Muscle Wire as a Means for Dynamic Motion in Prosthetics

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What is Muscle Wire?

Muscle Wire is a shape-memory nitinol wire. When electric current (AC or DC) is applied to the wire it contracts, hardens and shrinks. During this contraction the properties of the wire change.

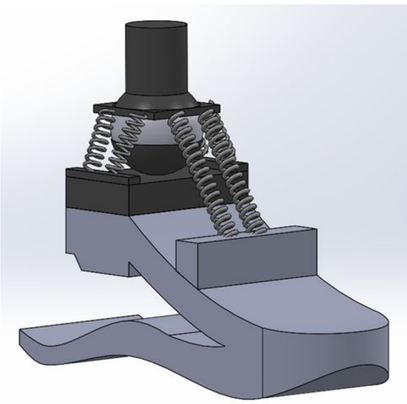
Specs:

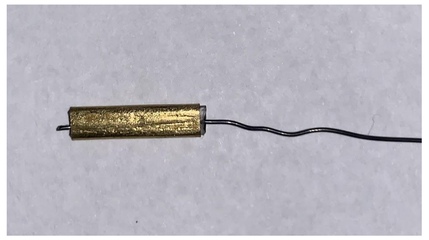
Material	Nitinol
Shape	Wire
Appearance	Plain
Diameter	0.02"
Diameter Tolerance	-0.0004" to 0.0004"
Tolerance Rating	Standard
Length	30 ft.
Container Type	Coil
Tensile Strength	157,500 psi
Fabrication	Heat Treated
Temper Rating	Softened
Finish	Black Oxide
Min. Temperature	Not Rated
Maximum Temperature	250° F
Specifications Met	ASTM F2063

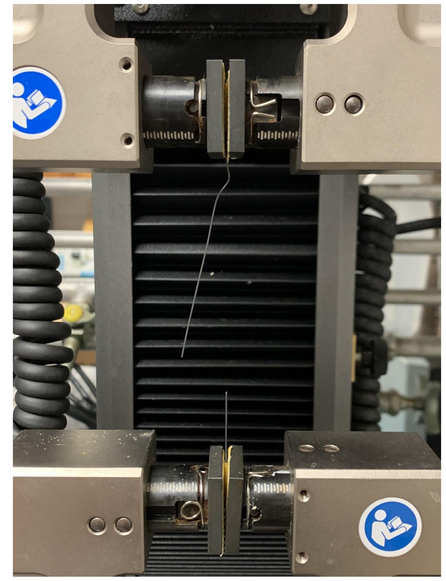
Introduction:

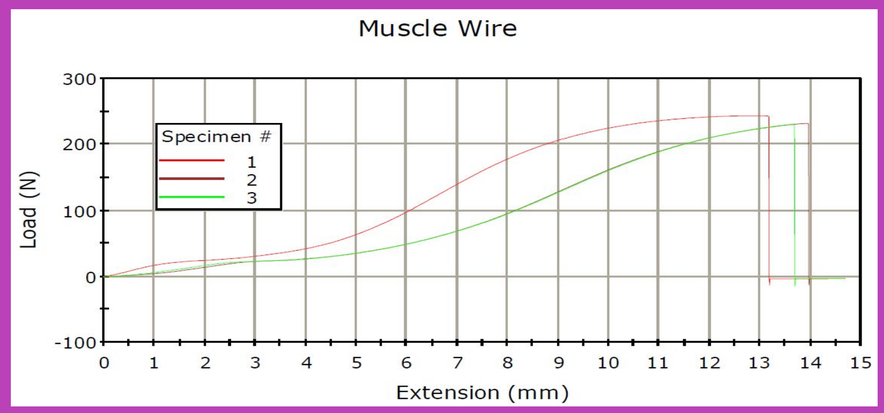
- As a part of the creative inquiry " Medical Devices in the Developing World" my team decided to address the issue of prosthetics for those with ankle amputations. We came up with a design for a prosthetic ankle which incorporates muscle wire technology, springs and pressure sensors.
- Of the 40 million amputees residing in developing countries, only 5% to 15% can receive a prosthetic. Many low-cost and readily available ankle prosthetics don't meet the unique functionality, climate, and durability demands essential to amputees in developing countries.
- Prosthetics which incorporate a dynamic element are imperative to keeping the amputee from developing skeletal issues and diseases which are caused by most immoble prosthetics

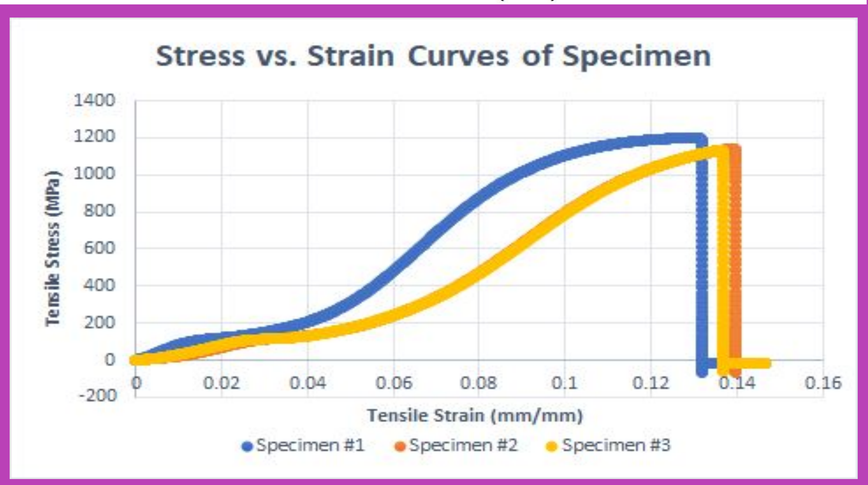
Purpose: **This research project aims to understand the mechanical and material properties of muscle wire and its potential as an assistive mechanism for ankle prosthetics. The wire needs to be able to function inside a device without generating too much heat and it needs to contain the electrical current used to activate the wire. The wire must be able to control the prosthetic in a manner which imitates regular ankle functions.**











Current Results:

- As a means to understand the difference between the properties of the wire with and without electrical current I decided to test the properties at both stages.
- To test the properties of the wire without current I decided to collect stress and strain information using a Isotron 500N load cell. To identify the load capacity of the wire I used force analysis and the specs of the wire to determine that the wire should break around 220N. Which is at least less than 10% of the 500N capacity.
- The test required an alternate grip to hold the wire between the plates on the machine. I used brass crimps with a PVC liner to hold the wire during the test.
- I tested three specimen with a length of 5 cm. I averaged the data to find the different experimental material properties:
  - **Young's Modulus: 47.31 GPa**
  - **Yield Strength: 100.943 MPa**
  - **Ultimate Strength: 1157.36 MPa**

The Next Step?

- The material properties of the wire are very different when current is run through it
- The next step will be to construct a safe and effective circuit to run current through the wire.
- Once there is an effective means to connect the wire to a current source the Isotron 500N load cell will be used to collect the force needed to pull the wire a certain length at different current magnitudes.
- The test will also provide information on how different current magnitudes effect the shrinking of the wire.
- An important aspect of the muscle wire is that it interacts well within the prosthetic. However as the current is put through the wire it will generate heat. To find the heat correlating to each current value I will conduct a thermoregulation test.
- Once all of the properties of the material are established I will set up a section test to gauge whether or not the muscle wire will function in the current design or if it needs to be adjusted.

Acknowledgements:

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References:

[1] "Shape-Memory Nitinol Wire." *McMaster-Carr*, www.mcmaster.com/1053N3/.

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