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SCR AND SNCR PROCESSES INCREASE RISK OF AIR PREHEATER FOULING

The selective catalytic reduction (SCR) process for NO_x control involves injection of ammonia into the flue gas where it reacts with NO_x in the presence of a catalyst to form molecular nitrogen and water. Not all of the injected ammonia participates in NO_x reduction reactions. . . some reaches the air preheater as ammonia slip, where it reacts with SO_3 to form ammonium sulfate and bisulfate compounds. These compounds can precipitate onto air preheater basket surfaces and cause problems of fouling and plugging. The available evidence suggests that bisulfate fouling will be a serious problem for some U.S. boilers. Researchers at the Energy Research Center have been developing the tools needed to determine how best to limit air preheater fouling due to ammonium compounds.

Ammonium bisulfate deposits at ESP inlet in a coal-fired boiler with ammonia injection for NO_x control.

According to Richard Conn, “Utilities in Japan and Western Europe have had considerable experience with SCR with coal-fired boilers and for the most part, they have not experienced problems due to air preheater fouling. However, their SCR installations are on boilers which normally fire coal of one percent or less sulfur content and the low incidence of fouling is probably due to the correspondingly low flue gas SO_3 content at the air preheater inlet. In fact, in one case, a boiler with SCR in Europe fired U.S. Appalachian coal with two percent sulfur and this resulted in excessive air preheater fouling within only a week. A Danish unit burned a 2.9 percent sulfur U.S. coal without air heater fouling, but in this case ammonia slip had to be maintained at very low levels.”

Conn continues, “A recent technical review by EPRI showed there is very little SCR experience in power stations firing coals containing greater than 1.5 percent sulfur. Of the issues most critical to SCR application in the U.S., coal sulfur content is probably the most significant. Almost 50 percent of the coal fired east of the Mississippi contains two percent or more of sulfur. Also significant is the fact that Eastern U.S. coals contain relatively low alkali levels. This eliminates the possibility that an alkali constituent such as calcium can lower the SO_3 concentration in the flue gas and thereby reduce the potential for ammonium bisulfate formation.

Of equal importance to SO_3, is the level of ammonia slip. German experiences have shown that the deposition rate increased by a factor of four as the ammonia slip increased from two to four ppm.”

A major problem associated with ammonium bisulfate formation is its impact on air preheater design and operation. The formation temperature of the ammonium bisulfate is such that it will precipitate out in the intermediate and cold end baskets of the air preheater. Deposits, formed in the cold-intermediate layer, are hard to remove with sootblowers. This deposited ammonium bisulfate degrades heat transfer performance of the air preheater, acceler-ates corrosion of air heater surfaces, and traps fly ash, which can lead to excessive air preheater pressure drop and ultimately cause a plant shutdown. Ammonium bisulfate deposition forms on heat transfer surfaces where the temperatures fall within 300-430°F. Experience in Japan shows that the fouling was noticeably higher when this temperature band extended across two layers of the air preheater.

It should be noted that ammonium bisulfate formation is not limited to SCR systems. This can also occur with selective non-catalytic reduction technology (SNCR), which also involves injection of ammonia into the flue gas. Ammonia slip can occur with SNCR processes and, here too, this can lead to the formation of ammonium sulfate compounds and air preheater fouling.

Sarunac adds, "...The end goal is to develop the means to be able to minimize problems of bisulfate fouling through design changes, operational changes and/or maintenance practice."

One possible solution is to modify the air preheaters to make them less susceptible to corrosion and plugging due to bisulfate formation. Indeed, extensive air preheater modifications are currently underway at some U.S. power plants which are installing SCRs. This typically involves either complete replacement of the air preheater or extensive preheater upgrades. Some of the more significant modifications to an air preheater include:

- combining the cold and intermediate baskets of the air preheater into one continuous basket,
- modifying the basket design to a notched flat surface instead of a double undulating surface,
- installing twin primary and secondary air heaters to allow on-line cleaning,
- placing high pressure, high temperature steam sootblowers at both inlet and outlet of the air heater,
- installing enamel baskets to provide additional corrosion resistance,
- installing spring nozzle banks at the inlet of the coal basket to permit on-line water washing. In addition, installing two- speed motors to slow the basket rotation and allow more effective washing.

Air preheater modifications such as those described above can be expensive. Some design studies have shown that the cost of these modifications are 25 percent of the cost of the SCR catalyst. For a 500 MW power plant, the cost of air preheater modifications is approximately $6 million. Replacement of the air preheater can cost as much as $25 million for a 500 MW power plant.

Conn adds, "Given the potential impact on the air preheater and the expense associated with making modifications to the air preheater to minimize the impact of fouling, we believe that it is important to find out more about the mechanisms of bisulfate formation. We also need information on the rates at which bisulfate fouling occurs and plant design and operational characteristics that affect bisulfate formation."

Nenad Sarunac adds, "We've developed a research program which we think will provide answers to the key questions. They are: What air preheater basket design changes are most cost effective in minimizing bisulfate fouling? How should a boiler and SCR system be operated to minimize ammonia slip? Are there additives or changes in sootblowing practice or on-line water wash strategies which can be helpful in controlling bisulfate fouling? Are there improved ways of controlling the ammonia injection rate to minimize ammonia slip?"

Sarunac continues, "Our group at the Energy Research Center has had considerable experience in dealing with air preheater performance issues and fouling problems. For example, we've developed modeling techniques for accurately calculating air and gas flow rates through the air preheater. We've also developed software for computing basket metal temperatures as a function of basket design, unit load, economizer O_2 and other key operating factors. These codes can be used to obtain insight into which portions of the air preheater are susceptible to fouling due either to formation of ammonium bisulfate or condensation of sulfuric acid. We've also developed techniques for calculation of acid deposition rate on a cold metal surface. The rates depend on the local metal temperature, concentration of SO_3 in the flue gas and concentration of H_2O vapor in the inlet air to the preheater. We've carried out laboratory experiments, field tests and theoretical analyses. The techniques we developed previously for predicting rate of fouling are geared toward sulfuric acid deposition. We plan to use those as a starting point for investigating rates of bisulfate formation. We are also beginning to work on development of a technique for calculation of the rate of ammonia slip out of an SCR and to calculate the SO_3 concentration leaving an SCR reactor."

Sarunac adds, "We are interested in forming a consortium of sponsors to enable us to complete this work on air preheater fouling. The end goal would be to develop the means to be able to minimize problems of bisulfate fouling through design changes, operational changes and/or maintenance practice." €

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