Systematic monitoring of the Selective Catalytic Reduction (SCR) installation at a coal-fired power plant in Thailand revealed various opportunities for improvement. This led to targeted SCR equipment upgrades as well as the finetuning of a number of operations and maintenance processes to dramatically increase SCR performance. “The case demonstrates the need for a more comprehensive approach to managing SCR performance.”

The 502 MW gross capacity coal-fired boiler, in operation since 2012, is equipped with two parallel high-dust SCR deNOx reactors in a 2+1 layer configuration. The plant’s EPC contractor initially equipped each reactor with two honeycomb catalyst layers. Arrays of sonic horns (five per layer per reactor) were put in place to periodically clean the layers so that they could continue to perform well until end-of-life, defined as a rather limited 16,000 hours operational.

Addressing design issues
Additional investigations were needed to confirm whether the catalyst replacement cycle could be stretched to save costs. “We needed to get a better view of the actual catalyst state and its performance,” confirms Mercier, “so we carried out detailed SCR inspections during an outage in 2015. Unfortunately, we found that large areas of the catalyst layers were severely plugged. Not only that, the sonic horns were severely plugged too, which is fairly uncommon.”

“To fully understand how this had happened, we analyzed the related operations and maintenance data. This revealed several design issues. For example, the choice of honeycomb catalysts and the way they were designed significantly contributed to the plugging issue. And the sonic horns provided insufficient acoustic energy to keep the reactor clean. We therefore launched programs to install custom plugging-resistant plate catalysts and upgrade the sonic horn system.”

“Challenging conservative OEM guidelines In 2014, the plant operator called upon ReNOx Laborelec to monitor the SCR installation. “It was a wise decision, because we have seen that only a few plants make the most out of their SCR installations,” says ENGIE Laborelec Senior Expert Frédéric Mercier. “An independent investigation could uncover a range of opportunities to improve performance and reduce costs.”

How sound O&M improves SCR deNOx performance
Managing SCR performance comprehensively

“According to our experience, catalyst layers are capable of performing well for a much longer period of time, often four or five years, provided they are operated under favorable conditions.”
Balancing the combustion

Despite the apparent design weaknesses, the ReNOX Laborelec engineers suspected that the poor catalyst performance and reliability also stemmed from unsatisfactory operating conditions. Mercier: “The limited catalyst lifetime surely couldn’t just be due to design issues. So, we carried out air-flow measurements and analyzed the boiler’s combustion data. This revealed significant imbalances in the combustion flow and temperature. For example, there was a big difference between the left and right primary NOx, by as much as twice the good practice guideline.”

“The imbalances identified meant that some SCR areas were being systematically overcharged, raising the required minimal deNOx potential in these areas and thus reducing catalyst lifetime. Once the plant operators understood this, they asked us to optimize the combustion by tuning secondary air flow rates and control loops. The balance is much better now.”

Adjusting to the changed coal mix

Note that operating conditions must be closely monitored on a permanent basis. “Any change in the plant’s process can significantly impact the catalyst,” says Mercier. “For example, in 2016 we learned that the plant’s coal mix source had changed, making for increased ash, sodium, potassium and sulfur concentrations. Our analysis showed that this increased boiler slagging and fouling and resulted in higher temperatures at the catalyst layers, leading to more rapid degradation. We therefore advised that the boiler cleaning program should be improved and intensified accordingly.”

Tuning NH$_3$ injection

ReNOx Laborelec also analyzed and improved the operation of the SCR reactors themselves. “Note that a sufficient quantity of NH$_3$ should be injected in all the catalyst areas to allow maximum completion of the NOx + NH$_3$ → N$_2$ + H$_2$O reaction,” explains Mercier. “Our measurements showed that there was a problem.”

“We analyzed the NOx distribution at the reactor outlets and found that there were areas with low NH$_3$ injection but high NOx, as well as areas with high NH$_3$ injection but low NOx. Both negatively impact performance: the first leads to incomplete deNOx, the other produces performance-degrading NH$_3$ slip. We therefore tuned the ammonia injection grid of both reactors to achieve a more even distribution and better equilibrium between the open and closed control valves.”

FACTS AND FIGURES

Global improvement in performance leads to savings of ~ $420k per year compared with OEM approach

- NH$_3$: tuning the ammonium injection grid leads to more homogeneous NOx distribution (from 23 to 12.5 RMS) and a significant reduction in the NH$_3$ slip (reduction of 1.3 vpm), with a positive impact on catalyst lifetime.

- Combustion tuning leads to significantly reduced unbalances, which also contributes to extending lifetime.

<table>
<thead>
<tr>
<th>Unbalance left / right</th>
<th>Good practice</th>
<th>Before tuning</th>
<th>After tuning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total secondary air [kg/s]</td>
<td>&lt; 10</td>
<td>-20</td>
<td>3-7</td>
</tr>
<tr>
<td>FEGT [°C]</td>
<td>&lt; 10</td>
<td>-10</td>
<td>2-7</td>
</tr>
<tr>
<td>O$_2$ [%w]</td>
<td>&lt; 0.5</td>
<td>-1</td>
<td>0.3 – 0.7</td>
</tr>
<tr>
<td>Primary NOx [ppm]</td>
<td>&lt;10</td>
<td>-20</td>
<td>&lt;5</td>
</tr>
</tbody>
</table>

Pressure drop is reduced from values above 10 mbar/layer using the OEM catalyst to values below 2 mbar/layer when using the custom ReNOx Laborelec catalyst design in combination with an improvement by ReNOx Laborelec of O&M practices concerning the use of sonic horns.