High-Dust SCR Design to Limit Impact of High Sulfur Operation on Air Preheater Operation

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Summary

Limiting SCR impact on air preheater operation is a substantial challenge in U.S. bituminous coal service due to uniquely high sulfur/ash ratio as contrasted with other worldwide fueling. Somewhat comparable European SCR operations and experience provides useful design and operational guidance. If the functioning of SCR is adversely affected by design inadequacies or changing operating conditions that lead to fouling, poisoning or plugging of the catalyst, resulting problems with air preheater operation and fly ash quality can be significant. Moreover, limiting of design ammonia-slip to no more than 2 ppm may be crucial for the most challenging of such U.S. applications, particularly in retrofit applications in which SO_3 generation and impact were already a significant operating problem prior to retrofitting. In assessing catalyst performance, the ammonia content of the collected fly ash should be measured daily. Conversely, when operations indicate that catalyst charge is excessive, it should be reduced so as to limit SO_3 generation. Back end flue-gas temperature should be stabilized (maintained), in part, particularly in cold weather operation, by tempering of inlet combustion air. Mitigation of boiler SO_3 generation and minimization of the impact of SCR, (in its generation of SO_3 and release of ammonia slip), is clearly important in the generally more difficult, high-sulfur, SCR applications in the U.S. Adequacy of design/operating provisions will, in turn, be highly dependent on sustained, unfettered performance of the in-place, SCR catalyst charge.

Key design considerations include:

- Means for tight control of SCR-reactor inlet temperature, (including provision for an adjustable, economizer gas by pass), may be essential. SO_3 formation due to catalyst increases greatly for some catalyst types when this temperature exceeds approximately 350°C (660°F).
- Nearly uniform flow distribution within the SCR reactor is essential. NO_x mass flow rate should not vary, cross-sectionally, more than + or – 15%, NH_3/NO_x ratio no more than + or – 3 to 5%, gas temperature no more than + or – 15°C (27°F) and particulate mass flow rate no more than + or – 30%.

- A good case can be made for limiting ammonia slip, i.e. measured at the air preheater inlet, to no more than approximately 1.5 to 3.0 ppm locally and less than 2 ppm averaged. This calls for close monitoring and sustaining of catalyst activity, increasing catalyst volume and/or activity in a timely manner by use of the spare/reserve layer or by periodic catalyst replacement.
- In some cases, for up to 2/3 of the air preheater height, enamel plating is needed on the flue gas side for protection within the critical flue gas temperature region. Heating plate surface-profile and grooving is selected for ease/effectiveness of in situ soot blowing.

The following special provisions for the challenging U.S. applications in typical low-ash, high-sulfur, coal-fired service (uncommon in Europe and elsewhere) are recommended:

- A catalyst with a low SO_2-to-SO_3 conversion rate, i.e. less than 0.3%
- Ammonia injection upstream of the economizer if necessary to adequately moderate air preheater acid corrosion and stack emission of sulfuric acid aerosol…this accomplished with sacrifice in the quality of collected fly ash
- Alkali injection upstream of the air preheater
- Enameled heating plates on the flue gas side of the air preheater extending to up to 2/3 of the plate height
- Protection against corrosion of the casing and rotor structure on the cold side of the air preheater
- Optimal means for adequate, in situ, soot blowing action within the air preheater
- Uniformity in transverse distribution of flow rate, concentration and gas temperature.

Depleted catalyst elements are preferably cleaned up and reused instead of being replaced. The need for disposal of a great amount of catalyst material is thereby avoided. The regeneration of the catalyst material uses 3 steps: washing, ultrasonic (mechanical) cleaning and chemical reactivation. Approximately 10,000 cubic meters of catalyst material has been reactivated in Germany to date. Successful regeneration has been accomplished with diverse catalyst types: plates, honeycombs, those with large and small pitch, and from different suppliers. Depending on site constraints the regeneration time for a 200 m^3 quantity of $deNO_x$ catalyst is between 7 and 10 days. Reactivated catalyst has been meeting specified reaction coefficients and SO_2/SO_3 conversion coefficients achieved before. Ultrasonic cleaning of the poisoned catalyst elements in a water basin is the best method of highly effective cleaning. Typically the mechanical strength of the catalyst base material is great enough to withstand up to 4 or more regenerations. After regeneration the catalyst regains 90 to 100% of the original activity. To date almost all catalyst types have been successful regenerated. The cost savings over catalyst replacement has been enormous.

Plugging of catalyst elements by popcorn ash in some services results in increased gas pressure loss, reduced catalyst efficiency and increased ammonia slip and can cause surface abrasion due to increased local gas flow velocity within catalyst portions receiving unobstructed gas flow. This can be avoided by installation of a popcorn separator to screen out these coarse particles upstream of the catalyst. The system is newly installed in several power plants and results will be available for publication this year.