

Dynamic Analysis of Bionic ARM

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ABSTRACT

In this day and age there is an expanding need to make artificial arms for various cruel circumstances where human communication is troublesome or incomprehensible. They may include taking readings from a dynamic spring of gushing lava to diffusing a bomb. This paper presents a study on dynamic analysis of multi degree freedom of a bionic arm that is designed in CATIA V5. The prototype is converted into standard for the exchange of product (.stp) file and is imported in the ANSYS software for the calculation of parameters such as maximum and minimum of deformations, stresses, strains, velocities, and acceleration. The analysis is done with giving different materials for the better optimization of the parameters such as reduced weight, less friction, and more strength. The fingers are revolute pairs that are free to rotate about certain degrees; this motion is given by actuators. The arm can be improvised by using sensors, actuators and mechatronic chips so that it mimics the artificial hand.

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KEYWORDS: - *incomprehensible, gushing, degree of freedom, optimization, mimics.*

1. INTRODUCTION

The term bionic is combination of two words biology and mechanics, which gives the function of mechanics through biological inputs. Bionic arm is a best revolution idea for the amputees across the world. This is as close as we can get to our natural limb. The main objective is to make the arm move with our brain unlike prosthetics that are robotic controlled. In case of bionic arm we take the nerve signals from brain and amplify it so that we can register the signal and convert that electrical signal to mechanical energy so as to move the mechanical device. The arm prosthesis is being used and constantly being perfected to suit human needs. Various types of prosthetic have been made to suit many actions but not all. But the bionic arm will be able to perform all the human limbs. A bionic arm combines robotics, biotechnology, and electronics to recreate the functions of the human arm. Advances in bionics can improve the lives of millions of people with lost limbs. In this challenge you will design and test a robotic arm, and learn how engineers create working artificial arms. This project aims at developing a neuro-controlled hand prosthesis design part and the analysis of the prototype. [1]

1.1 Prosthesis

In medicine, prosthesis is an artificial extension that replaces a missing body part. It is part of the field of bio mechatronics. Prosthesis are typically used to replace parts lost by injury or missing from birth or to supplement defective body part.[2]

1.2 Mechatronics

Mechatronics is the combination of mechanical engineering, electrical engineering, computer engineering and control systems.[2]

1.3 Bio mechatronics

Bio mechatronics is the merging of man with machine—like the cyborg of science fiction. It is an interdisciplinary field encompassing biology, neuroscience, mechanics, electronics, and robotics. The biomechanics focuses the interactivity of the brain with the electromechanical devices and the systems.[3]

1.4 Bio mechatronic hand

An ideal artificial hand should match the requirements of prosthesis and humanoid robotics. It can be wearable by the user which means that it can be perceived as part of the natural body and should replicate sensory-motor capabilities of the natural hand. This means that the artificial hand should be felt by the user as the part of his/her own body and it should provide the user with the same functions of natural hand.[4]

1.5 Bio sensors

Biosensors are used to detect the user intentions and to do the required functions. In some devices the information can be relayed by the user's nervous system or muscle system. This information is related with both bio sensor and the controller. Biosensors are in different forms such as needle implants, wired that detect nerve signals and electrode arrays with nerves growing through them. [4]

1.6 Controller

The controller in a bio mechatronic device is similar to bio sensors that relays the user intentions and send the inputs to actuators. It also interprets feedback information to the user that comes from the bio sensors and mechanical sensors. It also controls the device's movements.[5]

1.7 Actuators

The actuator is an artificial muscle that produces force and movement to the joints. Depending upon the device the actuator can be of different type such as motor assisted, gear assisted, tendon drive and etc...[5]

1.8 Natural Hands

These are the chief organs for physically manipulating the environment, used for both gross motor skills such as grasping a large object and fine motor skills such as grasping a small object. The fingertip contains some densest areas of nerve endings on the body, are the richest source of tactile feedback that senses the heat, roughness of a body, state of the body. The sense of touch is immediately associated with brain and is taken action against the action of the hand. [5]

1.9 How Bionic Hand Works

Bio mechatronics devices have to be based on how the human body works for example four different steps must occur to be able to lift the foot to walk first impulse from the motor center of the brain are sent to the foot and legs muscles next the nerve cells in the feet send information to the brain telling it to adjust the muscle groups or amount of force required to walk across ground different amounts of forces are applied depending on the type of surface being walked [6]

2. Materials Used In Bionic Arm

A prosthetic should consist of following parameters in order to most reliable and good handling, it should be lightweight, hence most of prosthetic devices are made from plastic. Metals such as titanium and aluminum are also used in prosthetics such that more strength and toughness and is available in it. These materials replaced much of steel in the pylon which is more weight. Now a days alloys of materials and composite materials are used in the prosthetic devices.[7]

2.1 Nano Composite Materials For Prosthetic Devices

Nanotechnology is the prosperous areas of development in material sciences by the current researchers, this is also a greatest development in medical sciences the word nano means dwarf which is derived from Greece.[7]

2.2 Classification Of Nano Composites

On the basis of composition of materials

- Non polymer based composites, mad
- Polymer based composites

2.1.1 Non Polymer Based Nano Composites

The components of nano materials which do not contain polymer based materials in its composition formula. These are further classified in to

- Metal-metal nano composites
- Metal-ceramic nano composites
- Ceramic-ceramic nano composites[7]

2.1.2 Polymer Based Nano Composites

The nano composites that mostly contain polymer materials in its composition formula. Some of those are

- Polymer-polymer nano composites
- Polymer-ceramic nano composites
- Inorganic-organic polymer based nano composites
- Inorganic-organic polymer based nano composites
- Inorganic half and half nano composites
- Polymer-layered silicate nano composites

2.3 General Materials Used In Prosthetic Devices

Materials used in prosthetic devices are should be of light weight, high strength, and good resistant to temperature

2.4 Acrylonitrile Butadiene Styrene

It is a common thermo plastic polymer. It is also called as ABS. glass transition temperature is about 105 degrees Celsius. ABS is amorphous and has no true melting point.

2.5 Polypropylene

A thermoplastic polymer used in wide variety of applications which is produced via chain growth polymerization. The monomer in this chain polymer is propylene.

2.6 Nylon 6,6 Polymer

It belongs to the class of amides, there are many types of nylon; the two most used in plastic industries are nylon6 and nylon 6,6. The monomers included in nylon 6,6 are hexa methylene di amine and adipic acid.

2.7 Plexiglas

Poly methyl meth acrylate, it is also known as acrylic glass and some more trade names as cry lux, Perspex, etc...It is a light weight material, resistant to shatter and transparent thermoplastic material. It is used in inks and coatings.

2.8 Properties Of Materials Used In Bionic Arm

| S. No | Materials | Properties |
|-------|---------------------------------|--|
| 1 | Acrylonitrile butadiene styrene | Melting temperature:- 210°C[8] Tensile strength: 44.81MPa[8] Modulus of elasticity:3100MPa[8] Density: 1.01 g/m ³ [8] Poison's ratio: 0.35[9] Shrinkage: 8%[8] |
| 2 | Polypropylene | Melting temperature: 168°C[10] Tensile strength:48MPa[10] Modulus of elasticity:200MPa[10] Density: 946kg/m ³ [10] Poison's ratio: 0.43[10] Fatigue strength: 30MPa[10] |
| 3 | Nylon 6,6 polymer | Melting temperature: 265°C[11] Tensile strength: 124MPa[11] Modulus of elasticity: 2930271807 N/m ² [12] Density: 1.14 g/m ³ [11] Poison's ratio:0.39[13] Fatigue strength: 41MPa[11] |
| 4 | Plexiglas | Melting temperature: 160°C[14] Tensile strength: 80MPa[14] Modulus of elasticity:3300MPa[14] Density: 1.19g/cm ³ [15] Poison's ratio:0.37[15] Yield strength:110MPa[14] |

3. Dynamic analysis of two fingered hand

3.1 Structural analysis

Few types of static structural methods are available one of them is material strength analysis which is also known as classic analysis. This method is generally used in where complex shapes are available; like robotic parts which require tedious and difficult calculations the calculations are mostly based on assumptions. These calculations lead to development of finite element analysis (FEA). These are solved by applying boundary conditions and loads gives thus obtaining the solution for the given problem.[16]

3.2 Strength of material

Every static or dynamic body contain some natural deformation when is subjected to some type of load or force. However, the resistive force is applied against to the actual force due to the cohesion between the molecules. This resistive strength is categorized as stress and strain. Stress is defined as the amount of resistive force per unit area where strain is defined as the change in dimension to the original dimension due to actual force. There are few types of strains named as tensile, compressive, shear volumetric. [16]

3.3 Finite element analysis

FEA is complex task that performs numerous calculations and iterations to get optimized and nearest possible solution for a given problem statement. ANSYS is a software that perform finite element analysis tasks based on computer programming.[16]

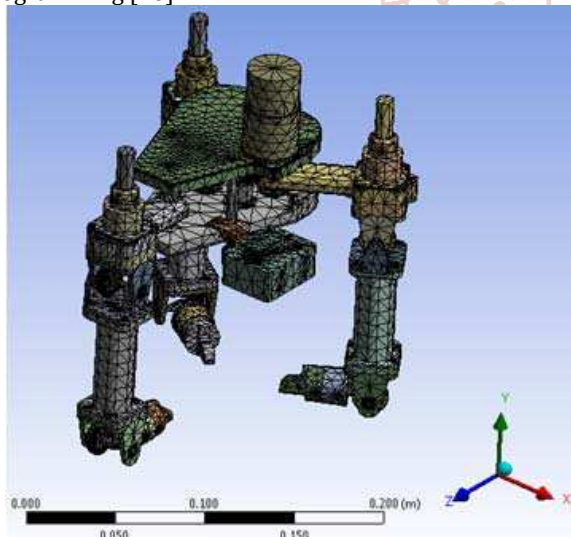


Figure 1 Mesh of the bionic hand[16]

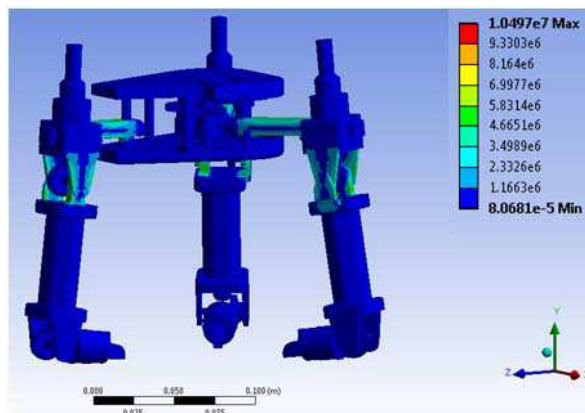


Figure 2 Equivalent (Von-Mises) stress[16]

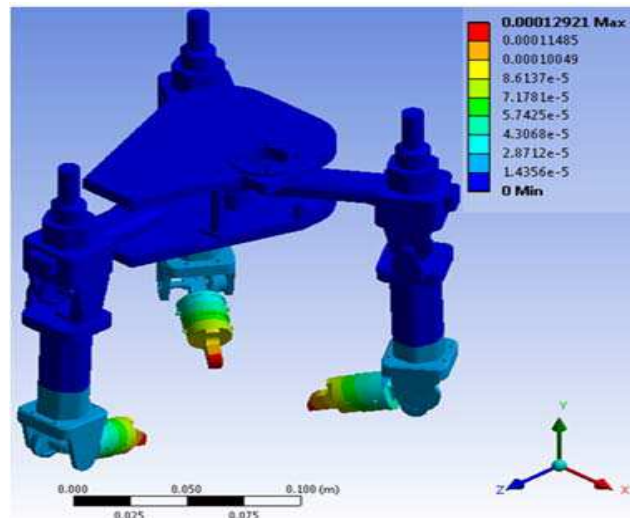


Figure 3 Deformation[16]

3.4 Evolution of grasping force

Grasping force is tendency to hold an object that may just touch the object or lift the object against gravity. Robotic grasp is strongly related to design of fixtures in the robotic parts that is good enough to do the job. Grasp planning includes the contact point of fingers for different objects with different configurations, for example holding a cylinder with a robotic arm is possible by four fingers excluding thumb whereas for a sphere like object thumb is used and the contact point of finger may change. Some of the grasp properties are[17]

3.4.1. Disturbance resistance

A grasp can resist disturbances in any direction either by finger positioning and immobility in the grasp in such cases the main problem is determination of contact point of fingers for complex objects.[17]

3.4.2. Dexterity

A grasp is dexterous if the hand can move the object in a compatible way with the task to be performed. When there are no task specifications, a grasp is considered dexterous if the hand is able to move the object in any direction.[17]

3.4.3 Equilibrium

A grasp is equilibrium if the some of forces is null in all directions.[17]

3.4.4 Stability

A grasp is stable if any error in the object position caused by a disturbance disappears in time after the disturbance vanishes.[17]

4. Conclusion

Bionics are used in wide variety of applications, mostly humans use this medics to relief them from getting depression for being lost of body parts. This paper concludes the types of materials that are used in prosthesis depending upon the work determination for example, a fire extinguisher prosthetic should be of material with high temperature resistant and a prosthetic that deals with fluids are of corrosion resistant. Deformation caused, stresses, strains are also developed in the hand are also evaluated.

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