

Magnetostrictive Torque Motor

Midpoint Progress

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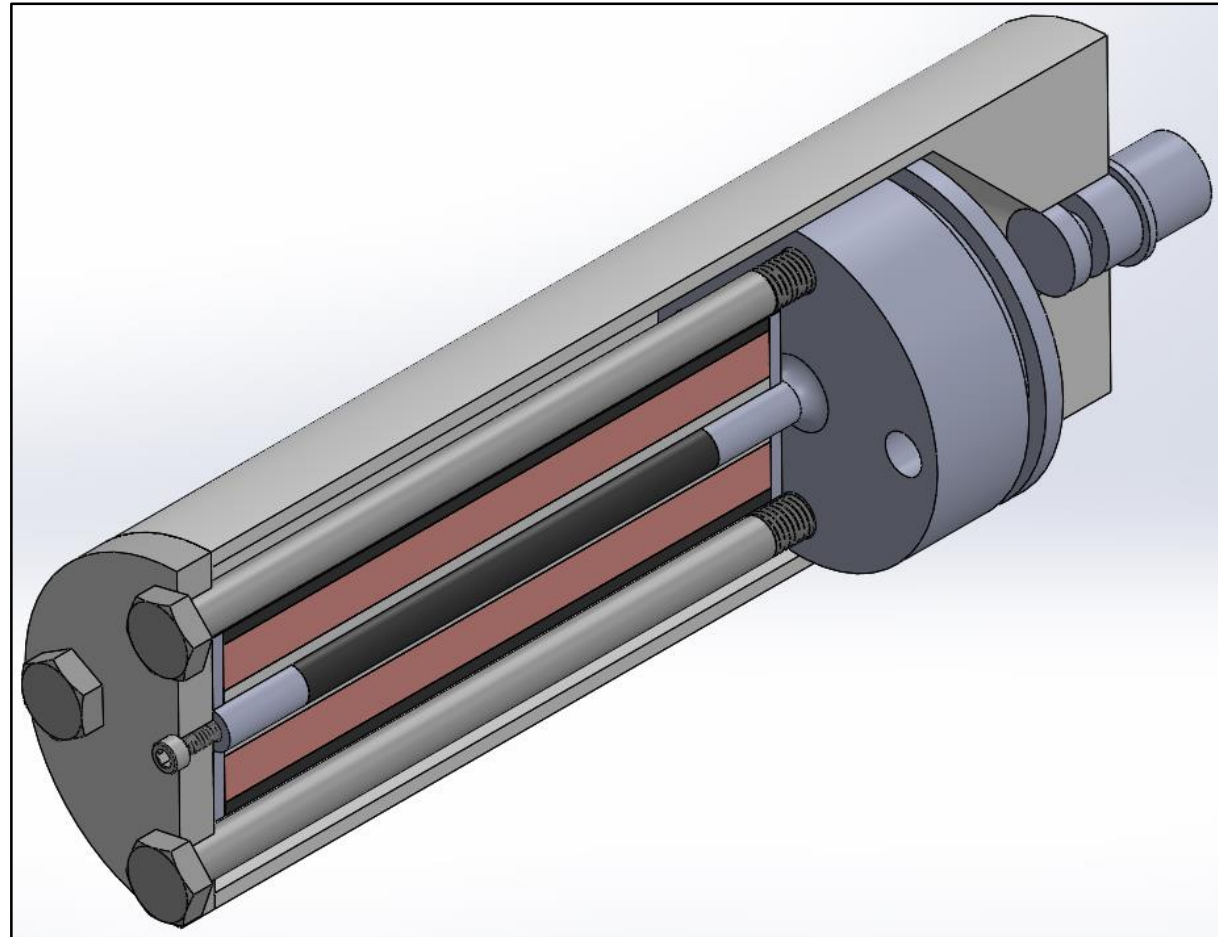
Overview

- Introduction
- Original Design
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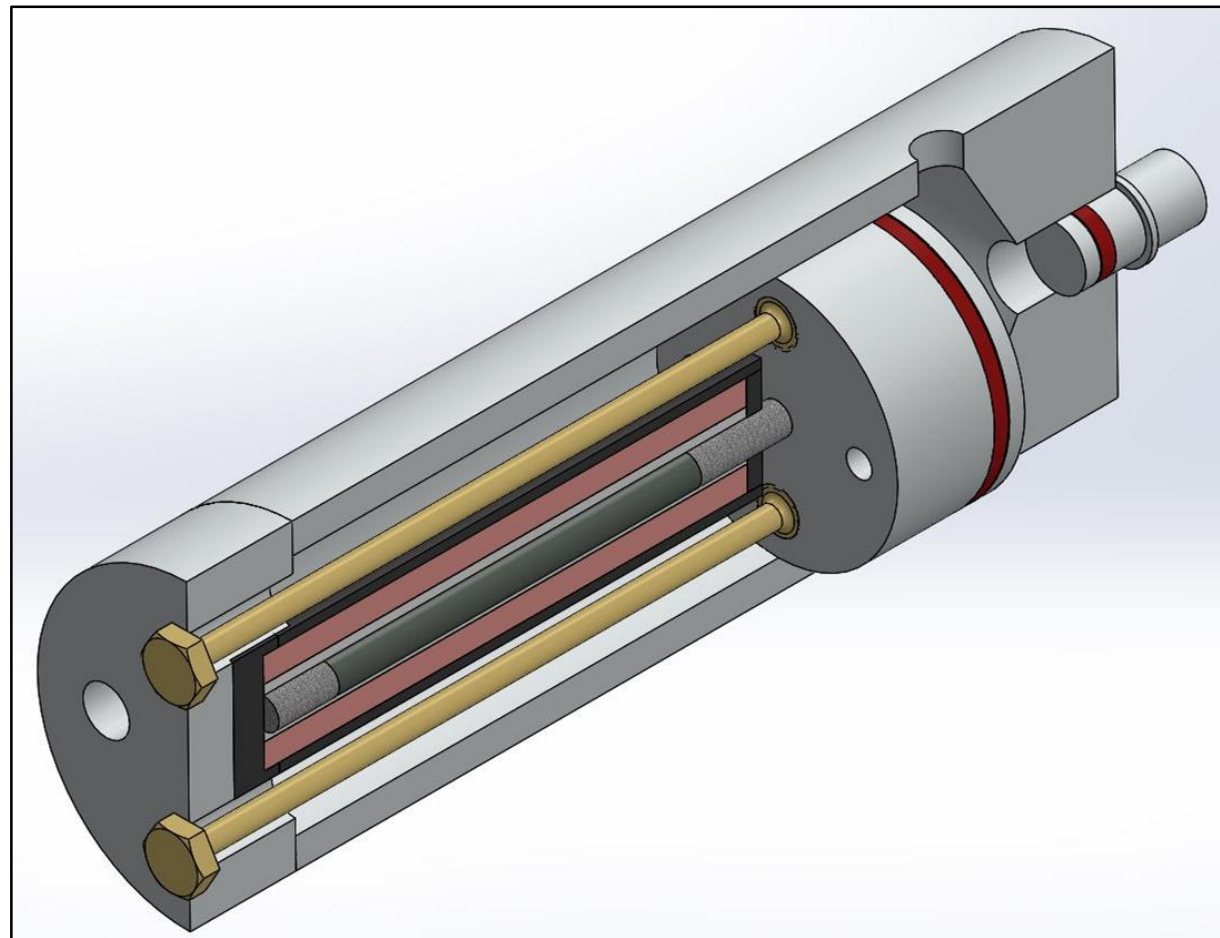
Introduction

- Honeywell Aerospace designs and manufactures numerous products and services for the commercial and military aircraft industry
- Honeywell contacts initiating the project are Michael McCollum, the Chief Engineer of Pneumatic Controls Technology and Mitchell Thune, a recent NAU graduate who is working with Michael McCollum on this project
- The clients want to replace an electromagnetic solenoid with a magnetostrictive material, Terfenol-D, in the pneumatic control systems used on commercial airliners

Original Design



Current Design



Current Progress

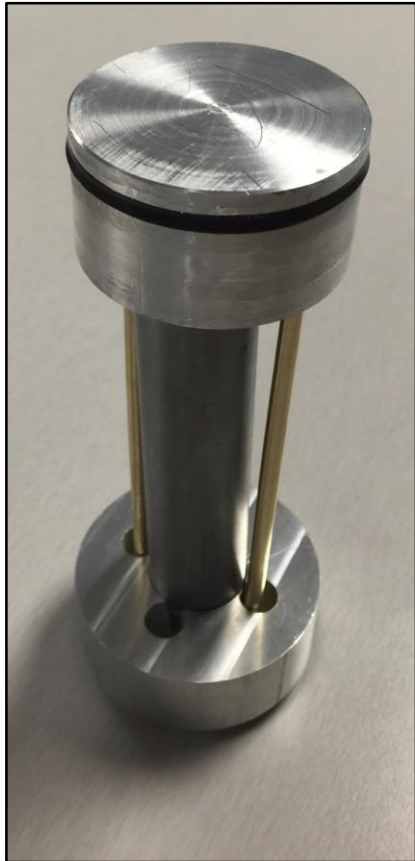
- So far, we have manufactured:
 - Aluminum cylindrical housing and endcap
 - Large and small pistons with seals fitted
 - Iron solenoid housing
 - Pre-stress bolts
- Also, we have a solution for filling the hydraulic chamber

Assembly



Acquired Components

Core Setup



Aluminum Endcap



Aluminum Housing



Brass pre-stress bolts



Small Piston



Large Piston



Changes to Design

- Increased thickness of aluminum endcap
 - Solenoid assembly length remains the same
- Iron endcap for solenoid housing
 - Heat fit
- Pre-stress bolts (number, diameter, and material)
- Chamber fill hole
- Small piston shaved down to fit seal

Iron Endcap



Problems with Design

- Fluid properties change over range of temperatures
 - Brake fluid expands with temperature changes
- Completing magnetic circuit (iron component)
 - NAU fabrication shop cannot weld iron to iron
- Filling the fluid chamber
 - Chamber must be sealed to prevent leakage when compressed
 - Chamber is difficult to refill
- Lead times

Currently Working On

- Drilling bleeder valve hole
- Finishing iron pieces
 - End caps
 - Core stops
- Threaded piston holes
 - Need to increase hole size to fit the bolts

Bill of Materials

| Item | Individual Cost (\$) | Quantity | Total Cost (\$) |
|-------------|----------------------|----------|-----------------|
| Aluminum | 41.52 | 2 | 83.04 |
| Iron Tube | 138.00 | 1 | 138.00 |
| Iron Rod | 171.00 | 1 | 171.00 |
| Solenoid | 790.00 | 1 | 790.00 |
| Brass | 10.97 | 1 | 10.97 |
| Terfenol-D | 447.00 | 1 | 447.00 |
| Large Seal | 5.56 | 1 | 5.56 |
| Small Seal | 3.94 | 1 | 3.94 |
| Brake Fluid | 9.95 | 1 | 9.95 |
| Cenospheres | 12.55 | 1 | 12.55 |
| Total Cost | | | 1672.01 |

Future Work

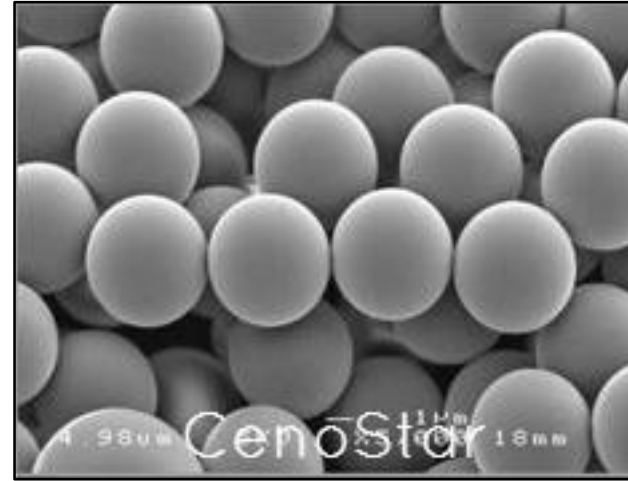
- Fill with fluid
 - Fluid chamber needs to be tested using a stand-in fluid to check for accuracy of movement and unexpected results
 - **Contingencies:**
New bleeder valve system, different materials vs lead times for obtaining and machining stock, potential need for cooling system, any redesigns must be minute

Aluminum Housing



Future Work

- Cenosphere testing
 - Test viability of cenospheres in lieu of fluid
 - **Contingencies:**
Find other viable fluid or obtain finer grain cenospheres
- Press fitting iron components
 - Iron washer used to complete magnetic circuit needs to be press fit into iron core cylinder
 - **Contingencies:**
If heat cannot be achieved, stronger heat gun must be acquired, must obtain more iron stock if the washer crushes or cylinder cracks upon cooling during press-fit process



Iron Core Cylinder



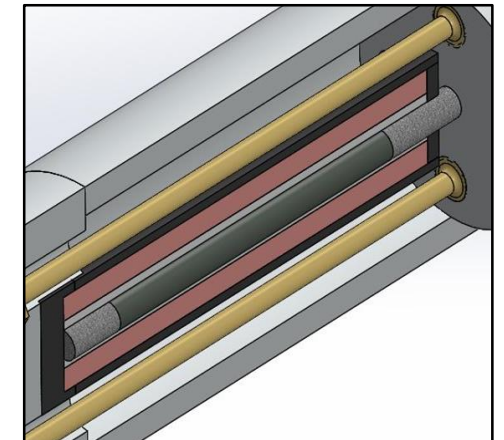
Future Work

- Attaching back end plate to main cylinder
 - Original design does not have internal parts physically secured to outer cylinder
 - **Contingencies:**
Thread additional external end cap to secure internal components, insert set screw through external shell the back end cap
- Solenoid wiring
 - Internal solenoid must connect to external power source
 - **Contingencies:**
Redesign back end plate, drill hole in portion of wall that does not bear load, or integrate internal wiring/circuitry

Endplate and Cylinder



Solenoid Location



Conclusions

- Original design did not meet assembly and manufacturability requirements
- We currently have the aluminum outer case, the aluminum pistons, and the brass bolts completed
- The major issues that are being faced is filling the vacuum fluid chamber and completing the magnetic circuit
- There have been several changes to the original design from Fall semester 2015. The number of components is the same, but their positioning and dimensions have changed
- Currently there are several work orders being manufactured. Once these work orders are complete, the only missing component will be the solenoid
- The next step in the design process is to fill the fluid chamber and begin testing with alternative design options