Honeywell Endurance Valve

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Abstract

The project scope was to research gem-like materials for a pneumatic control valve to maximize endurance. The material selected must withstand 10 million cycles operating at 10 cycles/sec and maintain a consistent seal. The original project description suggested using a ruby ball and sapphire seats to seal pressure; however, the team implemented Polycrystalline Diamond (PCD) instead after partnering with U.S. Synthetic. PCD is harder than ruby and sapphire, and promised an even better valve interface.

Background

In the past, Honeywell manufactured an air controlled valve used in missile guidance. The valve's interface was made of steel. It operated 800 times a second to guide the missile. Steel was an acceptable material for the valve because of the missile's short life expectancy.

Currently, Honeywell wants to expand this technology for commercial aircraft use. There is a market in the industry for a valve that is capable of enduring millions of cycles. This valve will keep the jet engine turbine rotating after landing to evenly cool its components.

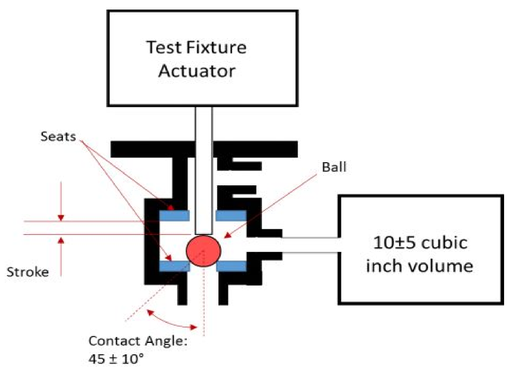

Figure 1: Original Three-Way Valve [1]

Problem Definition

The goal was to research materials that can survive 10 million cycles or more, and to track the leakage over time. Honeywell believed gem-like materials would be capable of this. This involved selecting a material, and constructing a pneumatic valve to test it.

Design Modifications

When the team implemented Polycrystalline diamond (PCD) into the design, the valve design shifted from a three-way valve to a two way valve.

A hemispherical PCD component was inserted into a chamfered seat as shown in figure 2. This combination allows for the rod to self align as it enters the chamfered opening, creating a tight seal.

Figure 2: PCD Fused to Polycarbonate

Construction

The assembly of the testing apparatus consists of a pull solenoid, steel armature, aluminum housing, linear bearing, and tubing that is connected to a 60 gallon tank. The solenoid is controlled by an Arduino microcontroller. The diamond was inserted into the end of the push rod. The components were assembled on a wooden platform with sheet metal as shown in Figure 3. Air was used to cool the solenoid during cycling.

Testing Procedures

For this experiment, we cycled a linear solenoid, smashing the poppet into the seat 10 million times. This operation was cycled ten times per second for roughly 11 days.

Measurements of the leakage of the seal were taken twice a day to monitor the wear of the PCD. This recording was performed by closing the seal, and then using a pressure transducer to measure the amount of air escaping through the seal.

Results

As shown in the graph below, Figure 5, leakage measurements seem scattered due to movement in the device over time. After cycling throughout the day, it vibrates into different positions, causing the quality of the seal to vary.

The variation was however consistent, residing between 1% and 2% loss in pressure per minute as shown below in figure #. These results imply that the device is operating consistently. The steady trend means the seal between the PCD has not been compromised after more than 10 million cycles.

There was however visual wear on the poppet as shown in figure #. This ring is more of a polished mark the surface, than an indented groove, and has not altered the seal.

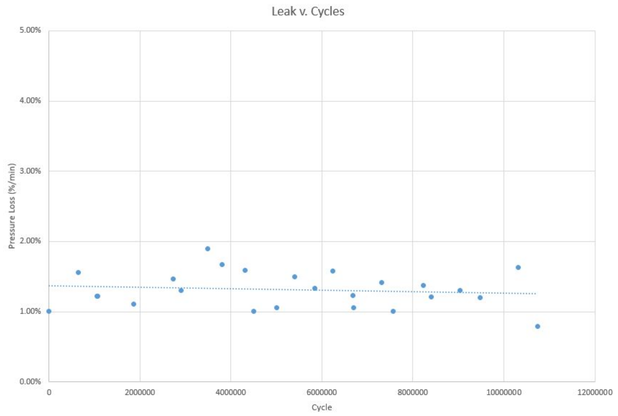

Figure 5: Plot of Leakage vs. Cycles

Final Design

The final design is shown in Figure 3. The solenoid retracts the armature, opening the valve. The spring pushes the armature back, sealing the valve. There is some clearance between the armature and bearing, allowing the poppet to self align with the seat. A ball valve is used to control pressure from the 60 gallon tank.

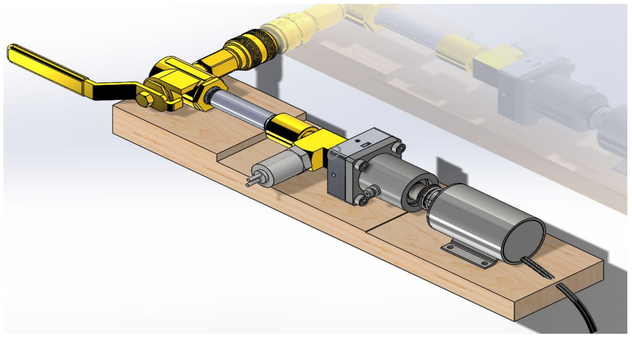

Figure 3: CAD Model

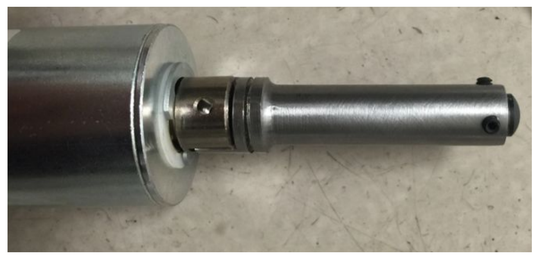

Figure 4: Poppet armature attached to solenoid

References

[1] Honeywell, "Honeywell Aerospace: Ruby Ball and Sapphire Seat Endurance Test Project," Flagstaff, AZ. 2016.
[2] "Polycrystalline Diamond (PCD)", Almax-easylab.com, 2016. [Online]. Available: http://www.almax-easylab.com/PCD.aspx. [Accessed: 24-Nov-2016].
[3] U.S Synthetic. (2016). [Online]. Available: http://www.ussynthetic.com/ [Accessed: 01-Sept-2016].

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