HONEYWELL REFERENCE PRESSURE REGULATOR

Honeywell

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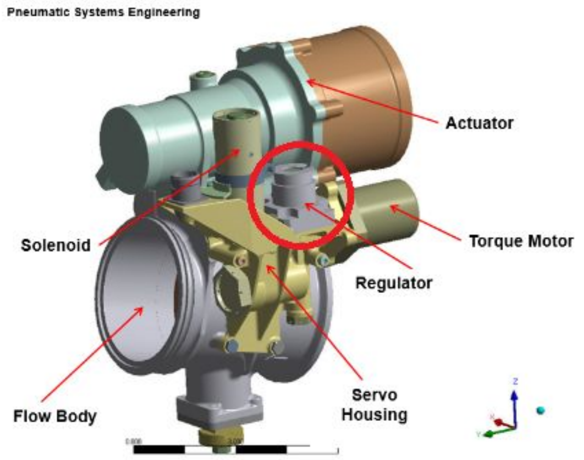
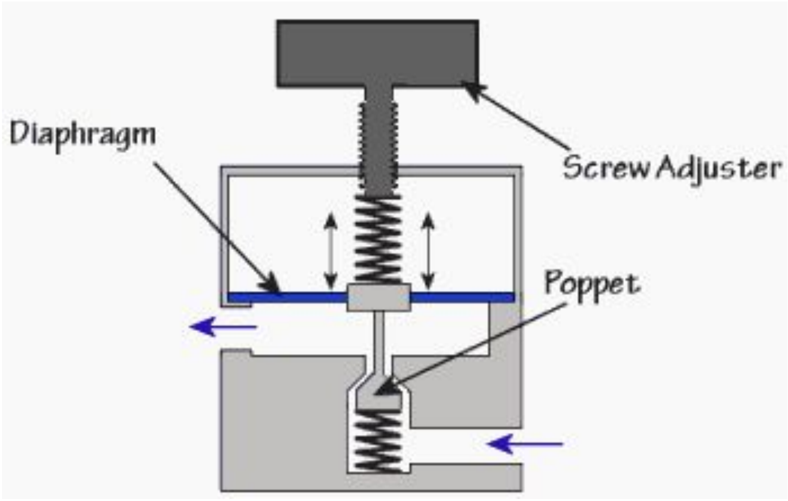
Project Description

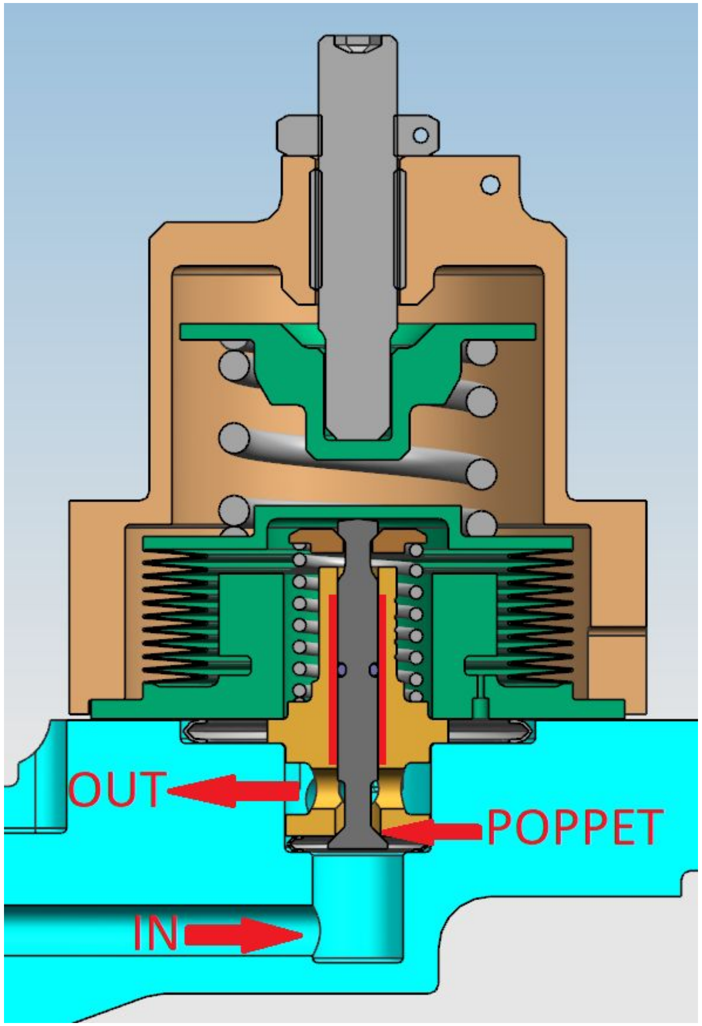
- **Client:** Honeywell
  - Dave Tornquist: Chief Engineer
  - Haley Flenner: Project Engineer
  - Kayla Goodrich: Project Engineer
- **Instructors**
  - Dr. David Trevas
  - Amy Swartz





- **Reference Pressure Regulator**
  - Takes a varying inlet pressure and turns it into a consistent reference pressure for use by pneumatic controls
- **Project Goal**
  - Trade study of historical designs and redesign to overcome identified issues

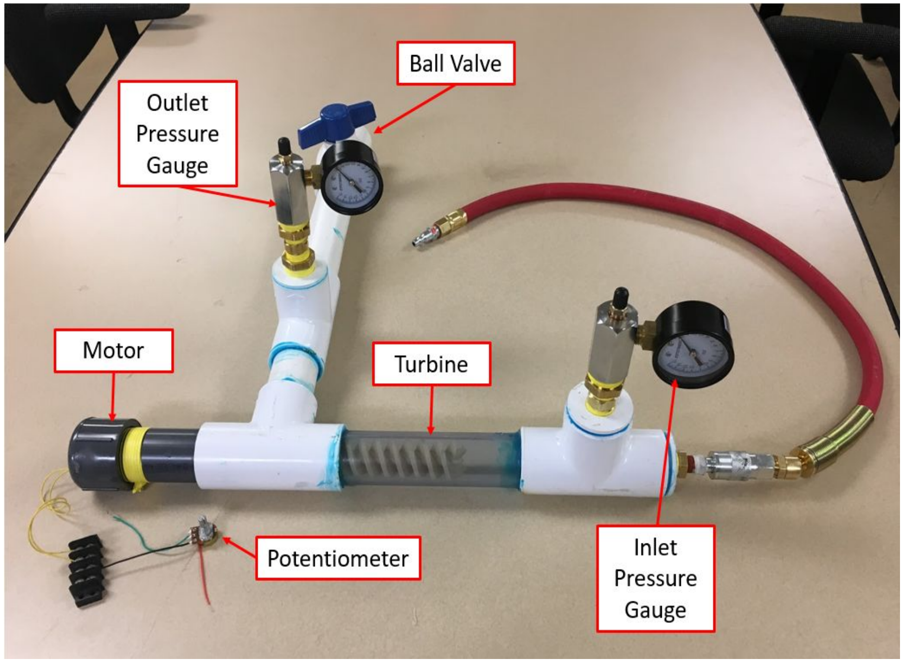
Current Design / Flaws



- **Identified Problems**
  - Hysteresis
    - Minimize hysteresis (friction) in system
    - Caused by air contaminants such as silica dust or smog
  - Leakage
    - Uneven wear on the poppet valve causes air leakage through valve
- **Final Product Requirements**
  - Temperature range from -40 to 1300 °F
  - Control inlet pressures between atmospheric pressure and 600 psig
  - Scalable from ⅜" up to 10" line diameter
  - Outlet pressure accurate to ±1 psig

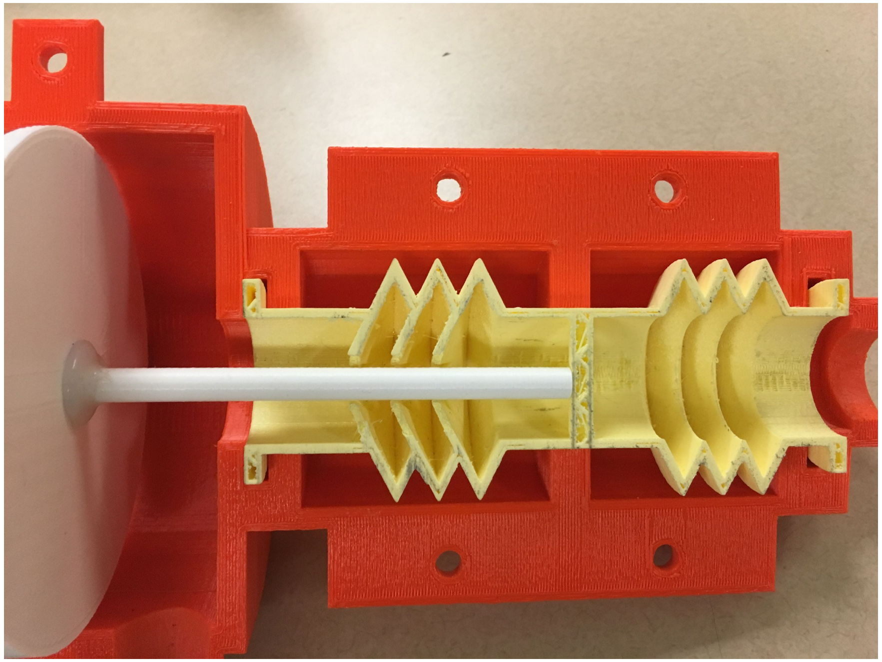
Concept Prototyping

Turbo Expander



- Pulls power out of the flow to reduce pressure and generates electricity
- Uses electric speed control (ESC) to apply magnetic drag to the turbine and create a controllable pressure drop proportional to turbine speed

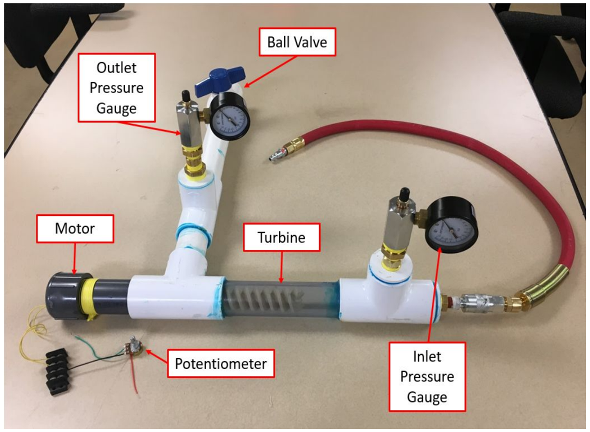
Bellows Valve



- Replaces poppet closure element
- Uses similar mechanical pressure balance as current design
- Valve closes around diaphragm stem to eliminate surface area prone to friction

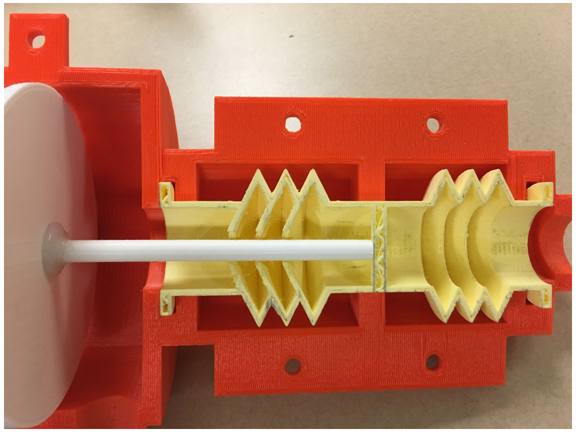
Prototype Pros and Cons

Both designs were viable - time constraints allowed significant progress on only one design



Turbo Expander

- Pros
  - Quick reaction
  - Digital accuracy
  - Generates power
- Cons
  - More modes of failure
  - Less scalable



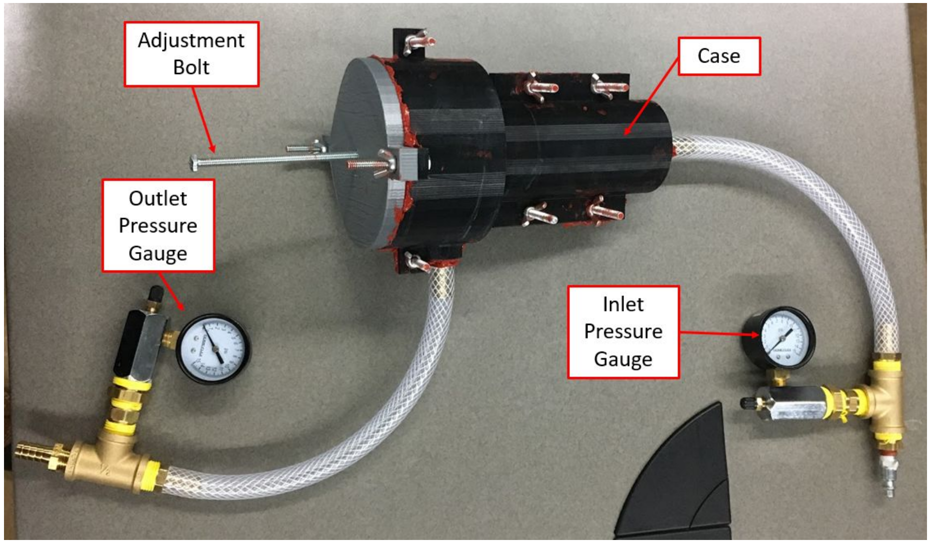
Bellows Valve

- Pros
  - Simple, mechanical function
  - Original design
  - Addresses hysteresis
- Cons
  - Difficult to manufacture

Decided on bellows valve to pursue an original design

Initial Prototype

Case



- Original case printed at Cline Library in PLA
  - The case warped while printing and cracked during assembly
- Tested case printed at Rapid Lab in ABS
  - Printed using soluble support material to achieve a high accuracy part
  - Some leaking issues

Closure Element

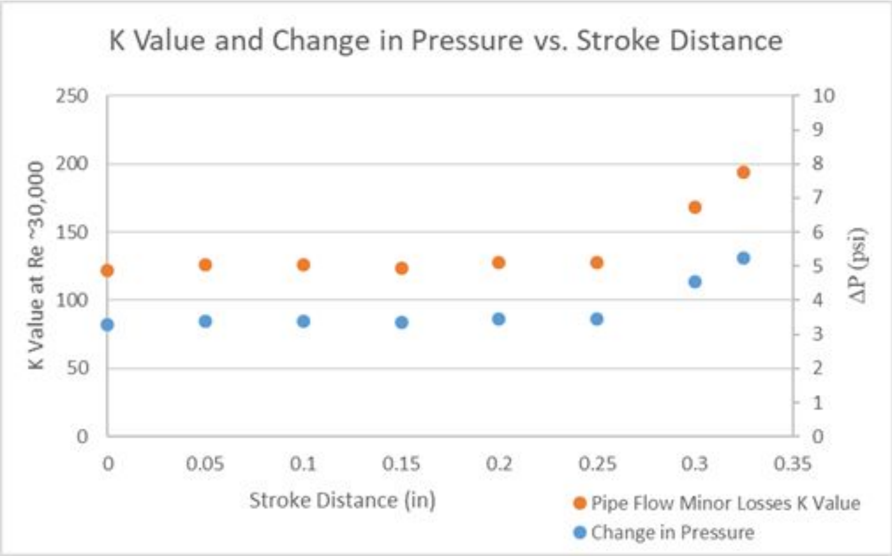
- Original bellows printed at Cline Library in PLA
  - Print failed because of incorrect orientation
  - PLA did not allow bellows motion
- Tested bellows printed on teammates personal printer in 3D solutech flexible filament
  - After some trial and error - a usable bellows was created

Testing Procedure and Data

Procedure

- Bellows were pushed closed with the adjustment bolt
  - Bolt turns converted to stroke distance with the thread of the bolt
  - Change in pressure was read across the two pressure gauges
  - A non-dimensional K-Value for the valve at each stroked distance was obtained with the minor head loss equation

$$h_{l,m} = K\frac{\bar{V}^2}{2}$$



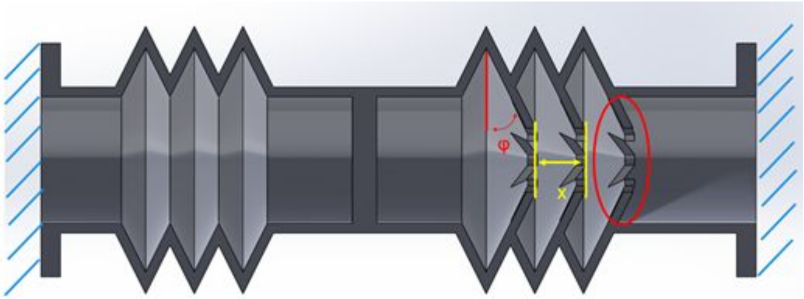
Results

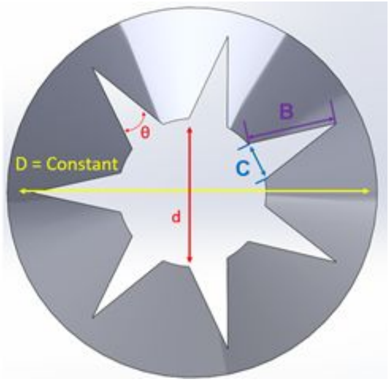
- Linear response is observed
  - Only represented by the 3 data points starting at .25 in stroke distance

- Redesign of the case and bellows required to determine an accurate response of pressure to stroke distance

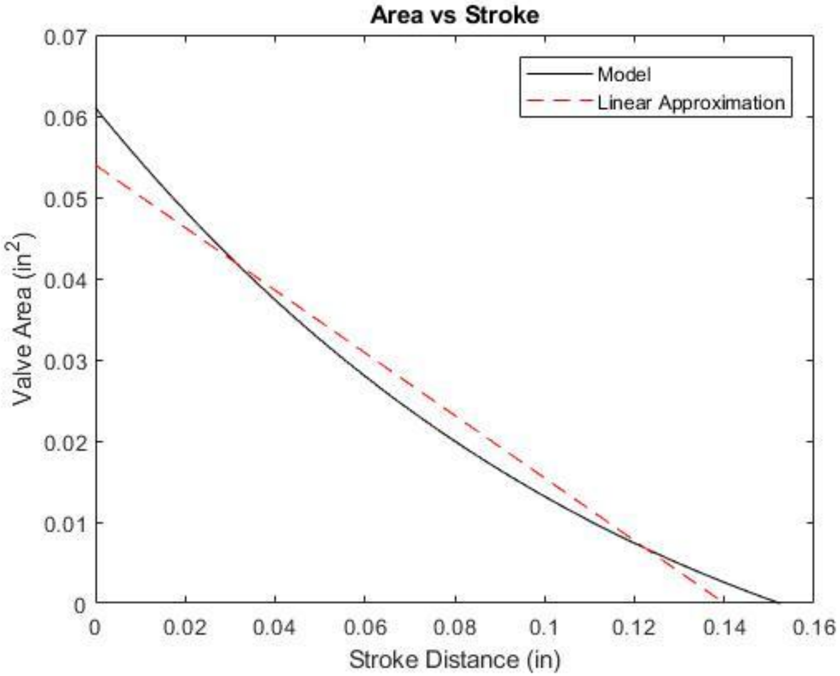
Post-Testing Improvement: Geometry Analysis

- Design Bellows to reach full closure to create greater throttling effect
- Orifice Area can be defined on a plane, rather than hyperbolically

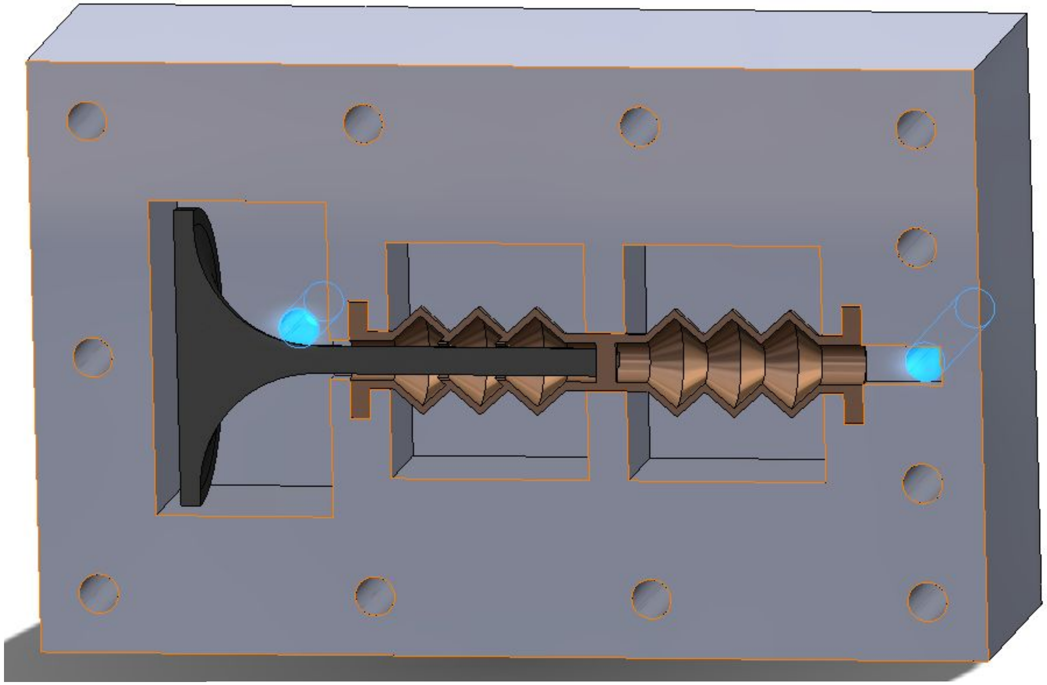


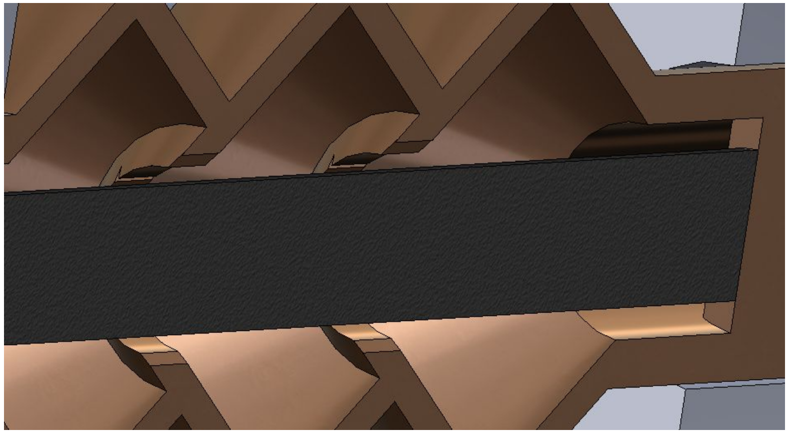


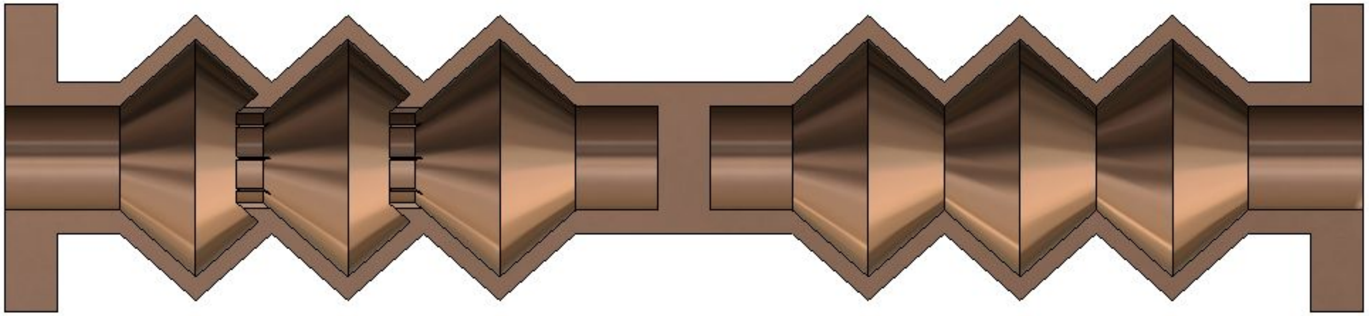
- Initial angles and lengths can be determined so that the valve is capable of full closure
  - Full closure occurs when the guide rod occupies the entire frustum area, the triangles will be closed



BELLOWS VALVE: FINAL DESIGN

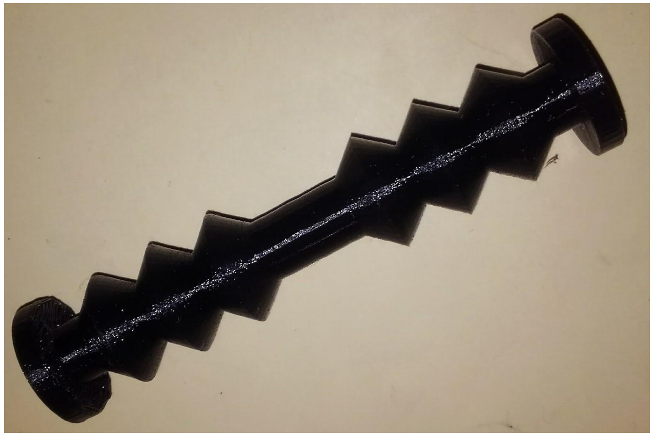


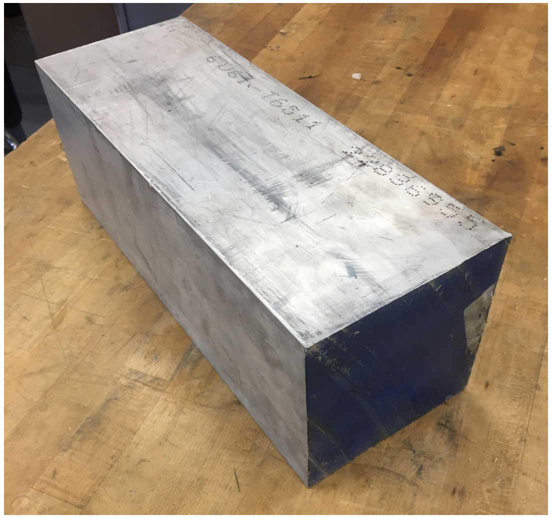




MANUFACTURING PROCESSES

- Prototyping: Multi-stage process
  - 3D Printing
    - Bellows Valve
    - Diaphragm
  - CNC Machining - Case Halves
- Final Product Manufacturing
  - Kinemotive Corporation - Bellows
  - Casting - Case Halves





Conclusion

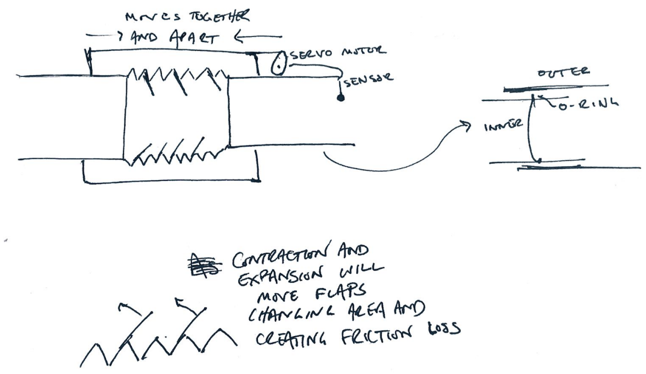
- The validity of the bellows closure element was proved through the testing data

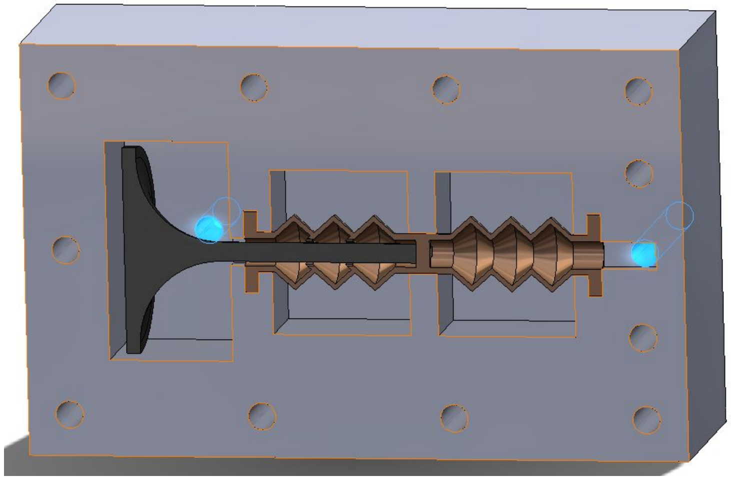
- Flaws Addressed
  - **Addressed Hysteresis**
    - Removing contact area within guide rod and sleeve
    - Friction minimized on guide rod
    - Resilience to contamination increased

  - **Leakage**
    - Further testing will be required to determine whether leakage was improved

Lessons Learned

- Reverse engineering a product and improving upon proven existing concepts
- Engineering team / client communication
- Scheduling and budget for a design process
- The time and effort required to take a complicated design from concept to reality





QUESTIONS?

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