Espresso Mini Rocket Engine Test Stand

MAE 189 Capstone Design | Advisor: Mark Walter
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Executive Summary

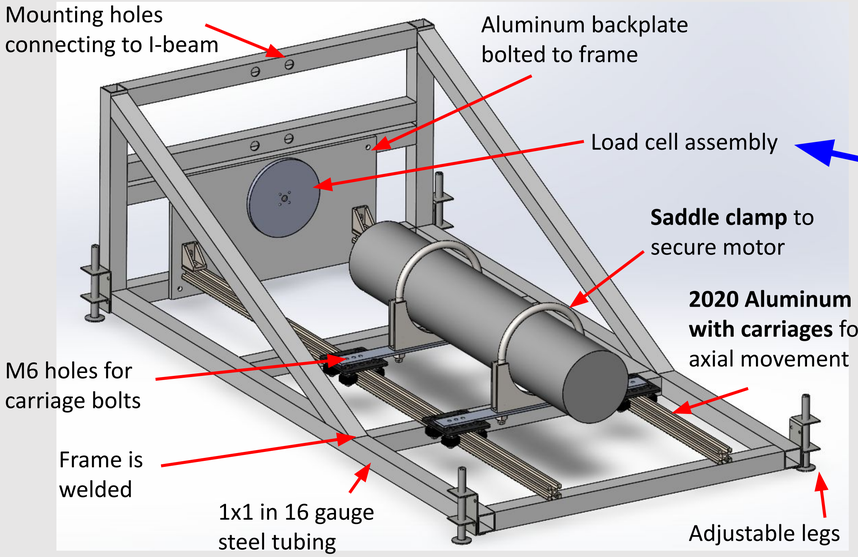
- The solid rocket team requires a framework to easily and consistently test fire new rocket designs and provide reliable thrust and burn time specifications of various motors
- It is important that the test stand be easily transportable to allow for rapid testing
- The team aims to test various rocket motor designs and thus the test stand should accommodate different geometries and thrust characteristics
  - Specifically, rocket diameters between 75mm and 98mm and thrust of up to 2,500 N
- A horizontal frame assembly using rails for uniaxial free movement, a load cell for force measurements, and exhaust clamps for securing the motor was designed to accomplish these goals

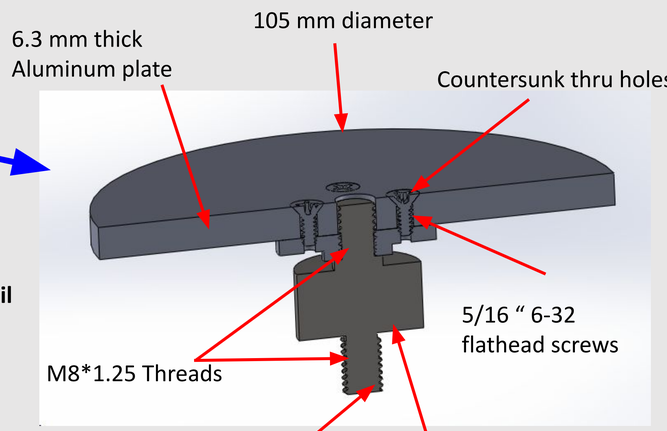
Key Considerations/Features

Location: The testing location determines the facilities available. The only nearby feasible test site is at F.A.R. [1] where they use I-beams for their static stand. The model is designed to bolt into the I-beam.

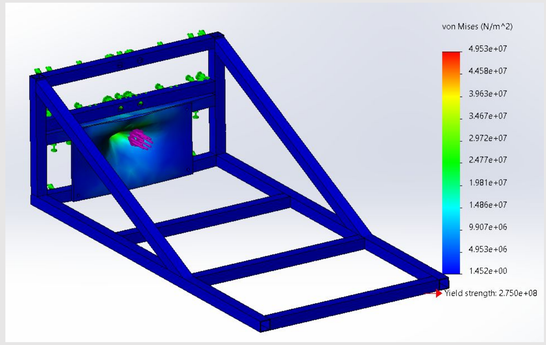
Orientation: Horizontal and vertical (pictured above [2]) test stands are widely used. We chose horizontal due to testing site compatibility, stability during use, and ease of manufacturing.

Final Design





Analysis



A FEA simulation of the loading scenario was performed. A 5000 N force on the load cell was applied through the backplate. The max stress of ~50 MPa occurs in the backplate. This is well below the yield strength of 275 MPa. A deflection of 0.03 mm was observed, also below the 1.5 cm requirement.

Desired Thrust Capacity: 2,500 N
Load Cell Output: 1~1.5mV/V
Required Amplification: Gain of ~700
Justification:

Load cell output with 5V excitation voltage:

$$5V \times \frac{1.5mV}{V} = 7.5mV = 0.0075V$$

The amplifier gain required to make full use of 5V DAQ input voltage:

$$\frac{5V}{0.0075V} = 667 \rightarrow Amplifier\ Gain\ should\ be\ as\ close\ to\ 667\ as\ possible$$

Conclusion

- Hardware Performance
  - Motor Mount - Utilizing prototyped solid motor, the motor mount limits lateral movement of the motor
- Future Improvements
  - In order to reduce eccentric load, a malleable material can be placed between load cell assembly and motor to allow for full force transfer
  - Smaller load cell assembly for more accurate thrust measurements
  - Blast shield to minimize thermal transfer to frame assembly/peripherals
- Environmental/Safety Factors
  - Backplate allows for frame to be fixed to an external structure, allowing for increased safety

Acknowledgements/References

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1. "Static Stands." *Friends of Amateur Rocketry, Inc.*
2. "Examples of Test Stands for Solid, Liquid, and Hybrid Rocket Motor Testing." *Aerocon Systems*.