Effect of Shape Memory Alloy and Analysis of Nitinol Wire

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Abstract— The abstract is about the parameter that affect power output of nitinol heat engine and the phase transformation characteristics of nitinol wire. And there results shows that how temperature of bath has a impact on the power output. There are many publications which concentrate on the thermal and mechanical effects on the transformation behavior of NiTi SMA. However, the study of different parameters study of SMA is still limited till date.

Key words: Waste Heat Recovery, Waste Heat Recovery Technique, Nitinol, Shape Memory Effect, Heat Engine

I. Introduction

A. *What is Shape Memory Effect of Nitinol?*

Shape memory is the ability of Nitinol to undergo deformation at one temperature, then recover its original shape upon heating above its transformation temperature. At high temperatures, Nitinol assumes to be simple cubic structure as austenite and at low temperature Nitinol spontaneously transforms to a more complicated monoclinic crystal structure known as martensite.

II. Properties of Nitinol

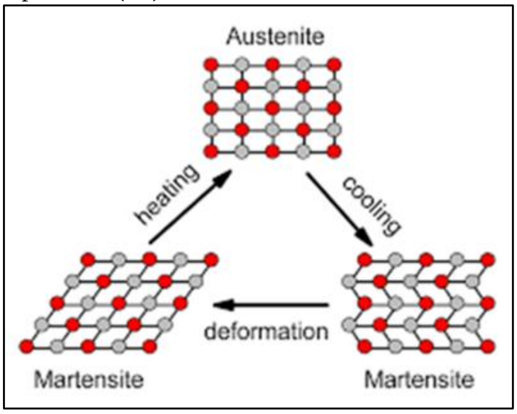
Nitinol alloys exhibit two closely related and unique properties shape memory effect (SME) and super elasticity (SE) also called pseudo elasticity (PE). Shape memory is the ability of nitinol to undergo deformation at one temperature, then recover its original, un-deformed shape upon heating above its "transformation temperature". Super elasticity occurs at an arrow temperature range just above its transformation temperature; in this case, no heating is necessary to cause the un-deformed shape to recover, and the material exhibits enormous elasticity, some 10-30 times that of ordinary metal.

A. *Shape memory effect*

“Shape memory” describes the effect of restoring the original shape of a plastically deformed sample by heating it. This phenomenon results from a crystalline phase change known as “thermoelastic martensitic transformation”. At temperatures below the transformation temperature, shape memory alloys are martensite is soft and can be deformed quite easily by de-twinning. Heating above the transformation temperature recovers the original shape and converts the material to its high strength, austenite, and condition.

There are four transition temperatures associated to the austenite-to-martensite and martensite-to-austenite transformations.

- Starting from full austenite, martensite begins to form as the alloy is cooled thus it’s called martensite start temperature (Ms).
- The temperature at which the transformation is complete is called the martensite finish temperature (Mf).
- When the alloy is fully martensite and is subjected to heating, austenite starts to form at the austenite start temperature. As, and finishes at the austenite finish temperature (Af).



III. Review of Literature

A. *JARONIE MOHD JANI, MARTIN LEARY, ALEKSANDAR SUBIC, MARK A. GIBSON:*

This work describes the attributes of SMAs that make them ideally suited to actuators in various applications, and addresses their associated limitations to clarify the design challenges faced by SMA developers. This work provides a timely review of recent SMA research and commercial applications, with over 100 state of the art patents which are categories against relevant commercial domains and rated according to design objectives of relevance to these domains. Although this work presents an extensive review of SMAs, other categories of SMMs are also discussed including a historical over view, summary of recent advances and new application opportunities.

B. *CHARLES J. BURSTONE:*

In this research A Chinese Nitinol wire was studied by means of a bending test to determine wire stiffness, spring back, and maximum bending moments. Chinese Nitinol wire has an unusual deactivation curve (unlike steel and nitinol wires) in which relatively constant forces are produced over along range of action. The characteristic flexural stiffness of Nitinol wire is determined by the amount of activation. Result shows that at large

Activations Nitinol wires has a stiffness of only 7% that of ac comparable stainless steel wire, and at small activations 28% of steel wire. For the same activation at large deflections, the forces produced are 38% more. Chinese Nitinol wire demonstrates phenomenal spring back. It can be deflected 1.8 times as far as nitinol wire or 4.4 times as far as stainless

IV. Aim and Objective

- The main aim of this project is to recover the energy from low grade heat energy sources.

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- Thus focusing on design and development of a prime mover which can convert the low grade heat energy into the mechanical work.
- To achieve this phenomena Nitinol material is used to make a prime mover for this work.

V. COMPONENTS:

- Nitinol Wire
- Light Weight Pulley
- Stand
- Heater and Temperature controller
- Tachometer
- Opening mechanism

VI. EXPERIMENTAL SETUP

VII. SPECIFICATION

Material	NiTi55(Nickle:-55%,Titanium:-45%
Diameter	0.96 mm
Length	2 m

VIII. TEMPERATURE VS RPM

TEMPERATURE	RPM
60	200
65	265
70	340
75	380
80	420

IX. RESULTS AND DISCUSSION

In this study power which is generated with the help of the prime mover system is calculated from the RPM and the Torque developed at the output shaft of the system. Result shows that power which is generated during the experimentation is dependent on the temperature of the hot source. Thus, as temperature of the hot source changes the power at the output will be change. It somewhere also depends upon the parameter like Nitinol wire diameter, driving and driven pulley diameter, center distance between shafts which leads to affect the overall efficiency of the system.

Here, system efficiency is directly depending on the different

parameters hence different combinations of the parameter should be considered and then hole experiment should be done again. Instead of doing this long procedure DOE software is used to get the combination of parameter where maximum efficiency of the system can be achieved. After this validation and changing the parameter of the system experiment should be repeated and result is compared with previous results.

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