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PRECISION PRESSURE CONTROL

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University of Washington Uses Equilibar in Continuous Flow Supercritical Water Reactor for the Deconstruction of Chemical Waste

Supercritical water gasification is an important and emerging technology with applications in the destruction of chemical waste, generation of gaseous fuel from biomass, and treatment of sewage sludge. Supercritical water (water above 378 °C and 22.1 MPa) is an environmentally benign organic solvent. Relying on the unique physical properties of water above the critical point, supercritical water gasification efficiently and effectively facilitates the decomposition of organic molecules.

Background

Brian Pinkard is a PhD candidate working in Professor Igor Novosselov's lab at the University of Washington to design and fabricate a continuous flow supercritical water reactor for the destruction of chemical waste. Long studied at the laboratory scale in batch style reactors, supercritical water gasification is transitioning towards continuous flow type reactors to improve economic efficiency and push the technology toward market competitiveness. A continuous flow style reactor has numerous benefits over its batch style counterpart, including smaller footprints, tunable process parameters, opportunities for in situ process monitoring, and higher reactant throughput.

Due to material and equipment constraints, all known supercritical water reactors rely on back pressure regulators to achieve precise pressure control within the reactor. Typically, the regulator operates in tandem with a constant mass flow rate pump at the front end of the system to supply pressure. In the laboratory setting, it is very important to have precise pressure control, especially at low flow rates, for performing studies of chemical decomposition rates.

The Challenge

When determining decomposition rates, establishing precise reaction residence times is crucial. Precision pressure control in the supercritical water reactor allows the establishment of precise residence times in the reactor section, which allows the generation of accurate chemical kinetic data for various test compounds. It is especially critical at low flow rates to have precise and consistent pressure control. The combination of high temperature, high pressure and accuracy at low flow rates are what led Pinkard and fellow researchers to investigate using an Equilibar® BPR for controlling the internal pressure of the supercritical water reactor. Equilibar technology offers the unique advantage of providing precise pressure control at extremely low flow rates while also being capable of handling extreme process conditions.

The Solution

Equilibar engineers helped determine the best back pressure regulator design and components to meet the needs of the process. They recommended an Equilibar® U6L Ultra Low Flow Series Precision Back Pressure Regulator with a PEEK diaphragm and Kalrez O-Rings. Figure 1 shows the schematic of the supercritical water reactor system with the Equilibar® back pressure regulator downstream of the reactor providing precise, consistent pressure control.

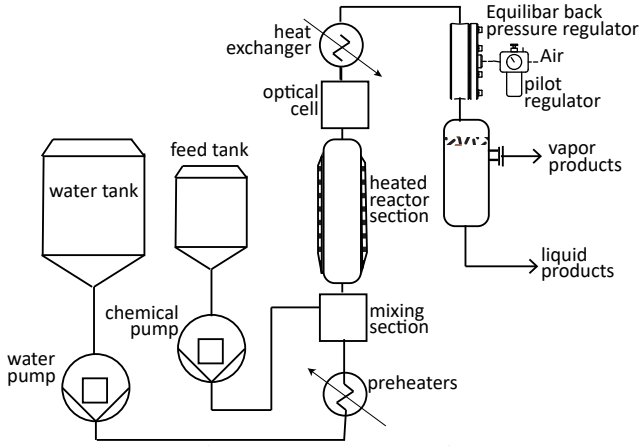

Figure 1: Supercritcal water reactor system schematic

Equilibar's U6L Research Series High Pressure Ultra Low Flow Back Pressure Regulator is designed to meet the demanding requirements of catalyst research and high pressure reactor control applications. It will hold stable pressure across very wide flow ranges and can handle liquids, gases, or multi-phase mixtures. These regulators will withstand highly aggressive chemicals and can perform at temperatures up to 450 °C.

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Equilibar Research Series units are 1:1 dome-loaded, meaning that a pilot pressure must be supplied to the dome of the BPR equal to the desired setpoint. This pilot pressure can be supplied by a manual gas regulator or by an electronic pressure regulator for automated control.

The Ultra Low Flow UL Series uses a single outlet orifice design.

Figure 2:Equilibar U6L Low Flow back pressure regulator

Customer Feedback

Figure 3 is a photograph of the Equilibar U6L in use in the lab equipment. Nitrogen gas is used to supply the pilot setpoint to the Equilibar U6L regulator.

Figure 3: Equilibar U6L installed in lab

"The U6L has performed admirably across a range of flow rates and set pressures and is an essential and reliable component in our supercritical water reactor system," Pinkard said. "The unit was easy to install and is straightforward to operate."

The graph in Figure 4 demonstrates that the internal pressure of the reactor stays remarkably constant across a range of flow rates and setpoints once the pressure is selected.

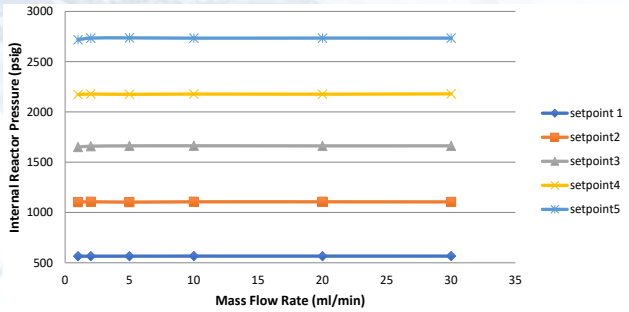

Figure 4: Internal reactor pressure at various mass flow rates and pressure setpoints

"Equilibar was accommodating in answering all our questions relating to the Equilibar U6L Series Precision Back Pressure Regulator. They helped us quickly find the exact BPR to meet our needs, and ensured that we had all the parts that we needed for full functionality."

-B. Pinkard

About Novosselov Research Group

The Novosselov Research Group at the University of Washington conducts multidisciplinary research in the areas of combustion, aerosol science, supercritical fluids, and fluid dynamics. http://depts.washington.edu/nrglab/

Contact Equilibar

Equilibar is a provider of unique and innovative pressure control solutions based near Asheville, North Carolina. The patented back pressure technology is used in a wide array of processes including catalyst, petrochemical, supercritical and other industrial applications. For more information contact an Equilibar application specialist at *inquiry@equilibar.com* or 828.650.6590.

Brian Pinkard is a second year Ph.D. student at the University of Washington with research interests in the areas of supercritical fluids, chemical waste destruction, and green energy production. Contact him via the Novosselov Research Group, Mechanical Engineering Department, University of Washington at pinkardb@uw.edu .

Diane Jacober is a Technical Marketing Specialist at Equilibar, LLC, provider of high precision pressure control solutions. She has B.S and M.S degrees in engineering and has worked as a process engineer, project engineer and technical marketing specialist in several industries. Diane can be reached at dianejacober@equilibar.com or 828-650-6590.