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DEVELOPMENT OF AUTOMOTIVE SIDE MIRROR ACTUATOR USING SHAPE MEMORY ALLOY (SMA) MATERIAL

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DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

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ABSTRACT

Shape Memory Alloy (SMA) is a metallic material that demonstrates the ability to return to some previously defined shape or size when subjected to the appropriate thermal procedures. The most use of SMA in the market is Nitinol due to its good electrical and mechanical properties. The unique behavior of SMA makes it suitable as an actuator .As an actuator, the shape memory component is design to exert force over a considerable range of motion, often for many cycles. SMA actuators nowadays are widely used especially in robotic field and medical field. In this generation of automotive industry, SMA has been studied for the changes of the former actuator such as motor. SMA probably can use in the automobile actuator in order to reduce the complex mechanism to more simple mechanism, less noise, less space. For example, automobile in the present mostly use motor actuator at their side mirror. SMA actuator could be changing that normal mechanism to a new one. According to the functional of SMA, it surely can be a new actuator to the car side mirror. The objective are, to create a new invention, although it will not guarantee the successive, but researches have been made for the best try. Many designs of SMA side mirror actuator have been made, and the best design is defined based on the value of advantages among all designs. From this project in making a new prototype of side mirror actuator, the results are very positive although there are some problems occur during fabrication. SMA wire can be the new actuator for the side mirror based on its own ability. Problems faced have been solved with the regenerative ideas on how to replace the SMA wire.

ABSTRAK

“Shape Memoy Alloy” (SMA) adalah bahan logam yang menunjukkan kemampuan untuk kembali ke bentuk atau saiz yang telah ditentukan apabila mengalami prosedur terma yang sesuai.Penggunaan sebahagian besar SMA di pasaran adalah Nitinol kerana sifatnya yang baik elektrik dan mekanik. Sifat unik SMA membuatnya sesuai sebagai penggerak(aktuator).Sebagai penggerak(aktuator), komponen SMA direka supaya menghasilkan kekuatan untuk bergerak dalam jarak yang besar dan kerap dalam kitaran yang banyak.. Pada masa kini,SMA aktuator banyak digunakan terutamanya dalam bidang robotik dan bidang perubatan. Dalam generasi automotif buat masa sekarang, SMA telah dipelajari untuk mengubah aktuator semasa seperti motor. SMA mungkin boleh digunakan dalam kereta aktuator untuk mengurangkan mekanisma kompleks kepada mekanisme yang kurang kompleks,kurang bising, dan kurang ruang digunakan. Sebagai contoh, kereta di masa sekarang, sebahagian besar menggunakan aktuator motor di cermin sisi mereka. Aktuator SMA boleh digunakan untuk menukar mekanisme normal kepada mekanisme yang baru. Berdasarkan fungsi SMA,ia pasti dapat menjadi aktuator baru pada cermin sisi kereta. Tujuannya adalah, untuk mencipta rekaan baru, walaupun ia belum menjamin keberkesanannya, tetapi kajian telah dibuat untuk mendapatkan hasil yang terbaik. Banyak rekaan aktuator cermin sisi kereta telah dibuat, dan rekaan terbaik akan ditentukan berdasarkan kelebihannya daripada yang lain. Daripada projek dalam penghasilan prototaip penggerak cermin sisi, hasilnya amat memberangsangkan berdasarkan sifat wayar SMA itu sendiri. Segala masalah yang dihadapai diselesaikan dengan mempelbagaikan idea-idea untuk meletakkan wayar SMA.

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURE

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.0 BACKGROUND

Nowadays automotive industries are moving to the more high technology and design. In term of mechanical behavior change to more electrical behavior for example, former steering car use normal rack and pinion system but now there are electrical power steering. The other example is former car use a normal system but now there are new systems which call drive by wire, the idea is to remove the mechanical linkages between the controls of a car and the devices that actually do the work. Instead of operating the steering and brakes directly, the controls would send commands to a central computer, which would instruct the car what to do. Same as side mirror, in the present many car manufacturers use a motor as an adjuster of the mirror. Now the technology is moving on and there is some idea to replace the motor adjuster or actuator to the shape memory alloy actuator. Shape memory alloy respond to temperature changes and mechanical stresses in non-conventional and highly amazing ways. They are therefore sometimes called smart or intelligent materials. Shape memory actuators have not yet penetrated the automotive market significantly. This is due in part to low market awareness about shape memory technology as well as little engineering data for the alloys. However, as the scientific and engineering communities come to understand the metallurgy and discuss it more openly. Shape memory components are becoming increasingly popular for automotive applications. The most important shape memory alloys are the near equiatomic Ni-Ti alloys, commonly known as Nitinol (from Nickel-Titanium Naval Ordnance Laboratory) and Tinel (Raychem brand name). Although there are other shape memory alloys only Ni-Ti alloys have proven themselves to be technically viable materials. I will study the new design and mechanism of shape memory alloy with the side mirror also test the performance on it. All of the purposes of these changes from this mechanical behavior to more electrical are to increase comfort, functionality and safety during the drive.

1.1 PROBLEM STATEMENT

To create a new actuator of existing car side mirror, from a motor adjustor to a shape memory alloy actuator. The goals are to reduce the maintenance, from complex component to more simple mechanism, and also supporting a future technology. From a mechanical technology to an electrical technology, due to the silent application, simple mechanism and less space needed.

1.2 OBJECTIVE

To design and develop car side mirror actuator using shape memory alloy material. To design a new mechanism of side mirror actuator using a shape memory alloy. Many ideas will be created in designing this new mechanism in term of comparing which one is the best for the actuator.

1.3 SCOPES

To study mechanical behavior of shape memory alloy (SMA) for actuator application. The study is included the conventional side mirror motor actuator and the new shape memory alloy actuator. The side mirror system chosen to be compare and analysis is the one that use two 12 volt motor such as Proton Wira, Proton Satria and ProtonGen2. To design and develop a prototype of car side mirror actuator using SMA material. In this case, a new side mirror actuator for a Proton Satria side mirror will be designed. To study the performance of the prototype. The performances that will study are about the how efficient it work, lifetimes of the prototype, how comfort it will deliver to us.

CHAPTER 2

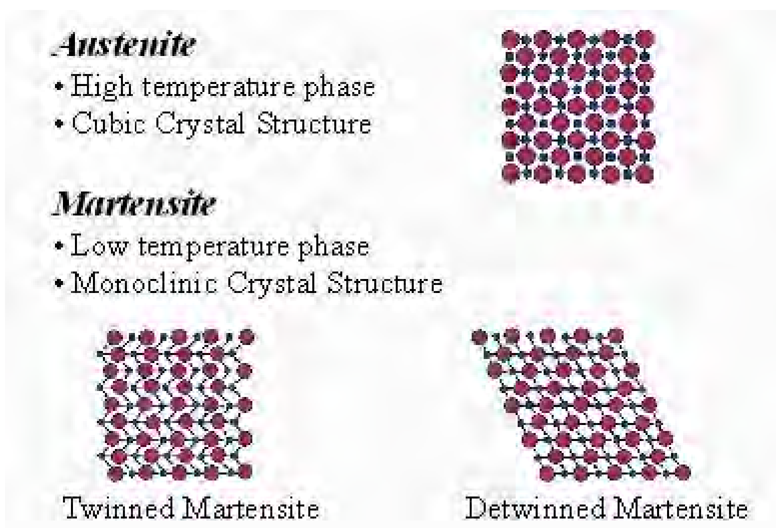
LITERATURE REVIEW

2.0 HISTORY OF SHAPE MEMORY ALLOY

First observations of shape memory behavior were in 1932 by the Swedish physicist Arne Olander in his study of rubber like effect in samples of gold and cadmium(Otsuka and Wayman 1998) and in 1938 by Greninger and Mooradian in their study of brass alloys (copper–zinc). Many years later in 1951 Chang and Read first reported the term shape recovery. They were also working on gold and cadmium alloys. In 1962 the U.S Naval Ordinance Laboratory William J. Buehler and his co workers discovered shape memory effect in an alloy of nickel and titanium(Lin 1996). He named it NiTiNOL (for nickel–titanium Naval Ordnance Laboratory).In 1966, the study of Nitinol's chemical properties and crystal structure commenced in Japan , resulting the discovery of a number of a new alloy that exhibited the SME (shape memory effect) as well as improvement in the manufacturing process on the NiTi alloy.The early 1970,there are some product that start use SMA.Most of these early application involved simple part using a onetime shape memory change, for example a pipe joint clamp. This product was the experimental artificial heart of Sawyer in 1971. The pump was electrically activated using pulse of current to heat the NiTi . By the late 70's the Delta Metal company in England proposed a several devices that operated more like a mechanical actuator such as a devices to automatically open and close greenhouse windows, control water pipe valves for the hot water heating of building and for use as automobile fan clutches. In the early 80's Japan also had a several commercial product available, such as a Matsushita Electric company of SMA controlled louvers in the air conditioners and Sharp's SMA controlled damper in electric oven.(Danny Grant, 1999)

2.1 INTRODUCTION TO SHAPE MEMORY ALLOYS

Shape memory alloys are a unique class of metal alloys that can recover apparent permanent strains when they are heated above a certain temperature. The shape memory alloys have two stable phases which in the high temperature phase, called austenite (named after English metallurgist William Chandler Austen) and in the low temperature phase, called martensite (named after German metallographer Adolf Martens).



(Osman Eser Ozbulut, 2007)

Shape Memory Alloys (SMA) is the materials which have the ability to return to its original shape when heated. The most common shape memory material is an alloy of nickel and titanium called Nitinol. This particular alloy has very good electrical and mechanical properties, long fatigue life, and high corrosion resistance. As an actuator, it is capable of up to 5% strain recovery and 50,000 psi restoration stress with many cycles. By example, a Nitinol wire 0.020 inches in diameter can lift as much as 16 pounds. Nitinol also has the resistance properties which enable it to be actuated electrically by heating. When an electric current is passed directly through the wire, it can generate enough heat to cause the phase transformation. In most cases, the transition temperature of the SMA is chosen such that room temperature is well below the transformation point of the material. In addition, Nitinol is an actuator, sensor, and heater all in one material.

Shape memory alloys, however, are not for all applications. We must know the forces, displacements, temperature conditions, and cycle rates required of a particular actuator. The advantages of Nitinol become clearer as the size of the application decreases. Large mechanisms may need solenoids, motors, and electromagnets, but in applications where such actuators cannot be used, shape memory alloys provide an excellent alternative. Nitinol is available in the form of wire, rod and bar stock, and thin film.

2.1.1 Shape Memory Alloy Phase

There are actually three different major phases of NiTi alloys which are the martensite, the austenite and the R-phase. The R-phase has a similar properties as the martensite phase, so it will be considers as identical to the martensite phase.The phase transition of the alloy are characterized by four transition temperature.There are, Martensite start temperature (Ms) which is the temperature at which the material starts transforming from austenite to martensite. Second is martensite finish temperature (Mf), at which the transformation is complete and material becomes fully in the martensite phase.At the reversible transformation. Austenite start temperature (As) is the temperature at which the reverse transformation starts and austenite finish temperature (Af) at which the reverse transformation is finished and the material is in the austenite phase.

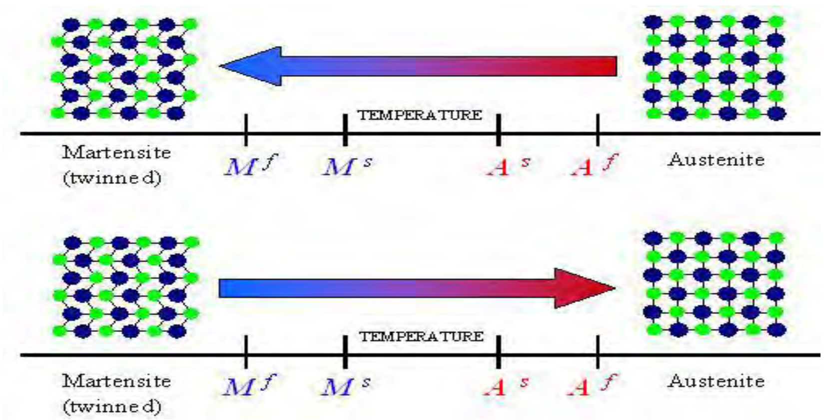


Figure 2.0: Shape memory alloy phase

(Danny Grant, 1999)

2.1.2 One Way Memory Effect

An alloy, which is in a state of self accommodated martensite, is deformed by applying mechanical load and then unloaded, remains deformed. The alloy is then reheated to a temperature above the austenite finish temperature, it recovers original macroscopic shape. This is so called one way memory effect (see Figure 2.1).

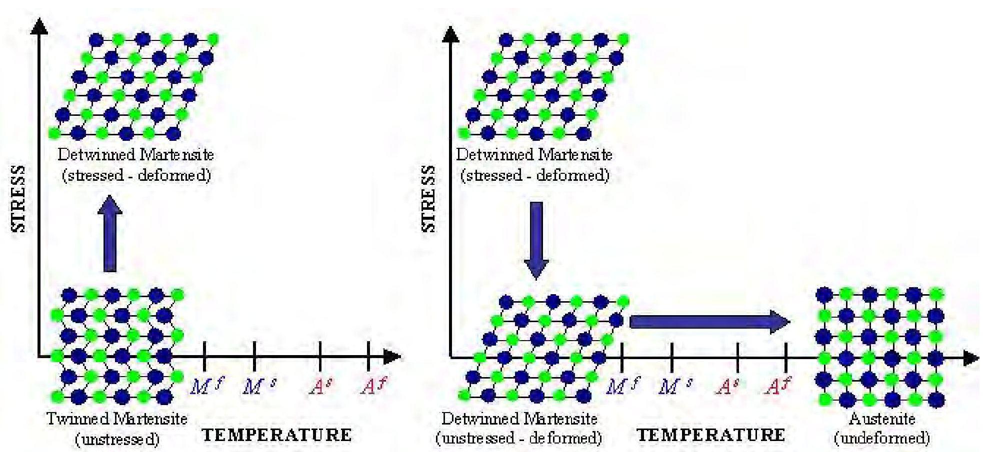


Figure 2.1: One way effect of Nitinol

(Prof. Ferdinando Auricchio, 2007)

2.1.3 Two Way Memory Effect

In one way memory effect there is only one shape “remembered” by the alloy. That is the parent phase shape. Shape memory alloys can be processed to remember both hot and cold shapes. They can be cycled between two different shapes without the need of external stress.

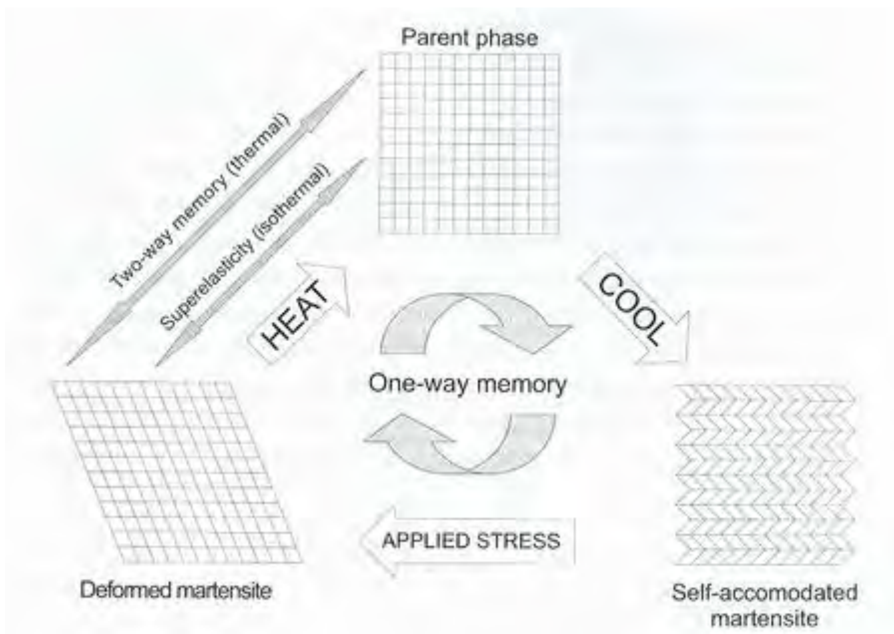


Figure 2.2: two ways effect of Nitinol
(Prof. Ferdinando Auricchio, 2007)

2.1.4 Physical Properties of Nitinol

Table 2.0: Physical properties of Nitinol
(Andrea Falvo, 2005)

Density:	6.45 g/cm3
Melting Temperature:	1240-1310° C
Specific heat capacity	470-620 J/kgK
Enthalphy of transformation	19.0-28.0 J/kg
Corrosion performance	excellent

2.1.5 Mechanical Properties of Nitinol

Table 2.1: Mechanical properties of Nitinol
(Andrea Falvo, 2005)

	Austenite	Martensite
Young's modulus	30-83 GPa	20-45 GPa
Ultimate Tensile Strength	800-1900 MPa	800-1900 MPa
Elongation at Failure	20-25%	20-25%
Recoverable strain	8-10 %	8-10%
Poisson Ratio	0.33	0.33

2.1.6 Setting Shapes In Niti

The use of a NiTi shape memory or superelastic element for a particular application generally requires the setting of a custom shape in a piece of NiTi. The process required to set the shape is similar whether beginning with NiTi in the form of wire, ribbon, strip, sheet, tubing, or bar. Shape setting is accomplished by constraining