

Laboratory Combustor Assessment of Hydrogen Peroxide Injection for NO_x Control

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Abstract

Selective catalytic reduction (SCR) and selective non-catalyst reduction (SNCR) systems are used for post combustion NO_x removal at power plants burning fossil fuels. With both processes, urea or ammonia is injected into a flue gas stream to reduce NO and NO_x into molecular nitrogen. These processes normally can achieve NO₂ removal efficiencies of 80–95% with SCR and 20–30% with SNCR. A more recently developed option for NO_x removal is the use of hydrogen peroxide (H₂O₂) injected into flue gas to oxidize NO into NO₂, which can then be removed by a downstream wet flue gas desulfurization (FGD) scrubber. The presence of SO₂ can result in increased SO₃ emissions due to oxidation of SO₂ by the H₂O₂. This report describes the results of laboratory combustor testing of hydrogen peroxide injection to verify the results of kinetic modeling and earlier testing as well as to study the effects of process parameters on the oxidation rate of NO to NO₂.

Objective

The objectives of the present test program were to confirm the results seen in prior testing and to investigate the effects of the following parameters on the oxidation rate of NO to NO₂:

- Injection temperature
- NO concentration
- SO₂ concentration
- Residence time
- NSR (normalized stoichiometric ratio; i.e., molar ratio of H₂O₂ to NO)
- H₂O₂ solution concentration

Approach

In conducting the tests, the project team set up a natural gas-fired combustor at a given condition with the gas composition measured without H₂O₂ injection. The team subsequently injected H₂O₂ and took another set of measurements after stabilization. For many of the tests, they took a final set of readings after injection had been shut off to ensure that the measurements taken before injection were replicated.

Results

In agreement with kinetic modeling and earlier pilot-scale testing, injection of H₂O₂ resulted in the conversion of NO to NO₂ as well as a reduction of overall NO_x. NO conversion was greatest at an injection temperature of 1000°F (538°C) with nominally 70% NO conversion obtained at a molar ratio of H₂O₂ to NO of 1.0 and 90% at a molar ratio of 2.0 with inlet NO values of 200 ppm. The presence of SO₂ shows little effect on NO conversion, but does increase overall NO_x reduction. Specific tests with SO₂ addition indicated that SO₂ to SO₃ oxidation rate was nominally 2.0–2.6%.

Application, Value and Use

Hydrogen peroxide reagent costs are on the order of \$4.00 per gallon, which is nominally three times the cost of a 50% urea solution. Thus, for this technology to represent a competitive alternative to SNCR, it must achieve overall NO_x reductions greater than 40% as measured at the stack and preferably on the order of 50–60%. While SNCR will typically yield NO_x reductions up to 30% on utility boilers and SCR up to 90%, this technology could provide an intermediate option if it can achieve consistent reductions of 40–60%. In addition, any SO₂ oxidized to SO₃ must be adequately mitigated across the wet scrubber so as to not generate a visible plume.

EPRI Perspective

The overall effectiveness of this technology will be contingent upon the degree of removal of NO₂ and SO₃ that can be achieved across a wet scrubber. The SO₂ to SO₃ oxidation rate of nominally 2.0–2.6% may be particularly troublesome for most coal-fired boiler applications since SO₃ emissions greater than 5–10 ppm may result in a visible blue plume.

While overall NO conversion levels appear high, the ultimate effectiveness of the technology will be contingent upon the NO₂ removal percentage across a wet scrubber.

Program

2010 Program 73 Post-Combustion NOx Control

Keywords

- Hydrogen Peroxide
- SO₃
- NOx reduction

Report

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Note

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