Investigation of Enhanced Coal Bed Methane (ECBM) Processes – Gravimetric Adsorption Measurements Under Realistic Conditions

Keywords: Natural Gas, ECBM, CO_2, Coal Bed Methane, Gravimetric Measurement

ABSTRACT

Coal bed methane is a promising alternative to conventional gas. The ECBM technology combines improved methane recovery with underground storage of CO_2. This process can be studied by gravimetric measurements of adsorption isotherms using the IsoSORP© system with magnetic suspension balance. Accurate gas adsorption data are required for planning ECBM projects.

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. Enhanced coal bed methane recovery (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 TA Instruments IsoSORP SA© systems to study the ECBM process by gravimetric measurements.

EXPERIMENTAL

The IsoSORP SA© system by TA Instruments 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 SA© system.

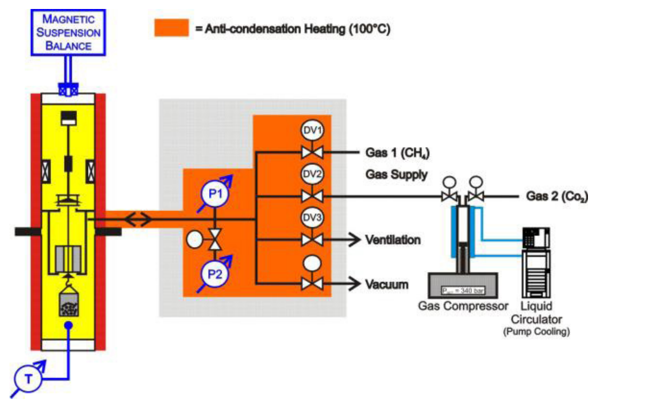

Figure 1: Flow Diagram of IsoSORP SA instrument with MSB and high pressure static gas dosing system for CH_4 and CO_2.

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].

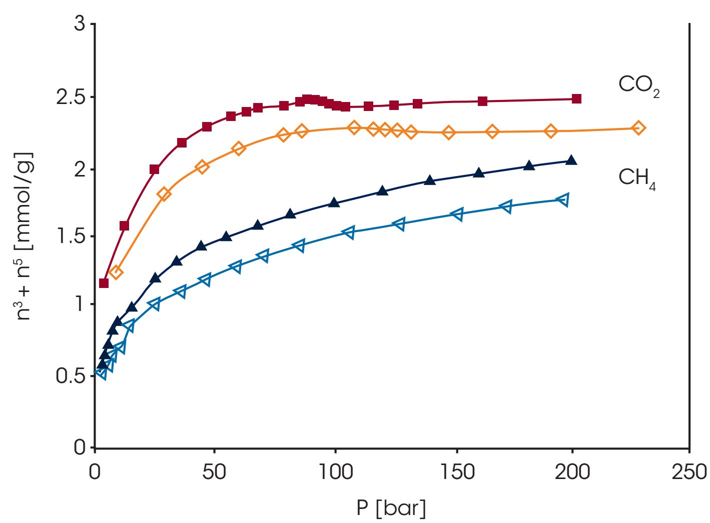

Figure 2: Absolute Adsorption of CH_4 and CO_2 on an Sardinian coal sample at 45 °C and 60 °C

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.

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.

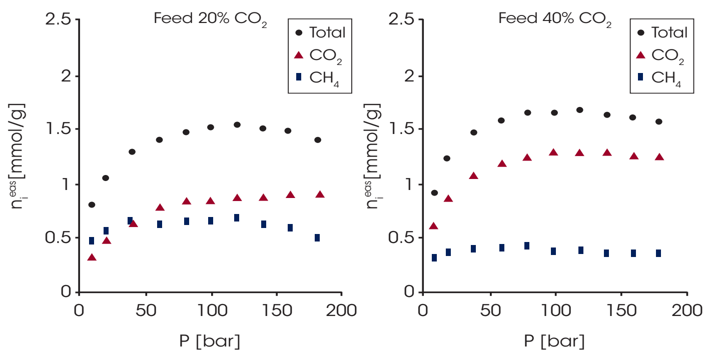

Figure 3: Total and component-wise (selective) adsorption of CH_4/ CO_2 mixtures on Sardinian coal at 45 °C

In order to generate gas mixtures with exactly defined composition, TA Instruments 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].

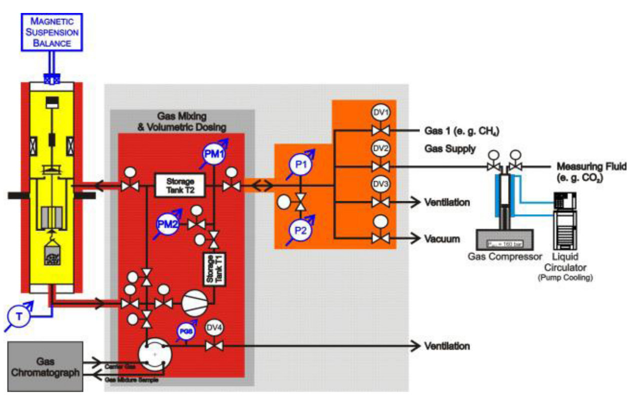

Figure 4: IsoSORP SA (MS-SC) system for high accuracy adsorption analysis of gas mixtures

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 TA'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.

TA INSTRUMENTS SETUP REQUIRED FOR THIS APPLICATION:

IsoSORP SA (150-350, S-SC) system
Magnetic Suspension Balance with measuring load 25 g
Fluid Density measurement
Pressure Range up to 350 bar for CH_4 and CO_2
Temperature Range ambient to 150°C (400°C at ambient p)

IsoSORP SA (150-700, S-SC) system
Same as above, maximum pressure 700 bar

IsoSORP SA (400-150, MS-SC) system
Same as above, maximum pressure 150 bar
Temperature Range ambient to 400 °C
Including MIX module for measurement of gas mixtures

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