EQUILIBAR
PRECISION PRESSURE CONTROL

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Carbon Geo-Sequestration Research: Equilibar used in Supercritical CO2 Application

Summary

Researchers at the Australian National University (ANU) in Canberra, Australia are using an Equilibar® Back Pressure Regulator to study granular materials, complex networks, and rock or natural porous media with the goal of developing better ways to sequester carbon dioxide emissions. The research focuses on deciphering the complexity of these materials by understanding the relationships between geometry/topology and the underlying laws of physics working at the micro-scale.

Background

Current models estimate fossil fuel resources including conventional oil, gas, coal, unconventional heavy oil and tar sands are sufficient to supply the majority of the world's energy needs for the next century; however, the rapid use of these resources is directly related to global CO2 emissions. Models also point to these levels of emissions causing alarming increases in the temperature of the earth's atmosphere.

Carbon sequestration is the process of capturing carbon dioxide by removing it from large sources and transporting it to a containment area. This process prevents the CO2 from entering the atmosphere. Previously, CO2 injection has been used primarily to increase oil recovery in declining oil fields. Geo-sequestration is a method of carbon sequestration where the carbon dioxide is injected into underground geological formations. It presents the opportunity to reduce excessive carbon dioxide emissions, and potentially help counterbalance the large scale use of fossil fuels.

At the Australian National University, core research helps to understand the mechanics working during Geo-Sequestration. Analyzing displacements of media in the porous structure can lead to more effective storage methods.

The Challenge

A core sample test consists of the following steps. 1) Saturation of the rock sample with brine, 2) Displacement of brine in the rock sample by supercritical CO2 (drainage), 3) Displacement of supercritical CO2 in the sample by brine.

During drainage in stage 2, the supercritical CO2 needs to flow continuously through the rock sample at a pore pressure above 1,100 psi. On average, a 50 pore volume of scCO2 is injected to the sample at a rate of 0.01 cc/min or lower. The test is designed to maintain 1,500 psi of pressure within the rock sample and tubing. When the pressure builds above this target the flow of scCO2 needs to stop. This requires accurate control with a back pressure regulator, with the added challenge of mixed phase fluids and phase-change of the scCO2 in the regulator itself.

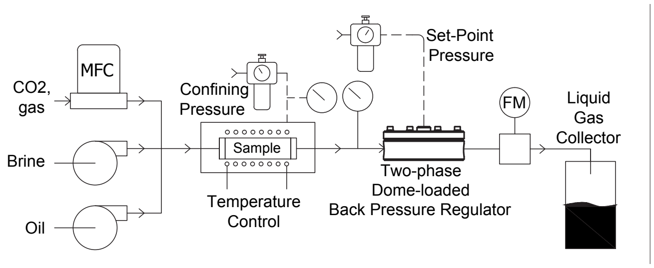

Figure 1: Schematic used to illustrate a core flooding schematic. Similar to the set up used by researchers at ANU.

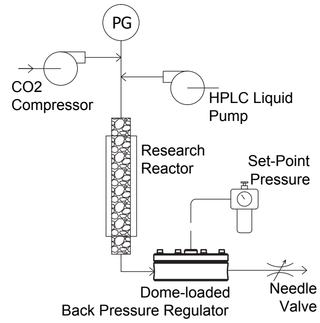

Figure 2: Schematic used to illustrate a carbon sequestration research.

The Solution

ANU researchers required a unique solution for their ultra low flow and scCO2 application. Together, the researchers and Equilibar engineers selected the EB1ULF1 back pressure regulator made out of SS316 with a stainless steel diaphragm and FFKM o-rings. This regulator is part of Equili-

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bar's Research Series and provides the following unique advantages:

- Chemical compatibility to the brine and scCO2
- Pressure and temperature compatibility
- Stable performance with mixed phase operation
- No deviation from required pressure set point over a wide range of flows.
- Ease of maintenance
- Low dead volume

The ULF is a single orifice unit capable of operating beyond the requirements of the customer with A286 bolts.

Selecting a diaphragm is often the most difficult challenge when working with supercritical fluids. In this particular application, the Stainless Steel diaphragm provided the ability for the unit to reach high pressures and withstand scCO2. Additional diaphragms such as Hastelloy C276, Polyimide and PTFE/Glass were sent as alternate diaphragms during the research. Each diaphragm has had success in various previous super critical applications. Metallic diaphragms are very robust but don't offer the best low flow performance. While PTFE and polyimide (polymers) have great flow performance, they might not meet the lifetime requirements for the testing cycle. After initial testing was performed researchers chose the metallic diaphragm to run the trials.

O-rings also present an issue when working with supercritical fluid. The exceptional solvent properties of scCO2 cause the fluid to penetrate the o-ring and can cause rupture from expansion during the depressurization phase. To prevent this, Equilibar recommends a higher grade and durometer of rubber such as Shore A90 FFKM with better mechanical properties to resist rapid gas expansion. Other supercritical CO2 clients have chosen to use HNBR and other rubber compounds.

Researchers were able to achieve their desired pressure control using the Equilibar® ULF. Because the metallic diaphragm chosen for this application did have a low leak rate between the diaphragm and orifice, a needle valve was installed in line to maintain the pressure when there was absolutely no flow.

Figure 3: Equilibar EB1ULF1 installed in ANU research application

Potential Improvements

Equilibar has suggested trials using the ZF Series back pressure regulator for future test stands. The ZF's unique feature is the ability to hold pressure with a true zero flow over mixed phase media. The unit is also part of the Equilibar research series with excellent pressure performance over a wide range of flow rates. It is available with HPLC fittings to help minimize the dead volume in core applications.

Additional information about supercritical applications, including diaphragm and o-ring selection, can be found on the Equilibar Supercritical CO_2 page.

Contact Equilibar

Based in North Carolina, Equilibar provides unique and innovative pressure control solutions for applications around the world. . Their back pressure technology is used in a wide array of processes including catalyst, petrochemical, supercritical and other industrial applications. For more information please contact an Equilibar applications specialist at www.equilibar.com or 828.650.6590.

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