ECBM: Gravimetric Adsorption Measurements Under Realistic Conditions

Using Teledyne Isco Syringe Pumps

Thomas Paschke, Frieder Dreisbach
Rubotherm GmbH, Bochum, Germany

TELEDYNE ISCO
Everywhereyoulook™

Syringe Pump Application Note AN38

Abstract

Coal bed methane is a promising alternative to conventional gas. Enhanced Coal Bed Methane (ECBM) technology combines improved methane recovery with underground storage of CO2. This process can be studied by gravimetric measurements of adsorption isotherms using the Rubotherm IsoSORP systems with magnetic suspension balances. Accurate gas adsorption data are required for planning ECBM projects.

Index Terms

- Natural Gas
- ECBM, CO_2
- Coal Bed Methane
- Gravimetric Measurement

Introduction

As a result of increasing energy prices, the investigation of unconventional sources for oil and gas is of key economic importance. Large resources of natural gas are present as coal bed methane (CBM) in coal seams. ECBM is a technique that has been developed to use the injection of carbon dioxide to improve methane recovery from coal seams [1].

Besides improved natural gas recovery, ECBM offers another advantage: CO_2 from CCS (carbon capture and storage) processes is safely stored underground and is not emitted in the atmosphere [2].

However, the displacement of methane by CO_2 is a very complex process: gases are not only adsorbed onto the coal surface but absorbed in the coal matrix as well, which causes the coal sample to swell. As a consequence, the development of the ECBM technology requires careful studies with individual coal samples under realistic conditions [3]. This application note explains the use of Rubotherm IsoSORP systems to study the ECBM process by gravimetric measurements.

Experimental

The Rubotherm IsoSORP system uses the magnetic suspension balance (MSB) for the gravimetric determination of adsorption isotherms.

A gas dosing system is used to supply pure or mixed gases at the required experimental conditions. Coal bed methane is present in coal seams at pressures between 30 and 300 bar and temperatures between 30 and 100°C. The laboratory scale measurements have to cover these pressure and temperature ranges. Creating a defined gas atmosphere with CO_2 at elevated pressures is not a trivial task: CO_2 needs to be compressed from cylinder pressure (60 bar) by means of a syringe pump [4] and the complete dosing system including all valves and tubings needs to be heated to avoid condensation. Figure 1 shows a schematic of the complete IsoSORP system.

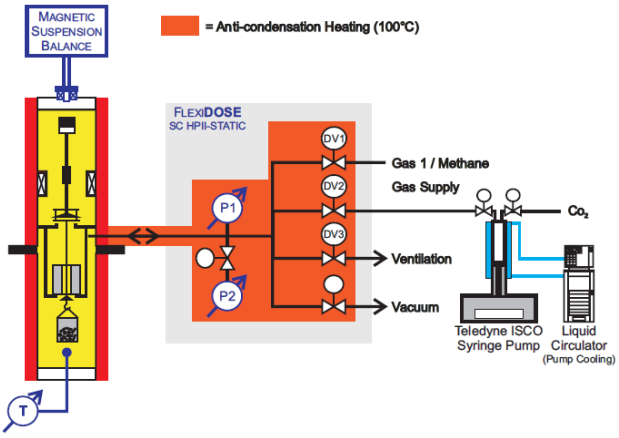

Figure 1: Flow diagram of IsoSORP instrument with MSB and SC HP static gas dosing system

Results

ECBM studies were performed on coal samples from the Sulcis coal province in southern Sardinia. The adsorption isotherms of pure CO_2 at 45° and 60°C are shown in Figure 2: Adsorption for CO_2 is higher than for methane, which is an important precondition for ECBM [5].

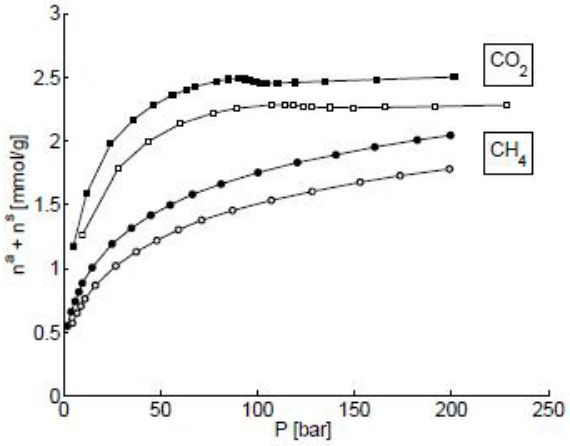

Figure 2: Absolute Adsorption of CH_4 and CO_2 on a Sardinian coal sample at 45 °C and 60 °C

The next step is to measure the adsorption of mixtures of CO_2 and methane. In this case, the magnetic suspension balance is used to measure the total adsorption isotherm gravimetrically. Based on these values, the adsorption data for the individual components can be gained by GC analysis of the remaining non-adsorbed mixture in the gas phase. Samples for GC analysis can be taken after depressurization, the expanded the gas flow is directed through a 6-port gas sampling valve. Analysis by MS is another alternative.

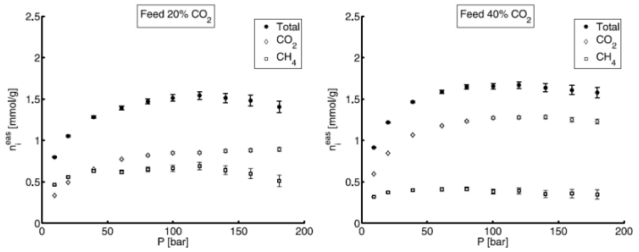

Figure 3: Total and component-wise (selective) adsorption of two CH_4 / CO_2 mixtures on Sardinian coal at 45°C

The data gained from these experiments (Figure 3) show that more CO_2 than methane is adsorbed in the coal even when CO_2 is the minor component in the mixed gas phase [6]. This confirms that CH_4 can be removed from coal seam deposits by CO_2 injection.

In order to generate gas mixtures with exactly defined composition, Rubotherm has developed MIX-modules as additional option: MIX instruments include storage tanks with calibrated volumes, a gas circulating pump and a gas sampling volume with sampling valve for analysis (Figure 4) [7].

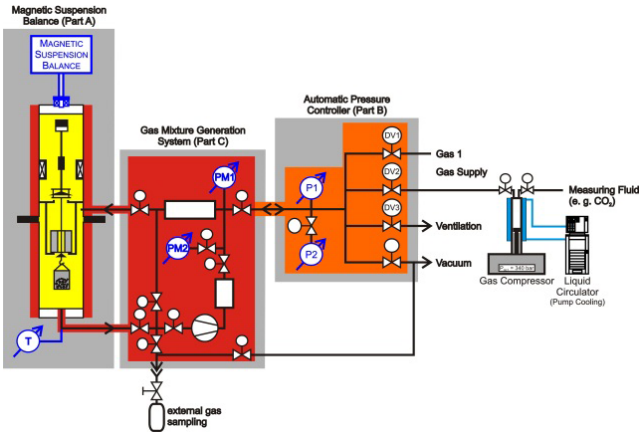

Figure 4: IsoSORP SC Mix static system for high accuracy adsorption analysis of gas mixtures

Conclusion

Coal bed methane (CBM) is a valuable future alternative to conventional natural gas. ECBM, the technology to use carbon dioxide injection for improved natural gas recovery, offers the additional advantage of long term CO_2 storage. It could be shown that Rubotherm's IsoSORP instruments can provide valuable data on gas storage capacity and the dynamics of methane replacement by CO_2 for the planning and design of ECBM projects.

Rubotherm setup required for this application:

IsoSORP MSB system

- High measuring load of up to 60 g
- Fluid Density measurement
- Pressure Range HP II up to 350 bar
- Temperature Range ambient to 150°C

SC-HPII STATIC Dosing System

- Heated to 100°C to avoid condensation
- Teledyne ISCO Syringe Pump for CO_2
- Optional: MIX module

***

References

1. R. Pini, D. Marx, L. Burlini, G. Storti, M. Mazzotti: Coal characterization for ECBM recovery: gas sorption under dry and humid conditions; Energy Procedia, Vol. 4 (2011) 2157-2161
2. Ch. Garnier, G. Finqueneisel, T. Zimny, Z. Pokryszka, S. Lafortune, P.D.C. Défossez, E.C. Gaucher: Selection of Coals of different maturities for CO_2 Storage by modelling of CO_2 and CH_4 adsorption isotherms; International Journal of Coal Geology, Vol. 87 (2011) 80-86
3. J.S. Bae, S.K. Bhatia: High-Pressure Adsorption of Methane and Carbon Dioxide on Coal; Energy & Fuels, Vol. 20 (2006) 2599-2607
4. Supercritical Fluid Applications in Manufacturing and Materials Production, Teledyne Isco, Syringe Pump Application Note AN1
5. S. Ottiger, R. Pini, G. Storti, M. Mazzotti, R. Bencini, F. Quattrocchi, G. Sardu and G. Deriu: Adsorption of Pure Carbon Dioxide and Methane on Dry Coal from the Sulcis Coal Province (SW Sardinia, Italy); Environmental Progress, Vol. 25 (2006), 355-364
6. S. Ottiger, R. Pini, G. Storti and M. Mazzotti: Competitive adsorption equilibria of CO_2 and CH_4 on a dry coal; Adsorption, Vol. 14 (2008)
7. FlexiDOSE Series Gas & Vapor Dosing Systems, Rubotherm 2013

Frieder Dreisbach holds a doctoral degree in mechanical engineering thermodynamics and is managing director of Rubotherm GmbH, Bochum, Germany. E-mail: fd@rubotherm.de
Thomas Paschke holds a doctoral degree in analytical chemistry and is application specialist at Rubotherm GmbH, Bochum, Germany.
E-mail: tp@rubotherm.de
Web site: www.rubotherm.de

Last modified November 18, 2013