IARJSET

ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue 11, November 2021

DOI: 10.17148/IARJSET.2021.81129

A Review of Shape Memory Alloy Fabrication

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Abstract: A shape memory alloy (SMA) is important topics that deal with material which regain to its original position when heat is applied on the material (1). The thermo mechanical and shape memory response were compared to the conventional. The part made of SWA will be light weight solid state alternative to conventional actuator such as hydraulic, pneumatic and motor base system. They can also be used to make hermetic joint in metal tubing. The shape memory response in compression was measured for stresses and transformation strain we found to be very compactly. The fundamental fabrication processes and problem in making shape memory alloy such as melting, heat working, cold working, annealing and heat treatment are described in this paper.

Keywords: Shape memory Alloy, Smart metal, Super elastic, Transformer Temperature, Thermo Mechanical Properties

I INTRODUCTION

Material which are capable of regain and withstanding large strain lacking of inflexible plastic deformation and remember the last configuration to reclaim the principle shape with varying temperature are class of smart material specified as shape memory alloy (4). Among several SMA Nickel – Titanium alloy are popular in medical and industrial, cellular phone, sensor, actuator, coupling, and helicopter rotor, etc. The ratio of titanium to the Nickel in the Ni-Ti alloy has a significant influence on transformation temperature. Nickel titanium based high temperature shape memory alloy are designed to operate at temperature above 100°C which especially enable their application in aerospace, automotive, oil and many other industries. These properties also place them as the center of studies in the field of material for the various research on the globe. The market is occupied by Ni-Ti alloys-based shape memory products in the markets. One chief reason for this is the excellent mechanical and electrical properties besides high fatigue life and high corrosion resistance possessed by Nitinol. Two very important factor that derive the manufacturing technology are better quality and reduced cost. Shape memory alloy are high desirable in today industrial requirement which generally demands high dimensional and finished surface and finished product at a nominal cost. Low machining cost in always preferable which can be achieve by increasing (MMR) material removal rate and perfect tool life this holds great importance from an economic point view (2). The opportunity and possibility for researches to explore and establish new findings in the domain of the non-conventional machining of SMA's is bought out.

II MATERIAL

2.Types of Shape Memory Alloy

SMAs having limitation like constraints on the extend of deformation operating temperature constraint, high manufacturing cost and low bandwidth, this forces the researches to explore some other types of SMMs

2.1 High Temperature Shape Memory Alloys

HTSMA are being focused extensively for the research purpose practically, HTSMAs can be defined as those SMAs which operate at temperature above 100°C. They can be classified into three groups and classified based on martensitic transformation ranges. At ambient temperature, HTSMA possesses poor fatigue resistance and limited ductility which makes it exceedingly difficult to process them further this makes HTSMAs expensive alloys to manufacture (2).

2.2 Magnetic Shape Memory Alloys

These alloys can be actuated (up to 1KHz) at higher frequencies. Actuation energy causes this actuation which is transmitted by magnetic fields which is not obstructed by the relatively shows mechanism of heat transfer. The strain rate possessed by piezoelectrical and magneto-strictive active element has matched with the FSMAs strain rate. FSMAs has

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the capacity of provided by SMAs. FSMAs have maximum strain which is approximately 32 times greater than the magneto-strictive Terfenol-D.

2.3 Shape Memory Material Thin Film

SMMs are made to deposited directly onto the micro material. Thin film shape memory alloy is a promising material for use in microscale drive for actuation and sensing due to their strong actuating force. Substantial distance and large surface to volume ratio. Ni-Ti in particular has been of great interest due to its bio compatibly and corrosive resistance. Effort has been directed towards adjusting the microstructure of as deposited films in order to modify their shape memory properties for specific application.

2.4 Shape Memory Polymers

Shape memory polymer is relatively easier. SMP is alternative source of low cost almost 10% cheaper. SMPs are biodegradable, and better efficiency and superior to in terms of mechanical properties. SME has three working mechanisms in polymeric material. Dual component mechanism (DCM). Partial transition mechanism (PTM) and Dual state mechanism. The almost 100% recovery precision of SMPs make it suitable for engineering application which are high in demand. SMPs have many advantages because of their biodegradable nature and hence SMPs offer more effective treatments.

III EFFECT OF SHAPE MEMORY ALLOY

3. Effects of Shape Memory Alloy

There are two types of temperature involves during transformation they are austenite start temperature (As) and the austenite finish temperature (Af) and then martensite starts temperature (Ms) and the martensite finish temperature (Mf). Md is the termed as the highest temperature at which no further stresses can be induced into martensite and above thin peak temperature on SMA starts deforming to the plastic deformation stage like other metallic materials.

3.1. OWSME (One Way Shape Memory Effect)

When external load is given in one way it will undergoes to deformation and it will regain to its original position when heat is given upon it.

3.2 Reversible or TWSME (Two Way Shape Memory Effect)

Two Shape Memory effect is also known as reversible shape memory alloy has the tendency to regain to its original shape at both minimum and high temperature is consider as two-way shape memory effect.

3.3 Super elasticity (SE) or pseudo elasticity (PE)

The original shape of an SMA is retain by loading the SMA component mechanically at a temperature within Af and Md. Then the shape change effect is termed as super elasticity at macroscopic level besides the material of TWAME as mentioned as a one-way shape memory alloy actuator acts as a mechanical TWSME which is more powerful, reliable and used extensively in many engineering fields.

IV MANUFACTURING

4.1 Melting and Casting of SMA

Fabrication of memory alloy is as complicated as their machining. We know that copper, gold, iron and zinc alloy based SMAs are available. Nonetheless iron based SMAs are more popular (4). Here in technical casting for Ti-Ni alloy is usually carried out using vacuum induction melting (vacuum high frequency dissolution furnace) VIM or (Vacuum arc remelting consumable electrode type vacuum electrode type vacuum arc casting) VAR or combination of both (1). The prescribe material for the crucible is carbon (graphite) or calico (Cao). Carbon crucible are cheap and good life and under adequate melting condition oxygen impurity is negligible and the carbon content can be kept to less than 0.5% (1). Not only vacuum melting but also other methods like which can be adopted to manufacture SMA are plasma melting and electron melting. Electro Magnetic induction is the standard on which vacuum induction melting works in these processes electrical eddy current is induced in the metallic charges and the graphite crucible. By using electromagnetic force, the melt is stirred and mixed together. Electro graphite crucible is used in SMA to achieve low carbon concentration. In

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plasma melting method low viscosity electron beam comes out from hollow plasma cathode. The leading advantage of extended by this method is desperate elastic depression in the lose of the alloy element.

4.2 Hot Working

Cold working of Ti-Ni alloy is low so hot working is regular employed for sizeable deformation. Casting create a heterogenous composites in the same way as in a normal metal. Hot working are hot rolling and hot forging, causes dynamic recrystallization. The strength of Ti-Ni alloy being decreasing temperature above 700K. So, workability in hot temperature is much better than at cold **temperature.**

4.3 Cold Working

Ti-Ni is an intermetallic compound cold workability is not good and there are many difficult with using these processes of fabrication. In cold working processes it is compulsory to Ti-Ni is high this makes the low in workability worse. The shape memory and super elastic behavior of the alloy also produce complication science even if the material is deformed it will revert to its original position.

4.4 Annealing

After coldworking annealing is common bear out in an air atmosphere, but to avoid oxidation is necessary to annealing to anneal Ti-Ni alloys in vacuum or an inert gas atmosphere, such as Ar or N_2 embrittlement cooling can be done with water or air although air cooling is desirable.

4.5 Heat Treatment

Development properties of NiTi sample can be fulfill by cold working of the sample elastic nitinol. Heat treatment in taken out at 500°C in the of SMA. The heat treatment is carried out in between 350°C to 450°C (2). Low heat treatment is done out after annealing and forming into the recommended shape and taken place at 200°C to 300°C. This method is extensively used for manufacturing eye glass frame and to mold and alloy after complete annealing (4).

IV APPLICATION

Shape memory alloy has different application. Shape Memory alloy plays a major role in automobile industry. It also used in electric generator to exhaust heat to generate electricity. Smart alloy has various of use in automobile value, mini actuator, sensors, actuator, it is also used to reduce noise in solenoid. It has its higher priority where application demand to minimize the efficiency by to decrease weight. It is also used in biomedical field slow response time, low efficiency small strain output large hysteresis. It is also used in civil engineering application for intelligent reinforce concrete (IRC) which is wires embedded with the concrete. Shape memory alloy also used to break bone cases also.

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