INVESTIGATION ON THERMAL BEHAVIOR OF NITINOL BASED ACTUATING ELEMENTS FOR BIOMEDICAL APPLICATIONS

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DECLARATION

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Name of Supervisor : Dr. Y.W.R. Amarasinghe

Abstract

In modern material world, important consideration is given to the group of fascinating materials called shape memory materials (SMMs) which respond quickly to a definite change of heat, light and chemical. The shape memory materials that have been established to date are shape memory alloys (SMA), shape memory polymers (SMPs) and shape memory hybrids (SMH). SMA play a significant role in various applications such as sensors, actuators, clamping devices, etc. Nickel – titanium (NiTiNOL) alloys are heavily used in SMA due to their strain recovery, excellent thermal characteristics, reliability and commercial availability, in addition to being used in macro and micro electro mechanical systems based biomedical applications (BMA) due to high biocompatibility, resistance to corrosion and high fatigue limit.

Previous researches have focused on developing integration between thermal stability and SMA microstructure. But they don't have enough thermal behavior data with different heat treatment temperatures. Although phase transformation temperatures and microstructure patterns with different heat treatment temperatures are unique characteristics of NiTiNOL. The aim of this study is to investigate NiTiNOL characteristics and thermal behavior of SMA based actuating elements for biomedical applications. The overall objective of this research study is to investigate the phase transformation temperatures for NiTiNOL alloy during different heat treatment temperatures and to propose the appropriate geometric shape of the actuating element in BMAs.

Therefore, a number of experiments were done at the laboratory level to characterize the thermal related behavior of the NiTiNOL alloy. Differential scanning calorimetry test measurements are used in this study to analyze the dissimilarities in phase transformation temperatures and properties of NiTiNOL (Ni-54 and Ti-46, weight percentages) alloy due to the variation of heat treatment temperature ranging from 400 °C to 600 °C. Further, microstructure and Energy – dispersive X-ray are determined using Scanning Electron Microscopy. It is found that most critical phase transformations are taken place between heat treatment temperatures of 550 °C and 600 °C and extraordinary unique behavior of phase transformations are exhibited by the respective specimens subjected to these temperatures. Further it is found that thermal behavior of actuator elements is dominated by the changes incurred in the microstructure of the NiTiNOL alloy during heat treatment.

Keywords: NiTi materials, Mechanical behavior, Transformation temperature

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M_f	: Martensite start
M_s	: Martensite finish
A_s	: Austenite starts
A_f	: Austenite finish
R_s	: R – Phase start
R_f	: R – Phase finish
B2	: Austenite (cubic)
B2’	: R – Phase (rhomohedral)
B19	: Orthorhombic
B19’	: Martensite (monoclinic)
HTT	: Heat Treatment Temperature
TT	: Transition Temperature
DSC	: Differential Scanning Calorimetry
OM	: Optical Microscopy
SEM	: Scanning Electron Microscopy
EDX/EDS	: Energy – dispersive X-ray
BMA	: Biomedical Applications
MIS	: Minimally Invasive Surgery