

An Experimental Program to Optimize SCR Catalyst Regeneration for Lower Oxidation of SO₂ to SO₃

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Summary

Introduction

SCR-Tech has regenerated more than 11,000 m³ of SCR catalyst in the United States, all completed on currently-used catalyst types: corrugated, plate and honeycomb. The SCR catalyst regeneration technology employed by SCR-Tech was originally developed in Europe and further optimized in the United States. While these process optimization efforts focused on restoring the catalyst's original activity level and NO_x reduction potential, SCR-Tech has observed that the majority of catalyst regenerated in accordance with their process demonstrated SO₂ conversion rates equal to or lower than those originally specified by the manufacturer for the fresh catalyst. SCR-Tech's observations, combined with industry concern with controlling sulfuric acid emissions, prompted the company to initiate an experimental study jointly conducted with American Electric Power (AEP) and Southern Company to quantify the primary effects of five carefully selected independent factors in SCR-Tech's catalyst regeneration process on the rate of SO₂ oxidation. This presentation will summarize the results of this study.

Catalyst regeneration at SCR-Tech is a multi-step process with each step involving treatment of the deactivated catalyst with a unique chemical solution. Following a rigorous mechanical cleaning to remove loose fly ash the overall regeneration process can be broken down into three phases:

- **Phase 1** – Remove species known to poison the catalytically active sites and/or block flue gas access to those sites. Examples of chemical poisons or pore blocking agents removed in phase 1 include arsenic, phosphorous, silica, aluminum oxide, calcium sulfate and alkali metals such as sodium and potassium.
- **Phase 2** – Neutralize and remove the chemicals used in phase one and remove any additional residual, soluble catalyst poisons and pore blocking agents leftover from initial treatments.
- **Phase 3** – Re-impregnate active catalytic species onto the support to return the catalyst to a performance level equal to or greater than the original specifications offered by the catalyst manufacturer. Phase three includes carefully defined heat-treatments that enable the control of both the distribution and dispersion of those active species.

Experimental Approach

SCR-Tech selected five treatment chemicals it believes are especially critical to the regeneration process, and then selected two concentration ranges for each of those chemical species that bracket the current operating concentration within the process. Catalyst type became another factor in the experimental design. Southern Company supplied deactivated honeycomb elements from one of its plants and AEP supplied deactivated plate catalyst from one of its facilities.

To define baseline values for K_a , K_{23} , and the concentration of surface and bulk deactivating species against which to compare the effects of SCR-Tech's various regeneration treatment levels, a set of four plate and four honeycomb catalyst

samples were submitted for testing and analysis. Mean and standard deviation for each of the parameters evaluated in the study were established from these baseline data, and the measured variances were used to determine exactly what level of difference between the treated samples and the baseline deactivated samples could be defined as statistically significant, and at what confidence level.

Regenerations were run in small-scale equipment designed to treat one honeycomb element or one plate set at a time. These small-scale treatment tanks, were designed so that the solution volume to catalytic surface area ratio is equivalent to the ratio used in SCR-Tech's commercial-scale process. Other factors, such as temperatures, flows and iron-to-catalyst surface ratios were also controlled to match the commercial-scale process.

SO₂ / SO₃ Conversion Results

Measured K_{23} on both the deactivated honeycomb and plate type catalyst was high enough to detect statistically significant differences for both populations due to the variation in the controlled regeneration process parameters. Baseline SO₂ conversion rates on the deactivated honeycomb samples was 0.34 percent under the conditions of the test, while baseline SO₂ conversion on the deactivated plate samples was 0.45 percent under the conditions established for those tests. After regeneration, the average K_{23} for all deactivated honeycomb samples was reduced to 0.19 percent, which was equivalent to the measured K_{23} on the fresh samples. There was sufficient resolution in the measured K_{23} values from the regenerated honeycomb samples for the team to develop a linear mathematical model for K_{23} as a function of all five process parameters which could account for approximately 94 percent of the total variability in the data. With this model it is possible to calculate the lowest achievable SO₂ conversion rate after adjusting all process parameters for minimal K_{23} within the studied range. Based on model results, that value is predicted to be less than 0.1 percent, which is competitive with SO₂ conversion rates specified by manufacturers for new low and ultra-low conversion catalysts.

The average reduction in K_{23} on the regenerated plate catalyst was less than expected based on SCR-Tech's experience with similar plate type catalyst regenerated in its commercial-scale process. As noted earlier, the baseline SO₂ conversion rate in the deactivated plate type catalyst was 0.45 percent, while the average regenerated SO₂ conversion rate was reduced to 0.38 percent. Using the K_{23} optimization model derived from the experimental data one can predict that the lowest achievable plate catalyst SO₂ conversion rate should be 0.28 percent. Although this is an approximate 38 percent reduction in SO₂ conversion relative to the baseline deactivated catalyst, it is significantly less than what SCR-Tech would have predicted based on general experience with commercial plate catalyst regenerations.

Conclusions

This study demonstrated that SCR-Tech's regeneration process can minimize SO₂ conversion while maximizing the restoration of NO_x reduction activity. The project team developed statistically valid linear models for K_{23} on both honeycomb and plate catalyst as a function of controlled regeneration process parameters. In the case of the honeycomb catalyst, the model predicts the ability of regenerated catalyst to achieve SO₂ conversion rates that are competitive with new, commercially available, low or ultra-low conversion catalyst while still restoring virtually all the original NO_x reduction potential. For the plate type catalyst samples, the model predicted the ability of regenerated catalyst to achieve a significant reduction in SO₂ conversion, although not as high a reduction as expected based upon SCR-Tech's experience in its commercial-scale process.