Selective Autocatalytic NO_X Reduction (SACR)

G Hesselmann
Mitsui Babcock, Porterfield Road, Renfrew, PA4 8DJ, United Kingdom
E-mail: ghesselman@mitsuibabcock.com; Telephone (+44) 141 885 3858; Fax (+44) 141 885 3860

D Hough
Mitsui Babcock, 11 The Boulevard, Crawley, West Sussex, RH10 1UX, United Kingdom
E-mail: dhough@mitsuibabcock.com; Telephone (+44) 1293 584654; Fax (+44) 1293 584331

Summary

Selective Auto Catalytic Reduction (SACR) is a gas phase NO_X reduction process suitable for installation in new boiler plant or retrofit to existing equipment. The process can be implemented in isolation or in combination with in-furnace NO_X reduction technologies, and comprises of the provision of the autocatalytic reaction zone and injection grid. Final NO_X levels as low as those attained by many SCR systems are envisaged.

The key feature of the process is the injection of an ammonia based reagent (typically but not exclusively anhydrous ammonia) and a hydrocarbon (such as, but not limited to, natural gas, propane etc.) into a flue gas containing NO_X and some O_2. At elevated temperatures the hydrocarbon auto ignites, forming a plasma, and creating radicals. These radicals catalyse the NO_X reduction reactions – autocatalysis – and the resulting flue gas contains greatly reduced NO_X and a small level of ammonia slip.

The SACR process was initially demonstrated for coal firing application at Mitsui Babcock's 0.55 MBtu/h (160 kWt) NO_X Reduction Test Facility (NRTF). This comprises of a cylindrical furnace, the flue gas exiting from this being fully representative of large plant with respect to temperature gas analysis and dust loading. A reactor vessel was installed to represent the reaction zone, and instrumentation allowed the inlet and outlet gases (NO_X, O_2, CO) and temperature to be monitored continuously. Ammonia slip was determined by wet chemistry methods. Having proven the process an extensive programme of parametric testing was undertaken to establish the process design. Parameters studied included:

- Ammonia flow (molar ratio)
- Hydrocarbon flow and type
- Temperature
- Residence time
- Inlet NO_X level
- Impact of cooling surfaces
- Coal type

From the data acquired it was found that NO_X reduction levels in excess of 80% could be achieved whilst maintaining ammonia slip levels to below 5 ppm, the outlet NO_X could be reduced to below 0.1 lb/MBtu. This performance was achieved with an ammonia to NO_X molar ratio of circa 2.0 and low hydrocarbon flows (equating to below 0.5% of heat input). Furthermore the performance was found to be insensitive to coal type (US, UK and world traded coals were tested). Sufficient data was obtained to allow the process design to be developed for a full-scale utility boiler.

However it was recognised that the NRTF is a very small scale facility – indeed only a single reagent injection nozzle was used – and large scale testing was therefore undertaken at a more representative scale with an arrangement close to that proposed for full scale plant. The tests were conducted on Mitsui Babcock's Multi-fuel

Burner Test Facility (MBTF), this was operated with a heat input of 135 MBtu/h (40 MWt). The aim of these large scale tests was to prove the mechanical design and scale-up to a multi-injector arrangement and to develop/prove the process control – a total of 8 injection lances (each 15ft long) were installed in the facility, giving 6 control zones where the flow rate of ammonia and hydrocarbon could be independently set. It was demonstrated that, at a more realistic scale, the process performance could be replicated; that the process could be controlled; and that the mechanical design of the injector lances was sound.

Based on this positive result, a full-scale plant demonstration was initiated. This was based on a tangentially fired utility boiler having a twin furnace arrangement (i.e. separate furnaces for superheat/reheat steam). Physically the dimensions of the injection lances are similar to those tested on the MBTF (21 ft vs. 15 ft, i.e. a scale up factor of just 1.4), with 9 separate control zones (compared to 6 on the MBTF). The current status is that the hardware has been installed and testing of the process is ongoing.