"SMART MATERIAL: TECHNOLOGY AND APPLICATIONS"

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Abstract - This paper presents an overview of the Smart & Innovative technology along with compressive case studies. It describes the detail definition of smart material and its all possible types. A smart structure is built with smart material. It focuses on basic components of smart structure.

This paper describes in detail a good number of case studies in various domains and applications like vibration reduction in sporting goods, smart aircraft, noise reduction in vehicles, and smart skin.

This paper draws a conclusion about the applicability, extensibility, feasibility and flexibility of the smart material and smart structures.

Key words – ***Smart Material, Smart System, Smart Structure****.*

I. INTRODUCTION

A. Smart Material

It a one whose properties or shape may change in response to some stimulus from the environment. Smart or intelligent materials are materials that have the intrinsic and extrinsic capabilities, first, to respond to stimuli and environmental changes and, second, to activate their functions according to these changes. The stimuli could originate internally or externally. Since its beginnings, materials science has undergone a distinct evolution: from the use of inert structural materials to materials built for a particular function, to active or adaptive materials, and finally to smart materials with more acute recognition, discrimination and reaction capabilities. To encompass this last transformation, new materials and alloys have to satisfy a number of fundamental specifications.

Smart materials are used to construct these smart structures, which can perform both sensing and actuation functions.' Smart materials' and systems sense and respond to their environment and have applications in areas as diverse as health, defense and packaging.

B. Types of smart material

Smart materials sense changes in the environment around them and respond in a predictable manner. Some types of smart materials include

1. Piezoelectric

Applying a mechanical stress to these materials generates an electric current. Piezoelectric microphones transform changes in pressure caused by sound waves into an electrical signal.

2. Shape memory

After deformation these materials can remember their original shape and return to it when heated. Applications include shape memory stents - tubes threaded into arteries that expand on heating to body temperature to allow increased blood flow.

3. Thermochromic

These materials change color in response to changes in temperature. They have been used in bath plugs that change color when the water is too hot.

4. Photo chromic

These materials change color in response to changes in light conditions. Uses include security inks and dolls that 'tan' in the sun.

5. Magnetorheological

These fluids become solid when placed in a magnetic field. They can be used to construct dampers that suppress vibrations. These can be fitted to buildings and bridges to suppress the damaging effects of, for example, high winds or earthquakes.

C. Smart structure

A smart structure is a system containing multifunctional parts that can perform sensing, control, and actuation; it is a primitive analogue of a biological body.

As described earlier, a smart structure is a system that incorporates particular functions of sensing and actuation to perform smart actions in an ingenious way. The basic five components of a smart structure are summarized as follows (Figure 1)

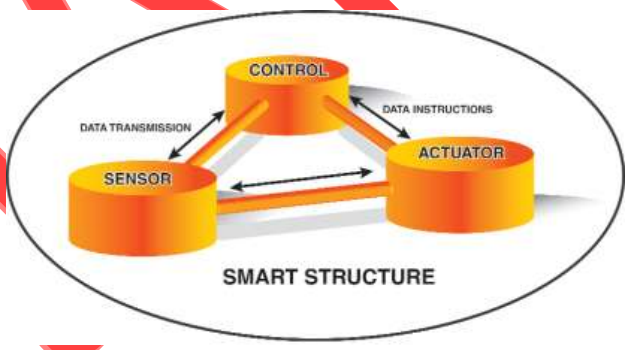

Fig. 1 the Basic Five Components of a Smart Structure [2]

1. Data Acquisition (tactile sensing)

The aim of this component is to collect the required raw data needed for an appropriate sensing and monitoring of the structure.

2. Data Transmission (sensory nerves)

The purpose of this part is to forward the raw data to the local and/or central command and control units.

3. Command and Control Unit (brain)

The role of this unit is to manage and control the whole system by analyzing the data, reaching the appropriate conclusion, and determining the actions required.

4. Data Instructions (motor nerves)

The function of this part is to transmit the decisions and the associated instructions back to the members of the structure.

5. Action Devices (muscles)

the purpose of this part is to take action by triggering the controlling devices / units.

D. Sensors and Actuators

For active noise control applications, microphones are used as acoustic sensors and loudspeakers as acoustic actuators. For displacement and velocity control, two types of transducers are convenient: Linear Variable Differential Transformers (LVDT) and Linear Variable Inductance Transformers (LVIT). Other devices are also available accelerometers and two basic types of actuators. Hydraulic and pneumatic actuators are employed when low frequency, large force and displacements are required, while the electromagnetic/ shaker types are utilized to react against an inertial electrodynamics mass.

1. Command and control Unit

The command and control unit is the manager of day-to-day operations, responsible for monitoring the health and integrity of the system by means of a communication network which works in real time. The unit operates by controlling a compendium of integrated non-destructive evaluation instruments, by managing optical fibre sensors and actuators, or by overseeing operational and control devices. This is the brain of the smart structure and has two basic and distinct functions.

2. The Processing Function

This function receives information; analyses it; sorts, arranges and classifies it; and stores and/or processes it depending on the nature, frequency and quality of the data and its origins. All these previous operations are dealt with by intelligent or smart processing, with or without human intervention, and with little or no human interaction. Special algorithms can be used to control

the behavior or detect damage. Pattern recognition algorithms, as well as neural networks with fuzzy logic can be efficiently employed to process the raw data. Finally, expert systems can handle the retrieval, management, classification, and storage of the data.

3. The Analysis Function

This function deals with the detailed examining of the raw data in an intelligent way. Using the analysis outlined above, it will exploit the results to assess the condition of the structure. This analysis consists of localizing and identifying specific variables, items or features as compared to threshold levels defined in advance, or specified in codes, rules, regulations or standards. When an adverse condition is detected and the appropriate corresponding conclusion is reached, decisions for action are sent to the action controlling devices, which will be triggered to react. Special algorithms are developed to operate these functions.

II. A FEW EXAMPLES

A. Vibration reduction in sporting goods.

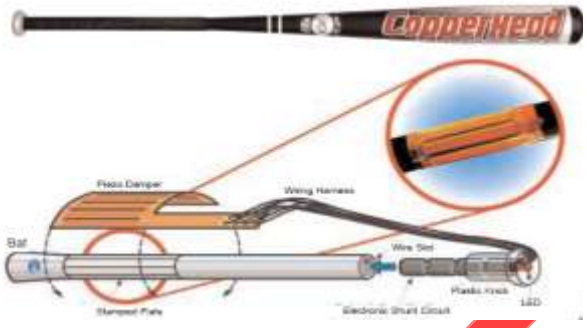

Fig. 2 A Smart Electrical Baseball Bat [2]

A new generation of tennis rackets, golf clubs, baseball bats (Figure 4) and ski boards have been introduced to reduce the vibration in these sporting goods, increasing the user's comfort and reducing injuries.

B. Smart Aircraft.

Fig. 3 Locations of Potential Smart Systems in an Aircraft [3]

Figure 6 presents a few potential locations for the use of smart materials and structures in aircraft.

C. Noise reduction in vehicles.

Filaments of piezoelectric ceramic fiber shaped into various geometries are used in conventional fabric or materials' processing to counter noise in vehicles, neutralizes shaking in helicopter rotor blades, or nullifies or at least diminish vibrations in air conditioner fans and automobile dashboards.

D. Smart Skin

In battle soldiers could wear a T-shirt made of special tactile material that can detect a variety of signals from the human body, such as detection of hits by bullets. It can then signal the nature of the wound or injury, analyze their extent, decide on the urgency to react, and even takes some action to stabilize the injury.

E. Autonomous Smart systems

Ground, marine or space smart vehicles will be a feature of future battles. These carriage systems, whether manned or unmanned, and equipped with sensors, actuators and sophisticated controls, will improve surveillance and target identification and improve battlefield awareness.

III. CONCLUSION

Today, the most promising technologies for lifetime efficiency and improved reliability include the use of smart materials and structures. Understanding and controlling the composition and microstructure of any new materials are the ultimate objectives of research in this field, and is crucial to the production of good smart materials. The insights gained by gathering data on the behavior of a material's crystal inner structure as it heats and cools, deforms and changes, will speed the development of new materials for use in different applications. Structural ceramics, superconducting wires and nonstructural materials are good examples of the complex materials that will fashion nanotechnology. New or advanced materials to reduce weight, eliminate sound, reflect more light, and dampen vibration and handle more heat will lead to smart structures and systems

This will definitively enhance our quality of life.

IV. REFERENCE

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