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WEBINAR SERIES

Experimental Simulation of Simultaneous Hydrogen Gas Stream Purification and CO2 Storage in Coal Samples using the RTAPK Core Analysis Method

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Steam methane reforming (SMR) is a common process for generating hydrogen but yields CO_2 as a byproduct which must be sequestered to make this a 'blue hydrogen' process. However, the separation of H_2 from SMR mixed gas streams at scale is costly and inefficient. It has recently been proposed to simultaneously purify the H_2 component of the SMR mixed gas stream and sequester the CO_2 component in deep, depleted coal seams. One possible target for this process is the deep Mannville coal in Alberta. In order to understand the primary controls on H_2 purification/CO_2 storage, experimental simulation of the process has been undertaken.

In this study, the RTAPK (rate-transient analysis, porosity and permeability) core analysis method is used to study the H_2 purification/CO_2 storage process in a Mannville coal sample. The RTAPK method can be used to experimentally simulate SMR gas injection, soaking, and production (e.g., a huff-n-puff, or HNP, scheme), and to determine permeability to single-component gases and gas mixtures.

Using a modified RTAPK instrument, a synthetic SMR gas (volume percentages: 75% H_2/15% CO_2/10% CH_4) was injected into the Mannville coal sample, allowed to reach equilibrium pressure, and then produced from the coal sample. Two HNP cycles were performed with this gas mixture using RTAPK applied to the coal sample at reservoir temperature. After the injection stage of cycle 1, the gas composition stabilized to ~95% H_2/2% CO_2/3% CH_4, demonstrating a simultaneous increase in H_2 component free-gas concentration, and decrease in CO_2 and CH_4 component concentrations. A similar result was obtained for cycle 2. At the start of the production stage for cycle 1, the produced gas was close to the equilibrated value, but at the end of this period, the produced gas composition was ~86% H_2/6% CO_2/8% CH_4 indicating H_2 concentrations were diluted due to the desorption of some CH_4 and CO_2 during production. A similar result was again obtained for cycle 2, but with a somewhat different (suppressed in H_2 composition) late-stage produced gas composition of ~81% H_2/7% CO_2/12% CH_4. For cycles 1-2, the amount of injected H_2 that was recovered at the end of the production stage was approximately 20% and 38% respectively; the amount of injected CO_2 stored was approximately 96% and 92%, respectively. The permeability of the coal sample to H_2, measured prior to SMR gas injection, was estimated to be ~0.03 md. However, after the SMR gas injection, the permeability of coal sample decreased to ~0.01 md.

This proof-of-concept study using the RTAPK method demonstrates that simultaneous H_2 purification and CO_2 storage can be achieved through injection of H_2/CO_2/CH_4-containing SMR gases into coal samples and subsequent production of the gas mixture.