Tabletop Torsion Device

Abstract

The Air Force Research Laboratory Munitions Directorate at Eglin AFB does thorough material testing for their products. Their current torsion machine is very large and ineffective when testing small specimens. They have a need for a smaller, more accurate torsion testing apparatus. Each component of the design was analyzed independently in order to ensure the optimal build met the specifications set by the AFRL. The machine must be able to apply a torque of up to 250 Nm while staying within the budget of $2000.

Background

Sponsor: Philip Flater – Air Force Research Laboratory

The Eglin Air Force Base Munitions Directorate has performed extensive research in the field of testing mechanical properties of materials commonly used in projectiles. They are interested in how different materials react under variable loads in a real life environment. In order to properly characterize the materials that end up in a product they have to test similar geometry in order the get accurate results.

The current torsion machine as shown in Figure 2 is quite large and utilizes high speed Digital Imaging Correlation (DIC) to accurately measure strain in the specimen, as seen in Figure 1. Our design will be much smaller while still utilizing this technology.

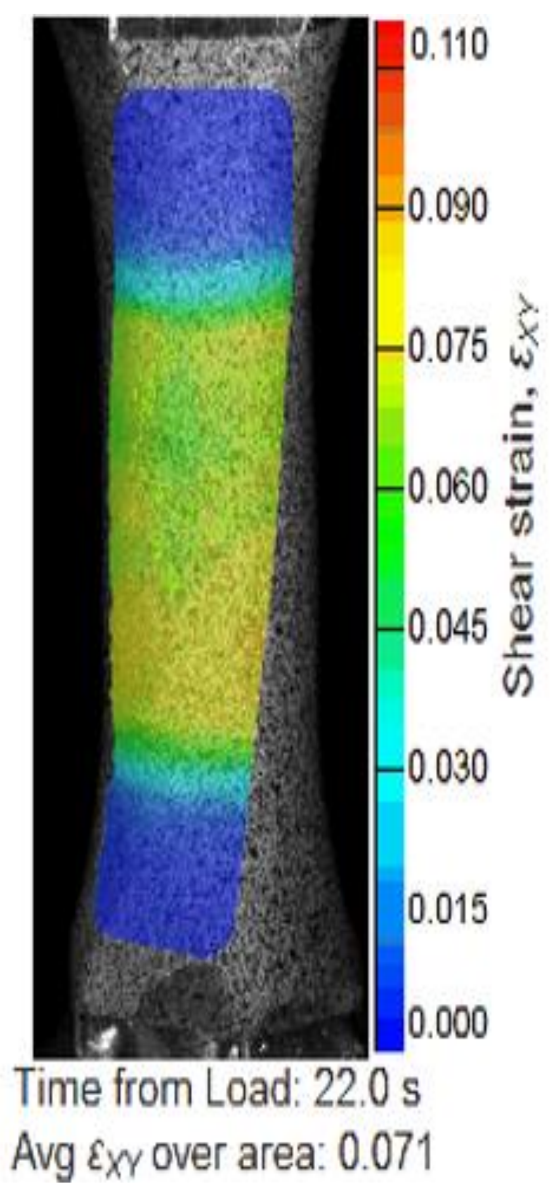


Figure 1. DIC imaging from sample in torsion

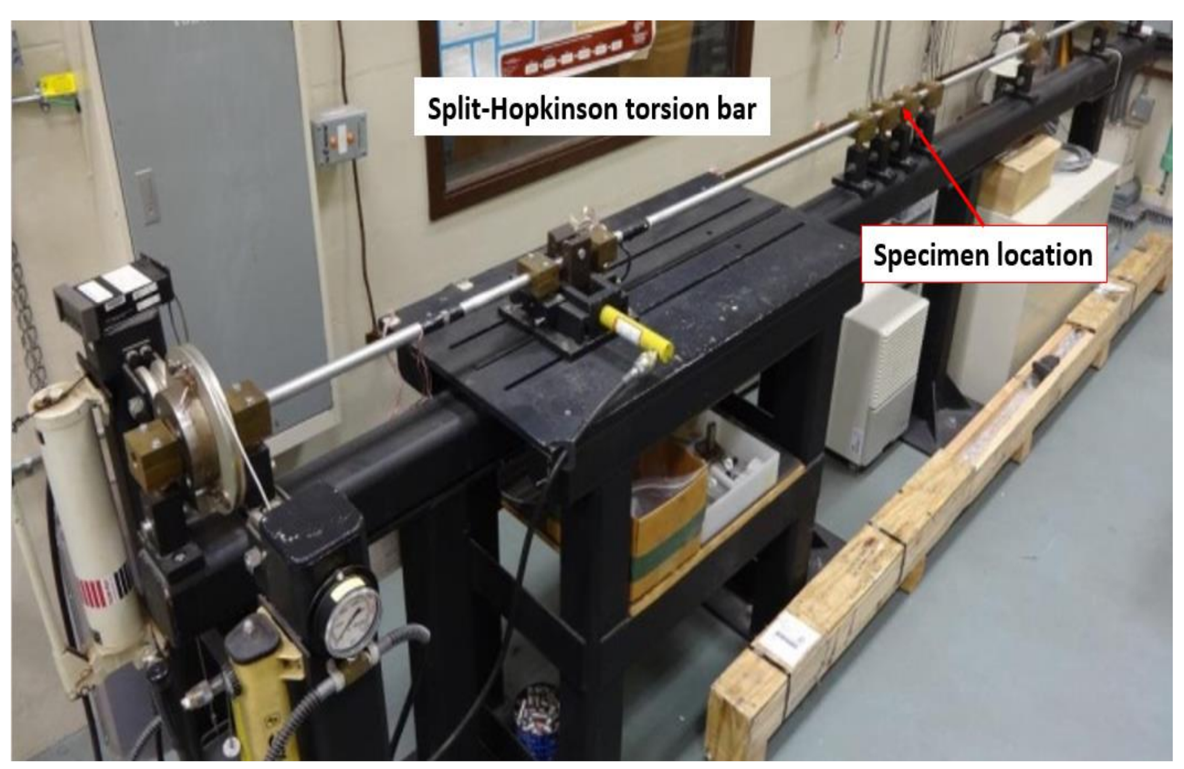


Figure 2. Existing torsion testing apparatus at AFRL

Design Constraints & Components

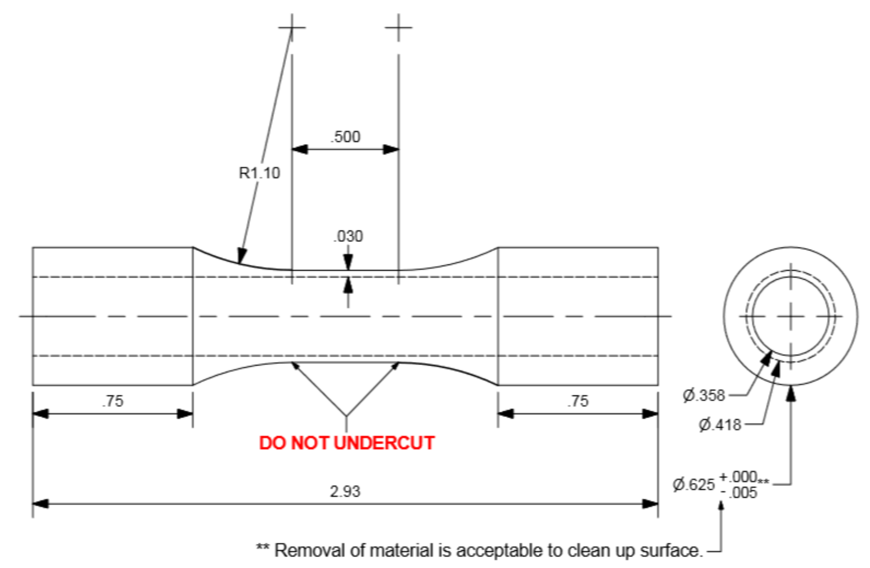


Figure 3. Sample geometry in inches

Constraints

- Budget: $2000
- Maximum torque applied 250 Nm
- Maximum footprint of 1m^2
- Monotonic and cyclic free end loading
- 1 axial DoF on free end

Load Generation – The torsion machine must be able to generate a maximum applied torque of 250 Nm. A DC motor and microcontroller was selected due to its variability, reliability, and accuracy

Load Application – The gripping mechanism used in this design must transmit the torque to the sample with zero slip as well as allow for a variety of specimen geometries. A 6-jaw chuck was selected due to its ability to self-center and apply a clamping force over a large surface area

Load Measurement – A measurement device is necessary to measure the applied load on the specimen. A strain rosette in conjunction with a program will determine the stress experienced by the specimen

Linear Motion – The free end of the tester must be able to allow for specimen contraction and expansion during loading. Therefore a 2 rail ball bearing guide system was selected due to its simplicity and friction reduction capabilities

Housing – The base and housing of the tester must be compatible with an optical table as well as be sturdy enough to withstand the forces experienced during testing. Aluminum was chosen due to its lightweight and cost effectiveness

Final Design

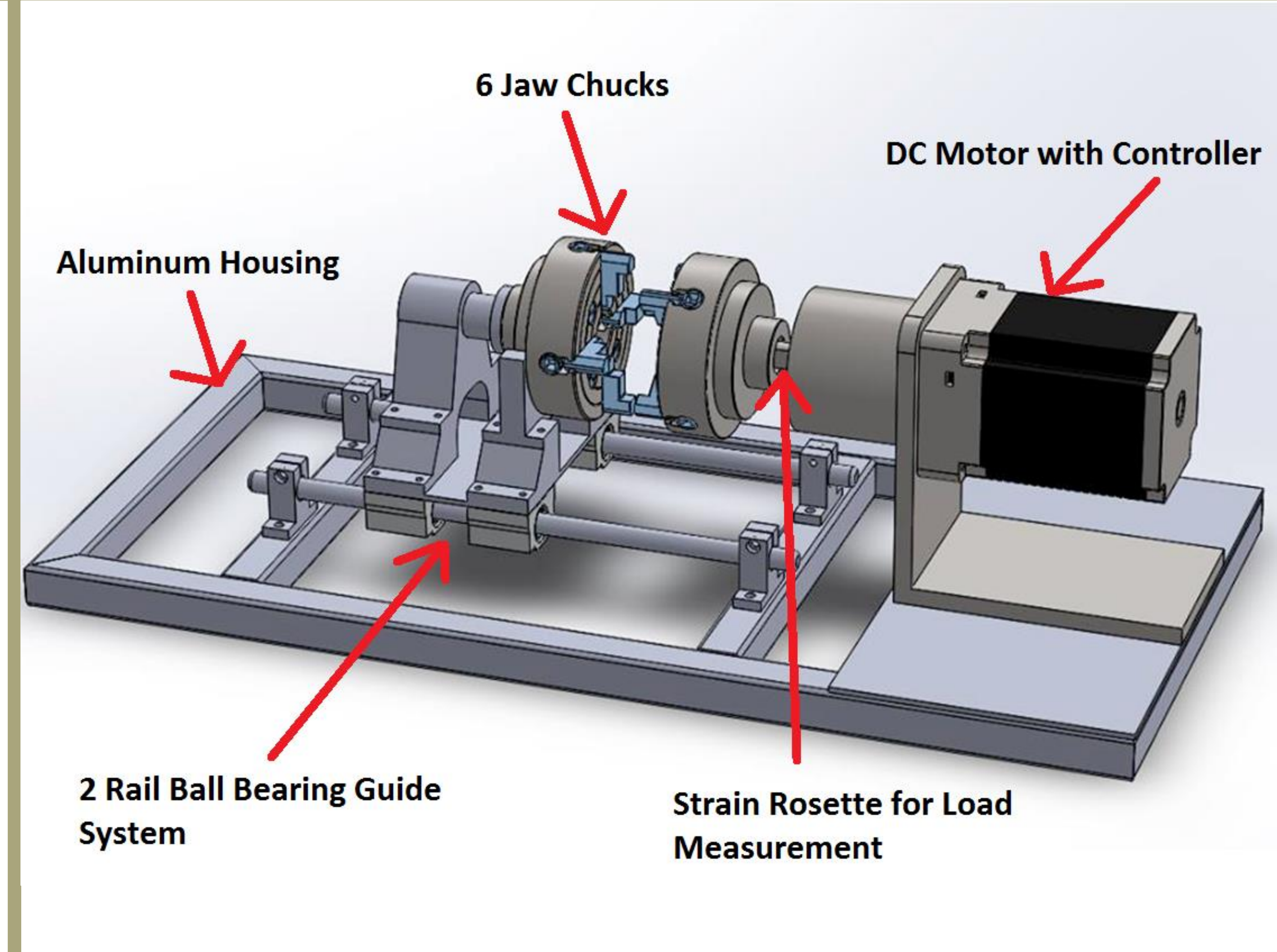
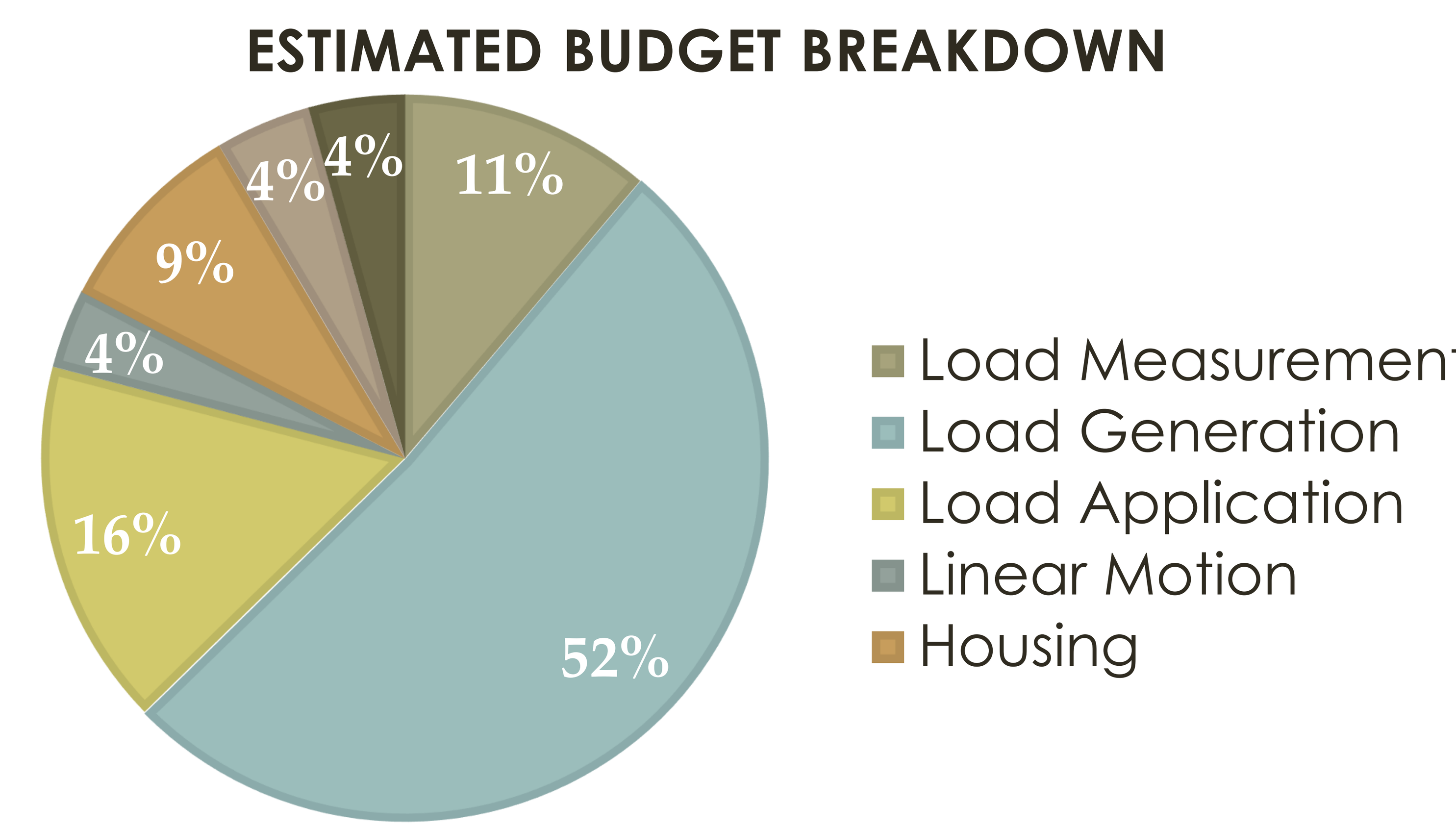


Figure 4. Optimal design of tabletop torsion device

Next Phase



Fall Semester: Finalize purchase orders and order all parts

Spring Semester: Assemble prototype and program motor, strain rosette, and user interface with LabVIEW

Group 13

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