Lateral Loading Device for Bi-axial testing of MSMAs

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Problem Formulation and Project Planning

Document

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ABSTRACT

The world of engineering is always pushing the boundaries of what humans can do with the materials which surround us. Currently, Dr. Constantin Ciocanel and his research team at the University of Northern Arizona are doing just that. They are experimenting with a certain material in order to determine its properties. With this information he hopes to pinpoint the materials potential uses in engineering. Dr. Ciocanel has employed our team in order to develop a means to help with this process. In the beginning stages of this project it is essential for us plan the project so that it will get done within the given time frame.

BACKROUND

At the Northern Arizona University, Dr. Constantin Ciocanel is experimenting with a magnetic shape memory alloy (MSMA). This MSMA is comprised of Nickel, Manganese, and Gallium, and exhibits strain under a magnetic field. The mechanical properties of this material are not well known, and it is Dr. Ciocanel's goal to find them. He and his team have set up a number of experiments in order to do so, which primarily use a machine which applies and measures forces on a sample. This machine is called an Instron machine. Coupled with the Instron is a set of electric dipoles which creates the magnetic field which in turn induces strain in the MSMA. Even with the current set up, all of the properties which Dr. Ciocanel is searching for cannot be found.

RECOGNIZING THE NEED

Dr. Ciocanel and his research team hopes to shed some light on the potential uses of this particular MSMA. He speculates that this material, given its apparent magnetic shape memory properties, may be used as an electro-magnetic linear actuator, or possibly be used within the realm of power harvesting. By further understanding the mechanical properties of this material, even more potential uses will be discovered. All in all, understanding the potential uses of this newer material will help the engineering world advance. Unfortunately, the current method of testing this material is limited in nature. The current process and equipment are not capable of performing tests which are required to determine the sought after properties of the material.

PROBLEM DEFINITION

In order to run tests which result in the desired data, a piece of equipment needs to be designed and created in order to facilitate the testing process and enable forces in a third dimension. This equipment must be effective, cost efficient, and precise, whilst interfacing with the current equipment. In order to achieve these goals, a set of constraints must be met. These constraints are listed below.

1) Full cost under $2,500:
   This includes all the parts and materials used within the design.

2) Capable of applying a force greater than or equal to 75 Newtons:
    The actuator must apply a constant force ranging from 0 to at least 75 N. This force is required to get a complete understanding of the MSMA material properties during testing.
3) The material used must be non-magnetic:
    The apparatus has high powered electro dipoles creating a powerful electric field. Therefore, the material selected must be resist the magnetism and function normally.
4) The width of the material in contact with the MSMA must be no greater than 10 mm:
    The distance between the electro dipoles is 10 mm. If our design has a width greater than the specified value it will not be able to make contact with the MSMA.
5) The height of the material in contact with the MSMA must be no greater than 12 mm:
    The distance between the grips that hold the MSMA in the testing apparatus during maximum material compression is 12 mm. The design must be equal to or less than the specified value to make contact with the MSMA and allow for a force to be applied.
6) Able to be installed by two individuals:
    On average two individuals will be working within the lab at any given moment. Therefore, the design must be such that two lab workers could install or uninstall the device for testing purposes. This will apply limits on the designs size and weight.

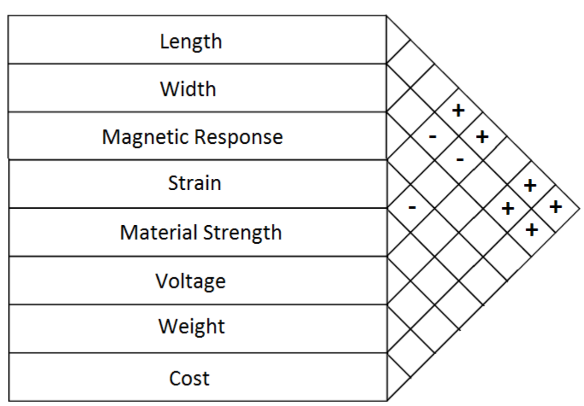
Along with constraints, there are requirements which must be met for this project. A Quality Function Deployment (QFD) compares the customer's requirements with the applicable engineering requirements. Our QFD, Table 1, shows the relationships between these requirements and helps to highlight the importance of each.

Table 1: Quality Function Deployment

Customer Requirements	Length	Width	Cost	Weight	Magnetic Response	Strain	Material Strength	Voltage
	Engineering Requirements							
1. Inexpensive			X					
2. Withstand Force						X	X	
3. Applied Force						X		
4. Provide Feedback								X
5. Limited Area	X	X						
6. Portable	X	X		X				
7. Non-magnetic					X			
8. Adaptable with Current System	X	X		X				
Units	mm	mm	$	kg	T	%	Pa	V
* To be determined	10	10	2500	*	0	*	*	*
	Engineering Targets							

It is important for us to compare the engineering requirements to see how they affect each other. This helps make important engineering decisions during the design process. The House of Quality (Table 2) represents this information.

Table 2: House of Quality



PROJECT PLANNING

As with most engineering projects, there is a time frame in which the project must be completed. As a tool to keep the team on track, a Gantt chart (Appendix A) has been generated. The time line with which this Gantt Chart was created was based upon due dates for certain deliverables, these being the Formulation and Planning, Concept Generation and Selection, Engineering Analysis, and Final Design Presentations.

CONCLUSION

The world of engineering is moving ever forward. Current research in MSMAs is underway at Northern Arizona University. This research project has a need to develop and expand the equipment used so that the mechanical properties can be discovered. Once these properties are found, applications for this material can be pinpointed. As the team tasked with this project, we have identified its need, defined the problem, and planned the project. All of this will assist us in delivering a solution for the need at hand.

CITATIONS

[1] Leo, Donald J. Engineering Analysis of Smart Material Systems. Hoboken, NJ: John Wiley & Sons, 2007.

Appendix A

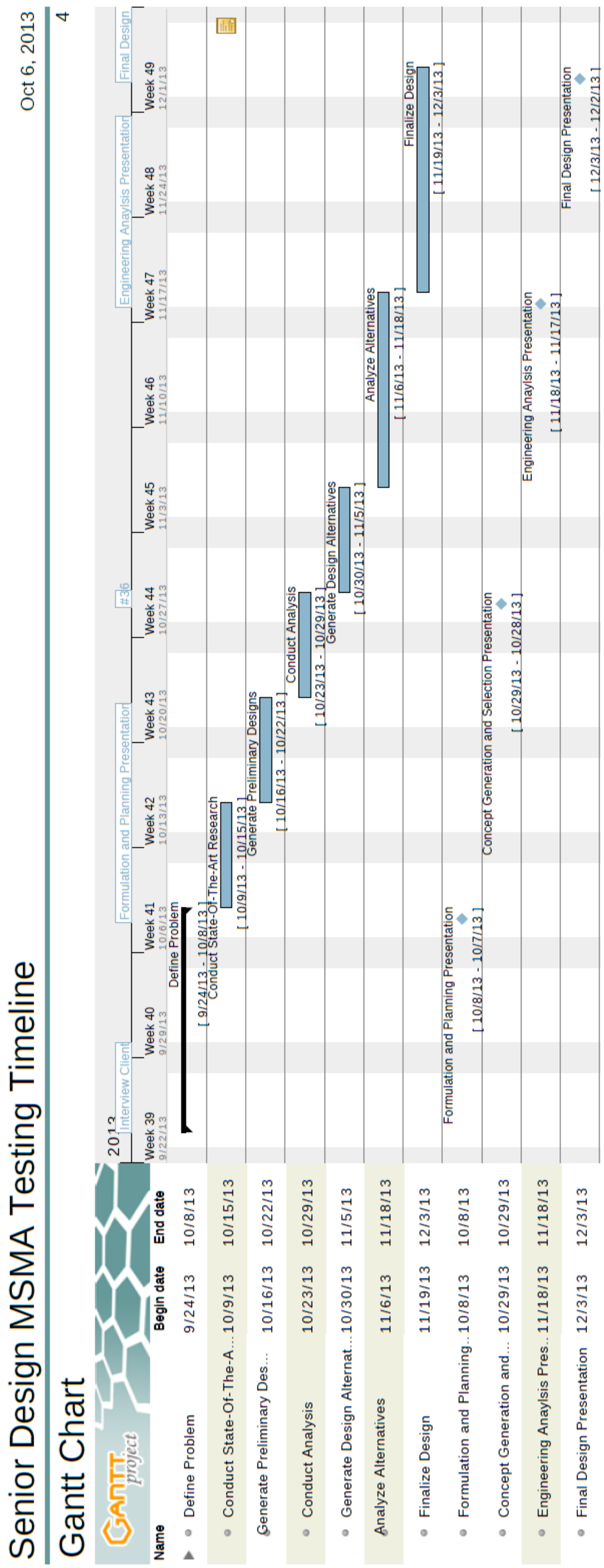


Figure 1: Gantt Chart