This Week at NETL

February 19, 2013

NETL Formulates Lower-Cost Oxygen Carrier for Chemical Looping Combustion

NETL scientists have exploited the advantages of using a mixture of metal oxides as a source of oxygen for the chemical looping combustion of methane and coal, a process that can avoid the significant energy penalty normally associated with carbon capture. The performance of samples with varying amounts of highly reactive copper oxide and inexpensive, environmentally compatible, iron oxide were evaluated using thermo-gravimetric analysis and bench-scale fixed-bed flow reactors. When optimized, the formulation obtained good reactivity while maintaining physical and chemical stability during cyclic reactions of exposure to fuel followed by re-oxidation. The bimetallic mix demonstrated a synergetic effect in which the copper oxide increased the rates and extent of reduction of the iron oxide in both methane and coal, while avoiding some of the particle-agglomeration issues normally encountered with copper oxide when used alone. The study will be described in the peer-reviewed Elsevier publication, *Fuel*.

Recovery Act–Funded Project Determines Regional Stacked Carbon Storage Capacities of Alabama Formations

The National Carbon Sequestration Database and Geographic Information System (NATCARB) has been updated with maps for all prospective reservoir zones in the Black Warrior basin along with new estimates of their potential storage capacities for supercritical CO_2. The total estimated capacity of the basin exceeds 3.2 metric gigatons of CO_2—more than 115 years of storage at current emission rates. The Pottsville sandstone, which can store about 50 years of emissions in a supercritical state, is particularly important for sequestration. However, different combinations of saline formations are prospective in different parts of the basin, so that a portfolio approach appears to be the most sensible path toward the application of commercial storage technology.

U.S.–China Collaborators Study Novel Syngas Clean-up Absorbent

Results of joint research among scientists at NETL, the Chinese Academy of Sciences, and Pacific Northwest National Laboratory (PNNL), show that magnesium oxide promoted with sodium carbonate has an absorption capacity for CO_2 of 15 percent by weight (3.4 millimoles of CO_2 per gram of absorbent) and can be easily regenerated at a higher temperature than can pure magnesium oxide. The absorbent is synthesized through the formation and activation of the precipitate that results from adding sodium carbonate to an aqueous solution of magnesium nitrate. The absorbent, which comprises magnesium oxide, sodium carbonate, and residual nitric acid after activation, forms a double carbonate of sodium and magnesium on exposure to CO_2. Computational thermodynamics predict that the preferred temperature range for CO_2 absorption by the double salt is significantly higher than magnesium oxide. Thermodynamic calculations also predict an important effect of CO_2 partial pressure on absorption capacity in the temperature range desired for processes such as integrated gasification-combined cycle and sorption-enhanced hydrogen production (300–470 °C). Sodium nitrate, while an impurity, is identified as a key component in facilitating CO_2 absorption by these materials. The work was performed as part of the U.S.–China Protocol in the Field of Fossil Energy Technology Development and Utilization and is described in the January 2013 edition of the Elsevier publication, *International Journal of Greenhouse Gas Control*.

Cost-Effective Joining Method Improves Creep Resistance in High Temperature Steel

As part of an NETL-supported field work proposal, researchers at PNNL have completed additional creep tests on base metal samples and cross-welded sections of friction stir-welded (FSW) P91 steel used for boiler steam tubes and pipes. Published data on P91 base metal were used to validate PNNL creep test machines and procedures. Test results show that, compared to conventional fusion-welded P91 joints, which become more susceptible to creep-induced failure than the base metal, FSW cross-welded joints last two to three times longer, even without post-weld heat treatment. The results suggest that FSW is a cost-effective P91 joining method that could eliminate early weld failures and the need for expensive heat treatment when constructing coal-fired boilers. Micro-structural characterization of the FSW joints is ongoing to determine the reasons for the comparatively better creep strength.

Milestone Reached in Producing High-Temperature Material for Advanced Ultrasupercritical Steam Turbine

In partnership with DOE and the Ohio Coal Development Office, General Electric Power—a member of the Advanced Ultrasupercritical (A-USC) Consortium, led by Energy Industries of Ohio Inc.—has engaged two U.S. foundries, MetalTek International and Flowserve, to apply traditional air casting techniques for pouring nickel-based alloys to make large-scale steam-turbine casings and valve bodies. To date, large step blocks of Haynes 282, with finished weights of 300 to 1,000 pounds, have been produced for evaluation. Plans are also in place to explore the centrifugal casting and static sand-casting of actual valve components with pour weights up to 6,000 pounds. These first-of-a-kind tests demonstrate the consortium's rapid progress in developing the materials technology needed to build and operate a 760 °C A-USC steam turbine. Moreover, the technology advancements in these foundries are critical to the development of a domestic supply chain for future A-USC components and other energy markets.

NETL Wellbore Cement Research Acclaimed at American Petroleum Institute Meeting

NETL scientist Dr. Barbara Kutchko presented selected results of her team's examination of offshore cementing practices to the American Petroleum Institute (API) Subcommittee on Oil Well Cements (SC 10), which develops and maintains standards on various oil and gas wellbore cementing procedures for the U.S. petroleum industry. Building on NETL expertise and history in subsurface borehole cementing research and development, Dr. Kutchko's team initiated the work following the 2010 BP-Macondo spill in the Gulf of Mexico to improve understanding of the foamed cement systems commonly used there. The presentation, delivered at the 2013 API Exploration & Production Winter Standards Meeting, exposed prominent members of the oil and gas industry to a recently published Technical Report Series, NETL-TRS-3-2012, assessing the research needed to improve primary cement isolation of formations in deep offshore wells. Wells in the Gulf of Mexico are being drilled in increasingly extreme environments: in water depths exceeding 9,000 feet with subsurface targets in excess of 20,000 feet below the seafloor. As a result, cement barriers in offshore wells are subject to a variety of temperature, pressure, and *in situ* fluid and formation conditions. Both the Technical Report Serices and research were enthusiastically received and recognized as important work to help decrease the risk of loss of control or spill events in deep offshore systems.

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