Material Testing Fixture

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Needs Identification

Report 1

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1. Introduction:

Our project is to design a new testing fixture for a magnetic shape memory alloy. These testing fixtures are going to be installed on an Instron 8874 hydraulic bi-axial testing rig. The testing fixture will operate in the presence of a magnetic field. Axial alignment is critical. Our client is Dr. Constantin Ciocanel, Assistant Professor in the Mechanical Engineering Department at Northern Arizona University.

2. Needs Identification:

During our meeting with Dr. Ciocanel, he explained to us how the current set up of the testing fixture caused unwanted bending. This unwanted bending in the material is caused by the magnetic field which induces material growth. The current testing fixture slot is slightly larger than the specimen, which allows the specimen to bend when the magnetic field is introduced. Dr. Ciocanel expressed the need for a redesign of the testing fixture in such a manner that will not cause the specimen to prematurely break. Dr. Ciocanel also expressed an interest in a testing fixture that could do both compression and tension tests. The current fixture design only allows for compression testing.

Need Statement: *The eccentric loading of the specimens causes fatigue failure. This is undesirable due to the high cost and limited availability of the material.*

3. Problem Statement:

The goal of our project is to design a new and improved material testing fixture. The specimen is going to be tested in two ways; tension and compression. For this project we are limiting our goal to small scale testing. The material testing machine uses a force analyzer to gather data on the force of compression as well as the magnetic field. This means that the redesign of the fixture cannot interfere with the machine's ability to gather the necessary data. The new fixture must be able to meet the current machines restrictions on the size of the fixture.

A digital camera is used to measure the growth rate of the specimen. This is accomplished by placing two dots on the specimen that are 6mm apart. The camera monitors the displacement of the two dots. This means that the new fixture must allow for at least 6mm of the specimen to be exposed. The pushrod and the specimen are shown below in **Figure 1: Pushrod**, and **Figure 2: Specimen**.

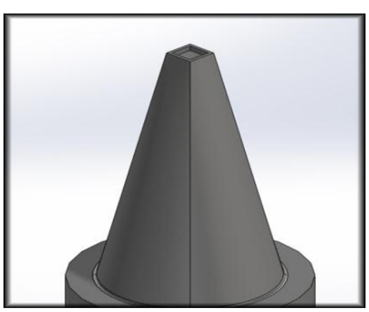

Figure 1: Pushrod

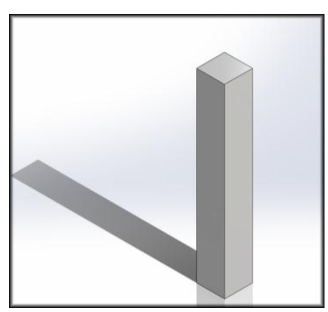

Figure 2: Specimen

4. Objectives:

In our there are four main objectives. First, the connection between the push rods and base need to be axial aligned. If this connection is not aligned, the eccentric loading will cause the specimen to crack. Second, the new fixture must be able to perform both compression and tension tests. Third, it is imperative that the new fixture not damage the specimen. The cost and rarity of the material make this objective of primary importance. Finally, the new design should be as inexpensive as possible without sacrificing any of our objectives. Below in **Table 1: Objectives**, our objectives and basis for measurement are shown.

Table 1: Objectives

Objective	Basis for Measurement	Units
Axial Alignment	Distance from perfect axial alignment	µm
Tensile/Compression Tests	Repeated Testing	# of Tests
Does not damage material	Cost of new specimen / Time for replacement	$$ / Months
Inexpensive	Cost to machine and purchase material	$$

5. Constraints:

For this project, there are seven constraints that the new design must meet. These criteria are listed below with a short description of each.

1) **Specimen size:** The specimen size is (3 x 3 x 20) mm.
2) **Exposed length:** There must be at least 6mm of the specimen for the camera to monitor.
3) **Grips must not damage specimen:** The grips cannot bite into the material causing damage.
4) **Pushrods and grips must be non- magnetic:** The magnetic field of the pushrods must not interfere with the applied magnetic field.
5) **The distance between magnets:** The space between the magnets is limited to 10mm.
6) **Magnetic field:** The applied magnetic field varies from (0.5 ~ 1.0) Tesla (T).
7) **Axial Alignment:** It is crucial that the specimen be axially loaded.

6. Testing Environment:

The specimen will be subjected to a magnetic and placed under strain. A digital camera is used to monitor the elongation and deformation of the material. The magnets on either side of the specimen limit the size of the pushrods. Measuring devices are used to gather data on the magnetic field and applied force.

7. Recapitulation:

Need: *The eccentric loading of the test specimens cause fatigue failure. This is undesirable due to the high cost and limited availability of the material*.
Goal: *Design an improved material testing fixture.*
Objectives:

Objective	Basis for Measurement	Units
Axial Alignment	Distance from perfect axial alignment	μm
Tensile/Compression Tests	Repeated Testing	# of Tests
Does not damage material	Cost of new specimen / Time for replacement	$$ / Months
Inexpensive	Cost to machine and purchase material	$$

Constraints:
1. Specimen size: (3 x 3 x 20) mm.
2. Exposed Length: 6mm.
3. Grips cannot bite into specimen.
4. Pushrods and grips must be non-magnetic.
5. Distance between magnets: 10mm.
6. Magnetic Field: (0.5~1.0) T.
7. Axial Alignment.

Appendix 1: Criteria Tree

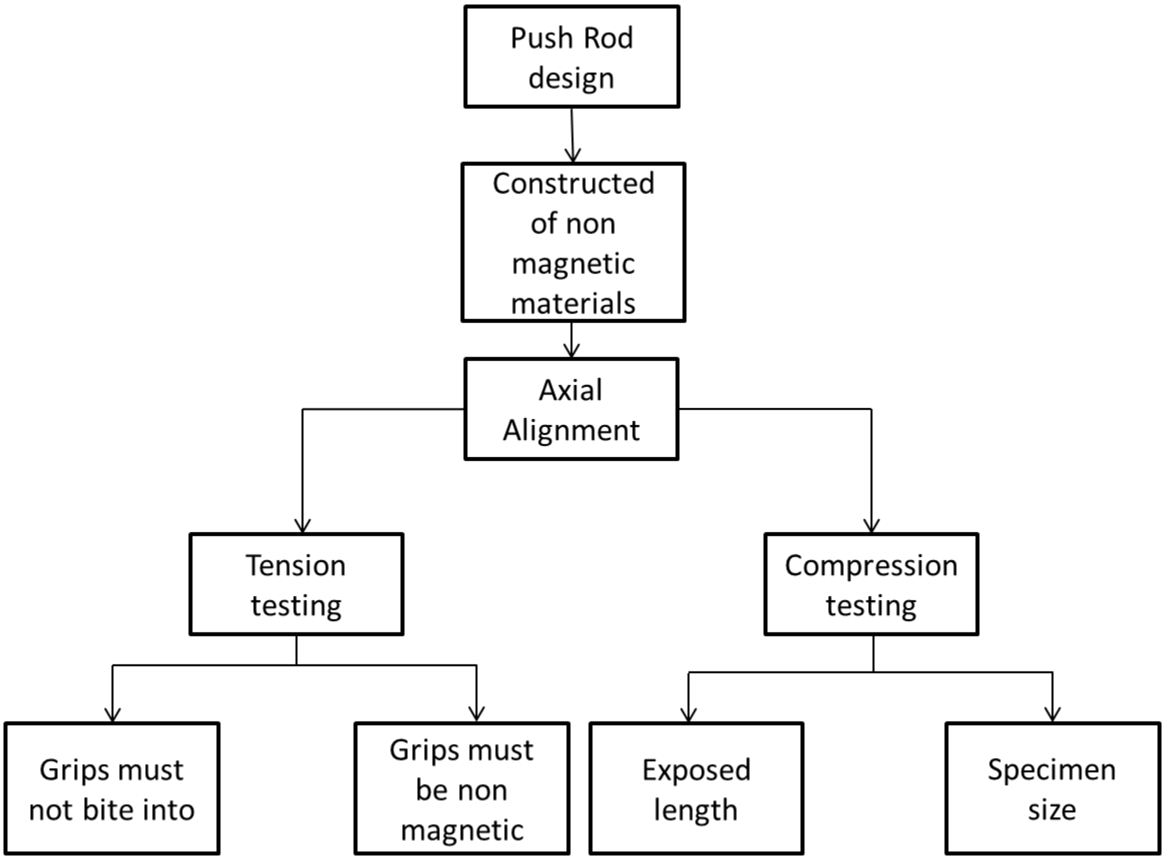

Figure3: Criteria Tree

Appendix 2: Quality Function Deployment

		Engineering Requirements						
		Strain	Tension	Compression	Exposed Length	Grip Size	Magnetic Field	Cost
Customer Requirements	Does not break	X	X	X				
	Tension Test		X					
	Axial Loading		X	X		X		
	Inexpensive				X			X
	Fits in Testing Device				X	X		
	Magnetic Field				X		X	
	See Specimen				X	X		
	Units	mm/mm	N	N	mm	mm^2	T	$$
		1.2	18	60	6	100	1	TBD
		Engineering Targets						

Figure 4: Quality Function Deployment

Appendix 3: House of Quality

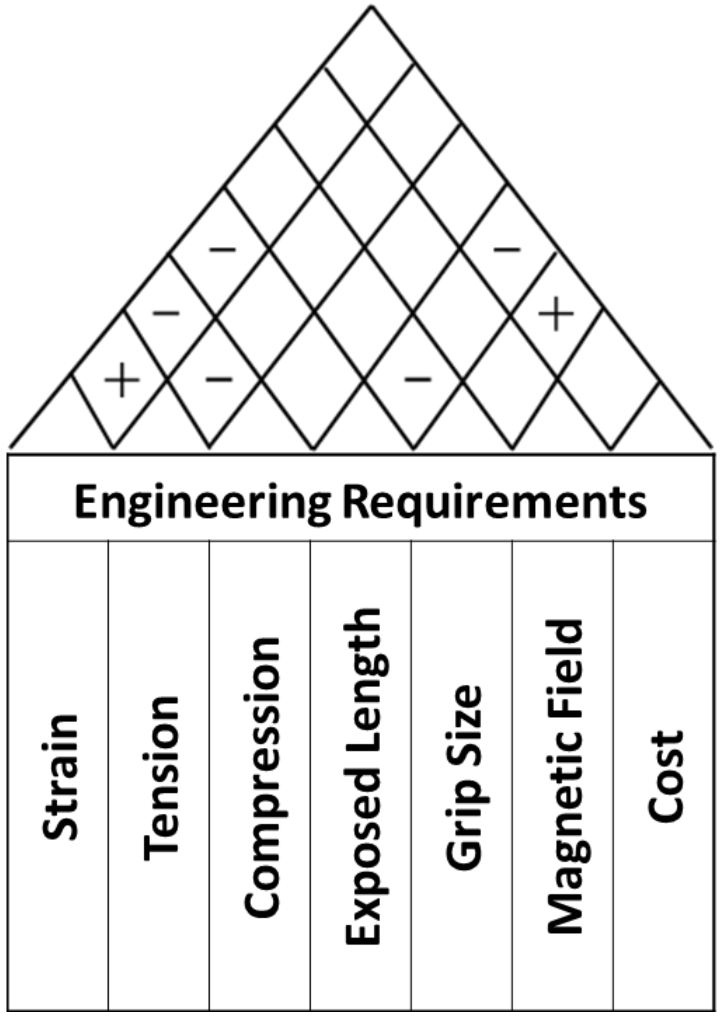

Figure 5: House of Quality

Appendix 4: Gantt Chart

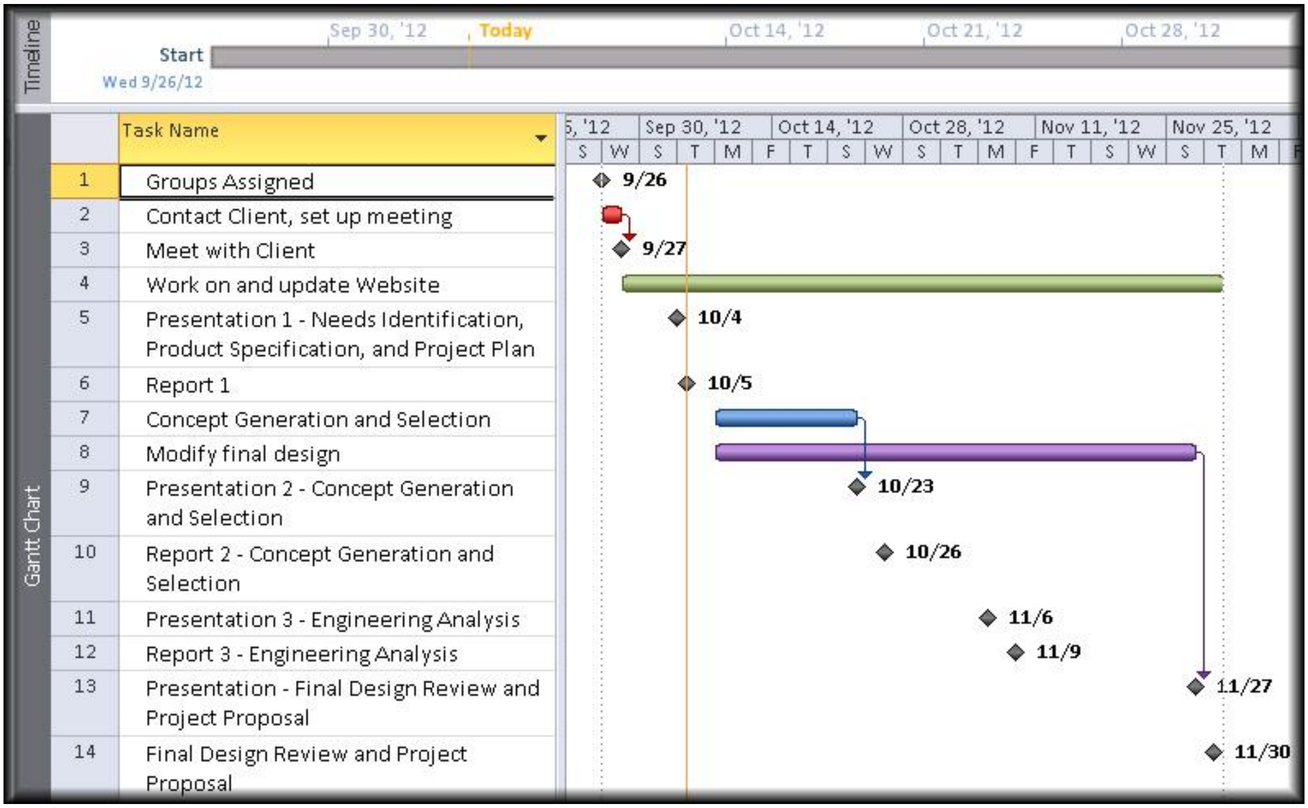

Figure 6: Gantt Chart

References:

Gantt Chart Creation:
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Magnetic Shape Memory Alloy:
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Dr. Constantin Ciocanel
http://nau.edu/CEFNS/Engineering/Mechanical/Faculty-Staff/