New SCR Catalyst for High NO_x Reduction on Gas-Fired Combustors

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Summary

Guild Associates has developed a novel catalyst for SCR systems on gas-fired combustors. The catalyst has dual functionality in that it simultaneously combines NO_x reduction with NH_3 (SCR functionality), and NH_3 oxidation with oxygen (NH_3 destruction functionality). This allows for higher NO_x reduction than obtained with conventional SCR catalysts, while yielding zero NH_3 slip. The high NO_x reduction is achieved through the use of excess NH_3, which, in turn, is destroyed without forming NO_x. In addition, the catalyst has the ability to oxidize CO to CO_2.

Laboratory experiments were performed to simulate two types of gas-fired combustors: 1) a gas-fired boiler with an atypically high concentration of NO_x in the flue gas, and 2) a gas turbine with a typical concentration of NO_x in the exhaust gas. In the former case, simulated flue gas with a volumetric composition of 80 percent nitrogen, 8 percent H_2O, 12 percent oxygen, 200 ppm CO, 570 ppm NO, and 30 ppm NO_2 was used. In the latter case, simulated exhaust gas with a volumetric composition of 80 percent nitrogen, 8 percent H_2O, 12 percent oxygen, 100 ppm CO, 24 ppm NO, and 6 ppm NO_2 was used.

The NO_x in flue gas typically consists of 95 percent NO and 5 percent NO_2, while the NO_x in turbine exhaust gas typically consists of 80 percent NO and 20 percent NO_2. The chemical reaction for the reduction of NO with NH_3 is thought to involve oxygen and have an NH_3/NO molar ratio of 1.00 (theoretical stoichiometric ratio of 1.00). The reduction of NO_2 with NH_3 does not appear to involve oxygen and has a theoretical stoichiometric ratio of 1.33. For a gas-fired boiler, the typical theoretical stoichiometric ratio is 1.02 (0.95 x 1.00 + 0.05 x 1.33), while for a gas turbine the typical theoretical stoichiometric ratio is 1.07 (0.80 x 1.00 + 0.20 x 1.33).

In order to prove the concept, the laboratory experiments were performed at a gas flow rate of 12 l/min with about 80 cm^3 of a monolithic catalyst with a square pitch of about 2.5 mm (100 cells/$in.^2$). This yields a space velocity of about 9,000 hr^{-1} and an area velocity of about 3.6 m/hr. The variables were the stoichiometric ratio of NH_3/NO_x, which ranged from 1.00 to 2.00; the concentration of NO_x, which ranged from 30 to 1,700 ppm; and the temperature, which ranged from 220 C to 440 C. The outlet gas from the catalyst was analyzed for NO and NO_2 using a chemiluminescent analyzer, for N_2O and CO using a gas chromatograph, and for NH_3 using an NH_3 converter in conjunction with the NO_x analyzer.

For the case of the simulated flue gas from a gas-fired boiler, >95 percent NO_x abatement was achieved over a temperature range of 325 to 365 C at an NH_3/NO_x ratio as low as 1.3. In all cases, the CO abatement was >95 percent.

For the case of the simulated exhaust gas from a gas turbine, >95 percent NO_x abatement was achieved over a temperature range of 250 to 300 C at an NH_3/NO_x ratio as low as 1.3. At the low end of the temperature range, the N_2O emission was <3 ppm. Again, in all cases, the CO abatement was >95 percent.

These data indicate that it is possible to achieve very high NO_x removal in SCR systems, even at high NO_x concentrations, with zero NH_3 slip. Work is planned to develop a dual function catalyst for SCR systems on coal-fired boilers.