MSMA Lateral Loading Device

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Team 10

Mid-Point Progress Report

Document

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List of Contents

List of Figures

List of Tables

1.0 Abstract

This report covers the current progress of the Magnetic Shape Memory Alloy (MSMA) lateral loading project and previously chosen design. More detail is given to the specific components of the design, and how they fit together. A few improvised changes have been made to the design, due to complications in the machining processes. These complications arose from the tapping of stainless steel, and were made to avoid usage of small taps. Additionally, a feedback control loop is being developed. This system, programmed using LabVIEW, will allow the user to input a desired force and keep it constant, throughout the deformation of the test specimen. The program will use such commands as a proprietary "GetPosition" command for the actuator, in conjunction with a while loop. An updated budget has been provided that shows the project has remained under budget, if only by a close margin. Current project planning is covered and includes a timeline for the rest of the semester. This includes finishing the system build, and programming the LabVIEW interface for both components.

2.0 Project Description

At Northern Arizona University, Dr. Constantin Ciocanel is experimenting with a MSMA, which 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. The bi-axial test of a MSMA involves testing on an Instron Machine, seen in **Fig. 2.1** and **Fig. 2.2**, where a compressive load is applied along the vertical direction and a constant magnetic field is present along the horizontal direction. With this current testing procedure the third dimension (the lateral direction) of the MSMA is left completely unexplored and uncontrolled.

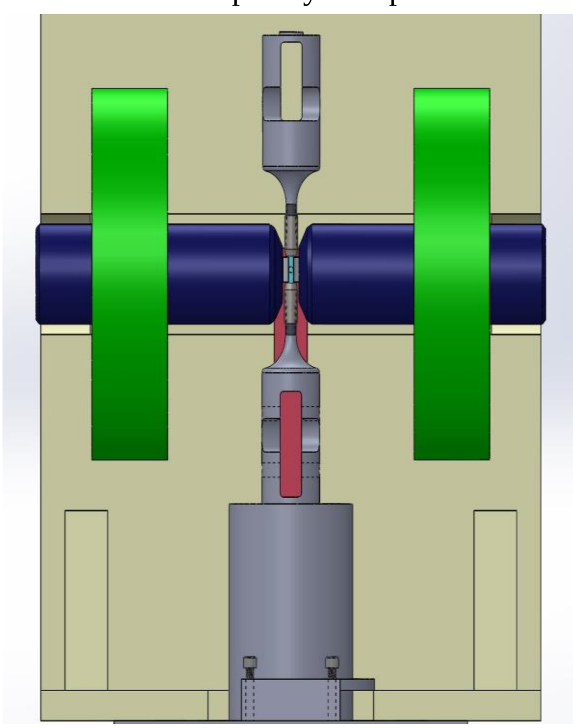


Figure 2.1: Close up of Instron machine

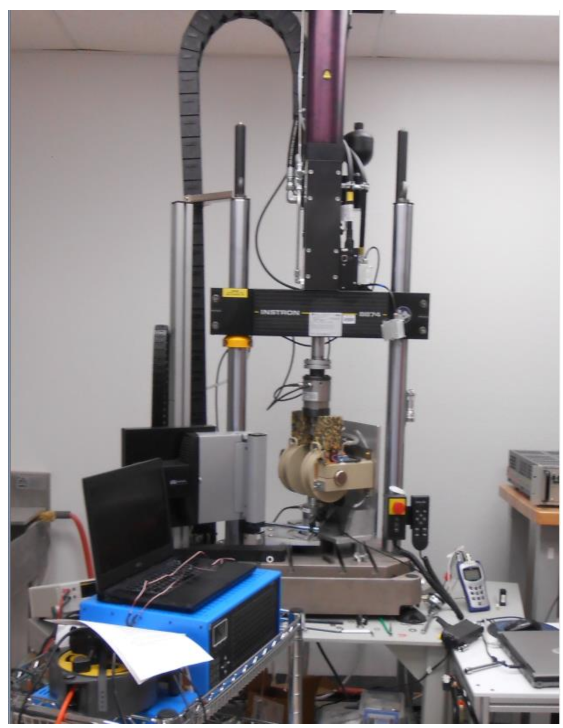


Figure 2.2: Full Instron machine

The goal of this project is to design a feedback controlled system that will allow the application of a compressive force in the lateral direction of the MSMA. In order to meet this goal the following set of constraints were set:

1. Total system 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 N: 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 materials 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.

3.0 Design Concept

In the previous report it was stated that the client was not satisfied with the rear mounting system, and he was still deciding if he wanted to go with the electromechanical or piezoactuator option. Since then, the client decided to continue with the piezoactuator option, and a design was created, seen in **Fig. 3.1**.

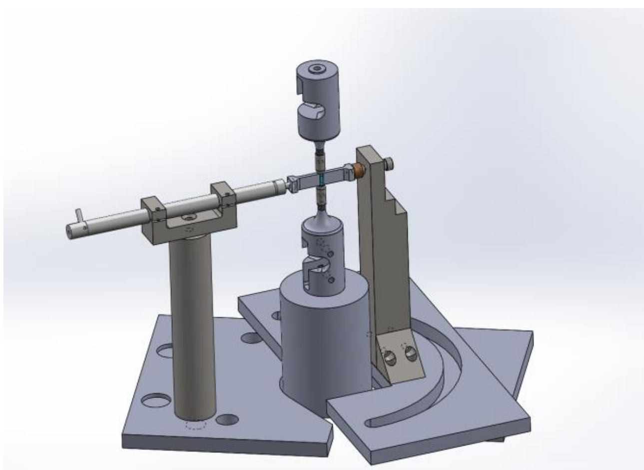


Figure 3.1: Full Assembly

The system consists of a force sensor and an actuator connected through feedback control. The force sensor is mounted on a rectangular steel column, and the piezoelectric actuator is mounted on a cylindrical steel column. The cylindrical column has a threaded end which screws directly into the aluminum bas plate. While the rectangular column is held in place by two custom-made triangular brackets. Two aluminum micro-tips that are in contact with opposite sides of the MSMA in the lateral direction are connected to the force sensor and actuator.

3.1 Actuator

For the actuator, the client selected the THORLABS PAS015 Piezo-Actuator with the T-Cube Piezo Controller. Unlike the electromechanical option, this product did not come with a custom mounting system. Therefore the team developed the design seen in **Fig 3.2**.

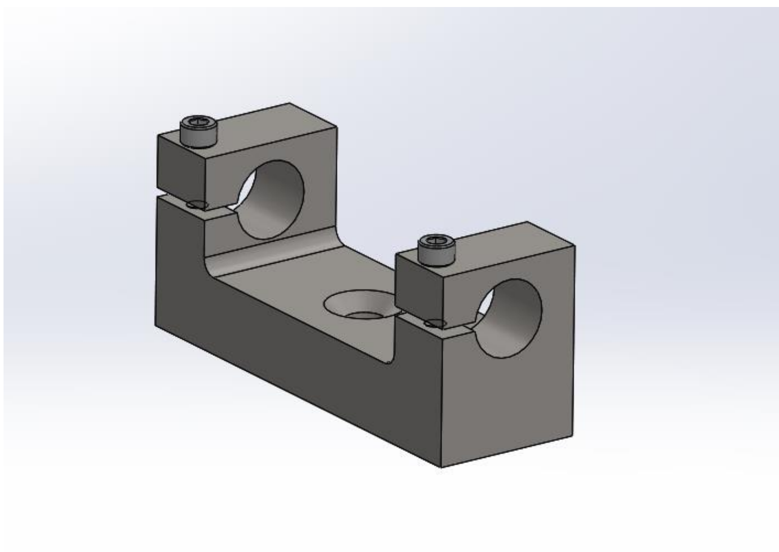


Figure 3.2: Actuator Mount

This mount works by creating a compressive force on the actuator’s cylindrical shell, through the tightening of two bolts. The mount is screwed into the cylindrical column allowing the user to make slight changes to the actuator position prior to testing.

3.2 Force Sensor

The Honeywell Model 11 strain gauge was used within this design. The constraints for redesigning the force sensor mounting assembly are as follows: the micro-tip must be able to move laterally toward or away from the MSMA without spinning and it must be compact enough to fit under the magnetic dipole system. The selected design can be seen in **Fig. 3.3**.

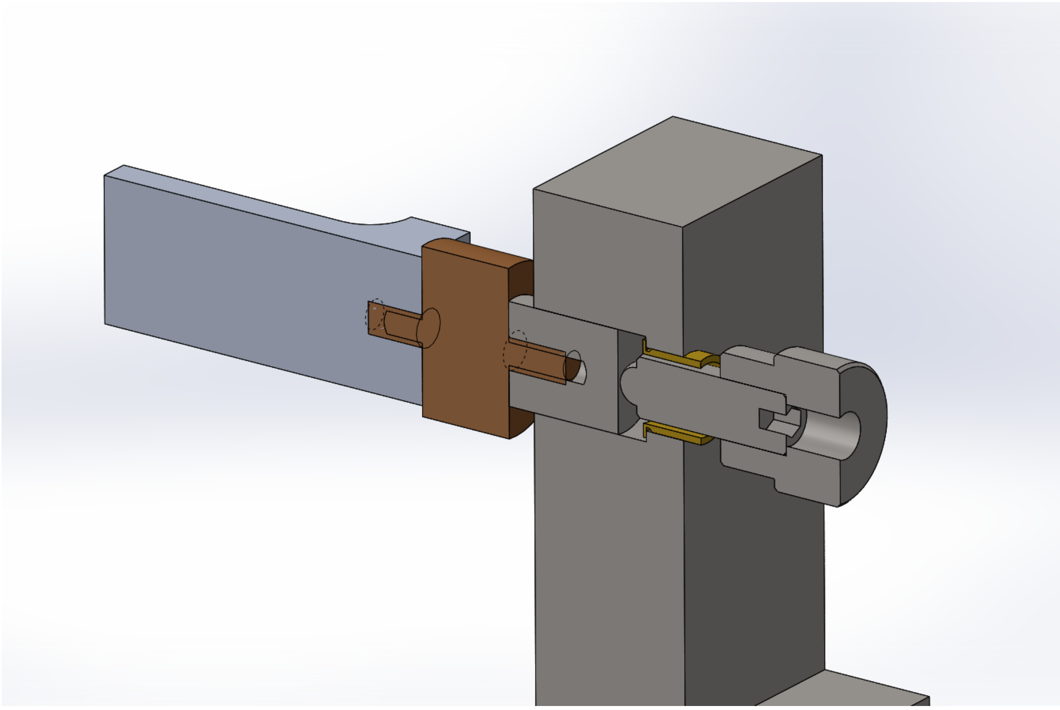


Figure 3.3: Force Sensor Configuration

In the design, the force sensor screws directly into the micro-tip and a slip cylinder. The user can turn a thumb attachment which turns a high precision screw and pushes the slip cylinder. This design meets all the requirements while maintaining a reduced cost.

3.3 Improvised Design Changes

During the machining process there were a few on the spot design changes made by the team. While machining the micro-tips, a mistake was made on one of them, making it thinner in an insignificant direction. This has no impact on the design, so it will be used as is. While machining the actuator mount, it was decided that by using a plastic bushing in the hole for the actuator, the actuator would have a softer and more compressible material to hold it in place. In order to accomplish this, the actuator hole on the mount was enlarged. Originally, the bolts used to tighten the mount onto the actuator were to be screwed into a tapped hole in the mount. However, in the process of tapping one of the holes, the tap broke off inside of the hole. To remedy this, through holes were drilled instead, and a nut and bolt setup was installed. The finalized actuator mount can be seen below in **Fig 3.4**.

Figure 3.4: Finalized Actuator Mount

This same type of change was made for the way the force sensor tower is connected to the aluminum base plate. Tapping was done on one of the triangular brackets, while through holes were drilled in the tower. This reduced the risk of breaking a tap in the tower since it is made of 304 stainless steel. The image of the corner brackets can be found below in **Fig 3.5**.

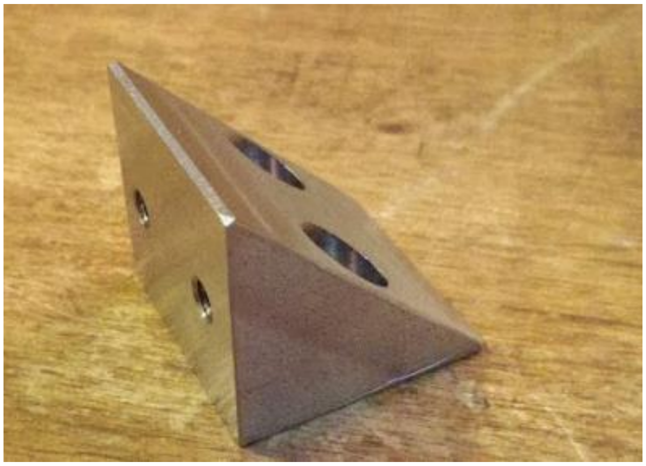


Figure 3.5: Completed Corner Brackets

4.0 Feedback System

The feedback system will be constructed using THORLABS APT System Software within LabVIEW. LabVIEW is capable of using ActiveX technology to communicate with the APT T-Cube Piezo Controller. A basic LabVIEW Block Diagram for this feedback setup can be seen in **Fig. 4.1**.

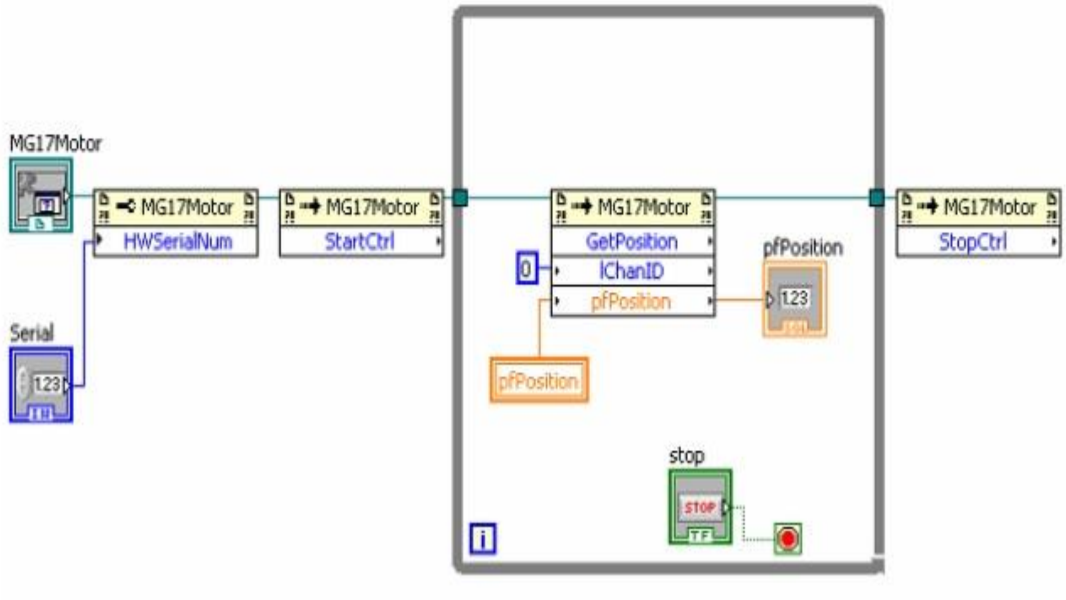


Figure 4.1: Generic Block Diagram for Feedback Control

In this diagram LabVIEW is able to control an APT motor or Piezo Controller depending on its serial number. The logic for this program is that the user can set an initial force that will be applied by the actuator. The code will use an input from the force sensor to make any changes needed in the force applied to the actuator until the user clicks the stop button.

This feedback control is still being constructed and may change depending on what new information the team can gather regarding programming for the force sensor. Currently within the while loop, illustrated by the large gray box in the above figure, IChanID can take the input value of the force that registers on the strain gauge. The GetPosition can then be used to create output changes in the actuator force based on pre-set allowances in force. This will continue until the end of the test when the user stops the program.

5.0 Updated Budget

After the design was finalized by the client, the ordering of all the products began. First, the piezoactuator was ordered because it was known that the product was shipping from New Jersey and it would take longer to receive than the other materials. After the piezoactuator was ordered, the steel and aluminum pieces were bought. The complete list of the materials, as well as their prices, is presented in **Table 5.1** below. The total for the entire project is at $2,498.80, which is below the allotted amount of $2,500.

Table 5.1: Updated Budget

Material	Cost
1.5" dia (1' length) 303 SST	$25.00
1" x 1.25" (3" length) 303 SST	$19.14
1.125" x 1.125" (11" length) 303 SST	$12.50
0.5" x 0.5" (3" length) 6061 extruded Alum.	$2.90
TB187-100-313 3/16 and 1/4 Fine Adjustment Carrier and Bushings	$3.75
KB187-100 Knob	$4.00
TS187-100-625 3/16-100 TPI Screw	$4.35
96006A259 6-32, 3/4" Long Stainless Steel Socket Head Cap Screw	$0.86
90585A144 1/4"-20, 9/16" Long Stainless Steel Flat Head Socket Cap Screw	$1.18
92220A173 10-32 1/2" Low Profile Socket Head Cap Screw	$9.44
UHMW Bearing, Flanged, for 1/2" Shaft Diameter, 5/8" OD, 1/2" Length	$15.96
THORLABS PAS015 Piezo-Actuator entire system	$2,370.26
Sales Tax	$4.96
Shipping	$24.50
Total	$2,498.80

6.0 Project Planning

In order to keep with the previous schedule, more resources had been delegated to machining the components of the system. Where previously it had just been Jonathan and Matt assigned to this task, the efforts of Thaddeus and Cody were added to expedite the machining process. The actuator and force sensor assemblies both took a week or more to complete. At this time the mounting system's parts are constructed. The only thing remaining is to assemble the system on the base plates of the Instron machine and make finalized face cuts to ensure proper alignment with the MSMA.

The LabVIEW program is set to be completed by Cody by March 10, after which comprehensive testing can commence. A significant time is allotted to the testing and redesign of the system if necessary. Upon finalization of the product, Joy and Jonathan will write the operations manual to complete the package for the client.

7.0 Conclusion

Since the last update much progress has been made on this project. The THORLABS PAS015 was elected to be the actuator used in the testing apparatus and the requisite modifications to the design were made. The parts required for machining were finalized and stainless steel was selected as the main building component. All of the materials were acquired and the process of machining the assembly was completed. There were also a few design changes that occurred during the machining process due to materials that were selected. This includes the decision to use a nut and bolt setup instead of further attempts to tap the stainless steel actuator mount. As it stands, the project is still below budget and still on schedule to be finished by the appointed time. Next on the schedule is to finish the design of the force feedback system using LabVIEW and begin the testing stage of the project.

8.0 References

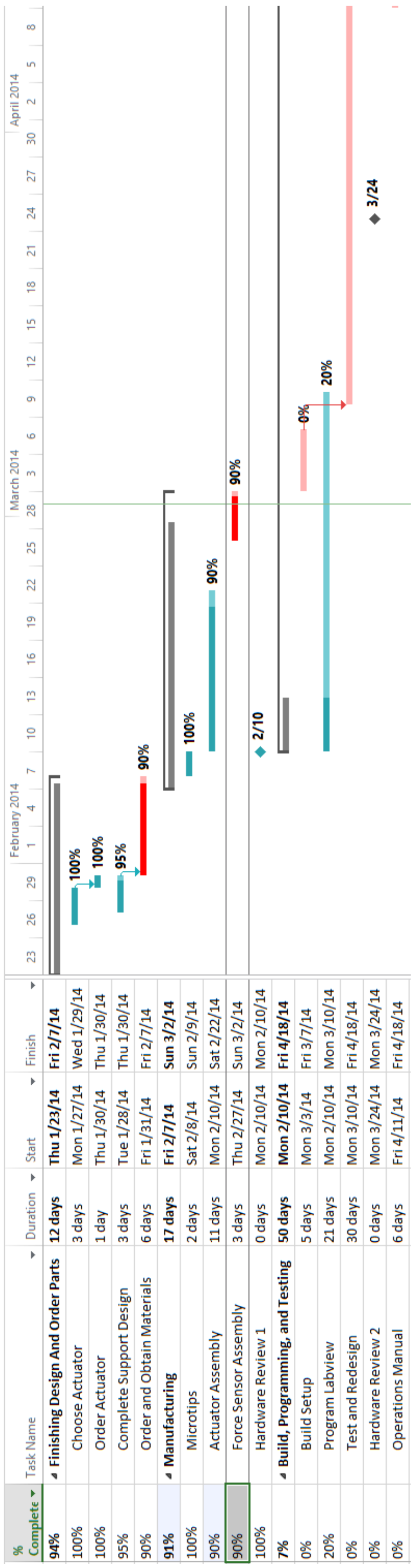
[1] Garcia, Matt, Randy Jackson, Jeremy Mountain, Qian Tong, and Hui Yao. *Material Testing Fixture*. *Material Testing Fixture*. Dr. Ciocanel, 2012. Web. 15 Nov. 2013. <http://www.cefns.nau.edu/capstone/projects/ME/2013/DFMTM/index.html>.

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

[3] "Model 11." *Model 11*. Honeywell International Inc, 2013. Web. 6 Nov. 2013.

[4] "Replaceable Tip Piezo Actuators." *Thorlabs*. N.p., n.d. Web. 15 Jan. 2014.

9.0 Appendices



% Complete	Task Name	Duration	Start	Finish
94%	**Finishing Design And Order Parts**	**12 days**	**Thu 1/23/14**	**Fri 2/7/14**
100%	Choose Actuator	3 days	Mon 1/27/14	Wed 1/29/14
100%	Order Actuator	1 day	Thu 1/30/14	Thu 1/30/14
95%	Complete Support Design	3 days	Tue 1/28/14	Thu 1/30/14
90%	Order and Obtain Materials	6 days	Fri 1/31/14	Fri 2/7/14
91%	**Manufacturing**	**17 days**	**Fri 2/7/14**	**Sun 3/2/14**
100%	Microtips	2 days	Sat 2/8/14	Sun 2/9/14
90%	Actuator Assembly	11 days	Mon 2/10/14	Sat 2/22/14
90%	Force Sensor Assembly	3 days	Thu 2/27/14	Sun 3/2/14
100%	Hardware Review 1	0 days	Mon 2/10/14	Mon 2/10/14
7%	**Build, Programming, and Testing**	**50 days**	**Mon 2/10/14**	**Fri 4/18/14**
0%	Build Setup	5 days	Mon 3/3/14	Fri 3/7/14
20%	Program Labview	21 days	Mon 2/10/14	Mon 3/10/14
0%	Test and Redesign	30 days	Mon 3/10/14	Fri 4/18/14
0%	Hardware Review 2	0 days	Mon 3/24/14	Mon 3/24/14
0%	Operations Manual	6 days	Fri 4/11/14	Fri 4/18/14

Figure A.1: Updated Gantt Chart for Spring 2014