Material Testing Fixture

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Midpoint Review

Document

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Introduction

This report is an update on the current status of our project and the prototypes that have been made. We will discuss each of the prototypes that were created, as well as some of the modifications that must be made as we move forward. Then, we will cover the upcoming tasks that must be completed as the semester progresses. We will also discuss some of the manufacturing options we are currently looking into. Finally, we will have an updated timeline, showing the tasks we are currently working on, and the remaining tasks for the rest of the semester.

Prototyping

In order to create some of prototypes for this project it was necessary to use a rapid prototyping process. The processes and machines were made available to us by Dr. John Tester who is in charge of the Rapid Prototyping Lab at Northern Arizona University. With his aid we were able to take the Solidworks drawings and create physical models of our parts.

It was also necessary to produce one of our parts using the Machine Shop. After creating Solidworks drawings, we converted the drawings to G-Code in order to operate the CNC machines.

Sleeve

The sleeve prototype was made using a prototyping process that sprays on the material. After each pass that the machine makes an ultraviolet light cures the liquid material. After it hardens, the part is ready to be used. Because of this process, we were able to model thread patterns in Solidworks and have the machine produce the threads. Two prototypes were created using this machine, but with different tolerances. The sleeve with less accuracy actually fit the tip prototype better than the sleeve with more accuracy. This was due to the fact that the sleeve with higher accuracy had too tight of tolerances when meshed with the collet prototype. In **Figure 1**, the thread pattern that was printed can be seen quite clearly.

Figure 1 – Sleeve Prototypes

As stated earlier, there were two different sleeves that were modeled. In **Figure 2**, the two different sleeves are shown.

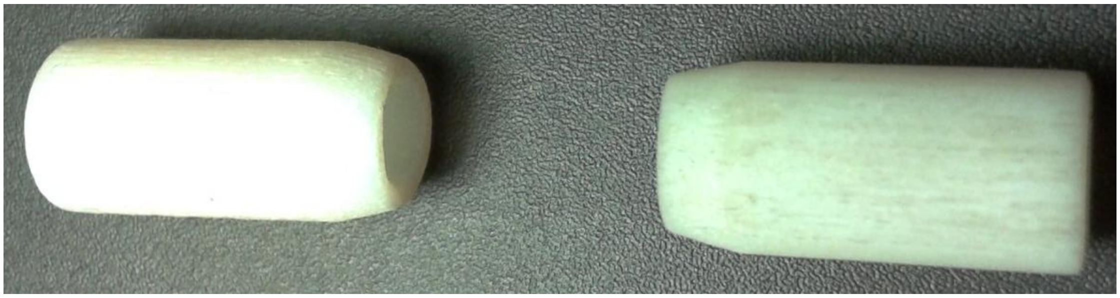

Figure 2 – The left sleeve has tighter tolerances than the right sleeve

The sleeves contain a slight taper at the top, which, when screwed onto the tip, causes the four tines to close in around the specimen, securing it in place.

Collet

The collet was also produced with spray-on rapid prototyping process. It was done this way because the threads could be accurately reproduced. In **Figure 3**, the collet is shown in comparison to a standard 0.5mm pencil.

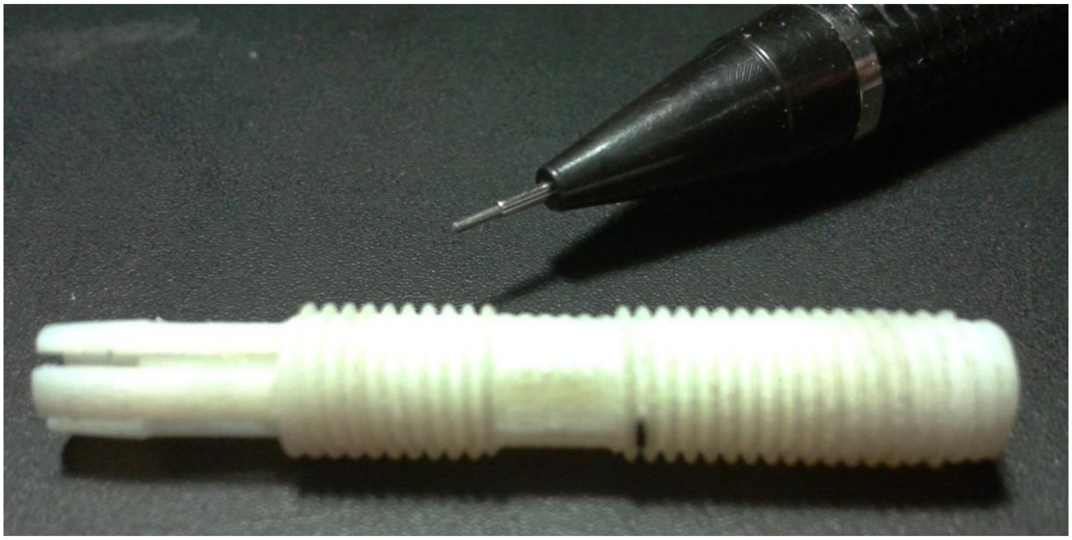

Figure 3 – Collet compared to a 0.5mm pencil

Here the threads of the tip can be seen. Also the tines which hold the specimen and even the slight taper are visible. For prototyping purposes the collet and base were created as two separate parts. This is because the cost of producing the smaller parts was much greater than using the less accurate Fortus FDM machine. There was also less material available to print with the accurate machine which meant that only the parts with the highest tolerances would be produced. This is not representative of the final product, which will be produced as a single part. The base and the collet will be machined out of one piece of Stainless Steel 316. The reason for this is that the alignment of a single part will be much easier to maintain rather than producing two separate parts.

Once the sleeve and collet had been produced it was time to see how the two parts were mated. In **Figure 4**, the assembly of the sleeve, collet and specimen is shown.

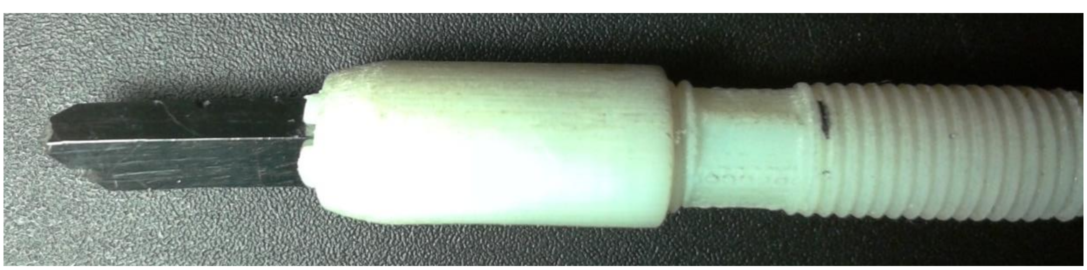

Figure 4 – Collet assembly

The mating of the collet and sleeve were quite accurate. Using the loose tolerance sleeve we were able to mate the sleeve and collet, while securing the specimen inside. The force that was exerted on the specimen was enough to keep the specimen in place during light tension; however, if too much force was applied the specimen would come free. This proved that the collet concept will meet the requirements of the project with a few modifications.

Base

The lower base design is a round cylinder that is large compared to tip. On the top of the base, there is a thread hole that was created for prototyping that allows the tip to screw into the base. This threaded part is purely modification for the prototyping, as the final product will be made from a single piece of steel as mentioned earlier. In **Figure 5**, the top of the base can be seen with the threaded hole. In **Figure 6**, the right side of the base is shown. Here the two holes for securing the micrometer can be seen. Also the round cutouts at the bottom of the base are there to allow an allen wrench to secure the base to the force analyzer.

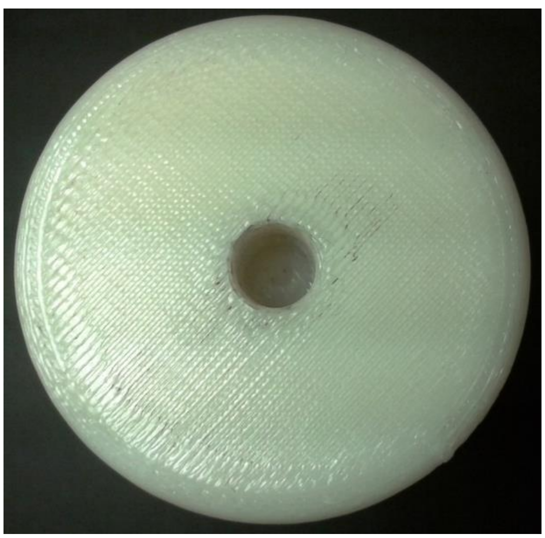

Figure 5 – Top of base

Figure 6 – Right Side

In order to secure the base to force analyzer a small round cutout is place in the bottom of the base. This will be used to secure the base with the force analyzer and provide the axial alignment. In **Figure 7**, the cutout can be seen. There are also cutouts in the center of the base that allows the micrometer to be positioned; this is shown in **Figure 8**.

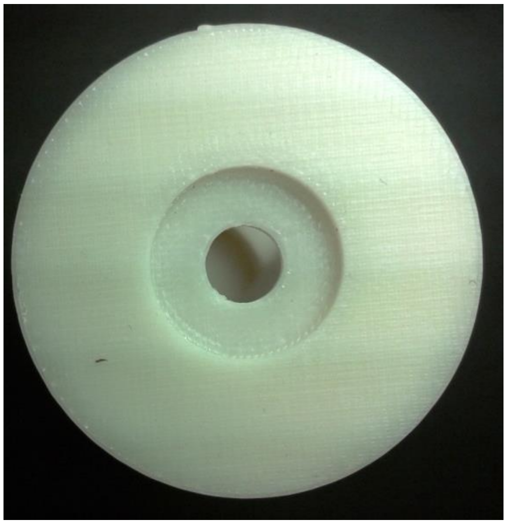

Figure 7 – Bottom view

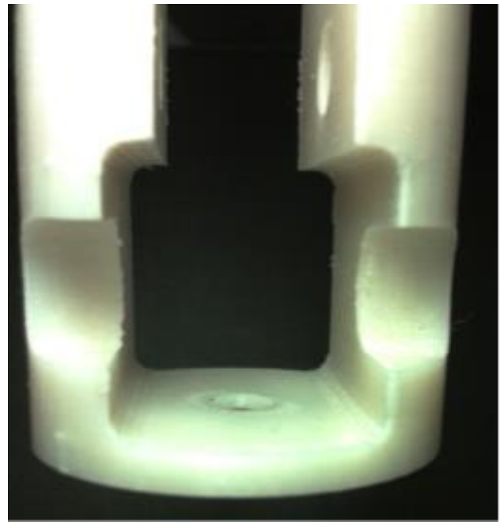

Figure 8 – Front view

Micrometer Tip

One addition to the project is that we needed to be able to apply lateral loads onto the specimen. In order to do this, we needed to create new micrometer tips. These tips will fit over the micrometer and allow lateral forces to be applied. We have several material choices for the tips which include; aluminum, copper and titanium. We decide to use aluminum because it is relatively easy to machine, and readily available. Because the lateral forces which are applied to specimen are so small, the yield strength of the material is not a high priority and the aluminum meets these requirements adequately. For the tip design, we implemented a simple design shown in **Figure 9**, to reduce the amount of machining time that it would require.

Figure 9 – Micrometer tips

The design of two tips are mostly the same, however, there is slight difference is at the bottom of the tips. One has a big hole which will be connected with the micrometer tip directly, while the other has a small threaded hole which allows a force sensor to be attached. This sensor allows the lab technician to collect and store data on the poisons ratio change as the magnetic field is applied. After considering manufacturing procedure and the material, we decide to use a CNC mill to produce the tips. First, we built up the model of micrometer tip in the Solidworks, and then we modified the manufacturing procedure in CAMWorks to output the G-Code which runs the mill. Finally, using the SuperMax CNC machine and the assistance of the lab technician, the parts were fabricated. In order to understand the role that the tips play in applying the lateral force an image of the tip assembly is shown in **Figure 10**.

Figure 10 – Lateral Assembly

Finally, in order to ensure that the tips will not damage the specimen, a very thin silicon rubber sleeve will be attached to the area which contacts the specimen.

Modifications

Because of high quality of the prototype that was created, there are very few modifications that need to be made.

The first modification has to do with the taper of the sleeve and tip of the collet. Once the parts were made it was discovered that the force to hold the specimen in place was not enough. To fix this problem, the taper on the sleeve and tip have to be adjusted so that the tines clamp down more with each turn. This change consists of varying the outer diameter at the small and large end of the taper. By lower the slope, each turn will be able to provide slightly more force to the specimen.

Another modification that must made is at the connection of the collet to the lower and upper bases. Because the final product will be machined from a single bar stock of steel, the area where the collet meets the base will see the most stress of the system. By increasing the radius and taper at that point, the stresses will be minimized. This connection is shown in **Figure 12**, and is indicated by the black arrow.

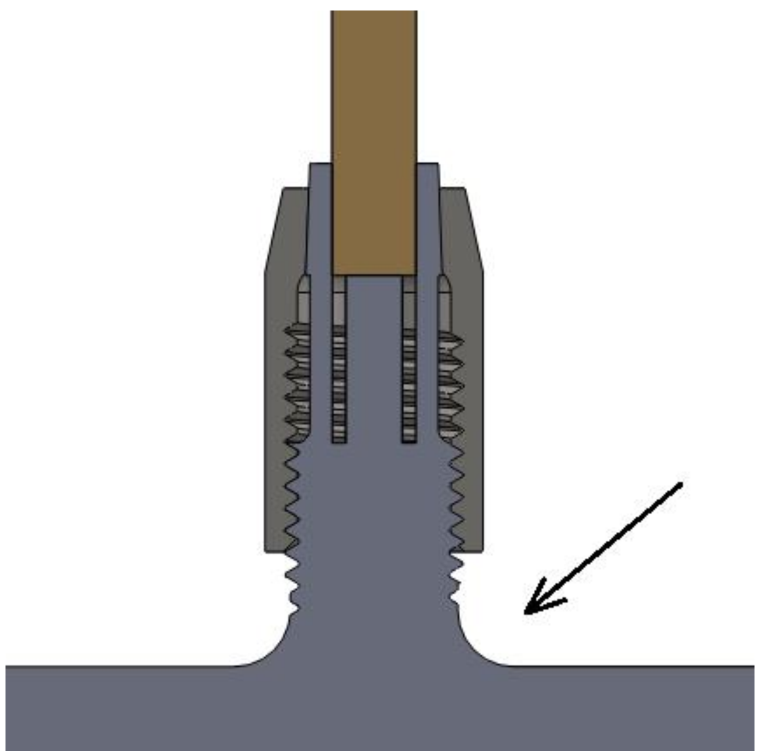

Figure 12 – Stress concentrator

The last modification that must be made is to the tines of the collet, shown in **Figure 13**, and indicated by the black arrow.

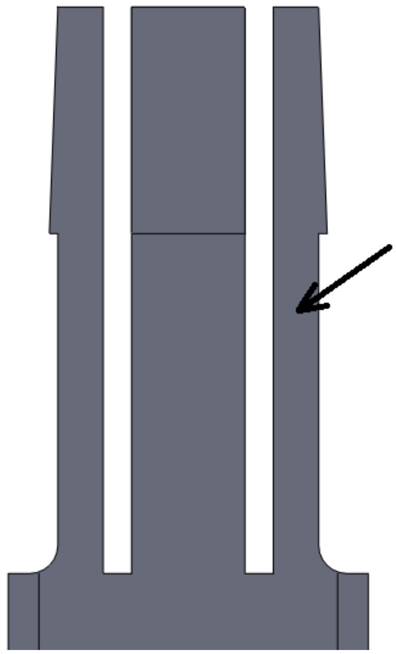

Figure 13 – Tines

This modification is for the purpose of strengthening the collet. Because this is such a small scale, the tines are prone to breaking. By increasing their thickness, the part will be more durable. This modification is also to ensure that fatigue does not set in a cause cracks in the connections.

Upcoming Tasks

In order to complete this project there are number of tasks that still need to be completed. The first task is to use finite element analysis on the tines of the collet. Using the COSMOS software, we plan to build and model the tines so that an analysis can be performed. This will help us understand how the forces and stress act on the collet tip so we can find the factor of safety in the tine area.

The next task that must be completed is to complete the manufacturer's drawings for rest of the parts. By making the drawings professional, it will save the machinists time and money, and they will be more inclined to accept the job. We are currently talking with different machinists in order to help refine the drawings to such a degree.

The final task is to create the product. By working with machinists and different companies we will be able to send the drawings out and receive the parts. Because of the high price of the stainless steel, it is not practical or cost efficient to create multiple prototypes from metal. As this is the case, we don't expect to have run any iterations of the part out of metal. This means that once we get the metal version, we will have our final product. This stresses the importance that the manufacturer's drawings need to be at a professional level.

Manufacturing

One of the main problems we are currently facing is finding a method of manufacturing that will create such small parts. The small scale of the parts makes them difficult to machine, and prevents us from using many conventional machining methods. The extreme tolerances that are required mean that many of the most readily available machines are not capable of producing such the parts.

For the final product, we are currently in contact with a company in California that may be able to make the part. They use a special process call Electro Discharge Machining (EDM). This process removes material by discharging a current between an electrode and the material. Each time the electrodes arc, a small amount of material is removed from the part. This process allows for very high tolerances, and extreme accuracy. By using this process, small dimensions and tolerances can be easily achieved.

We are also looking into using the Northern Arizona University machine shop, and the Haas CNC machine to produce the parts. This may be difficult as there are not many people with the knowledge or experience that can operate this machine.

In the case that neither of these options will produce the part, we are looking into local manufacturing companies that will be able to produce the final product. This is the third and final option as it will be the most expensive.

Conclusion

This report has covered the problem statement, to remind you of the constraints and requirements we must follow throughout this project. We covered the prototypes created using Fused Deposition Modeling. We talked about the modifications that must be made in the upcoming weeks, before making the final product. We listed the upcoming tasks that must be completed to finalize the project. We discussed our manufacturing options, which include both local and out-of-state manufacturing companies. And finally, we showed an updated timeline, which tracks our progress on current tasks, as well as our remaining tasks.

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Updated Timeline