SMART STRUCTURES AND THEIR BACKGROUND

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Abstract: Smart materials are made with constituents like smart materials, sensors and actuators, and these smart structures will act according to its boundary conditions, in simple terms these materials will adapt to its surroundings. By adapting to the surroundings smart structures provide safe, reliability and longer life for the component. In this paper all the important data related to smart structures and there background is discussed briefly.

Introduction

Smart Structures and Development Background

Smart materials or smart structures systems are those which assimilate actuators and sensors that mostly combine into the structures and have structural functionality, and also as mostly integrated control logic signal conditioning, as well as signal power amplification electronics. Such actuating, sensing and controlling are extract into a structure for the use of impact its states or characteristics by thermal, magnetic, chemical, optical, mechanical and electrical. By giving the example mechanically smart structures is methodical of modifying both its mechanical states and its mechanical characteristics like stiffness and damping. Optically smart structures, to match its background could change colors.

Combining 3 historical trends to establish the potential practicable of smart structures. In laminated materials first is a transition. Previously structures were fabricate from large pieces of monolithic materials which were forged, apparatus, and formed to a finished structural shape creating it difficult to visualize the incorporation of energetic elements. However, in the past thirty years a transformation to technology of laminated materials has appeared. Laminated material technology which are built up from small scale constitutive elements within the structural that allow for the easy incorporation of active elements. One can now envision the incorporation of a smart carrying sensors, actuators, inter-connections and processors within the laminated materials technology.

The other trend has been the utilization of the off-diagonal terms in the material which currently enables smart structures that constitute relations. The full constitutive relations of materials incorporate characterization of its electromagnetic, mechanical, optical, thermal, physical, chemical properties. For the most of it researchers have concentrated only on terms like block diagonal. For its structural benefits those focused in exploiting a material have focused only on the mechanical characterization. Where much can be utilized by exploiting the off-diagonal terms in the particular relations in which for couple the electrical and mechanical properties. The creation of smart structures has led to the characterization and utilization of these off-diagonal material constitutive relations.

The other perhaps most obvious advance comes in the computer science and electrical engineering disciplines. These additional development of microelectronics, architectures, bus switching circuitry, and also fiber optic technology. And central to the emergence of smart structures is the development of information processing control disciplines and artificial intelligence. By all these three evolving technologies has generated the enabling infrastructure in smart structures which can develop.

Smart Structures

The term “smart structure” is more frequently used to a super system where intrinsically adaptive materials are employed. Smart structures are the structures made of smart materials, in other words and also those which incorporate actuators and sensors that are combine into the structure and have structural functionality also integrated control logic signal conditioning and power amplification electronics. Those actuating, signal processing and sensing elements are added into a structure for the reason of impact its states or characteristics they mechanical, electrical, magnetic thermal, chemical, optical. Optical intelligent structure could for example, change color to match its framework. The truly intelligent structural system learns and acquires its behavior in reaction to the external stimulation provided by the environment in which it activates.

There is a wide range of less experienced smart materials and structures which exploit the basic sub-disciplines which defines 3 classes of smart materials. These include materials with only sensing capabilities, those with only actuation capabilities and those with both sensing and actuation capabilities, at primitive level relative to notions of intelligence.

Critical Component Technologies of Smart Structures

In the surroundings of intelligent materials there is substantial focus on sensors, actuators, and control capabilities. The current generation of smart materials and structures assimilate one or more of the features:

1) “Sensors” which are either implanted in a structural materials or bonded to the surface of that material. Substitute the sensing function can be performed by a functional material, which, measures the strength of the stimulus associated with a thermal, stress, electrical, strain, radioactive and chemical phenomenon. In some circumstance this functional material may, also serve as a structural material.

2) “Actuators” are embedded inside a structural material or bonded to the surface of the material. These actuators are generally elevated by an external stimulus, in order to change their geometrical configuration or to change their stiffness and energy dissipation properties in a controlled manner. Alternatively, the actuator function can be performed directly by a hybrid material, which serves as both a structural material, and also as a functional material.

3) “Control capabilities” which permit the behavior of the material to respond to an external stimulus according to a prescribed functional relationship or control algorithm. Based on the utilization of an automatic control theory these capabilities typically interfere in 1 or more microprocessors and data transmission links.

To get a better study of the active materials field it is suitable to introduce an approach to classify different smart materials. Ideally the classification should be collectively exhaustive and mutually exclusive. The most common way of structuring is by looking at the input and the output of a material system as illustrated. The input or stimulus can be for example a change in temperature or in magnetic field. The material then intrinsically responds with an output, which in turn can be for example a change in length of the material, change in viscosity or change in electrical conductivity. Active materials can be divided into two groups. These materials generate one group comprises the classical active materials as viewed by the academic community and is characterized by the type of response. By the application of a stimulus the materials react with a modification in shape or in length of the material

Therefore input is always convert into strain, which can be utilized to introduce motion or dynamics into a system. These materials are the most waste used group for creation of smart structures, where active materials are c into a mechanical host structure (for example a building or a helicopter rotor blade) with the goal to change the geometrical dimensions of the structures.

The desired change in geometrical dimensions is mostly time dependent and often the steady state of the structure is a dynamic system where integrated active materials or devices are constantly agitated to change in real time the characteristics of the host. Devices based on materials that respond with a change in length are often referred to as actuators or solid state actuators to be more specific.

Conversely active materials can also be used as sensors as a strain applied on the material is transformed into a signal that allows computation of the strain levels in the system. Examples include the electro- and magneto rheological fluids, which respond with an increase in viscosity upon application of an external

About Smart Structures RTN

The objective of the RTN network is to develop an educational and research framework for developing macro-scale noise control applications based on intelligent material systems. The scientific and technological objective of the network is to advance the state-of-the-art in smart materials research to the level of system integration and industrial applicability, with a specific focus on solutions for noise and vibration reduction and for vibration-based damage detection. This requires that the involved research teams not only focus on the development and use of novel materials and control algorithms, but that they explicitly address the integration into sensor/actuator material systems and even further into application-level solutions. The study will include not only the target performance of the solutions, but also their constraints with respect to system reliability and cost. In this process, particular attention is paid to modelling aspects on the different scales: models for the intelligent materials and material systems, for the sensors and actuators, for the integrated control systems and the system-level applications.

Smart structure and active control

In the surroundings of intelligent structures and materials there is substantial concentration on actuators, control capabilities and sensors.The aim of creating a design that bound vibration amplitudes and extent in the existence of both vibration and shock disturbances face limitations in the form of constraints on the damping, choice of mass, and stiffness (static deflection) values. For instance, in the design of an isolation system, it often occurs that the desired calls for a value of stiffness that results in a static deflection that is too large for the intended application. Sometimes, a given outlying design might be necessitate to operate over a range of load that is unbearable to meet with a single choice of mass and stiffness. With addition once the materials are fixed for a given system it is tough to change the mass and stiffness of the system further than of a few percent. Basically, the choice of the physical parameter m, c, and k determines the response of the system. The choice of these parameters to obtain a desired response is the design problem. This design procedure can be thought of as passive control (e.g., adding mass to a machine base to lower its frequency). If the constraints on mass (M), damping (C), and stiffness (K) are such that the desired response cannot be obtained by changing M, C, and K, active control may provide an attractive alternative.

Active control uses an external convertible device, called actuator to supply a force to the device and structure whose vibration properties are to be modified. The force applicative to the structure by actuator is dependent on a computation of the response of the system. This is named feedback control. If the goal of the active control system is to remove unwanted vibration, the control system is called active vibration suppression, which consists of measuring the output or response of the structures to determine the force to apply to the mass to obtain the desired response. The device used to apply the force, together with the sensor used to measure the response of the mass and the electronic circuit is called the control system. The mathematical rule used to apply the force from the sensor measurement is called the control law.

Working control systems provide improved versatility and better operation in the design of vibration suppression systems. They do so with substantial improvement in cost and potential decrease in reliability. Even in the part of extension cost and complication, active control methods for vibration suppression are often the only substitute.

Sensory Elements

It is clearly conspicuous, to understand sensor's mechanism is requisite to the full picture of smart structure. Crawley in the year 1994. Sensory elements of smart structures should be sensitive to the mechanical states of the structure and competent of being highly distributed. The ideal sensor for a smart structure converts strain or rearrangement or their temporal derivatives instantly into electrical outputs. The foremost function requirements for such sensors are their sensitivity to the strain or derivatives, spatial resolution and bandwidth. Secondary necessity include the transverse and temperature sensitivity, hysteresis and linearity electromagnetic compatibility, size of sensor packaging. Although actuators are so huge they must be explicitly accommodated in the built-in laminates, it is sensible to make sensors small enough to be placed in interlinear or otherwise unobtrusive positions.

Lee and Moon in the year 1990 proposed various modal sensors and Callahan and Baruh2 developed to segmented piezoelectric film sensor. Tzou, et al3 discovered membrane modal sensitivity and transverse modal sensitivity for piezoelectric shell sensor. Nevertheless, some problems are still to be reappraise for instance possibility of general modal sensor, nonlinear effects, and random effects. This comes to our inducement. Where some general problems of piezoelectric sensor mechanics have been considered. It shows that modal sensor cannot be constructed for general plate, shell, case of beam, except the case of Lee and Moon. It means that distributed sensor generally detect a number of vibration modes simultaneously and can reduce but not completely remove the control spillover. Noise effects, random sensor, finite element incorporate of sensor equation and smart finite element formulation of smart structures have also been reported. As well with emphasis on and beam and plates complete results presented here are also valid

Sensor Analysis

In linear piezoelectric classical plates theory assimilate the piezoelectric effect into the elastic laminate constitutive equation has been studied by Lee4, Moon and Lee in the year 1990, Callahan and Baruh in the year 1995, all of them presume the in-plane displacement v and u to be negligible juxtapose to the transverse deflection w and the output signal is generated by w only. By this study, we will not omit the in-plane displacement, in the case have laminated plates because they should be contemplate, until the sensor were in the mid-surface. The consequence of transverse malformation will be also contemplate because the inter-laminar shear Modula are usually much smaller than the in-plane.

If using Mindlin plate's theory, the charge generated by each piezoelectric sensor is given by

qr(t) =∫ ∫AFrP0[e]T [L][u] + zr[θ])dxdy, r = 1, 2, ·,N.

Which is generally called as sensor equation. The signal output $qr(t)$ is an average quan- tity over the sensor coverage. It has demonstrate that frequency of charge qr(t) is similar to the prevalence of sensors and their host structure. In which z = (zk + zk−1)/2 is the generally distance from the geometric middle of the rth sensor to the mid-plane of the laminate and N is the number of piezo sensors, A is the sensor reportage and is the polarization profile Lee and Moon in the year 1990 and F(x,y) is Heavy side type of function.

$F(x, y)$ = 1, if (x,y) is within the r^{th} sensor coverage A 0

As Tzou t al in the year 1993 pointed out that signal outcome of sensor can be separated into 2 parts or know as sensitivities:

1) Transverse modal sensitivity

2) Membrane modal sensitivity.

In common, the transverse modal sensitivity is known for transverse natural modes and the membrane modal sensitivity for natural in-plane modes. The transverse modal sensitivity is defined for rotation or precisely change of curvature, so no explicit contribution from transverse deflection w; the reason is that in the sensor's constitutive equation both e33 and e34 are null. In order to capture the contribution of w, it is suggestion to choose a piezoelectric material has no-zero e33 and e34.

Modal sensor

A_m and B_m are constant coefficient. By using classical plate theory and omitting in-plane displacement u and v, Lee and Moon 5 have shown that if the spatial electrode pattern of the rth lamina is proportional to the modal strain distribution along the length of the plate, one can obtains a true modal sensor based on the orthogonally of the eigenvalue-solution of the beams with respect to their stiffness. In other words, observer spillover will not be present in systems adopting this type of sensors. Furthermore, Lee and Moon also proposed modal actuator which excites each particular mode independently so that actuator spillover will not be an issue in one-dimensional plates actuated by this type of actuator. Unfortunately, for both linear and nonlinear of the Mindlin plate theory, since no general orthogonally for both um and θ_m, it is impossible to have the mode sensor like beam whatever how we choose $qr(x)$. In other words, observer spillover will always be present in the system adopting Mindlin type of sensor. As an outcome, the modal actuator will be no exist either in the case of plates. Only one extraordinary case, If it is placed on the mid-surface the sensor that can only be used as membrane sensor, zr = 0. In this case, modal actuator for beam type plates one can obtain membrane modal sensor and membrane.

CONCEPT OF SMART STRUCTURAL SYSTEMS FOR BUILDINGS

In aerospace engineering the conception of smart structural system was originally recommended where smart structural system was illuminate as a system that can recognize damage and intercept damage propagation, regulate the riposte from external inconvenience actively and acclimatize its geography to prime state for the environment for building the requirements and objectives of a smart structural system engineering are different from those for aerospace engineering

The worth of a building should be purposeful not only by structural safety but also by taking into account non-engineering points of view such as function, economy, and beauty. Environment surrounding a building and environment itself are also indispensable in building engineering.

Smart Structural System for Aerospace Engineering and Building Engineering

Design Philosophy

- In aerospace Engineering amalgamate smart functions into a structure to attain less weight and more performance.
- In building Engineering Put smart functions to a structure to attain objective achievement at nadir life cycle cost

Characteristics of structure:

- In aerospace Engineering Airplane is initially adaptive and active. Airplane works as a single unit and has a simple usage.
- In building Engineering Building is not required to be adaptive or active. A group of buildings form a social unit having multiple usage.

External disturbance and objective safety:

- In aerospace Engineering Structure must be safe in daily usage and disturbance. Constant maintenance is required.
- Building Engineering Structure must be safe in rare events, such as strong winds or an earthquake. Free-maintenance is desirable.

Research needs:

- In aerospace Engineering Development of smart devices integrated into a structure.
- In building Engineering Development of a system effective for objective performance. High demand for health monitoring

Research Needs in Building Engineering

Disaster prevention:

Needs of research: By prevention of ground collapse or building reintegration of aged structures devastation detection of concealed structural elements human welfare at eventual stage recondition of building damage appraise and seismic safety in urban habitat Public education toward disaster mitigation.

Function:

Needs for research: Effective control of noise and vibration Creation of large open space without column and wall Design of highly irregular buildings Flexibility in building usage Extension of building life

Production:

Needs for research: Countermeasures against shortage of expert builders Improvement of construction quality High speed construction Development of new material.

Environment:

Needs for research: preservation of nature Control and environmental pollution Control of industrial waste depletion of noise and dust during establishment

Conclusion

Smart structures will help to develop sophisticated and advanced machinery, they have evolved a lot during the past few years and can be developed in to a lot more, the scope for development, applications of smart structures is very huge and worth full .

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