J. Text. Color. Polym. Sci., **Vol. 22,** pp. 179-185 (2025)

Journal of Textiles, Coloration and Polymer Science

https://jtcps.journals.ekb.eg/

Egyptian Society for Textile Science and Technology
الجمعية المصرية لعلوم وتكنولوجيا النسيج

The effect of using smart materials to improve the efficiency of industrial products

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Abstract

Due to the continuous technological development in the field of smart materials in the recent period, and since smart materials have become widely used in various production and design processes, this research studies smart materials and the extent of their impact on various industrial products and their applications in different fields, and the research contributes to providing a study that shows the extent of the impact of smart materials on industrial design products. Smart materials are those that can sense and respond to environmental events, influencing their surroundings. They can change their shape and properties when exposed to external influences. They have various applications, such as in space equipment, satellites, smart jobs, and building materials. Smart materials offer features like remote control capability, lightweight and durability, self-healing, and the ability to sense different types of energy. Examples mentioned include ETFE material, smart packaging material, fiber-optic cables, piezoelectric cells, and liquid crystal technology. They play a significant role in industrial design by improving the function, value, and appearance of products.

Keywords: Smart materials; technological development; industrial products; applications; impact

Introduction

The environments in which humans live have shaped the raw materials used over time. For instance, when humans first emerged on Earth, they were unable to find stones nearby from mountains and rocks, so they made the majority of their tools, such as spearheads for hunting and self-defence, from these materials. Later, they discovered bronze, from which they made statues and other decorative items. was dubbed the "Bronze Age" until he discovered the copper human; evidence of the copper's introduction into Egyptian civilization comes from the discovery of a Pharaonic-era foundry in Sinai; iron was used during the Hyksos Ian occupation of Egypt, when the Hyksos arrived with iron swords and Egypt continued to use copper swords; iron ore then spread throughout all military and industrial supplies during this time. Whereas traditional raw materials, whether natural or industrial, have exhausted their properties over centuries in technological development. Science has tended to search for new raw materials that have other features and different properties that can be employed in the functional techniques of products, so new materials called smart raw materials appeared in the modern millennium, and these raw materials appeared and evolved with the development of nanotechnology, as this scientific field was able to control the granular structure of the raw material, which gives New properties on the material or improves its traditional properties. These raw materials have the ability to be affected by conditions and take different reactions to directions according to their characteristics. Due to the emergence of new characteristics of such raw materials on the industrial arena, this has led to pushing the wheel of innovation and invention to employ these raw materials in new jobs called smart jobs .

This type of smart raw materials has appeared in the design and development of space equipment and satellites, and due to the need is the mother of invention, space conditions are what led to the invention of these raw materials and even improved by

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Receive Date: 29 December 2023, **Revise Date:** 15 February 2024, **Accept Date:** 21 February 2024
DOI: 10.21608/jtcps.2024.259230.1295

various experimental research, and due to their distinct and modern characteristics, they have been used in various functional techniques .

aim of the work

In this thesis, the work presented has three-fold objectives which can be stated as follows:

1. Identify the types and characteristics of smart materials.
2. Identify the actual applications that have been made by employing the properties of raw materials.

Smart materials

This type of raw materials began among researchers and industrialists more than 40 years ago. The tremendous development in this field has led to the emergence of new materials that are more advanced and processed with high electronic technology. Smart materials are defined as: "These are those things that sense environmental events and make operations on that information they have obtained and then influence the environment around them." Smart materials are used in products or systems whose design requires the ability to take acceptable reactions to meet the needs of performing a job, knowing that these triggers can arise internally or externally. Smart materials can include microscopic sensors and mechanical actuators inside or associated with them to become an integral component of their system, and they are responsible for acting and responding in a predictable and calculated way to external variables in a manner that is similar to a pattern that may mimic or deviate from familiar biological functions. [1-10]

Because of their ability to respond to the surrounding environment, through very accurate devices integrated with these materials, such as sensors and microchips, and these devices can monitor changes in the external environment, such as temperature change or light intensity. Hence the influence on the intelligent material to shrink or expand to conform to environmental variables. Smart material responses are to respond to environmental stimuli and changes, to establish their effectiveness, or to emphasize certain properties in them. [11-19]

Composites Smart are materials that are produced by combining two or traces of smart materials to reach a new combination of properties that combine all the properties of the selected materials, which is the goal of any new intelligent composite material. There are two main types of smart compounds:

Fully synthesized composite material: It is characterized by strength, durability or high hardness, and this material can combine with thin plates to create composite metal sheets or structural materials that are lightweight and able to withstand high stress. Combined mono / composite materials with Fiber reinforced plastics: It is used as a supporting material for concrete, steel and other structural materials and is a distinct alternative to other materials such as steel when compared to cost, weight, processing, and ease of transportation, and these materials are also flexible when dealing with multiple design applications.

The most important thing that differentiates between smart raw materials and traditional raw materials is the set of technological characteristics that highlight their ability and field of use, such as:The possibility of remote control and the ability to include them in electronic systems. · Light weight and endurance · Ease of replacement and ease of disassembly and installation

The ability to self-heal if exposed to a destructive effect. The ability to sense different types of energy such as storage at the time of high temperature, sunshine, or the availability of the effect and its release when temperatures drop or the effect disappears. Self-change and transformation to suit the surrounding environmental conditions

Definition of smart materials:

- Raw materials have the ability to be affected by conditions and take different reactions to directions according to their characteristics.
- Another definition: They are materials that have properties that can change their shape and properties as a result of being affected by external influences.

.Smart materials give the ability to the industrial designer to innovate and new functions that lead to the humanization of products, and this is through the self-feedback taken by smart materials to save human decision-making efforts, and therefore these materials are not only to replace traditional materials, but replace control systems.

Kinds of intelligent materials

Intelligent substances are classified according to their reactions into - Intelligent materials that are subject to change:

This change appears in one of two manifestations (change in color - change in shape) · Smart materials that emit lighting have retained: Each type of these classifications includes some types of smart materials responsible for an apparent change in the material when exposed to a stimulus, and the following figure shows the classification of smart materials according to their reactions after exposure to various influences such as heat, light, and electricity, as well as their ability to reflect the lighting that they have retained. -1/6 Material Smart Changing Color These materials are distinguished by their ability to change their color when exposed to one of the external stimuli such as any change in the surrounding environment (thermal, photovoltaic, chemical, electrical, etc.) and the color change of smart materials is according to the type of

this material and includes smart materials changing color main types of materials lie in the following-:

Materials whose color is affected by heat (thermochromic) Material Thermochromic are materials whose color changes directly when exposed to a change in temperature, and this change in color takes place at certain temperatures if colors can be determined at certain temperature levels to become a device for measuring temperature change.

Some designers in "Sweden" used chronothermal materials in some furniture covers, in the normal situation the table cover is monochromatic, and when exposed to a high temperature, some drawings and various shapes appear

Sensitive materials react predictably to changes in their surrounding environment. Certain kinds of Among the clever materials are:

1. Piezoelectric: These materials produce an electric current when mechanical stress is applied to them. Sound waves induce pressure changes, which piezoelectric microphones convert into an electrical signal.
2. Shape memory: When heated, certain materials that have undergone deformation can regain their previous shape.
3. Shape memory stents are one type of use; they are tubes that are inserted into arteries that expand when heated to body temperature, increasing blood flow.
4. Thermochromic materials undergo colour changes in response to variations in temperature. Bath plugs that change colour when the water becomes too hot have been made with them.
5. Photochromic materials undergo colour changes in response to variations in light intensity. Uses include dolls that "tan" in the sun and security inks.
6. Magnetorheological: When these liquids are exposed to a magnetic field, they solidify. They can be utilized to build vibration-suppressive dampers. These may be installed on structures like buildings and bridges to lessen the negative impacts of things like strong winds and earthquakes.

Features of smart materials

Although some materials carry more than one property, such as sensor and animation elements together, which reduces the size and complexity of the system, smart materials can also be a complex part of an integrated structural system. Smart materials respond by changing themselves in response to external changes or by responding to these changes through a signal.

Smart materials are often a component of integrated smart systems, as they are unable to establish an integrated system on their own. When used as building materials in general and for the building envelope in particular, smart materials provide a wide variety of characteristics and benefits for buildings due to their direct interaction with the external environment and its changes.

Smart Material Classifications

We can classify all smart materials in terms of properties as shown in into three main groups as follows:

- Variable properties Property changing materials
- Energy converter and energy exchange material
- Material exchange

The first category of substances with variable properties materials finds extensive usage in building casings; the second group is mostly employed in construction services, including motors and sensors; and the third group finds employment as an insulator.

Examples of smart materials

After we learned about the properties of smart materials, their types, and how they respond to the environmental variables and influences surrounding them, we are now in the process of identifying some practical examples of these smart materials.

ETFE Material

It is a thin plastic film that has been widely used as a substitute for glass, due to its light weight and great flexibility in transportation and formation and even at low temperatures. In addition to its great resistance to fire and light transmission with the ability to disassemble and install.

A form of PV photovoltaic technology has been developed that directly integrates solar cells with ETFE. It is suitable for use in green building covers because of its UV resistance and pollution resistance, in addition to the self-cleaning feature

Smart Packaging Material:

It is a thin plastic film that acts as a smart multi-tasking wall surrounding the building. The smart packaging material integrates all the functions of conventional walls (insulation, protection and windows), with additional functions (the ability to store energy and regulate heat digitally as well as provide and control light) into a single high-tech material, no thicker than millimeters. In addition to its light weight, speed of transportation and installation with its reusability.

The example illustrates the Cellophane House's clever packaging envelope, where the outer wall consists of four layers that stretch into an extruded aluminum frame.

Each panel included a transparent weather insulation wall PET, an inner PET layer with thin solar cells, an inner layer of solar heat, a UV blocker film, and an inner layer of PET

A cavity was created between these layers to trap heat in winter and vent it in summer, reducing the amount of energy needed to heat and cool the house.

Embedded Fiber-Optic Cables

Embedded fiber optic cables will be used to assess cracks, severe bends, vibrations, stresses and morphological defects.

It relies on the method of analyzing the characteristics of the light transmitted through the integrated fiber optic cable, as morphological defects, bends, cracks and other effects associated with actual or imminent damage sometimes change or affect the properties of the transmitted light.

Piezoelectric Cells

They are very small electrical cells that oscillate rapidly on the outer walls to predict the surroundings of the building and send interactive waves to the building's central control devices.

It can also be used to produce energy, which represents a concept for transforming high-rise towers into power plants by covering the Stockholm skyscraper with electricity generation hairs that act as a wind farm for the building.

Optical Fiber

It is used to connect the building to the outside world using multiple connections that can be used to measure temperature, stress, etc.

It can also be used as a means of daylight access to all spaces of the building without windows, where it can drive and transmit daylight rays through long fiber optic tubes.

This type of glass distributes the light evenly in the space without the formation of shadows. His work is based on a thin sheet containing a large number of hives-like cells with very thin, transparent or white walls that distribute light in the vacuum.

In addition to the insulation property, it provides through the high reflectivity of the cell walls that it contains. Thus, this glass provides solar control according to the time of year or according to the day or night, and it exists in different forms.

Liquid Crystal Technology

Liquid crystals between the two layers of glass in smart windows regulate the quantity of light transmitted from them by altering the liquid crystals' response to electrical charges. This technology is utilized in the building's external apertures.

The crystals are regularly arranged by electric charges, which makes the glass transparent and enables light to flow through and see both ways. When the electric charge is removed, the crystals revert to their erratic, random positions, scattering light and preventing light from flowing through them to appear as a diffuse layer that obscures vision and provides privacy.

One of the most important features of this type of smart window, in addition to its efficiency in achieving thermal comfort inside the place, is to achieve energy efficiency

It achieves energy savings of up to 40% than regular windows, so it is suitable for supporting climate control systems in building casings.

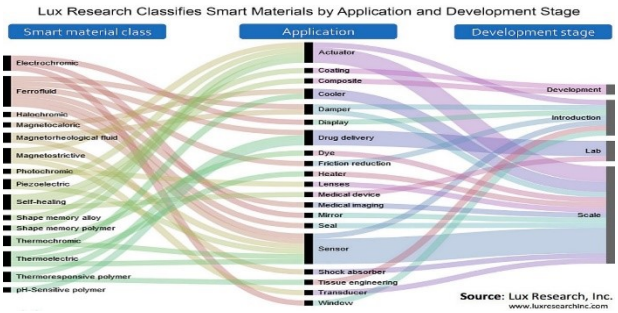

Figure 1: Image showing the smart material and its applications

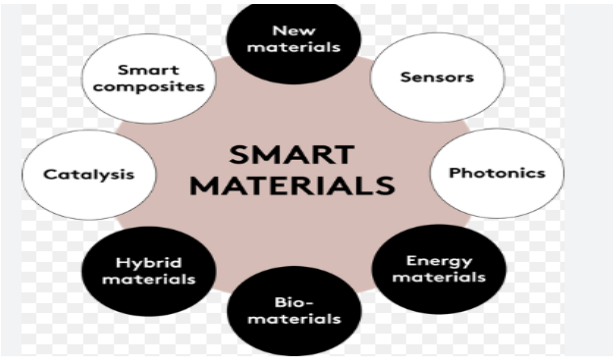

Figure 2: Types of smart materials

Figure 3: Application of smart material

Industrial design

Industrial design is a creative activity aimed at creating formal and functional characteristics of products, services and systems to serve humans, taking

into account several factors such as safety, economy, environment, manufacturing..... Etc.

Industrial design is a practical art aimed at improving the aesthetics and benefits of manufactured products**.**

This is one of the types of design, which works on the development of the use aspects, external appearance, engineering and industrial processes, etc.

Defined by the International Council of Industrial Design Societies as a creative activity aimed at determining the formal characteristics of things produced through industry and these characteristics include external features and structural and functional relationships that transform the system into a coherent unit, whether from the point of view of the producer or the user and extends industrial design to include all aspects of the human environment associated with industrial production.

The American Association of Industrial Designers defined it as a professional service for creating and developing concepts and specifications that improve the function, value, and appearance of products and systems for the mutual benefit of both the user and the manufacturer.

Industrial designer

An industrial designer is a person who is able to create and develop concepts and specifications that improve the function, value and appearance of a product as he is a conscious person who is able to understand the surrounding human and environmental needs. [20]

Industrial product

Design elements: color, font, material, size vacuum, texture**.**

Material: It is used by man through work, industry or to create products or buildings. Including smart materials.

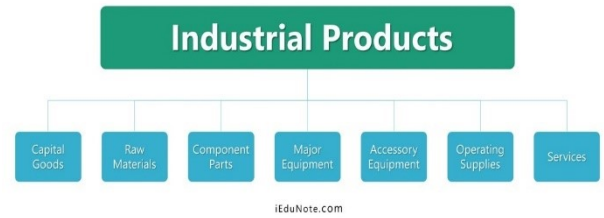

Figure 4

Smart materials and their role in raising the efficiency of the industrial product

The materials directly affect the designer's thought and his creations of innovative designs, each material has its limits, capabilities, advantages and shortcomings, so good design requires the designer to be conscious and renewed with modern materials in order to be able to present his designs within the framework of the new advanced materials, taking advantage of the possibilities offered by these materials.

In the following, we will shed light on some of these materials, as their use leads to a major qualitative leap in the production of creative design for new products.

Smart materials are one of the most important areas of scientific research at the present time, and they are materials that respond to the surrounding environment through accurate devices such as ultra-stray electronic chips, and these devices can monitor variables in the external environment such as temperature change or light intensity and are affected by them so that they shrink or expand to comply with these variables in the environment.

It can be used in the field of industrial design in the manufacture of artificial organs for humans, which are not rejected by the body and adapt to the rest of its members and are also used in the manufacture of aircraft, where they can perform the functions of diagnosing defects that appear and self-repair and thus reduce the cases of malfunction and damage in aircraft and this works to raise the efficiency of the industrial product.

To what it was before exposure to the shock and the first experiment was carried out in research laboratories on synthetic carbon fiber and is characterized by durability and light weight, but proved unreliable due to its sudden exposure to fracture.

Smart materials applications in the field of industrial design

Demonstrates the use of electrical reaction materials in the buttons of electronic devices (piezoelectric).

Figure 5

Demonstrates the application of shock-absorbing materials in car seats Materials affected by electromagnetism

Figure 6

One of the applications of this type of smart material is to use them as bumpers or as valves in control systems or in brakes, engagement systems and shock absorber

Thermochromic

This type of smart material when affected by heat changes color, (how to change the color from black to zero as a result of the effect on temperature.

Demonstrates the application of the properties of the electro electric materials for the self-operation of cooling fans.

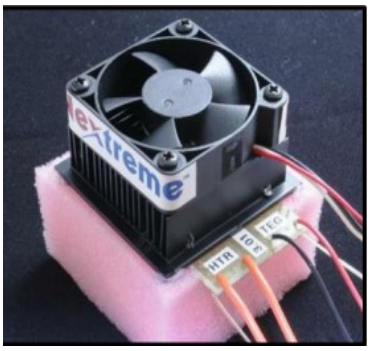

Figure 7

This type of raw materials is used in different technologies and applied in the commercial and military sectors, and this material includes the following applications: optics, Ideophone (water amplifier), Violating sector, depth probe, thickness gauges, flow detector, level indicators, alarm systems, strain gauges and fire positions for aircraft.

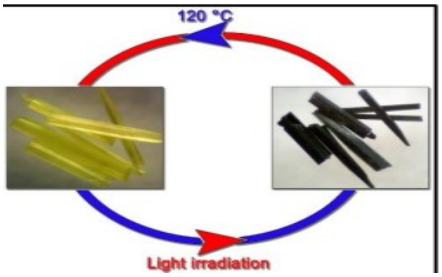

Figure 8

Summey

This text selection discusses the evolution of materials used throughout human history, leading to the development of smart materials in the modern era. Smart materials are defined as those that can sense environmental events, make operations based on acquired information, and influence their surroundings. They can change their shape and properties when exposed to external influences. Smart materials have various applications, such as space equipment, satellites, smart jobs, and building materials. They can be used in composites, packaging, fiber-optic cables, piezoelectric cells, and more. The features that differentiate smart materials from traditional materials include remote control capability, lightweight and durability, ease of replacement and installation, self-healing, ability to sense different types of energy, and adaptation to surrounding environmental conditions. The examples of smart materials mentioned in the text include ETFE material, smart packaging material, embedded fiber-optic cables, piezoelectric cells, optical fiber, liquid crystal technology, and more. Smart materials play a significant role in industrial design by improving the function, value, and appearance of products. Industrial designers need to be aware of the capabilities and limitations of different materials, including smart materials, to create innovative designs and enhance the industrial product's efficiency.

Funds

The author declares that there is no funder.

Conflict of Interest

There is no conflict of interest in the publication of this article.

Acknowledgements

The author thanks National Research Centre (Scopus affiliation ID 60014618), Textile Research and Technology Institute Giza, Egypt

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