# HONEYWELL REFERENCE PRESSURE REGULATOR

NORTHERN ARIZONA UNIVERSITY
College of Engineering, Forestry, and Natural Sciences
Honeywell

**Myla Azofeifa, Jordan Loos, William McGinn, Alex Rustaey, YiTong Zhang**

Department of Mechanical Engineering, Northern Arizona University; Honeywell International, Inc.

## ABSTRACT

The focus of this project was to address issues with the commercial reference pressure regulator in use by Honeywell through a redesign or an original design. The Honeywell design exhibits unwanted hysteresis (friction) and is susceptible to failure in environments with large amounts of contamination. The team became familiar with the Honeywell reference regulator design, and then compared and contrasted that design with other commercial regulator designs. The team has designed a new mechanical closure element called a "bellows valve." While testing is still in preliminary stages, the valve is not expected to achieve full closure. The valve's primary application is in creating a controllable change in the pressure of an airflow via throttling.

## BACKGROUND

The reference pressure regulator is used onboard aircrafts for pneumatic control. The pressure extracted from the engines is used for things such as wing anti-ice and cabin pressurization. The current design consists of a pressure balance operation with a poppet closure element. A large diaphragm is used to create a pressure balance and to position the poppet valve. There are several issues with the current design:

- Hysteresis
- Accuracy
- Leakage
- Uneven wear on the poppet
- Contamination

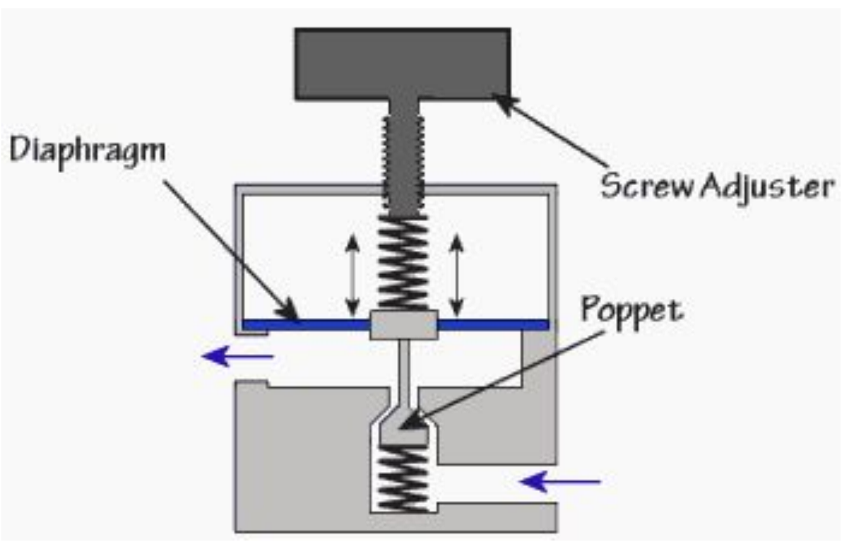


**Figure 1:** Basic Reference Pressure Regulator

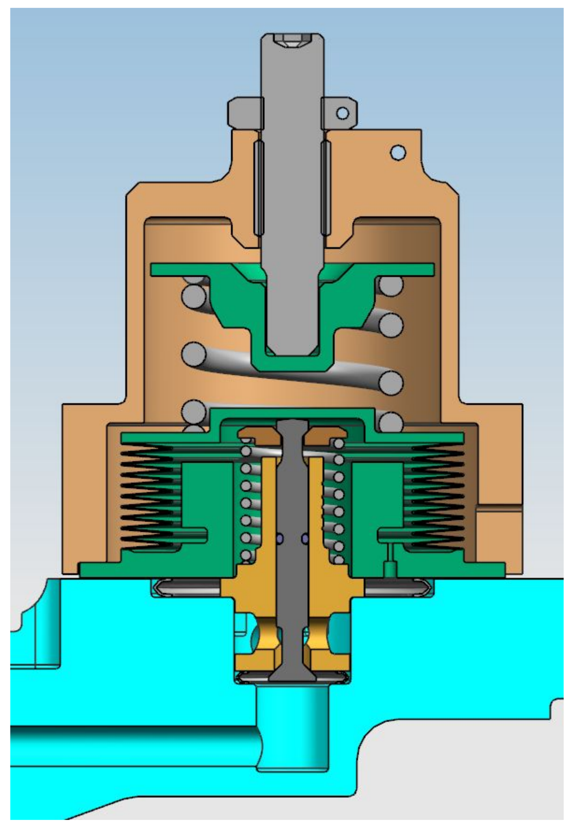

**Figure 2:** Current Honeywell Regulator Design [1]

A reference pressure regulator operates on the basic principle of a mechanical pressure balance. When the inlet pressure increases, the diaphragm in the outlet senses the pressure change and is compressed, causing an area closure due to a rigidly connected poppet valve. The opposite is also true: a decrease in inlet pressure will lead diaphragm spring expansion. The area closure/expansion leads to an increase/decrease in the pressure difference between the inlet and outlet. This difference is calibrated such that the outlet operates at a constant pressure while inlet pressures vary.

The current Honeywell valve faces issues with increased hysteresis as the part life increases. The hysteresis is caused by contaminant air particles such as smog and silica dust. The valve contamination can cause a part with expected life of five years to need replacement after as little as ten days.

## DESIGN

The redesigned reference pressure regulator utilizes bellows with a frustum to nozzle the flow area. As the bellows is stroked closed and the outlet pressure tries to rise, the frustum is closed onto the guide rod that passes through its center. The derived equation below describes the geometry and gave the team manufacturable design parameters.

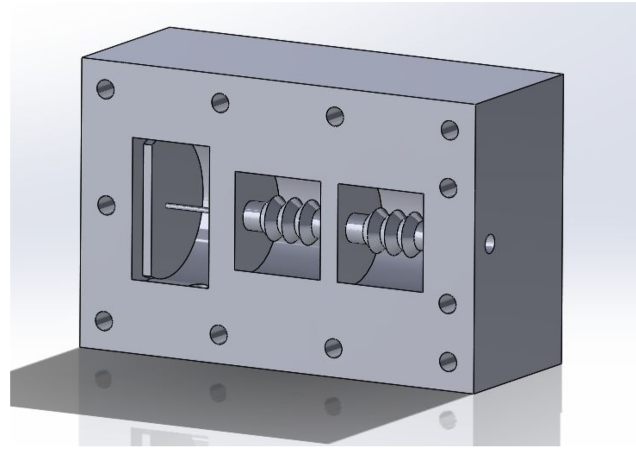

**Figure 3:** Regulator Half

$$d(x) = D - 2\left(\frac{x}{Tan\left[\frac{\Phi_0}{x_0}x\right]}\right)$$

$$\theta = 2\sin^{-1}\frac{C}{2B}$$

$$A_{center} = \frac{\pi}{4}\left(d(x)^2 - d_{rod}\right)$$

$$A_{triangle} = \frac{CB\cos(\theta/2)}{2}$$

$$A_{Total} = A_{center} + N * A_{triangle}$$

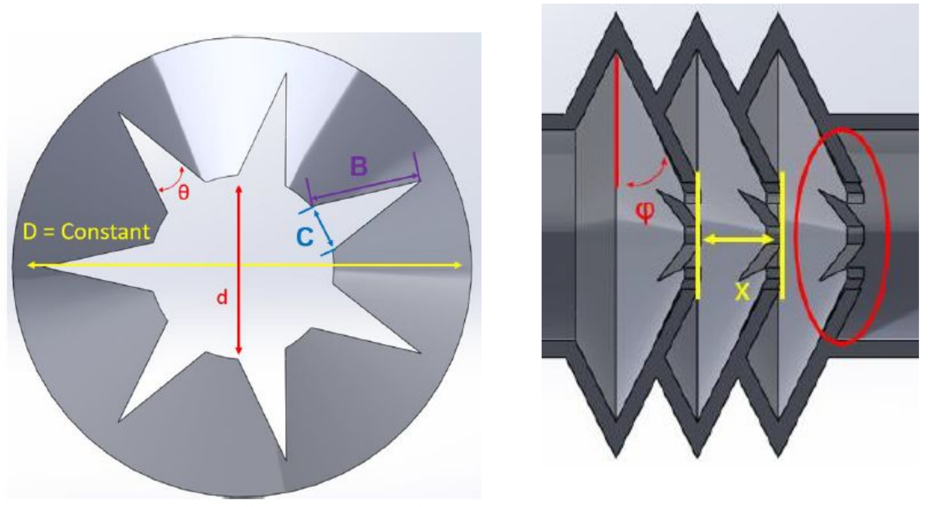


**Figure 4:** Frustum Closure Geometry

## SYSTEM OPERATION

The bellows valve achieves pressure regulation similarly to the current Honeywell system. A stem attached to the diaphragm uses a pressure balance in the diaphragm to open and close the valve. In the bellows valve, the valve closes around the stem, whereas the current design allows the stem to move through the valve. The redesigned system directly addresses the friction induced hysteresis by eliminating the surface area where contaminants accumulated and interfered with the function of the valve.

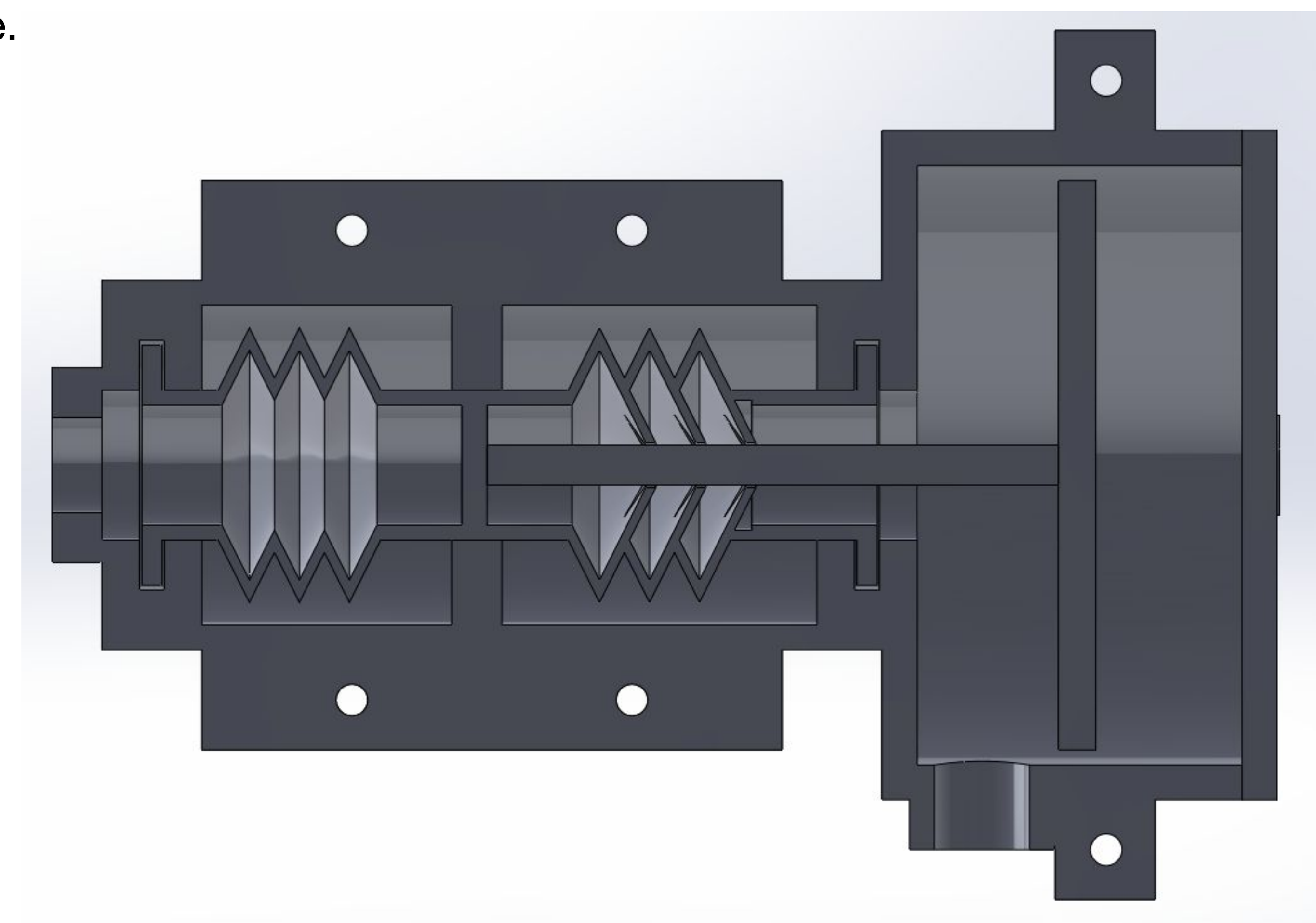

**Figure 5:** Proof of Concept Prototype

## RESULTS

The data was obtained by pushing the bellows closed with an adjustment bolt. The turns of bolt were converted into stroke distance using the thread of the bolt. During testing, a 59% increase in ΔP over the stroke length was observed. The K value for the valve was calculated from the equation for minor head losses in pipe flow shown in the equation [3]:

$$h_{l_m} = K\frac{\bar{V}^2}{2}$$

While the response was linear, it occurred between .25 and .35 inches and is only represented by 3 data points. A redesign of the case and bellows will allow more accurate and thorough testing of the bellows valve to determine the response of the pressure to stroke distance.

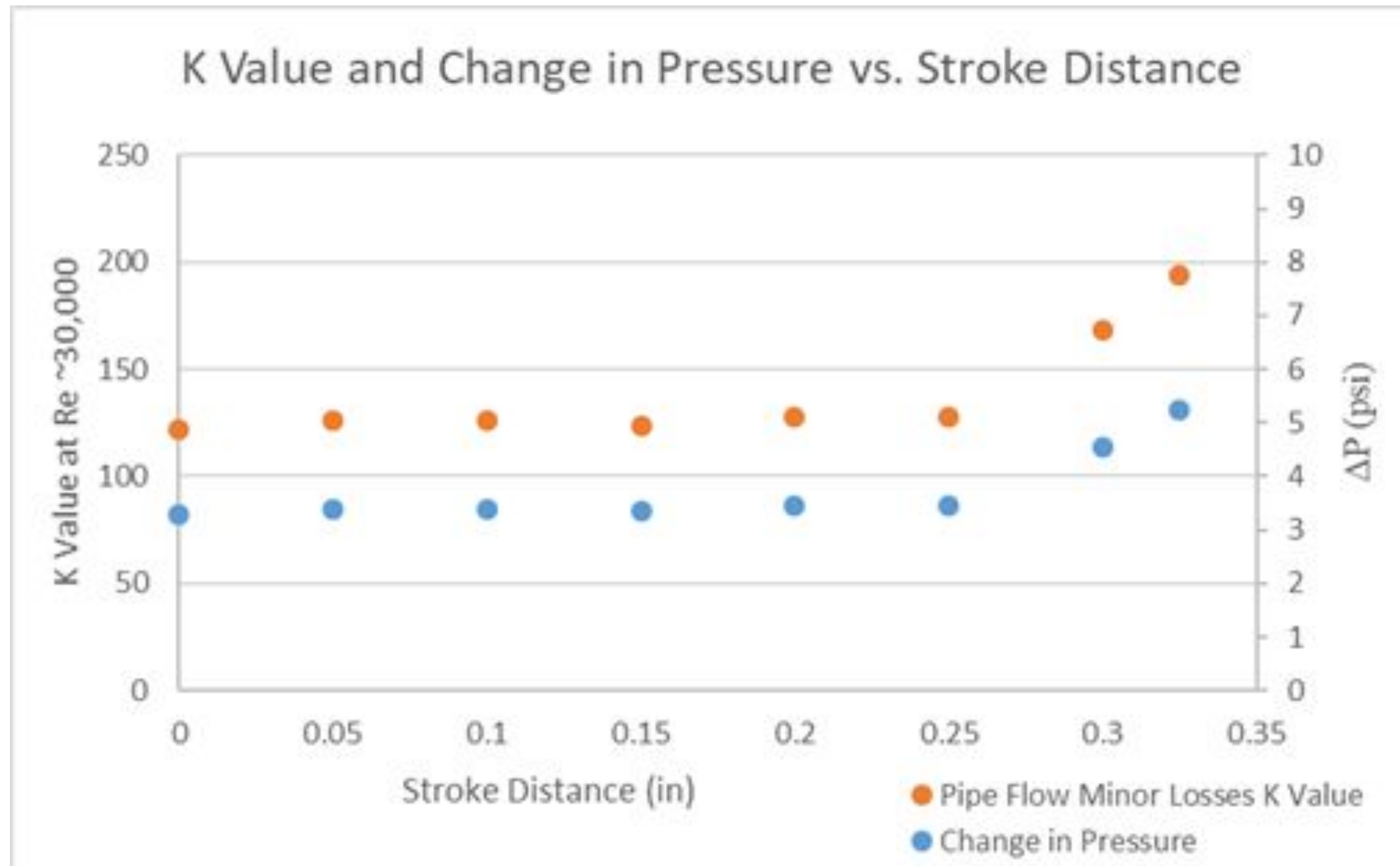


**Figure 6:** Testing Data

## REFERENCES

[1] Honeywell International, Inc., Reference Pressure Regulator - Technical Exchange, Tempe: Honeywell International, Inc. , 2008.

[2] Honeywell International, Inc., "Closure Elements - Technical Exchange," Tempe, 2010.

[3] P. J. Pritchard, Introduction To Fluid Mechanics, 2015.

## ACKNOWLEDGMENTS

Dave Tornquist - Honeywell Chief Engineer
Haley Flenner - Honeywell Engineer I (NAU Graduate)
Kayla Goodrich - Honeywell Engineer I (NAU Graduate)
David Trevas - Class Instructor and Advisor
Amy Swartz - Class Teaching Assistant