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PRECISION FLUID CONTROL

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Stable pressure control for laser absorption spectroscopy research

Advanced laser-based sensors could be used to study wildfire combustion, pollution formation, exoplanetary atmospheres and other extreme scenarios

Background

The Precision Laser Diagnostics Lab at the University of Colorado Boulder focuses on developing advanced sensors for applications ranging from combustion systems to atmospheric monitoring. The sensors are based on laser absorption spectroscopy, which can be used to determine the temperature, pressure, flow velocity, or concentration of gases based on the way molecules absorb laser light.

The lab's sensors can be useful for studying processes that are not easily characterized with more traditional sensors due to extreme conditions. They have been used to locate gas leaks in energy infrastructure and have also been used in aerospace applications and industrial flame systems. They offer the potential to benefit astronomers and planetary scientists who study exotic exoplanetary atmospheres that can reach extremely high pressures and temperatures.

More fundamentally, advanced laser-based sensors are used to study essential combustion processes. For example, they can be used in studies of new fuels, studies of pollution formation chemistry, or studies of wildfire combustion.

Challenge

Ryan Cole is a PhD Candidate in the Precision Laser Diagnostics Laboratory, which is headed by Dr. Greg Rieker. He is involved in studies of laser absorption spectroscopy in high pressure and high temperature environments.

"Our experiment consists of an optically accessible gas cell that can reach temperatures and pressures in excess of 1000 K and 50 bar," Cole said. "The design relies on a glass cell that confines an absorbing gas in the high-pressure and -temperature region at the core of a pressurized ceramic furnace. To avoid shattering the glass cell, we surround it with a bath gas that does not absorb the laser light." Cole and his co-researchers designed and built the gas cell over a period of more than four years, and their design was published recently in the Journal of Quantitative Spectroscopy and Radiative Transfer [1].

The experiment requires a slight pressure differential to be maintained between the absorbing gas in the glass cell and the surrounding bath gas. This ensures that the glass cell remains intact regardless of the absolute pressures in the system. For accurate absorption spectroscopy, the pressure of the sample gas must be precisely controlled.

Initially Cole and his co-researchers had used a manual pressure regulator and a needle valve to control the pressure and flow into the glass cell. They found that this method was slow and lacked the precise control needed to smoothly run the experiment. Cole contacted Equilibar to find a better option.

Solution

Working with Equilibar engineers, Cole and his team selected an EPR-3000-EPDM regulator with internal materials compatible with high pressure CO_2, a gas that is frequently studied in their experiment.

According to Cole, the Equilibar regulator enables precise and repeatable pressure control. Additionally, the regulator is easy to interface with the LabView program that they use to control and monitor other aspects of the experiment.

"While this was not a requirement for us initially, it ended up being a huge benefit to have fully computer-interfaced pressure control for our experiment," Cole said. "The performance of the regulator and its ability to be computer controlled are far superior to the manual pressure control that we implemented previously."

The regulator has been in operation for two years and has worked well with no issues.

Figure 1. Photo of Equilibar EPR 3000

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Application details

The schematic below shows the details of the test setup. At the left is the laser system and sensor with the glass sample cell. The Equilibar EPR 3000 controls the pressure of the sample gas in the glass sample cell. The sample gas pressure also drives a spring-biased differential pressure regulator that controls the pressure of the bath gas. The dP regulator is set to maintain the bath gas at a slight pressure differential above the sample gas pressure. In this way, the EPR 3000 regulator provides a single control point for both the sample gas and the non-absorbing bath gas, keeping the glass cell from breaking regardless of the absolute pressure of the system.

> *"Equilibar engineering staff listened to our specific application and were very helpful in finding a product that would address the problems we were having." Ryan Cole*

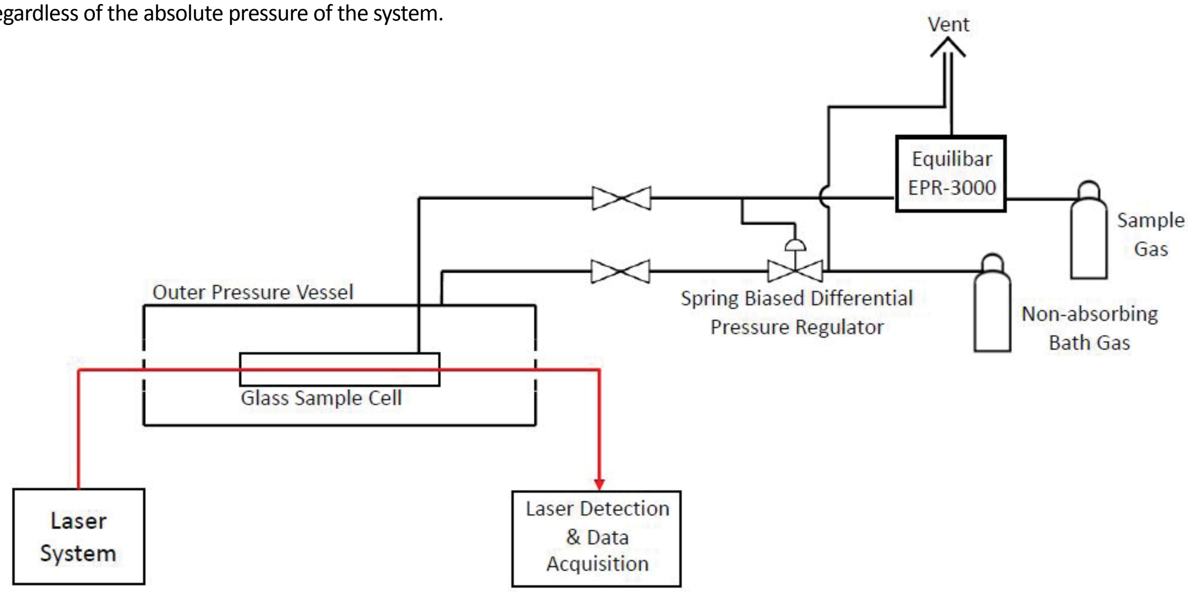

Figure 2. Schematic of laser sensor system with Equilibar EPR 3000 controlling sample gas and bath gas pressures

Citations

[1] Cole, Ryan K., et al. "Demonstration of a Uniform, High-Pressure, High-Temperature Gas Cell with a Dual Frequency Comb Absorption Spectrometer." Journal of Quantitative Spectroscopy and Radiative Transfer, vol. 268, 2021, p. 107640., doi:10.1016/j.jqsrt.2021.107640.

Contact Equilibar

Equilibar is a provider of unique and innovative pressure control solutions based near Asheville North Carolina. Equilibar's patented pressure regulator technology is used in a wide array of processes including catalyst, petrochemical, sanitary, supercritical and other industrial applications. For more information please contact an Equilibar applications engineer at inquiry@equilibar.com or 828-650-6590.

About the Author

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