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Conference Paper

APPLICATIONS OF SMART MATERIALS IN MECHATRONICS TECHNOLOGY

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Abstract

The standard of living and welfare of the people is closely related to the development and performance improvement of new engineering materials and devices. These new engineering materials have impacted the emergence of new smart engineering devices and systems, such as mechatronics systems also with high performance that is used in various industrial fields in order to reduce the cost of living and to extend the quality of everyday services in all aspects. In recent years, smart materials have received a wide range of applications due to their special properties during interactions with the external stimuli in the controlled condition. Using these special properties of smart materials with functional integration and interaction methodology has impacted on the emergence of mechatronics technology as a new technology that combines mechanical, electrical, computer and information technologies. Mechatronics technology requires these smart materiasl with certain properties, to change or adapt their behavior according to the externally controlled condition, including stress, strain, temperature, light, pressure, electric field, magnetic field, etc.
This article aims to describe the applications of smart materials in mechatronics technology, using the available literature data of this technology. The use of smart materials in mechatronics technology improves the efficiency and effectiveness of this technology which has a strong influence on manufacturing and engineering technology.

Keywords: smart materials, materials properties, smart systems, mechatronics technology.

1. Introduction

In recent years, smart or intelligent materials have received a wide range of applications due to their special properties during interactions with the external stimuli in the controlled condition. Using these special properties of smart materials with functional integration and interaction methodology has impacted on the emergence of mechatronics technology as a new technology that combines mechanical, electrical, computer and information technologies. Mechatronics technology requires this smart or intelligent material with certain properties, to change or adapt their behavior according to the externally controlled condition, including stress, strain, temperature, light, pressure, electric field, magnetic field, different types of radiation, etc.
This article aims to describe the applications of smart materials in mechatronics technology, as e new technology that combines mechanical, electrical, computer and information technologies, by focusing on the literature review and basic properties/behavior of smart materials. The objective of this article is focused on the application of mechatronics technology in manufacturing engineering and technology.

1.1.Definition of smart materials

In the literature, there are different definitions for the term smart or intelligent materials or sometimes adaptive materials. In the beginning, smart or intelligent materials were defined as the materials with response to their environments on time, however, the definition of smart materials has been expanded to the materials that receive, transmit, or process a stimulus and respond by producing a useful effect that may include a signal that the materials are acting upon it [1]. According to [2] smart or intelligent materials may be defined as materials that respond to environmental changes at the most optimum conditions and manifest their functions according to the changes. According to [3] smart or intelligent materials may be defined as the material which reacts to its environment on its own, the reaction may exhibit itself as a change in volume, color, viscosity, odor and this may occur in response to a change in temperature, stress, electric current, pH value or magnetic field. According to [4] 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. In the literature, there are also other definitions for intelligent materials such as: smart or intelligent materials are materials that "remember" configurations and can conform to them when given a specific stimulus [5], smart or intelligent materials are materials that can significantly change their thermal, optical, mechanical and electromagnetic properties in a controllable and predictable manner in response to their environment [6], smart materials are materials, which possess the ability to change their physical properties in a specific manner in response to specific stimulus input [7], smart engineering materials are any innovative material which undergoes a macroscopic change in one of its physical-mechanical properties due to a non-mechanical external stimulus and that is capable of being controlled [12]. Consequently, the term smart materials‖ is not very well defined and frequently used to describe different systems and systems behaviors [5].

1.2.Classification of smart materials

It is worth to be noted that according to their different bahavior, different types of smart or intelligent materials are available in the literature. There are many types of smart or intelligent materials, but still, a lot of research and work will be done in the field of these materials, but in this paper will be considering only a few types of intelligent materials that are mostly used in mechatronics technology.

According to [8, 9, 10] smart or intelligent material can be active or passive, figure 1. Active smart materials possess the capacity to modify their geometric or material properties under the application of electric, thermal or magnetic fields, thereby acquiring an inherent capacity to transduce energy. Piezoelectric materials, SMAs, ER fluids and magneto-strictive materials are considered to be the active smart materials and therefore, they can be used as force transducers and actuators [1]. On the other hand, the materials which are not active are called passive smart materials [1] or passive smart materials are the materials which are inactive to response [8]. Piezoelectric materials shape memory alloys (SMAs), ER fluids and magnetostrictive materials are considered to be the active smart or intelligent materials and therefore, they can be used as force transducers and actuators [1]. Fiber optic material is a good example of a passive smart or intelligent material. Such materials can act as sensors but not as actuators or transducers [1]. This classification of smart/intelligent material is no standard classification, therefore the different classification of smart/intelligent materials is used in the academic, scientific or industrial community [5]. From the reviwed literature can be seen that piezoelectric smart materials, shape memory alloys (SMAs), magnetostrictive

smart materials used mostly in mechatronics systems included in manufacturing engineering and technology. It is worth mentioning that in other fields used other mechatronic systems, but in this case, they are produced from other smart materials, which as mentioned above are in a wide spectrum. In recent years, smart materials have proven to represent an effective means for developing a novel generation of miniaturized electromechanical transducers. Thanks to their many features such as high energy density and efficiency, low power requirement, low cost, scalability, and high compactness, smart material can help to improve the performance of several mechatronics systems, ranging from industrial to non-industrial applications [15]. These smart or intelligent materials have the ability to react to an external stimulus (electrical, magnetic, thermal) and thanks to these features, such materials are often referred to as active materials [15].

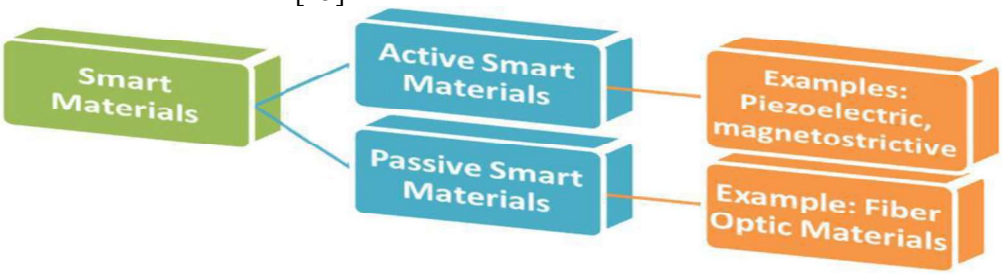

Figure 1. Types of smart/intelligent materials

1.3.Applications of smart materials

Smart or intelligent materials form a group of new and state-of-the-art materials now being developed that will have a significant and a wide range of applications due to their varied response to external stimuli [7]. Smart materials are usually used for sensors and actuators and these components in combination with the control mechanism form the mechatronics system, or smart/intelligent system, figure 2, which integral function is important and attractive in a number of practical applications. It is worth mentioning here that integration of these components, technically and technologically is more advanced and requires multidisciplinary and interdisciplinary knowledge.

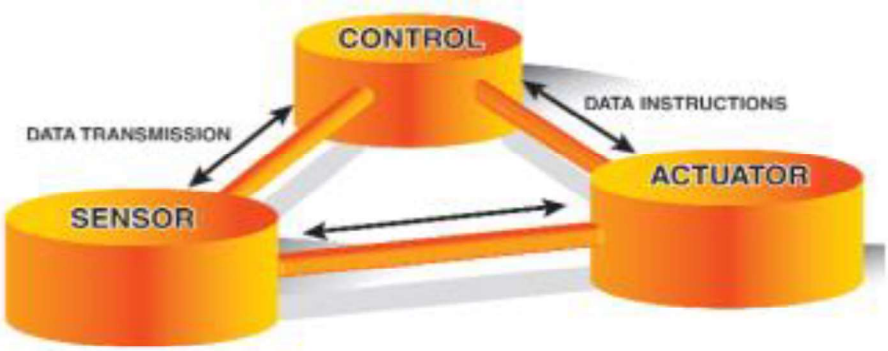

Figure 2. A typical mechatronics system

Mechatronics system or smart/intelligent system integrates the properties of sensors, actuators and control/processing mechanisms in order to respond to a given stimulus in a functionally useful manner. Mechatronics technology using beneficial effects of mechatronics systems is still in its initial stages of development and the scientific community in this field continues to explore its beneficial potential in our daily lives. Recently one distinctive feature of mechatronics system is that sensors, actuators, and control/processing mechanisms can be

embedded at discrete locations inside the system or co-fabricated in silicon wafer. Mechatronics system or smart/intelligent system is a system containing a sensor, control/processing mechanisms, an actuator that can perform sensing, control/processing, and actuation of action, hence it is a primitive analog of a biological body system, figure 3. Smart or intelligent materials are inspired by nature and try to mimic the adaptive characteristics of natural systems. In brief, it is possible to say that smart materials have special properties that couple mechanical and non-mechanical fields, conferring adaptive characteristics [14].

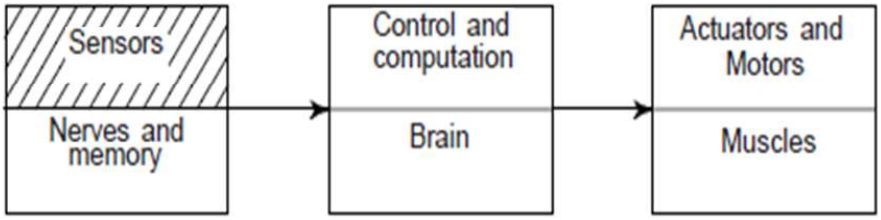

Figure 3. Mechatronics system/intelligent system versus biological body system

Mechatronics system or intelligent system incorporated with other engineering systems lead to growing the flexibility and performance of these integrated systems operating in various existing or new applications in the field of science, engineering, and technology. Smart materials are the future materials in science, engineering, and technology, with a wide range of applications in mechatronics systems, figure 4.

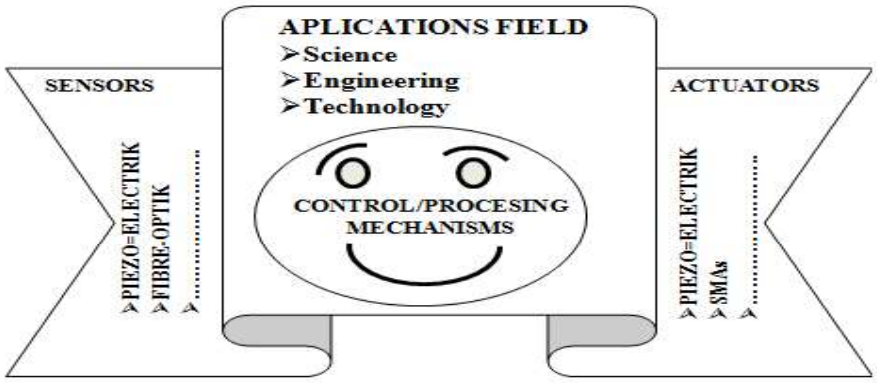

Figure 4. Smart/intelligent materials for mechatronics/smart system

Applications of smart materials in mechatronics systems and integration of these systems with other engineering systems create more functional and smart devices that are used in everyday life in various applications such as automobiles, rail transport, medicine, aerospace, marine, etc. It is worth mentioning that smart materials incorporated in the mechatronics system encompass all fields of science and engineering.

The key to 21st-century competitive advantage will be the development of products with increasing levels of functionality. Smart or intelligent materials will play a critical role in this development [11, 13].

2. Conclusions

By reviewing the available literature data, can be drawn the following conclusions:
Smart or intelligent materials in conjunction with mechatronics system or intelligent system grow the flexibility and performance of these integrated systems operating in various existing or new applications in the field of science, engineering and technology in general and especially in manufacturing and engineering technology.
Most of the comforts to the society are the outcome of smart materials and in the future, smart or intelligent materials going to play dominant role in the mechatronics technology and we can expect new multifunctional smart or intelligent materials in this field, which will further enhance the quality of our life through development of new and attractive products using manufacturing and engineering technology.

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