SCR Deactivation Mechanisms Related to Alkali and Alkaline Earth Elements

C. Senior (senior@reaction-eng.com), T.Linjewile, and M. Bockelie
Reaction Engineering International
77 West 200 South, Suite 210
Salt Lake City, UT 84101

L. Baxter, C. Bartholomew, and W. Hecker
Brigham Young University
350 Clyde Building
Provo, UT 84602

K. Whitty and E. Eddings
University of Utah
1495 East 100 South
Salt Lake City, UT 84112

Reaction Engineering International (REI) has been funded by the US Department of Energy (under cooperative agreement DE-FC26-00NT40753) to carry out a program titled "NO_x Control Options and Integration for US Coal Fired Boilers." The overall goal of the program is to evaluate and demonstrate low cost NO_x control strategies and to study the potential impact of these NO_x control technologies on overall electric utility boiler performance.

One of the tasks in REI's program is called "SCR Performance Under Co-firing Conditions." The objective of this task is to develop a deeper understanding of the operating costs of SCR with regard to catalyst deactivation from alkali and alkaline earth elements. The focus is on sub-bituminous fuels and coal-biomass co-firing; both instances in which the alkali or alkaline earth metals in the fuel may have a harmful effect on SCR catalysts.

This will be accomplished by the following four tasks:

1. Building and operating a multi-catalyst slipstream reactor to be deployed at a power plant for approximately six (6) months. Six catalysts are exposed to flue gas in parallel and activity measurements are made in the field. The first field test is underway at a plant burning a mixture of PRB and bituminous coal. The second field test is planned for spring of 2004; a plant burning bituminous coal and biomass is desired for this test.
2. Laboratory measurement of field exposed catalyst and fresh catalyst for detailed investigation of deactivation methods.
3. Experimental work on regenerations methods for field-exposed catalyst.
4. Development of a deactivation model that can be incorporated into REI's existing suite of boiler modeling tools.

Professors Larry Baxter, Calvin Bartholomew and William Hecker at Brigham Young University (BYU) are carrying out Task 1 and 3. Two catalyst flow reactors and several additional characterization systems provide the analytical tools required to achieve the objectives of these tasks. The flow reactors include the *in situ* surface spectroscopy reactor and the catalyst characterization system for measuring catalyst activity. Much of the work to date at BYU has consisted of *in situ* FTIR studies of V_2O_5/TiO_2 catalyst samples. Absorption and desorption behaviors of SO_2, NH_3, and NO_x, and other species are monitored.

The objectives of the FTIR investigation are to (1) understand at a fundamental level the interactions of SO_2 with vanadia/titania and how these interactions affect activity, selectivity, and deactivation of the catalyst and (2) determine the extent to which and rates at which vanadia and/or titania are sulfated under reaction conditions. Furthermore, indications of co-adsorption of NH_3 and NO_x will help elucidate mechanisms and rates of both reactions and deactivation.

The most significant finding of these investigations is a consistent indication that vanadium does not sulfate during SCR activity in the presence of gas-phase SO_2 while both the substrate (anatase) and modifiers (molybdenum) do. In addition, mass-spectroscopy-based analyses of product gases from this reactor system are being completed that will allow analysis of fundamental kinetics and deactivation mechanisms.

Task 2 is being conducted by REI, working with Professor Eric Eddings and Dr. Kevin Whitty at the University of Utah. The University of Utah built the multi-catalyst slipstream reactor. This reactor is designed to withdraw flue gas upstream of the air preheater at a power plant. The reactor contains six catalysts, five commercial catalysts and one experimental catalyst developed by BYU. Ammonia is injected upstream of the catalysts. NO_x and O_2 are measured continuously at the inlet and the outlets of the individual catalyst chambers. REI developed a sophisticated control system that allows automated flow control with the ability to remotely monitor and control temperatures and gas flows in the reactor. Samples of the catalysts will be removed periodically for characterization at BYU to assess the damage incurred during exposure to the ash-laden flue gas.

Testing of catalysts at the first site, AEP's Rockport Unit 1, has commenced. This plant burns a blend of subbituminous and bituminous coals. The slipstream reactor has been installed at the plant and has accumulated over 1000 hours of exposure of the catalysts to flue gas.