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S.M.A. Molding

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***Abstract*— Shape Memory alloys are a material which remembers its original shape during change in temperature. Introducing of molding by using Shape Memory Alloy surely provides a wide opening for large scale molding in limited period and cost. The only external labor is the loading and unloading of material since the rest of the process occurs automatically. Shape Memory Alloys are the alloys which change its shape from its original shape to new shape and while heating or cooling it will return to its original shape. The objective of this project is to introduce a new molding technique which can be operated simply and can be introduced worldwide in industries for molding operations in large scale. In SMA the shape recovery process occurs not at a single temperature, rather it occurs over a range of temperature, called as the transformation temperature. For the proper process one should choose a SMA of high memory strain and temperature range which co-matches with the molding material properties. A two-way SMA is advisable in this molding process, which produces spontaneous and reversible deformation just upon heating and cooling even without load. Initially at the lower temperature, the SMA will be at matensitic phase. When the molten material is been poured into the SMA, the temperature raises over the transformation temperature. Thus the phase change occurs from martensitic phase to austenite phase. Now the pre-determined shape is been achieved by the SMA material. Then molten material is allowed to cool and solidify. At complete solidification the temperature comes down to the transformation temperature, unwrapping the molded material. Now the initial martensitic phase is achieved.**

***Index Terms*—Austenite, Martensite, Molding, Two Way S.M.A.**

I. INTRODUCTION

Molding of metals is a prolonged and time taking process which uses a large number of labors for doing the work. The major benefit of molding is the increased strength and life of a material which is molded. But now a day's many industries try to eliminate the molding process due to the time and labor that have to be used. But still when it comes to quality and strength the molding is suggested to be the best. So for this we introduce a new and innovative technique called the S.M.A Molding which decreases the labor and time of molding. This is a simple and practical concept which allows the easy and high quality molding possible.

Shape Memory alloys is a material which remembers its original shape during change in temperature. These alloys change its shape from its original to new and while heating or cooling it will return to its original shape. The objective of this project is to introduce a new molding technique which can be operated simply and can be introduced worldwide in industries for molding operations in large scale.

In SMA the shape recovery process occurs not at a single temperature rather its occurs over a range of temperature, called as the transformation temperature. For the proper process one should choose a SMA of high memory strain and temperature range which co-matches with the molding material properties.

A two-way SMA is advisable in this molding process, which produces spontaneous and reversible deformation just upon heating and cooling even without load. Initially at the lower temperature, the SMA will be at matensitic phase.

When the molten material is been poured into the SMA, the temperature raises over the transformation temperature. Thus the phase change occurs from martensitic phase to austenite phase. Now the pre-determined shape is been achieved by the SMA material. Then molten material is allowed to cool and solidify.

At complete solidification the temperature comes down then the transformation temperature, unwrapping the molded material. Now the initial martensitic phase is achieved. Introducing of molding by using Shape Memory Alloy surely provides a wide opening for large scale molding in limited period and cost. The only external labor is the loading and unloading of material since the rest of the process occurs automatically. Thus it becomes the best and most suitable method, which can be introduced in the large scale molding operations in the industries.

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STUDY OF SUBJECT

SHAPE MEMORY ALLOYS

The shape memory effect is the ability of some alloys to remember, and return to, the form which they had at one temperature after being plastically deformed at a lower temperature. This property can be exploited in many ways and devices based on it are being developed in fields as far apart as astronautics and medicine.

In order for an alloy to have the shape memory property it must undergo a martensitic transition; one in which relatively small displacements (slips) between atomic planes lead to an abrupt change in the crystallographic structure at a certain temperature.

The alloy is formed at a temperature above that of the transition and deformed below it. The memory arises because residual stresses introduced when forming, influence which slips occur in the martensitic transformation, and hence which variants of the martensitic phase are present at the lower temperature.

The low absorption of neutrons by these alloys, makes them an almost ideal probe with which to view the martensitic transformation on a microscopic scale, and allows the evolution of the different martensite variants to be followed as the temperature is varied.

The combination of shape memory with ferromagnetism vastly increases the range of applications. Magnetic fields can also influence the phase transition and the possibility of controlling shape memory properties by a magnetic field is currently receiving much attention.

The Heusler alloy is one of the rare ferromagnetic shape memory alloys. It undergoes a martensitic transition from the cubic Heusler structure to a tetragonal variant at a temperature around 200 K.

Neutron diffraction experiments have been carried out on single crystals by using the 4-circle diffractometer (d9). On this instrument a small position sensitive detector records the scattered neutrons. At 235 K, above the transition, neutrons are scattered into a single compact peak, the 220 reflection of the cubic phase.

At 206 K the martensitic transformation is under way, the originally single peak has broken up into seven smaller peaks, and each corresponds to a different martensite variant. On further cooling to two of the variants grow at the expense of the others so that at 200K there are just two peaks in the pattern. On reheating the process is reversed and the original cubic single crystal restored.

The low temperature phase is weaker, allowing the material to be bent and pulled out of shape. When deformed at a low temperature and then heated, nitinol will return to the shape established when in the high temperature, stronger phase. By heating the material, the atoms are given enough energy to rearrange themselves back to their high temperature phase.

The composition of the wire can be varied slightly to change the transformation temperature. This ability to remember and revert to the original shape gives this material the name “shape memory”.

Nitinol is an ordered inter-metallic compound. This means that the atoms have very specific locations in the crystal structure. Nitinol is a popular choice for a variety of applications: as a material in temperature control systems, retractable antennas in cell phones, springs in orthodontic braces, and for eyeglass frames! See the Introductory Presentation for examples of real-world applications of shape memory alloys.

IMPORTANT TERMINOLOGY

To know and understand the working of Shape Memory Alloy we should posses some basic knowledge about it. The basic terminologies used are:-

Phase: - Phase is the region of a material that is chemically uniform, physically distinct and usually mechanically separable by applying of force

Phase change: - Phase change is the change from one phase to another which is often caused by a change in temperature in the system.

Thermal shape memory: - Thermal shape memory is the ability of a material to remember its original, cold-forged shape and return to it when heated

Alloy: - Alloy is a metal containing two or more elements combined together as one. Alloys may or may not have resemblance of properties of its parent metals.

Nanoscale: - Nanoscale measuring deals with objects that are smaller than 1/10 of a micrometer.

Macroscale: - Macroscale is the measuring that deals with objects that have size features measurable and observable with the naked eye.

Crystal structure: - Crystal structure is the unique and orderly arrangement of atoms or molecules in a crystalline solid.

Two Way S.M.A:- A two way S.M.A is the one which remembers both its shape at its various temperatures.

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PROPOSED METHODOLOGY

PRINCIPLE USED

Shape Memory Alloys (SMA) is the alloy which changes its shape from its original shape to new shape and while heating or cooling it will return to its original shape.

In this technique we use a Two Way S.M.A for the proper and easy function of the molding possible. The Two Way S.M.A is the type of material which produces spontaneous and reversible deformation just upon heating and cooling even without load.

STAGES OF SHAPE MEMORY ALLOY MOLDING

S.M.A Molding is a five stage process which allows the most effective and economical molding possible. They are:

STAGE 01 : Initial Martensite Phase
STAGE 02 : Introduction of Molten Metal
STAGE 03 : Transformation is starting
STAGE 04 : Transformation is completed
STAGE 05 : S.M.A unwrapping

The only work of a labor is in the introduction of molten material and collection of molded body.

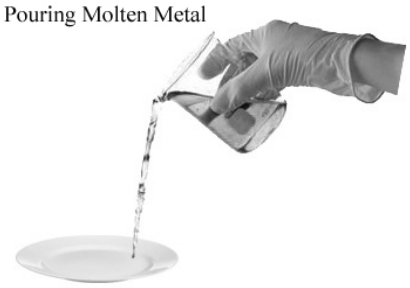
STAGE 01 : Initial Martensite Phase

In the initial phase the material is set to a defined shape as needed. Mostly an open shape is advised which allows equal distribution of liquid metal.

In the Martensite phase the initial temperature will be equal to that of the room temperature.

STAGE 02 : Introduction of Molten Metal

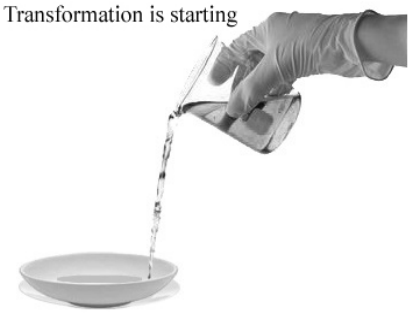
The introduction of molten metal to the S.M.A is done here. The molten metal of high temperature is poured to the S.M.A. which posses a particular the shape at the Matensite phase.



The change in temperature occurs in the system when molten metal is poured into the S.M.A. One should only pour the molten metal slowly, so that the distribution is made without capture of any air bubble inside.

STAGE 03 : Transformation is starting

The Transformation occurs in this third stage, when the introduction of the molten metal is made in the system. The temperature difference makes the Phase change occur.



In this stage Martensite phase is able to change its shape from the initial defined shape to the final defined shape.

STAGE 04 : Transformation is completed

The complete transformation of S.M.A from the initial shape to the desired final shape takes place within minute of introduction of the molten material.

The liquid metal occupies the shape of the container at which it is introduced. Then the metal is allowed to cool and solidify. Additional artificial cooling methods are advised for fast solidification of metal.

STAGE 05 : S.M.A unwraps releasing the Molded Metal.

After sufficient time, the metal cools down and solidifies normally. Now when it crosses the range of transformation temperature shape deformation takes place.

Now the decrease in the temperature results in the change of phase from the Austenite to the Martensite.

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CONCLUSION

Introducing of molding by using Shape Memory Alloy surely provides a wide opening for large scale molding in limited period and cost. The only external labor is the loading and unloading of material since the rest of the process occurs automatically. This introduces a new molding technique which can be operated simply and can be introduced worldwide in industries for molding operations in large scale.

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