AUTOMOTIVE CNG PRESSURE REGULATION

CAL POLY POMONA

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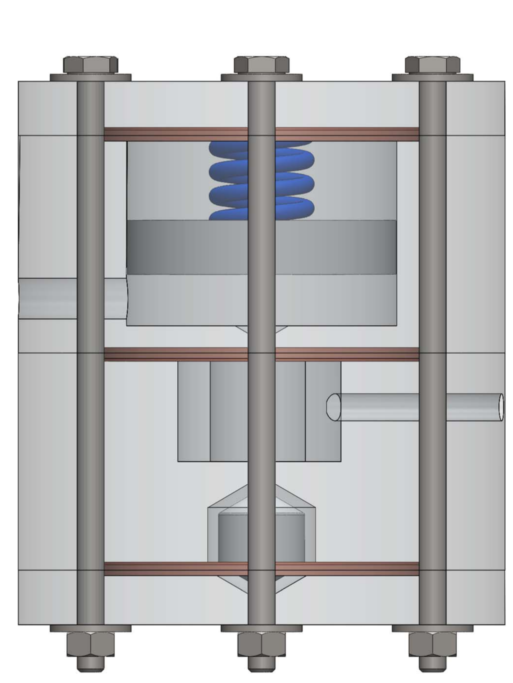
ABSTRACT

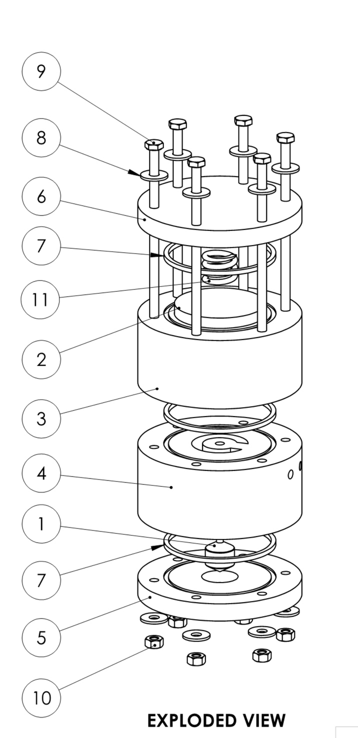
With the introduction and rising number of Compressed Natural Gas (CNG) as an alternative fuel source for automobiles, improvements in the pressure regulation of the natural gas within the vehicle has become an area of emphasis. Conventional pressure regulators for Compressed Natural Gas (CNG) systems govern natural gas pressure regulation through use of a diaphragm and spring combination. An inherent issue in conventional pressure regulator design is the droop effect, observed through drops in the desired outlet pressure. This decrease in outlet pressure diminishes the instantaneous delivery of fuel sent to the engine upon acceleration. This droop effect is primarily attributed to the presence of a diaphragm and spring in regulation, and the wearing of these devices over an extended period of usage. In efforts to minimize the effects of droop and allow for a more instantaneous fuel on demand, a CNG regulator for automotive applications was designed and tested without the incorporation of a diaphragm, rather utilizing a linear spring to achieve the desired output pressure.

CRITERIA

- Eliminate the use of a diaphragm in low pressure regulation of natural gas in a compact Compressed Natural Gas (CNG) vehicle.
- The functional regulator design must utilize a control mechanism using the high pressure fuel provided at the inlet to regulate a consistent low pressure output at a desired pressure and flow.
- The regulator must be lightweight and compact to allow for installation under the hood of the compact CNG vehicle.
- Operating conditions:
    - 4,000 psi inlet fuel pressure from fuel tank
    - 100 psi outlet fuel pressure to engine
    - 150 lb/hr. of natural gas flow
    - Withstand under-the-hood conditions of -40ºC to 150ºC
    - No leakages or deformation under UL, NFPA, and ISO 15500 testing.
- The regulator must withstand the safety criterion of UL, ISO, and NFPA standards. Housing chambers must undergo a pressure test of four times the working pressure, equating to 16,000 psi without leakage or permanent deformation.

PROPOSED DESIGN

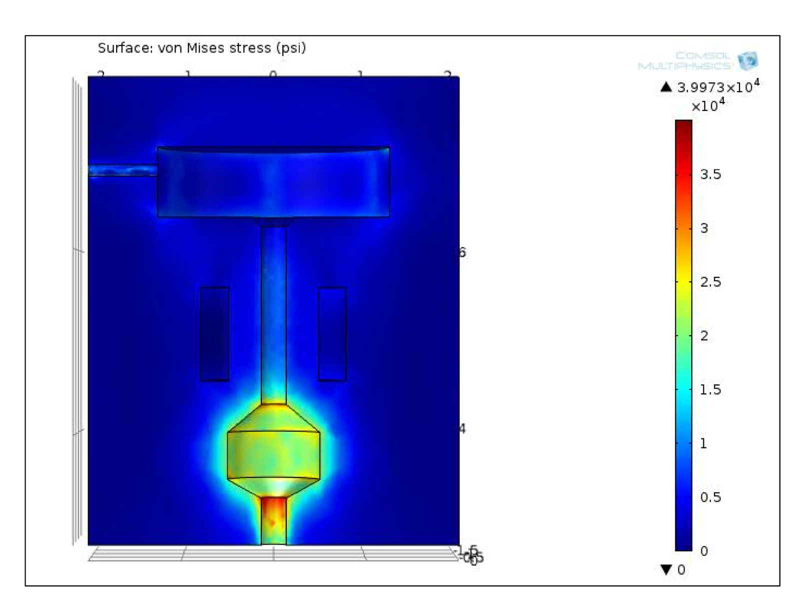


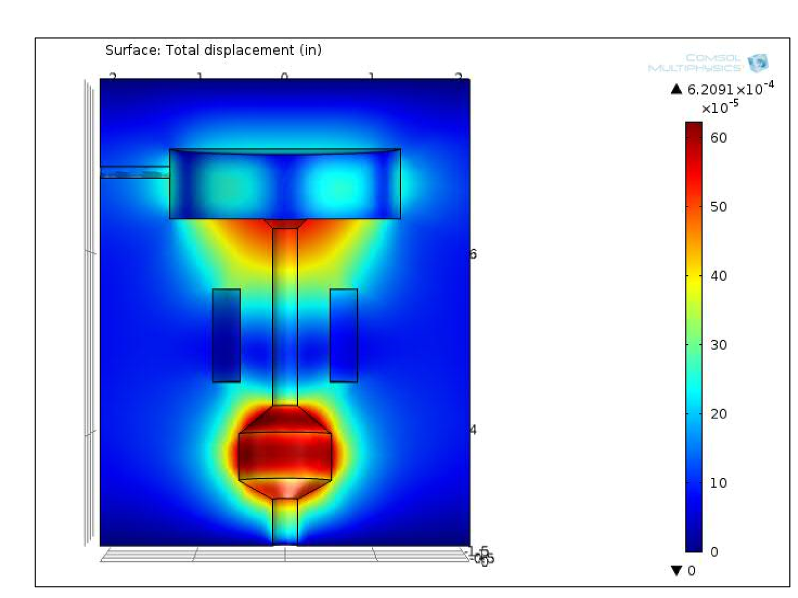


The proposed design is characterized by the following features:

- Piston cylinder mechanism to regulate fluid flow at the required pressure differential.
- Linear stainless steel spring calibrated to ensure desired fluid flow output pressure.
- Aluminum 6061-T6 for enhanced corrosion resistance, unreactive properties to the natural gas, minimization of weight and manufacturing cost, and ease of machinability.
- Coolant chambers to account for temperature drops characterized by the Joules-Thompson Effect.
- Inlet/Outlet fail safe mechanism incorporated in poppet design for deviations in desired pressures.
- Cylindrical design that measures 4.5 inches in diameter and 5.0 inches in height.
- Six mounting bolts for ease of installation under the hood of the vehicle.

DESIGN ANALYSIS





When testing for compliance with the NFPA and UL standards, the chamber housing of the proposed design was able to withstand four times the desired working pressure, at 16,000 psi, without exceeding the yield stress of the Aluminum 6061-T6 and showing no significant deformation. The introduction of the coolant chambers maintains the working fluid and the chamber at an acceptable working temperature for automotive CNG regulation.

FUTURE CONSIDERATIONS

Although the proposed design eliminates the necessity of a diaphragm, a linear spring was still incorporated. Droop is primarily caused by two variables—spring and diaphragm effects. The selected linear spring possessed a spring rate of 459 lb/in. Utilization of a spring with a lower spring rate will assist in the minimization of droop; however, elimination of the spring altogether will yield the most effective results for instantaneous natural gas demand for the CNG vehicle.