Material Testing Fixture

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Concept Generation & Concept Selection

Report 2

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Table of Contents

1. Introduction:

In this report, we will restate our problem statement and some of the constraints that we must meet. Then we will discuss the concept generation, which includes two designs for the tip of the pushrods, and three designs for the base that attaches to the force analyzer. Then we will discuss our concept selection and how each of our criteria played into our final design decision.

Then, we will discuss and show the selected designs for the tip and the base. Finally, we will discuss the updated timeline.

2. Problem Statement:

The current pushrods and base connections are causing the specimen to bend due to eccentric loading and results in premature failure. The goal of our project is to redesign the pushrods to conduct compression and tension testing while maintaining axial alignment. In addition to tension testing, the improved pushrod design must also operate within the constraints that are mention below.

3. Constraints:

The team identified seven constraints with which the new design must comply as well as a brief description of each constraint.

1. The specimen size is 20 mm long with a 3 x 3 mm cross sectional area.
2. 6 mm of exposed length in the center of the specimen to allow for a camera to monitor specimen during testing.
3. Each specimen is unique and high in cost therefore grips cannot bite into specimen causing unwanted damage.
4. The magnetic field is crucial to specimen characteristics therefore pushrods cannot interfere with magnetic field.
5. Magnets which induce magnetic field are positioned 10 mm apart.
6. The applied magnetic field operates between 0.5 – 1.0 Tesla.
7. It is critical that the specimen remain axial loaded throughout testing.

4. Concept Generation:

In this section we will discuss the different designs that were generated and some of the pros and cons of each. There are two tip designs where the specimen is physically held, and three base designs that connect to the force analyzer

Clamp Tip:

This design consists of a redesigned pushrod, four independent clamping components, screw adjustable tension clamp, and a rubber insert. The unique feature of the clamp tip is the screw guided clamping components which are controlled by the tension clamp. This design is user friendly and allows for easy one screw adjustment while also maintaining axial alignment. In the center of the four clamping components is a rubber insert or rubber coating to ensure that the specimen remains undamaged while conducting tension testing. Below in **Figure 1: Clamp Tip**, a model of this design is shown.

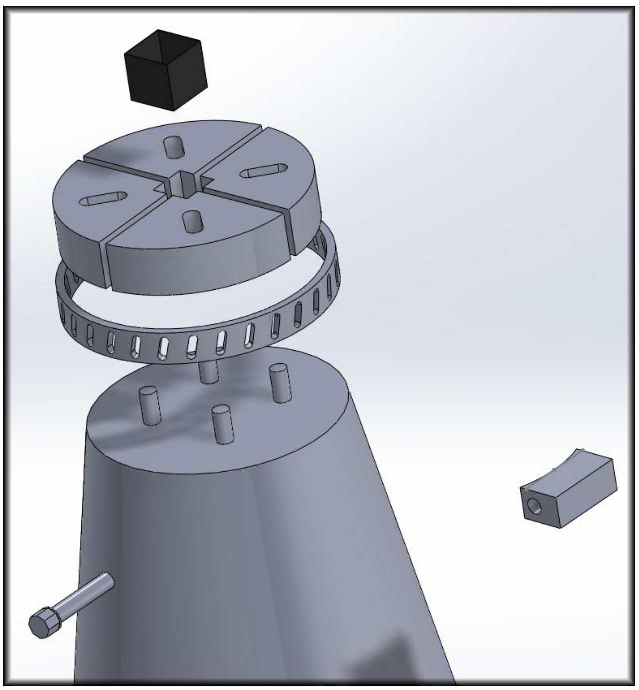

Figure 1: Clamp Tip

Screw Tip Design:

The goal of the screw tip design is to ensure the axial alignment of the specimen by using four set screws to control the alignment of the specimen. This design also allows for the specimen to be tested in tension. In order to make the design not damage the specimen, a rubber insert is placed between the screw ends and the specimen. This design however will require a lot of adjustment each time a specimen is tested. Below in **Figure 2: Screw Tip**, a model of this design is shown.

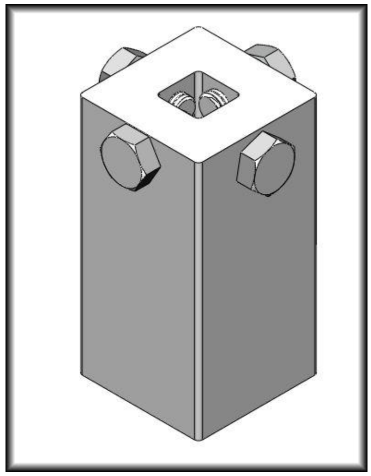

Figure 2: Screw Tip

Adjustable Base:

In this design there are 4 adjustment screws that press on the force analyzer to align the tip that hold the specimen. The problem with this design is that while it corrects the alignment of the specimen, it transfers the misalignment to the force analyzer. This simply shifts the location of the problem rather than fixing the design. Below in **Figure 3: Adjustable Base**, a model of this design is shown.

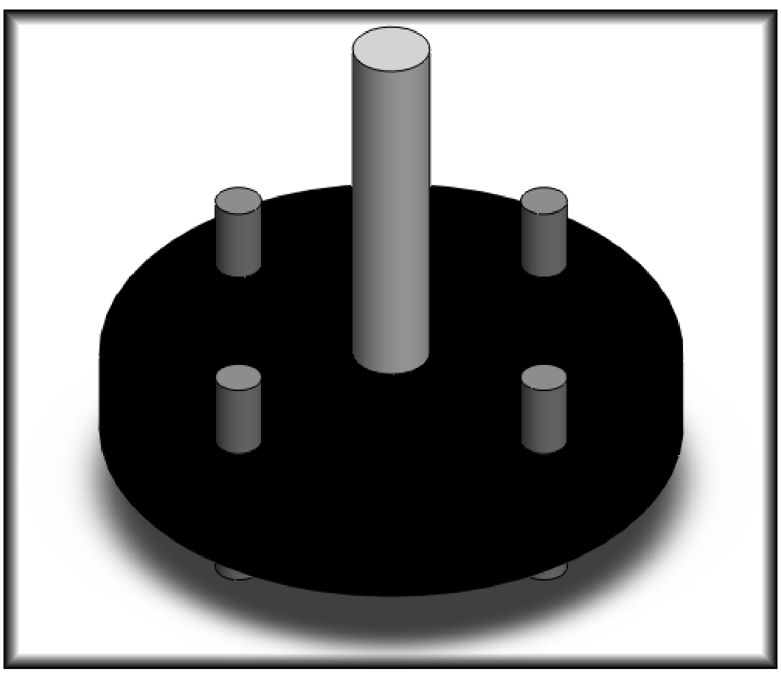

Figure 3: Adjustable Base

Base Sleeve:

This design is comprised of four main components. They are the pushrod, sleeve, force analyzer and securing screw. First the pushrod is inserted into the sleeve. Then the sleeve and pushrod are inserted into the force analyzer. Next, a screw will be used to secure sleeve and the pushrod. This design has three main characteristic. First, in order to keep the connection between the pushrod and base perfectly aligned, the sleeve will be made as large as possible. This large base will ensure that the pushrod is stable. Second, in order to ensure axial alignment, the tolerance between pushrod and sleeve will about 50μm. Finally, because there is only one screw, this design requires very little adjustment. Below in **Figure 4: Base Sleeve**, a model of the base sleeve is shown.

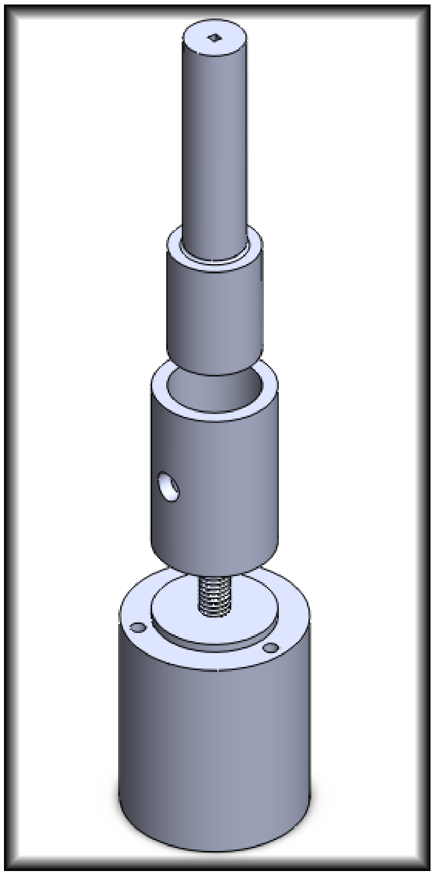

Figure 4: Base Sleeve

Collar Base:

This design is comprised of four main parts. They are the pushrod, collar, force analyzer, and four screws. Using the existing screw holes on the force analyzer, the screw holes are extended and tapped out. Then using the tapped out screw holes, the collar will be secured to the force analyzer. This will ensure the axial alignment of the pushrod. Then the pushrod will be inserted in the center hole of collar, and a set screw will be used to secure the pushrod to the collar. This design will ensure that the pushrods are axially aligned and there is no extra horizontal force applied to the force analyzer or specimen. This collar will ensure that the bottom of the pushrod and the force analyzer sensor are perfectly aligned. This sensor is used to collect data for the compression force. Finally, the tolerance between the center hole of the collar and the pushrod will also be machined to about 50μm to provide the perfect axial alignment. Below in **Figure 5: Collar Base**, a model of the collar base is shown.

Figure 5: Collar Base

5. Concept Selection

In this section we will discuss the decision making process and the methods used in selected an initial design. The first aspect of the concept selection process was to weigh our goals and objectives. Below in **Table 1: Analytical Hierarchy**, a table is shown that rates the importance of our objectives to a scale from 1 to 9.

Table 1: Analytical Hierarchy

Judgment of Importance	Numerical Rating
Extremely Important	9
	8
Very Important	7
	6
Strongly Important	5
	4
Moderately Important	3
	2
Equally Important	1

As seen in the table above, this rating is on a scale of 1 to 9 in order of equally important to extremely important. Using this criteria we can then make a judgment of how important our objectives are. To do this we created a matrix and assigned values to each of our objectives. Below in **Table 2: Weighted Objectives**, the values and the corresponding objectives are shown.

Table 2: Weighted Objectives

Axial Alignment	9
Tension & Compression	5
Damage To Specimen	9
Inexpensive	4

As can be seen from this table, "Axial Alignment", and "Damage To Specimen" are critical. The axial alignment is crucial because the eccentric loading of the test specimen is causing crack propagation. This ultimately leads to the catastrophic failure of the test specimen. Because of the rarity of the specimens it is crucial that the specimens not be damaged. For this reason, "Damage To Specimen" is rated as extremely important.

Although not a primary objective of this project, we would also like to design the new fixture to be able to perform tension tests which are currently not supported. For this reason the objective "Tension & Compression" was given a rating of 5, which corresponds to "Strongly Important."

Finally, we would like to make the new fixture as inexpensively as possible without compromising any of our objectives. Thus, the objective "Inexpensive" was given a rating of 4, which corresponds to slightly more than "Moderately Important."

To proceed with the selection process another scale was created that relates how closely our designs match our objectives. Below in **Table 3: Objective Matching Scale**, this scale is shown. The values range from 1, meaning the design does not meet objective, to 5, meaning that the design meets the objective extremely well.

Table 3: Objective Matching Scale

Meets Objective	Numerical Rating
Extremely Well	**5**
Very Well	**4**
Well	**3**
Not Well	**2**
Not At All	**1**

Next, all of these criteria are substituted into a large decision matrix. Below in **Table 4: Final Decision Matrix**, each of the designs is matched to our objectives and then weighted. The weighted total is calculated and shown at the bottom of the matrix.

Table 4: Final Decision Matrix

	Tip		Base			Objective Weight
Objectives	**Clamp Tip**	**Set Screw Tip**	**Adjustable Base**	**Base Sleeve**	**Collar Base**	
Axial Alignment	5	2	1	4	5	9
Tension & Compression	4	4	3	3	4	5
Damage To Specimen	4	4	N/A	N/A	N/A	9
Inexpensive	2	4	4	3	2	4
Total	15	14	8	10	11	
Weighted Total	109	90	40	63	73	

According to the decision matrix and our ranking scales, we decided that for our initial design, we will proceed with the Clamp Tip and Collar Base.

6. Timeline

The timeline has been updated from the first report. We have removed the tasks of working on presentations and reports, because those are not major events in our design process. We have added time to generate designs, meet with our client to discuss possible design ideas, perform engineering analysis, finalize our designs and prepare a final proposal. We also have an ongoing task for updating our team website which includes uploading presentations and reports after they have been edited and corrected. We also plan to include a biography section on the website that will display a picture of each team member along with a small biography. Our timeline still has the major milestones, including presentations and reports. We have also included time to meet with our client after our final presentation to go over our final design choices. The updated timeline can be found in **Appendix 1: Updated Timeline**

7. Conclusion

In this report we restated the problem statement, the objectives we plan to meet, and the constraints by which our prototypes must operate. We presented the concept generation which consisted of two tip designs and three base designs. Then we also briefly discussed the features behind each design and the features which make each design unique. Then each objective was weighted based on importance and each concept ranked on the ability to meet those objectives. These rankings were used in creating a final decision matrix which helped in the selection of an initial design. Finally we concluded by providing an updated timeline showcased our progress and plans for the foreseeable future. In this updated timeline, important events and the progression of those events were shown to provide the reader with a detailed look at the upcoming weeks.

References

1. **Gantt Chart Creation:**

http://www.youtube.com/watch?v=sPwURRG9_Gs

2. **Magnetic Shape Memory Alloy:**

http://nau.edu/Research/Feature-Stories/NAU-on-Leading-Edge-of-Smart-Materials-Research/

3. **Dr. Constantin Ciocanel**

http://nau.edu/CEFNS/Engineering/Mechanical/Faculty-Staff/

4. **SolidsWorks 2012**

http://www.solidworks.com/

Appendix 1: Update Timeline

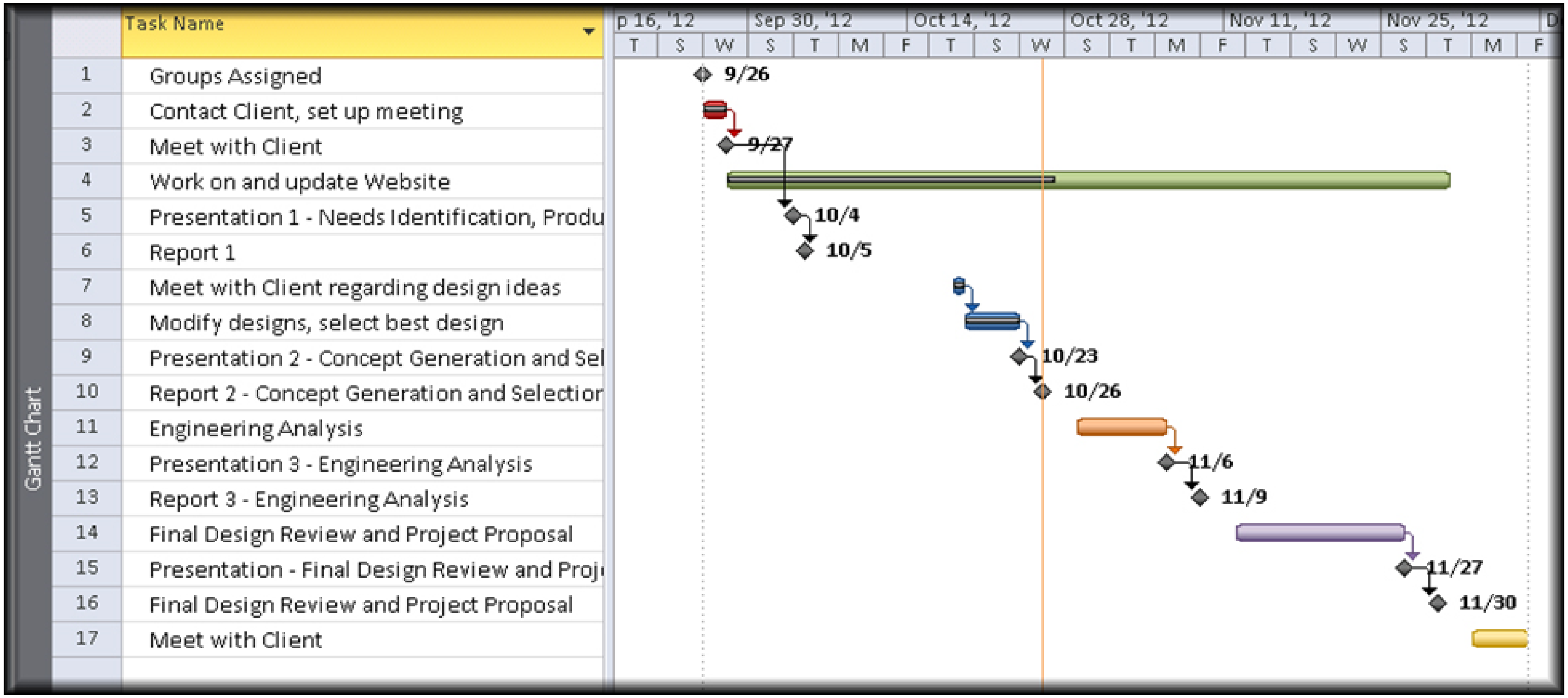

Figure 6: Gantt Chart