al*., 1992, presents the static, dynamic and thermal characteristics of NITINOL-reinforced composite beams. The NITINOL fibers will be utilized to control the buckling and the flow-induced vibrations of NITINOL-reinforced fiberglass composite beams. (Baz *et al*, 1992)

Guojun Sun and C. T. Sun, 1995, developed a constitutive relation for bending of a composite beam with eccentrically embedded SMA wires. (Guojun Sun, 1995)

Chen and Levy, 1996, discussed an active vibration control method for a flexible beam by means of SMA layers which shows that Young's modulus ratio and temperature of SMA layer will affect the natural frequency of the beam. (Chen & Levy, 1996)

Brinson *et al*., 1996, examined the active control of beam deflection through heating and cooling of Shape Memory Alloy (SMA) wires. Issues of design constraints for shape control with shape memory wires are addressed and the model is qualitatively verified by experiments. (Brinson *et al*, 1996)

Soong and Spencer, 2000, gave an outline of various types of vibration control process and their basic application to retrofit and civil engineering. (Soong & Spencer, 2000)[13]

P. Sittner and R. Stalmans, 2000, discuss how a SMA wire is integrated into fiber reinforced composites. They also discuss Modeling and property tuning. (Sittner & Stalmans, 2000)

Song *et al*., 2000, presented the design and experimental results of using a shape memory alloy (SMA) wire as an actuator for position control of a composite beam. A simple proportional and derivative controller plus a feed-forward current is designed and implemented for controlling the tip position of the composite beam. (Soong *et al*, 2000)

Turner, 2000, demonstrated the thermo mechanical performance of a shape memory alloy hybrid composite beam specimen. A material system consisting of a glass/epoxy matrix with embedded Nitinol actuators was chosen for this study. Elimination of a thermal post-buckling deflection by the activated SMA was observed.(Turner, 2000)

Armstrong and Lorentzen, 2002, reports macroscopic thermal-mechanical and in-situ neutron diffraction measurements from a NiTi fiber–actuated aluminum-matrix composite and homogeneous aluminum control materials. (Armstrong & Lorentzen, 2002)

Kin-tak Lau, 2002, SMA actuator, Nitinol wires, were embedded into advanced composite structures to modulate the structural dynamic responses, in terms of natural frequency and damping ratio. (Kin-tak Lau, 2002)

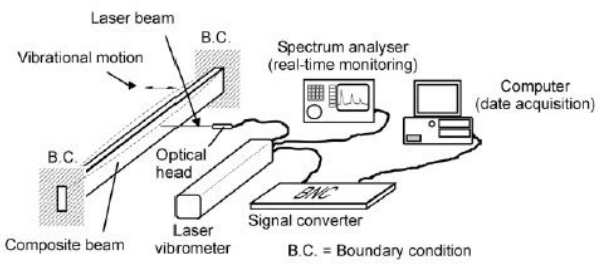

Fig.2 Relation between externally applied current and surface temperature of SMA wire (Kin-tak lau,2002)

Marfia *et al*., 2003, proposed a simple SMA model to simulate the super elastic behavior as well as the shape memory effect. The proposed SMA constitutive model is employed in a novel layer wise beam theory to develop new SMA beam finite element models with suitable interpolation of the field variables involved. (Marfia *et al*, 2003)

Turner and Patel, 2004, implemented a thermo mechanical model for shape memory alloy (SMA) and SMA hybrid composite (SMAHC) materials in the commercial finite element codes MSC, Nastran and ABAQUS. The model is based upon definition of an effective coefficient of thermal expansion (ECTE). (Turner & Patel, 2004)

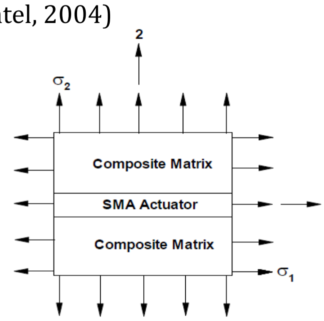

Fig.3 Representative volume element for a SMAHC lamina

Fig.4 SMAHC element cross-section type 1; embedded SMA ribbon

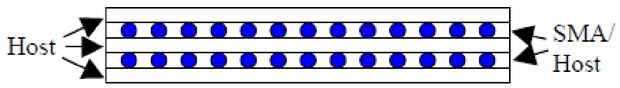

Fig.5 SMAHC element cross-section type 2; embedded SMA round wire

Davis *et al*., 2005, performed an experimental and numerical investigation into the static and dynamic responses of SMAHC beams. The SMAHC beam specimens consisted of a composite matrix with embedded pre-strained SMA actuators, which act against the mechanical boundaries of the structure when thermally activated to adaptively stiffen the structure. (Davis *et al*, 2005)

Shahin, *et al*., 2005, uses SMA-reinforced patches for enhancing adhesively bonded joints. An analytical solution for evaluation of the stresses in a SMA wire reinforced composite patch used for repairing cracks in banded joints was created. The variables considered in the model are the fraction of SMA wires, the associated phase transformation strain, patch thickness, and adhesive layer's thickness and mechanical properties. (Shahin *et al*, 2005)

YingZhaoa, *et al*., 2006, investigated an energy absorbing composite structure made of a concentric NiTi spring and a porous NiTi rod. Both NiTi spring and porous NiTi rod are of super elastic grade. Ductile porous NiTi cylindrical specimens are fabricated by spark plasma sintering. (YingZhaoa *et al*, 2006)

Lee *et al*., 2005, performed thermal post-buckling analysis of shape memory alloy hybrid composite (SMAHC) shell panels using the finite element method formulated on the basis of the layer wise theory. The hybrid composite structure with SMA actuator is investigated for position, shape and vibration control. (Lee *et al*, 2005)

Yang *et al*., 2006, presented experimental modeling and active shape control of hybrid composite structures actuated by shape memory alloy (SMA) wires. For faster and more accurate shape/deflection control of the hybrid composite structure, feed-forward and PID feedback controllers are designed and applied to the hybrid composite structure. (Yang *et al*, 2006)

Auricchio *et al*., 2006, presents and compares two different uniaxial constitutive models for super elastic SMAs, suitable to study the dependence of the stress-strain relationship on the loading-unloading rate. The ability of both models to reproduce the observed reduction of damping properties through the modification of the Hysteresis size is discussed by means of several numerical simulations. (Auricchio *et al*, 2006)

qTan *et al*., 2006, observed the different angle of orientation for the Flexinol wire on the composite plate showed to be important to control the amplitude of vibration for the composite plate in both activated and inactivated condition. (Tan *et al*, 2006)

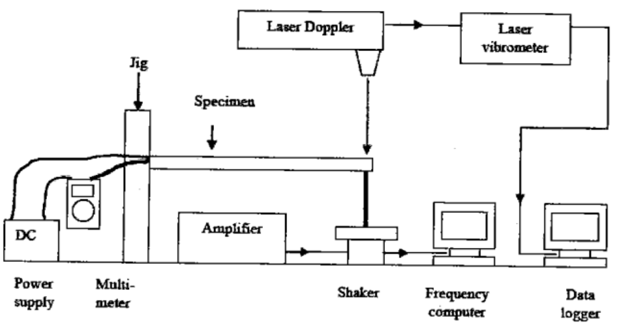

Fig.6 Experimental set up for vibration test (Tan *et al*, 2006)

Diodati *et al*., 2007, shows Dynamic behavior of structural elements and their performance may be remarkably affected by several parameters, like geometry, material properties, stress field, etc. Ability of adaptively controlling one or more of these parameters leads to a structure fitting different requirements in several working conditions. (Diodati *et al*, 2007)

Kanas *et al*., 2007, study comprises finite element simulations and experimental studies of the shape memory effect due to the presence of SMA (shape memory alloy) wires in composite materials. (Kanas *et al*, 2007)

Pappada *et al*., 2009, presented two types of SMA-hybridized composites for investigating the mechanical and vibration characteristics, unidirectional super elastic SMA wires and embedded knitted SMA layers. By measuring the vibration mode of a clamped cantilever using laser vibrometry, the influence of both SMA arrangements on the vibration characteristics has been investigated. (Pappada *et al*, 2009)

Tiseo *et al*., 2010, examines a novel model of an Adaptive Tunable Dynamic Vibration Absorber (ATDVA), based on the use of Shape Memory Alloy materials (SMA). (Tiseo *et al*, 2010)

Rajiv Kumar, 2010, suggested that by making the controller adaptive, ideal performance and granted stability of the closed loop system can be achieved for even a large change in system parameters. Adaptive controllers based on minimum variance, pole placement and linear quadratic techniques are investigated. (Rajivkumar, 2010)

Wu and Zhang, 2011, studied nonlinear design of shape memory alloy (SMA) composite structures, the force-displacement characteristics of the SMA layer. It is shown that SMA's energy dissipating capacity is proportional to the stiffness difference of bilinear model and nonlinearly dependent on Ms-Strain.(Wu & Zhang, 2011)

Meo *et al*., 2012, analyze and compare the behaviour of thermoplastic composites and Shape Memory Alloy Hybrid Composites for aeronautical applications, based on findings from numerical analyses and experimental tests. (Meo *et al*, 2012)

Biffi *et al*., 2012, prepared SMAHC of CuZnAl with FGRP by vacuum induction melting. The patterning of the SMA sheets was performed by means of a pulsed fiber laser. After the laser processing, the SMA sheets were heat treated to obtain the desired martensitic state at room temperature. The transformation temperatures were measured by differential scanning calorimetry (DSC). The damping properties were determined, at room temperature, on full-scale sheet, using a universal testing machine (MTS), with cyclic tensile tests at different deformation amplitudes. Damping properties were also determined as a function of the temperature on miniature samples with a dynamical mechanical analyzer (DMA). (Biffi *et al*, 2012)

Barzegari *et al*., 2013, presented analytical relations for evaluating the exact solution of natural frequency and mode shape of beams with embedded SMA wires. By defining some dimensionless quantities, the effect of different mechanical properties on the frequencies and mode shapes of the system are carefully examined. (Barzegari *et al*, 2013)

Aguiar *et al*., 2015, deals with the experimental analysis of shape memory alloy dynamical systems by considering an experimental apparatus consisted of low-friction cars free to move in a rail. A shaker that provides harmonic forcing excites the system. The vibration analysis reveals that shape memory alloy elements introduce complex behaviors to the system and that different thermo mechanical loadings are of concern showing the main aspects of the shape memory alloy dynamical response. (Aguiar *et al*, 2015)

Yuvaraja and Senthilkumar, 2013, presented the Shape memory alloy and piezoelectric based composites for investigating the vibration characteristics with SMA and PZT attached to beam. The vibration characteristic of GFRP beam is more effective when SMA is used as an actuator. (Yuvaraja & Senthikumar, 2013)

Chavan *et al*., 2013, supports the following conclusions,

• The pre-strain of the embedded SMA wire has a significant effect on the recovery force.

• Increasing the activation numbers of the wire it will increases the temperature of beam, and it may reduce The natural frequency of the beam because of the increase beam temperature.

• Current distribution depends on number of wire activation.

• Frequency of the beam is also depending on the volume fraction of the SMA wire.

• Since epoxy resin exhibits low stiffness at high temperature, increasing temperature results in lower natural frequency.

• The results may vary if wire elongations are 6% and 8%. (Chavan *et al*, 2013)

Birman and Rusnak, 2013, illustrate an approach to the passive vibration control of thin plates utilizing prestressed super elastic shape memory alloy (SMA) wires. The SMA wires can freely slide within protective sleeves that are either embedded within the structure or bonded to its surface. (Birman & Rusnak, 2013)

Damanpack *et al*., 2014, examined the vibration control capability of shape memory alloy (SMA) composite beams subjected to impulsive loads. Extensive numerical results are presented to provide an insight into the influence of pre-strain, temperature, location and thickness of SMA layers on the vibration control of SMA composite beams subjected to various blast pulses. (Damanpack *et al*, 2014)

Pinto and Meo, 2014, prepared SMA composite laminates and subjected to low-velocity impact and check their response with a traditional composite. Ultrasonic C-scan analysis has done after the impact to estimate the extension of the internal delamination. Results show reduction in the extension of the internal delamination. (Pinto and Meo, 2014)

Simoneau *et al*., 2014, focuses on the development of a finite elements model of an adaptive composite panel with embedded shape memory alloy actuators. It is shown that a combination of shell, beam and link elements could be used to model the panel. (Simoneau *et al*, 2014)

Barjibhe and Bimlesh Kumar, 2015, developed shape memory alloy (SMA) spring based dynamic vibration absorber for extinction of vibration in cantilever beam. The result demonstrates that the SMA spring reduces the amplitude of vibration for wider frequency range. (Barjibhe and Bimlesh Kumar, 2015)

Asadi *et al*., 2015, investigated nonlinear free vibration and primary/secondary resonance analyses of shape memory alloy (SMA) fiber reinforced hybrid composite beams with symmetric and asymmetric lay-up. Numerical results reveal that geometrical and physical parameters such as the SMA volume fraction, the amount of restrain in the SMA fiber, orientation of composite fiber, vibration amplitude and temperature are important factors affecting the free vibration characteristic in the pre/post-buckled region, and primary and secondary resonance of the laminated beams reinforced with SMA fibers. (Asadi *et al*, 2015)

Xu *et al*., 2015 studied the interfacial properties of SMA composites by the combination of theoretical analysis and experimental methods. Surface treatment of SMA fibers on the three methods is used to improve the surface roughness to increase the interfacial bond strength between SMAs and matrix materials. (Xu *et al*, 2015)

Atiyah, 2015, studied an analytical solution for the calculation of natural frequencies of composite cantilever beams with embedded SMA wires. It was found that the natural frequencies of beams decreased with increasing the number of embedded SMA wires at a temperature below Martensite temperature transformation and increased with increasing the number of embedded SMA wires at a temperature above austenite finish transformation. Various parameters such as width of beam, thickness of beam, length of beam, diameters of SMA wires, modulus of elasticity of Glass fiber epoxy, and austenite ratio in SMA wires are studied. (Atiyah, 2015)

Gur and Frantziskonis, 2016, study shows the effects of temperature modulation on the design of SMA dampers for structural vibration control. Detailed parametric studies, under varying damper properties, beam properties, excitation intensity and frequency, temperature, reveal the superior performance of the tmSMA over the unmodulated SMA damper. (Gur & Frantziskonis, 2016)

Lebied *et al*., 2016, investigated the mechanical properties of epoxy resin composites filled with Ti-Ni alloys wires. Results show the influence of the SMA wires upon changes in mechanical behaviour of a composite plate with the SMA components, & the actuating ability and reliability of shape memory alloy hybrid composites. (Lebied *et al*, 2016)

Eduardo *et al*., 2016, implemented a hybrid (passive-active/adaptive) vibration control system over a metallic beam excited by a broadband signal and under variable temperature, between 5 and 35°C. Viscoelastic dynamic vibration neutralizer and an active-adaptive vibration control system (based on a feed forward approach with the use of the FXLMS algorithm) can be used. (Eduardo *et al*, 2016)[50]

Shajil *et al*., 2016, reports on self-centering ability, ductility of beams and beam-column joint achieved by randomly distributed pseudo elastic SMA (PESMA) fibers. Three point loading experiments on prisms and specially designed prototype beam-column joint specimens with steel and PESMA fibers show that the ductility and self-centering ability of the composite with PESMA fibers is far superior to that of the steel fibers. (Shaji *et al*, 2016)

Parhi & Singh, 2016, focused on the nonlinear free vibration analysis of spherical and cylindrical composite shell panels embedded with shape memory alloy fibers. The incremental method is used to generate the inputs for the temperature-dependent nonlinear properties of materials. (Parhi & singh, 2016)

EnhaoWang *et al*., 2016, fabricated a novel Shape Memory Alloy NiTi fiber-reinforced metal-intermetallic–laminate (SMAFR-MIL) composite with a volume fraction of ∼3.5% NiTi using vacuum hot pressing method. SMAFR-MIL composite was determined by compression test. In addition, damping capacity was measured using Dynamic Mechanical Analyzer (DMA). (EnhaoWang *et al*, 2016)

Bodaghi *et al*., 2015, Rectangular plates under dynamic loads with integrated polycrystalline NiTi shape memory alloy (SMA) ribbons are developed. Numerical simulations showing the implications of pre-strain state and temperature of the SMA ribbons, respective dynamic loads, are presented and discussed in detail.

Noolvi *et al*., 2017, studied the vibration absorption characteristics of Smart Adaptive Composites (Shape Memory Composites) as tuned vibration absorbers. Thin cantilever plate of SAC works as the absorber system in the configuration. (Noolvi *et al*, 2017)

Karagiannis *et al*., 2017, proposed two innovative actuating concepts for aerospace morphing applications, based on shape memory alloys. A composite plate incorporating embedded SMA wires and a novel rib configuration, which incorporates a compliant mechanism for enabling aerofoil's leading edge morphing. (Karagiannis *et al*, 2017)

ZhiyuanGao *et al*., 2017, A smart aircraft model is constructed using fiber Bragg grating (FBG) sensors and piezoelectric ceramics. Vibration shape reconstruction of the aircraft model is achieved using discrete fiber Bragg grating sensors based reconstruction method. Vibration control is achieved by employing modified multi input multi output (MIMO) hybrid filtered-x least mean square (FXLMS) control algorithm with online identification and reference signal self-extraction using distributed piezoelectric patches.(Zhiyuangao *et al*, 2017)

Kamarian & Shakeri, 2017, presented free vibration analysis of laminated composite skew plates with embedded shape memory alloys under thermal loads. The plates are assumed to be made of NiTi/Graphite/Epoxy with temperature-dependent properties. A parametric study is carried out to demonstrate the influence of skew angle, pre-strain and volume fraction of shape memory alloys, temperature, and stacking sequence of layers on the natural frequencies of the structure. (Kamarian & Shakeri, 2017)

Gnanaraj & Vijaya Kumar, 2017, the vibration caused by the step input on a Cantilever beam is controlled by using different piezoelectric actuators. Vibrations are actively controlled at the free end of cantilever beam using piezoelectric actuators. Optimal Linear Quadratic Regulator is designed for active vibration control based on the cost function related to minimization of deflections of the beam. Vibrations are very rapidly controlled when the piezoelectric actuator is placed very near to the fixed end of the cantilever beam. Vibrations are very quickly controlled when the length of Piezo electric actuator is placed fully along the length of the beam. (Gnanaraj & VijayaKumar, 2017)

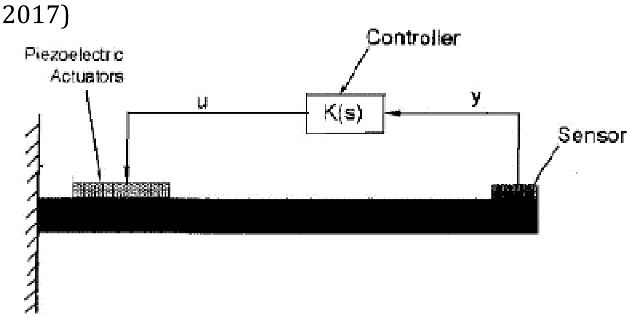

Fig.7 Cantilever beam with sensor, control system and actuator (Gnanaraj & VijayaKumar, 2017)

Gupta *et al.*, 2018, studied effect of using SMA to increase the damping of glass fiber reinforced plastic (GFRP) composites. A comparative study between SMA and steel was made as reinforcement material in GFRP composites to enhance damping. (Gupta *et al*, 2018)

Salim *et al.*, 2018, analyzed thermal buckling and free vibration of laminated composite cylindrical shells reinforced by SMA wires. The natural frequencies and buckling temperatures the structure are obtained by Generalized Differential Quadrature (GDQ) method. A parametric study is done to show the effects of SMA volume fraction, dependency of material properties on temperature, layup orientation, and restrain of SMA wires on the natural frequency and buckling of SMAHC cylindrical shells. Further optimization of SMAHC cylindrical shells in order to maximize the fundamental frequency parameter at a certain temperature is carried out. (Salim *et al*, 2018)

Mane *et al.*, 2018, evaluated the dynamic performance characteristics of a stiffness controlled Adaptive tuned vibration absorber (ATVA). (Mane *et al*, 2018)

Kheirikhah & Khosravi, 2018 studied the natural vibration and buckling behaviors of the composite sandwich plates reinforced by SMA wires. The Active Property Tuning method is used for modeling the SMA-embedded sandwich plates. The effects of plate's thickness, face sheet's thickness and plate aspect ratio and also boundary conditions on the natural frequencies and buckling loads of the plates are inspected. (Kheirikhah & Khosravi, 2018)

Tehrani & Kabir, 2018, presents a semi analytical investigation on the non-linear load-deflection response of SMA-reinforced composite circular cylindrical shells. The cylinder shells are under uniform external pressure load. Several parametric studies are conducted in order to investigate the effect of SMA volume fraction, SMA pre-strain value, and SMA activation temperature on the response of the structure. It is shown that suitable usage of SMA wires results in a considerable enhancement in the load-deflection response of the shell due to the generation of the SMA tensile recovery force. (tehrani & Kabir, 2018)

Wang *et al.*, 2018, investigated Effect of enhancement of interface performance on mechanical properties of shape memory alloy hybrid composites. Composite laminates without Ni-Ti shape memory alloy (SMA) fibers, with Ni-Ti SMA fibers polished, corroded and modified by silage coupling agent KH550 were taken into comparison to investigate the effect of surface treatments. The conclusion shows that embedded Ni-Ti SMA fibers can enhance the mechanical performance of composite laminates. However, the performance of Ni-Ti SMA fibers was restrained by the poor interface performance. After surface treatments, SMAHCs illustrate better mechanical performance owing to the enhanced interface performance. (Wang *et al*, 2018)

Remarks

Smart Structure comprise of host structure along with Sensors, Actuators & controller networks. These structures are made of Smart Materials such as Piezo electric materials, Magnetostrictive materials, Shape memory alloys, electro rheological materials etc. Smart materials can be embedded in the structures without affecting the structural properties. With such features incorporated in a structure by embedding functional materials, it is feasible to achieve technological advances such as vibration and noise reduction, shape control with high pointing accuracy, damage detection, damage mitigation etc.

Shape memory alloys can act as actuator and sensors. It can be easily embedded in composite materials in the form of wire, rod, ribbons, thin films etc. the advantages of using can be high energy density, high strain recovery, good response time, High deflection with no moving parts. Shape memory alloy hybrid composite (SMAHC) finds various structural applications.

Till now a lot of research work is carried on investigating performance of Shape memory alloy hybrid composite under active and passive vibration control. But very less research work is carried on investigating performance in Hybrid vibration control.

Various researchers found various analysis on SMAHC such as acoustic control, shape control, bending, deflection, position control, static and dynamic response, damage and crack repair, energy absorbing capacity, mechanical behavior, (tensile, self-centering, impact, ductility), post buckling, vibration characteristics, surface treatment etc.

Parametric study being done by many researchers such as SMA wire length and diameter. Concentrated mass value, frame structure and configuration, prestrain of SMA wire, volume fraction of SMA wire, effect of current, temperature variations.

The major aspect for study by researchers focuses on different ply orientation, various excitation frequencies, wire diameters. The study for an actuator should consider various forces, displacement, temperature conditions, cycle rates.

It is observed that natural frequency of composite decreases due to increase in overall density of composite due to embedding of SMA into composites.

The literature found that high recovery stress greater than 700 MPa with high strain up to 8 %. The major advantage of embedding SMA into composites is voltage required for actuation is very less also stiffness changing mechanism of SMA offer more influence over natural frequency of flexible structures.

As a part of passive vibration control SMA can be used as a spring and attached to a structure as an actively tuned dynamic vibration absorber. As a part of active vibration control the vibration of a structure is reduced by applying counter force to the structure that is appropriately out of phase but equal in force and amplitude to the original vibration. As a result two opposing forces cancel each other, and structure essentially stops vibrating.

Techniques like use of springs, pads, dampers, etc. have been used previously in order to control vibrations. These techniques are known as 'Passive Vibration Control Techniques'. They have limitations of versatility and can control the frequencies only within a particular range of bandwidth. Hence there is a requirement for 'Active Vibration Control'.

'Active Vibration Control' makes use of 'Smart Structures'. This system requires sensors, actuators, a source of power and a compensator that performs well when vibration occurs. The analysis of a basic structure can help improve the performance of the structures under poor working conditions involving vibrations.

According to the way in which controllers are designed, the control techniques have been properly implemented and controlled for a particular application. The controllers normally used are linear quadratic regulator, PID control, feed forward control.

For the purpose of study on SMA hybrid composites under vibration control, thermo mechanical model has to be built in Finite element code such as ANSYS, NASTRAN, force displacement characteristics and relations, model to adopt constitutive relationship of SMA material. Beams are modeled using Euler–Bernoulli, Timoshenko and third order beam theories. For the purpose of nonlinear dynamics, micromechanical models and Galerkin procedure can be adopted for obtaining analytical solutions.

Very less research work is carried on performance of shape memory alloy hybrid composite (SMAHC) in twisting capability, airfoil shaped cantilever beams, using Multiple springs as passive control. No research work is carried on investigating performance of SMAHC in aluminum metal matrix composites applications, in literature SMA is mostly embedded in fiber reinforced composites. Very little work is found on the optimization of the parameters of SMAHC under vibration control

Conclusion

Thermal Shape memory effect and Pseudo elasticity effects of shape memory alloys can be used to improve vibration characteristics of structures. Embedding the SMA in the composites can be act as an actuator for controlling the vibrations.

Therefore research work should be carried on investigating performance of SMAHC in vibration control applications, use in aluminum metal matrix composite, and study over hybrid vibration control. The parameters can be Effectiveness of SMH beam, Performance of controller in terms of vibration suppression and disturbance cancellation, Simulation results in Time and Frequency domain, and Optimization of parameters.

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