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Use of Smart Material made an Industrial Revolution in Development of Automobile

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Abstract: *Smart materials have been in use since 1980's and they have found large number of applications in the field of automobiles, constructions, transport, medical and domestic areas. A smart material is one which reacts to its environment by itself. It has various types such as Shape Memory Alloys (SMA), piezoelectric materials, magnetostrictive materials, smart fluid (magneto and electro-rheological materials), chromic materials etc. This paper highlights the present development in application of Shape Memory Alloy's (SMA) and piezoelectric especially in automobile. The types of Shape Memory Alloys (SMA) like such as copper-aluminum-nickel and nickel-titanium (NiTi) are also explained in short with their use in automobile. Applications of SMA especially in automobiles (shock absorbers, engines, etc.) are shown along with robotics, and aerospace are also explained in details also applications of piezoelectric (e.g. Fuel indicator, sensors, etc.) in automobiles are also explained in details. It also covers the development of SMAs and its future scope as element of automobile parts. Emphasis is placed on study results by various authors. This study will be helpful to understand the applications of smart materials in Automobile as well as various engineering fields and its further development.*
Keywords: *Smart Materials, Piezoelectric Material, Shape Memory Material (SMA), Automobile.*

I. Introduction

Smart materials have been in use since 1980's and they have found large number of applications in the field of automobiles, constructions, transport, medical and domestic areas. smart material have been around for many years and they have found large number of application the use of the term smart and intelligent to describe materials and system came from the U.S and started in 1980s despite the factthat some of some of these so-called smart materials have been Around for years. A smart material is one which reacts to its environment by itself or something which is astute or operating as it by human intelligence. Smart materials are designed materials that have one or more properties that can be significantly changed in a controlled fashion by external stimuli, such as stress, temperature, moisture, pH, electric or magnetic fields. Otherkeywords related to smart material are such as shape memory material (SMM) and shape memory technology (SMT).In this paper we are specially focused on Shape Memory Alloy and piezoelectric materials-

SMA (Shape memory alloy):
A shape-memory alloy (SMA, smart metal, memory metal, memory alloy, muscle wire, smart alloy) is an alloy that "remembers" its original shape and that when deformed returns to its pre-deformed shape when heated.

Fig no 1.A Deformed spring regaining shape on application of heat by a lighter

This material is a lightweight, solid-state alternative to conventional actuators such as hydraulic, pneumatic, and motor-based systems. Shape-memory alloys have applications in industries including automotive, aerospace, and biomedical and robotic.

Shape memory alloy (SMA, also known as memory metal) is a metal that "remembers" its initial geometry during transformations. After a sample of SMA has been changed from its "original" conformation, it regains its original geometry during heating (one-way effect) or, at higher ambient temperatures, during unloading

(pseudo-elasticity or super-elasticity). These extraordinary properties are due to a temperature-dependent martensitic phase transformation from a low-symmetry to a highly symmetric crystallographic structure. (Those crystal structures are known as martensite and austenite.)Shape memory alloys (SMAs) are metallic alloys which can recover permanent strains when they are heated above a certain temperature. The key characteristic of all SMAs is the occurrence of a martensitic phase transformation.

Piezoelectrics:

Fig no 2. Piezoelectric Crystals

Piezoelectricity is the electric charge that accumulates in certain solid materials (such as crystals, certain ceramics, and biological matter such as bone, DNA and various proteins) in response to applied mechanical stress. The word piezoelectricity means electricity resulting from pressure. It is derived from the Greek piezo or piezein which means to squeeze or press, and electric or electron which means amber, an ancient source of electric charge. Piezoelectricity was discovered in 1880 by French physicists Jacques and Pierre Curie.

Mechanism of Piezoelectric:

Quartz , Rochelle salt , etc crystals have property that when certain mechanical pressure is applied to it they produce certain amount of electricity and when the crystal vibrates an electric current is produce through it ,in same way reverse of it is use to produce vibration of crystal to produce ultrasonic waves this both effects has many applications of it .

Nickel Titanium alloys:

The nickel-titanium alloys were first developed in 1962–1963 by the United States Naval Ordnance Laboratory and commercialized under the trade name Nitinol (an acronym for Nickel Titanium Naval Ordnance Laboratories). Their remarkable properties were discovered by accident. A sample that was bent out of shape many times was presented at a laboratory management meeting. One of the associate technical directors, Dr. David S. Muzzey, decided to see what would happen if the sample was subjected to heat and held his pipe lighter underneath it. To everyone's amazement the sample stretched back to its original shape.NiTi alloys change from austenite to martensite upon cooling.

Appilcations of SMA (Shape Memory Alloy)

In Leaf springs:

Fig 3. Application of Sma's in leaf springs.

In case of leaf springs shape memory alloys are used in composite materials. Here the shape memory alloys are used for regaining original properties of the leaf springs. The leaf springs are generally programmed to bear the high stresses and toughness and to prevent the passengers from shock. The leaf springs due to shock may sometimes deformed or broke down or may become loose so in order to regain its properties an sma is introduced in it, so that after heating it it may regain its original properties.

Inan actuators An actuator is one which is used in order to on or off a circuit (generally mechanical) the below figure explains the working of an actuator it consists of an sma wire one end attached to batteries and another to the hook which is used to open or close the box ,the box is also attached with the spring which tends

to open it the sma wire is made up of typical nitinol alloy, it has the tendency to contract on heating (Nitinol Wire Contracts 0.040 in per inch [1.016 mm] per inch)

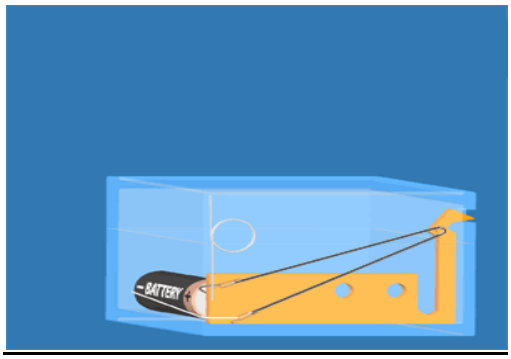

Fig no 4 Nitinol Wire used in actuators.

Application of Piezoelectric: Currently, industrial and manufacturing is the largest application market for piezoelectric devices, followed by the automotive industry. Strong demand also comes from medical instruments as well as information and telecommunications. The global demand for piezoelectric devices was valued at approximately US$14.8 billion in 2010. The largest material group for piezoelectric devices is piezocrystal, and piezopolymer is experiencing the fastest growth due to its low weight and small size.Piezoelectric crystals are now used in numerous ways:

Transducers as a sensor (in parking):

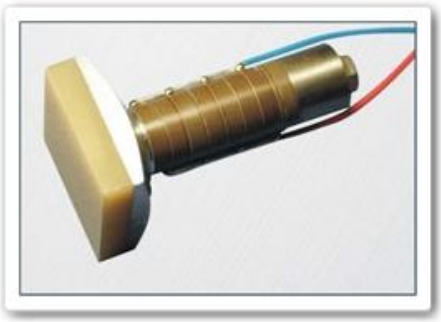

Fig No: 5 A Actuator.

A. In parking as well transducers are useful, the transducers as usual produces ultrasonic waves and while parking or when there is smog/smoke/fog in atmosphere this transducer gets signals when they are collapsed at defined range and reaches back to the transducer, this signals directly gives signals to the engines and the engine stops working and any damage or accident is prevented.

A. Fuel level indicator:

Fig no 6 Fuel level indication.

The sensor is installed at the bottom or top of the interior of the fuel tank. An electric current is sent to the piezoceramic/piezoelectric material, which responds to the current by oscillating. This then sends a sound wave into the liquid that returns to the transducer registering the current fuel level based on a ‘time of flight’

measurement. “But these aren’t ideal for high performance vehicles. There is a lot of movement within the tank and float-based sensors simply can’t deliver as accurate a reading as the ultrasonic equivalent.”

Piezoelectric car tyre:

In car tyres(piezoelectric) the piezoelectric chips are placed as shown in figure. When the tyres deform due to humps or uneven road surfaces the piezoelectric chips converts this mechanical force into electrical energy which is stored in the generator. And this energy can be used for various purposes.

***Robotics*:**

One of the biggest problems with robots simulating Human behavior is that they have difficulting with the simulation of our muscle and basic movements. Things like holding a pen or a pencil, feeling/touch, or just moving a finger are great challenges for Robotics.With Shape memory alloys work and simulate human muscle very well. When we heat a wire it bends down to regain its original shape and the spring is fitted in it which after cooling (or removal of heat) regains its original shape and thus movement is possible very easily than that of other complicated devices.

Smart wings:

The smart is a new technology that uses Shape memory alloys to Change the Shape of the Wing of a Plane to make it more maneuverable.This is done by simply sending an electric current throw the part of the plane to heat it to the desired temperature. This changes the shape of the wing making the Plane more maneuverable. This was previously done with a heavy Hydraulic system, thus significantly reducing the weight of the plane.

II. Development and Its Future Scope

From the above application it is clearly noticed that there is much development in SMA and piezoelectric materials its use to mankind has increase nowadays and it is essential to harness it. It can be well harness and became handy to human and used well. Advantages of SMA such bio-compatibility, Good mechanical properties, etc has taken SMA to the next level. Similarly advantages of piezoelectric material such as:. No wear and tear. No backlash or frictionetc. has taken Smart materials to the next level. Still more development is excepted in it as it has many limitations such as expensive to manufacture, fatigueproperties, etcfor SMA, and lower power production need of higher mechanical energy etc. in case of piezoelectric materials.So in order for **MANKIND** it is much necessary to develop these materials.

III. Conclusion

These "smart materials" are just starting to emerge from the laboratory, but soon you can expect to find them in everything from laptop computers to concrete bridges. SMA and Piezoelectric is an open door to modern technology **in automobiles.**

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