

The Perfect Mix for Clean Air

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NO_x are mono-nitrogen oxides produced during combustion. These oxides are poisonous, can react with the oxygen in the air to produce ozone, which is an irritant, and are one cause for harmful acid rain when dissolved in atmospheric moisture. A common means of reducing NO_x emissions of fossil-fired power plants is selective catalytic reduction (SCR), where a gaseous or liquid reducing agent is added to the flue gas stream and guided onto a catalyst. Sulzer Chemtech offers static mixers and injection grids, which are very well suited to add and distribute evenly the small amounts of reducing agent to the continuous stream of flue gas in power plants.

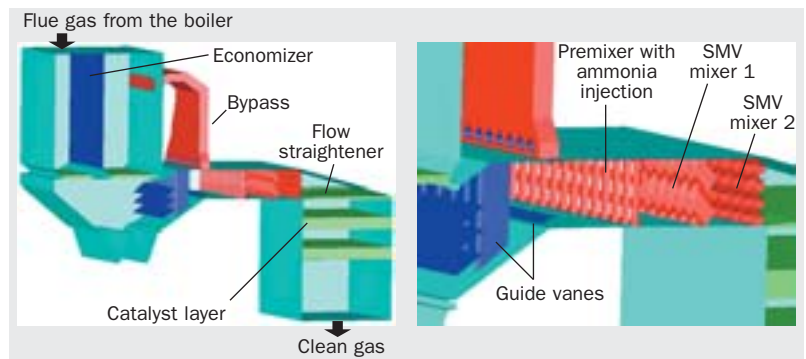
▶ In fossil-fired power plants, flue gas is treated with a series of chemical processes including catalytic converters, which remove pollutants, such as dust, SO₂, or NO_x (Fig. 1). The power station Elm Road is located in Wisconsin (US). It has 2 new coal-fired boilers with 2 SCR reactors each. In the DeNO_x system of this power plant,

liquid ammonia water solution is injected instead of gaseous ammonia, which has been the most common technology in the past. Using a liquid reducing, or deoxidizing, agent, is beneficial for reasons of safety, as no storage and handling of gaseous ammonia outside of the flue-gas ducts are required. Sulzer Chemtech US delivers the ammo-

nia-water injection system and SMV static mixers for this power plant.

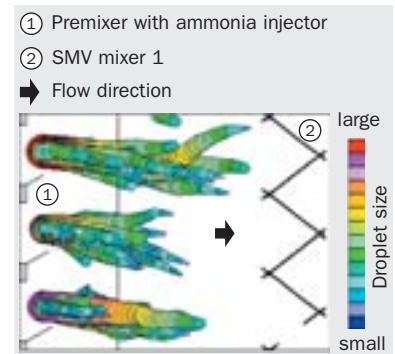
Challenging Arrangement

In the view of the extremely difficult duct arrangement, namely the short distances between the 2 mixers, downstream flow straightener, and SCR reactor (catalyst), the performance requirements are challenging. For the velocity, the coefficient of variation (CoV, relative standard deviation based on the mean value) has to be below 10%, whereas a CoV of 5% is required for the NH_3/NO_x ratio at the inflow to the SCR reactor. All drops have to evaporate within the very short distance between the injection plane and the first mixing element. Therefore, sophisticated injection nozzles for the liquid media creating very small droplets (below $100\ \mu\text{m}$) must be used in order to produce a liquid surface area high enough to allow evapo-



2 The Sulzer SMV mixers distribute the ammonia water droplets evenly across the catalyst layers.

ration. The necessary droplet size and droplet size distribution are achieved with 2-phase nozzles, which use pressurized air as a secondary medium to support liquid breakup into small droplets. This requirement is attributable to the fact that the application is a high-dust application without electrostatic filter between the boiler and the SCR reactor to remove dust particles. The flue gas is therefore heavily dust-laden. If liquid ammonia water would reach the



3 The CFD calculation yields droplet size and their flow path. Skillful regulation of the amount of ammonia water in each injector nozzle ensures that all droplets have evaporated before reaching the mixer.

- 1 The cooling towers of a thermal power plant emit innocuous water vapor. Cleaning the flue gas from the stacks, however, requires sophisticated technology. Sulzer Chemtech offers proven components for the removal of harmful nitrogen oxide.



sheets of the static mixer or other surfaces, severe material build-ups would occur in the presence of dust particles.

CFD Study Complements Model Test

As typical for such projects, model tests on a small scale (1:14) have been performed. However, it is not possible to downscale the problem correctly regarding the liquid ammonia water injection, as no adequate similarity laws are known for droplet size distribution and droplet evaporation behavior. Therefore, Sulzer Innotec studied the droplet evaporation using computational fluid dynamics

(CFD) (Fig. 2). The CFD study delivered flow field, pressure loss, and information on the mixing quality in the SCR installation and associated ductwork.

Requirements Met

For the model tests, a gaseous CO₂ tracer was used to simulate ammonia/water injection. The results of numerical simulations and measurements make it possible to adjust the equipment in order to meet the requirements of the application, including the individual fine-tuning of the amount of ammonia water injected at the various positions (Fig. 3).

Start-up of the first line of the Elm Road plant is planned by the end of 2007, of the second line end of 2008.

New Mixer Developed

Sulzer Chemtech has equipped DeNO_x installations in over 50 plants with SMV mixers. Experience from these applications as well as intensive research and development work have led to a new type of static mixer, the Contour™ mixer. This new mixer consists of multiple mixing vanes, which can be arranged according to the requirements of the specific application (Fig. 4). In admixing applications like SCR, the mounting rod,

on which the mixing vanes are attached, can serve as injector.

Flexible Arrangement

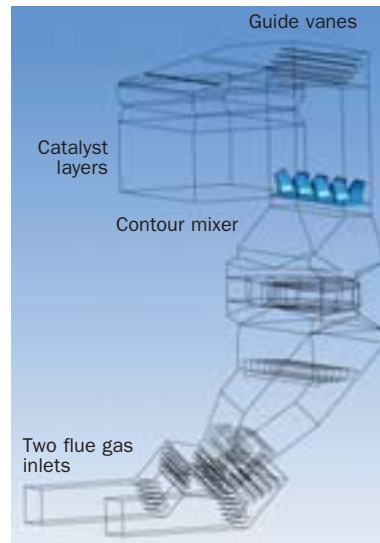
CFD heavily supported the development of this new component (Fig. 5). As the mixing vanes can be mounted with varying angle and arrangement, dimensioning and layout of the mixer are very flexible, however a little more intricate than those of a conventional mixer.

The Sulzer Contour mixer creates a smaller pressure loss than other systems on the market and delivers very good mixing quality. The flow in the mixer is very stable and free from separation, which leads to constant mixing quality over time and space.

Model Tests

Prove Performance

Sulzer Chemtech carried out model tests and numerical flow calculations to prove the performance of the new mixer (Fig. 6). Before the test, the mixing arrangement was designed and fine-tuned using numerical parameter studies. The flow parameters for numerical study and model test were air flow of 21,000 m³/h and an added stream of 180 m³/h, representing the deoxidizing agent. The results of both studies showed very good



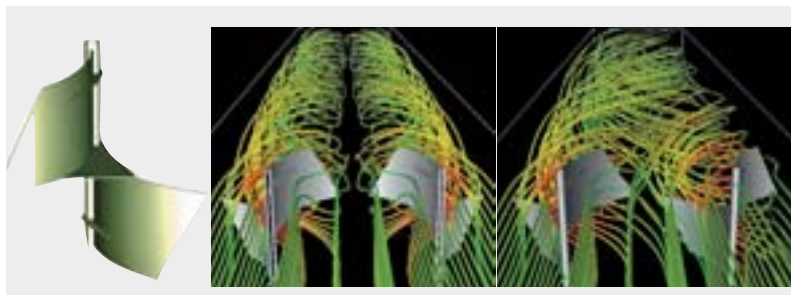
5 The calculation domain for the numerical study of the Contour mixer in a DeNO_x installation of a fossil-fired power plant.

spacial mixing with smallest pressure loss. The CoV values from the CFD study and the measurements agree very well. This is an important result as it proves the applicability of CFD as a reliable design tool for Contour mixer arrangements. With this tool, the contour mixer can be very well adapted to the requirements of any specific application. ◀



6 Experimental setup for the evaluation of the Contour mixers. The variations in speed and droplet density resulting from the flow calculations and the experiment were in good agreement.

4 The new Contour mixer allows generation of vortices rotating in the same or opposite directions depending on the application.



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