ANALYSIS OF SMA (SHAPE MEMORY ALLOYS) AS A FEASIBLE TENDON MATERIAL FOR INFUSED BIONIC ARM

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ABSTRACT

The bionic arm has the history of the wood and metal materials to smart material. When the bionic arm started to use in the real it's very helpful to the people to handle the things in their life, when it comes to pervious technology to present technology the arm has undergone many changes like shape and this project is aimed at the main consideration of the reducing weight of the arm and accurate controlling. Bionic arm which is developing from the servo motors to smart material which gives the benefits of using it for the life cycles which doesn't get damage of materials. By using smart material also reduces the weight of the arm. In this project aims to the analysis of the tendon material and heat effect on the Cladder. This bionic arm as the measurement consideration of the anthropometric of a human arm on basis of age and gender. Using the anthropometric for Ansys to get accurate results for the prosthetic bionic arm. This improves the efficiency of the bionic arm. In this project aimed to do "analysis of SMA (shape memory Alloys) as a feasible tendon material for infused bionic arm". When use the smart materials it produces the heat which will be identified by analysis of transient and fatigue to ensure that heat produced by SMA should with-stand by the material.
Key words: *shape memory alloy, tendon, bionic arm, anthropometric, transient, Fatigue.*

1. INTRODUCTION

1.1 Bionic

Bionics is a field that analyzes biological principles and systems to apply this knowledge to the creation of engineering systems. The word: "bionics" drive from the combination of two words: the "bio" of biology and "onics" of electronics.

A large focus of this field is on human bionics the creation of electromechanical devices that interact with the human body to replace or restore bodily functions through engineering, the idea is to create a seamless integration between human thought, generated in the brain, and movement, generated by an externally created mechanical device.

In this field of design, there are several different methodologies currently used to achieve communication with the brain: some researchers focus on implanting electrodes in the brain or scalp, while others experiment with detectors outside of the body. The brain generates a command signal that is transmitted through the nerves to sensors that measure the electric impulses, and then to a computer that analyzes these impulses. This data is then transmitted to mechanical prostheses—hands, arms, and legs—that move according to the impulses generated by the brain. An example of the use of this technology is a prosthetic arm that sends electronic signals directly to the nerve endings of the residual limb to restore mechanical functions of above-elbow amputees [1].

1.2 Prosthesis

Prosthesis, artificial substitute for a missing part of the body. The artificial parts that are most thought of as prostheses is those that replace lost arms and legs, but bone, artery, and heart valve replacements are common and artificial eyes and teeth are also correctly termed prostheses. The term is sometimes extended to cover such things as eyeglasses and hearing aids, which improve the functioning of a part. The medical specialty that deals with prostheses is called prosthetics. The origin of prosthetics as a science is attributed to the 16th-century French surgeon Ambroise Paré. Later workers developed upper-extremity replacements, including metal hands made either in one piece or with movable parts. The solid metal hand of the 16th and 17th centuries later gave way in great measure to a single hook or a leather-covered, nonfunctioning hand attached to the forearm by a leather or wooden shell. Improvements in the design of prostheses and increased acceptance of their use have accompanied major wars. New lightweight materials and better mechanical joints were introduced after World Wars I and II [3].

Figure 1:Prothesis [31]

1.3 Bionic Arm

A bionic arm is an electromechanical device that attaches to the human body and attempts to replicate the functionality of a natural arm or hand. It always consists of a bionic hand or partial hand and, depending on the level of amputation, may also include a powered wrist, elbow, and/or shoulder. Bionic and Prosthetic technology connect the mind to the prosthesis through sensors that detect muscles' electrical signals and translate those contractions and signals to various movements. They help improve sensation, integration with the body, and control. Bionic arms attach to the body via a customized compression cup with sensors that contact the skin.

Bionic arms go a step beyond traditional designs that use body-powered harnesses to move muscles, such as shrugging the shoulders to open and close a prosthetic hand. Bionic arms improve upon technology that previously required users to retrain their muscles to perform actions. Bionic prosthetics technology has become more intuitive because it can pick up specific electrical impulses from muscles and translate them to actions such as grasping motions. Movements are tied to the actual muscles that would have performed that movement prior to the amputation. Connections to nerves are also becoming possible, improving precise function and the ability to sense motion and other feedback, such as grip on an object.

The bionic arm's sensors are electrodes that touch the skin and record muscle activity through a process called electromyography. You can easily remove and reattach the prosthetic device without affecting its usage. Despite improvements in the technology used to create bionic prosthetics, note that you might still need to undergo rehabilitation to strengthen the muscles themselves [4].

Figure 2:Bionic Arm [32]

1.4 Shape Memory Alloy

The term shape memory alloys (SMA) are applied to that group of metallic materials that demonstrate the ability to return to some previously defined shape or size when subjected to the appropriate thermal procedure.
Generally, these materials can be plastically deformed at some relatively low temperature, and upon exposure to some higher temperature will return to their shape prior to the deformation. Materials that exhibit shape memory only upon heating are referred to as having a one-way shape memory.
Some materials also undergo a change in shape upon re-cooling. These materials have a two-way shape memory. Although a relatively wide variety of alloys are known to exhibit the shape memory effect, only those that can recover substantial amounts of strain or that generate significant force upon changing shape are of commercial interest. To date, this has been the nickel-titanium alloys and copper-base alloys such as Cu-Zn-Al and Cu-AI-Ni. A shape memory alloy may be further defined as one that yields a thermoelastic martensite. In this case, the alloy undergoes a martensitic transformation of a type that allows the alloy to be deformed by a twinning mechanism below the transformation temperature. The deformation is then reversed when the twinned structure reverts upon heating to the parent phase [6].

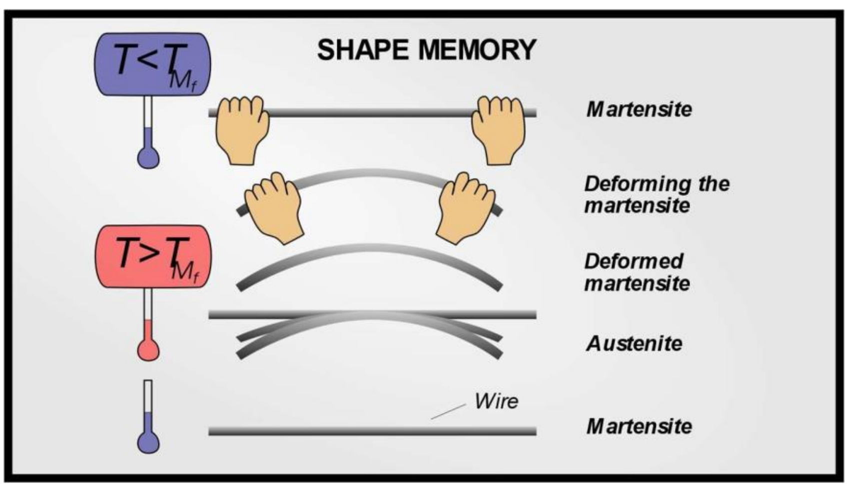

Figure 3:SMA [33]

2. LITERATURE SURVEY

Mishra, et. al: In this paper author refers to the intelligence of the smart materials in the industrial applications. Smart materials are the unique material which has the characteristics of smartness of the material is self-adaptability, self-sensing, self-healing with respect to the external input. In this kind of materials shape memory alloy are so the one of the materials which as the property of the to regain to its original shape when it is subjected to the external input as the stresses, temperature, electric felid, magnetic felid.[8]

C. Naresh, et. al: In this paper author discuss about the application of the shape memory alloys properties and application of the material. Shape memory alloys as the below transformation it undergoes low yield strength and will deform easily into new shape, when it is again heated it retains its original position. SMAs works under these effects shape memory effect (SME) and pseudo-elasticity which are related with the specific way the phase transformation occurs, biocompatibility, high specific strength, high corrosion resistance, high wear resistance and high anti-fatigue property. SMA are used in many applications such as aerospace, medical, automobile, tubes, controllers for hot water valves in showers, petroleum industry, vibration dampers, ball bearings, sensors, actuators, miniature grippers, micro valves, pumps, landing gears, eye glass frames, Material for helicopter blades, sprinklers in fine alarm systems packaging devices for electronic materials, dental materials, etc. [9]

Roy, et. Al: In this paper author discuss about the different alloys which are smart materials. This material is a lightweight, solid-state alternative to conventional actuators such as hydraulic, pneumatic, and motor-based systems. Shape-memory alloys have applications in industries including automotive, aerospace, biomedical and robotics. The two main types of shape-memory alloys are copper-aluminium-nickel, and nickel-titanium (NiTi) alloys but SMAS can also be created by alloying zinc, copper, gold and iron. Although iron-based and copper based SMAS, such as Fe-Mn-Si, Cu-Zn-Al and Cu-Al-Ni, are commercially available and cheaper than NiTi, NiTi based SMAs are preferable for most applications due to their stability, practicability and superior thermo-mechanic performance. SMAs can exist in two different phases, with three different crystal structures (i.e., twinned martensite, detwinned martensite and austenite) and six possible transformations. [10]

PAWAN, et. al: In this paper the ideology of the author is, which is to utilize advanced actuators to design and develop innovative, lightweight, powerful, compact, and dexterous robotic technology. The key to satisfying these objectives is the use of advanced or smart materials, such as Shape Memory Alloys (SMAs) to power the joints of a robotic arm, and other dexterous robotic hands. A new robotic arm actuated by Shape Memory Alloy (SMA) type artificial muscle has been developed in this paper. Different from typical geared motor, SMA actuator is lightweight and silent, however shows a little short stroke and small attracting force per each unit. To achieve enough output force and motion range of arm, multiple SMA type artificial muscles with special device which facilitates enough length are equipped in the arm. The fundamental properties of the SMA type artificial muscle including output force and electrical response were determined experimentally and considered for the design of arm mechanism. Besides, the structure of arm and whole system has been designed based on observation of human arm. The electrical hardware to control multiple shape memory alloy type artificial muscles has been also developed. Finally, the usefulness of the robotic arm has been investigated through experiments for lifting several types of objects. [13]

Carlos Molino, et. Al: The purpose of this article is to develop a new concept of modular and operative prosthetic hand based on rapid prototyping and a novel shape-memory-alloy (SMA) actuator, thus minimizing the manufacturing costs. An underactuated mechanism was needed for the design of the prosthesis to use only one input source. Considering the state of the art, an underactuated mechanism prosthetic hand was chosen to implement the modifications required for including the external SMA actuator. A modular design of a new prosthesis was developed which incorporated a novel SMA actuator for the index finger movement. The primary objective of the prosthesis is achieved, obtaining a modular and functional low-cost prosthesis based on additive manufacturing executed by a novel SMA actuator. The external SMA actuator provides a modular system which allows implementing it in different systems. This paper combines rapid prototyping and a novel SMA actuator to develop a new concept of modular and operative low-cost prosthetic hand. [15]

Somasundar, et.al: In this paper it talks about the replacements of the servomotors in the aerial manipulator. Light weight and high force to mass ratio, but further introduces the problem of nonlinearities such as Hysteresis into the system. A nonlinear dynamic model of the hysteretic robotic arm is systematically developed to perform closed loop simulations. [27]

Morvan, et.al: Shape memory alloys (SMAs) are a group of metallic alloys capable of sustaining large inelastic strains that can be recovered when subjected to a specific process between two distinct phases. Regarding their unique and outstanding properties, SMAs have drawn considerable attention in various domains and recently became appropriate candidates for origami robots, that require bi-directional rotational motion actuation with limited operational space. However, longitudinal motion-driven actuators are frequently investigated and commonly mentioned, whereas studies in SMA-based rotational motion actuation is still very limited in the literature. This work provides a review of different research efforts related to SMA-based actuators for bi-directional rotational motion (BRM), thus provides a survey and classification of current approaches and design tools that can be applied to origami robots to achieve shape-changing. For this purpose, analytical tools for description of actuator behaviour are presented, followed by characterisation and performance prediction. Afterward, the actuators' design methods, sensing, and controlling strategies are discussed. Finally, open challenges are discussed.[29]

Parveen Kumar, et.al: Shape memory alloys are mostly functional intermetallic which are now practically being used for making actuators, couplings, medical guide wires etc., and are also used for smart materials, which already exist. In this paper, various developments on shape memory alloys and martensitic transformations, on which shape memory effect and super elasticity are based, are reviewed. Along with this, we have also discussed the ductility and density of point defects in inter-metallics, as they are major problems in intermetallic in general. These materials have the tendency to regain their original shape after a deformation that seemed irreversible. [30]

2.1 Anthropometry

Anthropometry is the science of measurement and the art of application that establishes the physical geometry, mass properties, and strength capabilities of the human body. It involves the systematic measurement of the physical properties of the human body, primarily dimensional descriptors of body size and shape. The knowledge of body dimensions is essential for designers of equipment and workplaces. The anthropometric measurements are essential for the correct design of the work areas [31].

2.1.1 Method

This research was conducted on arbitrarily selected 300 adults (150 male and 150 female) aging 18–60 years (37.333 ± 12.198 years in males; 38.707 ± 12.538 years in female) without any type of physical handicap. Measurement data was collected from students, staffs and teachers of Rajshahi University of Engineering & Technology (RUET) and civil people all around Bangladesh. Data was collected from April 2017 to August 2017. In times of data collection, the temperature of the environment was ranged from 24 °C to 32 °C. Formal information on age and sex was also collected by questioning each subject while taking stature and hand measurements of each participant. Consent and permission were taken from the participants in a written form. This research is committed to protect personal information about each subject. Ethical approval was granted by RUET administration. The participants were informed about the study, and each indicated his or her willingness to participate by signing a consent to participate form. At the time of the study, none of the participants reported a hand injury or disability. Three experimenters were trained to take measurements in this survey by practicing on themselves. They started data collection only after their measurements were considered accurate and consistent. Measurements were taken daily between 08:00 to 17:00, and data were collected over a period of 2 months.

3. REFERNCE

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