


# Science in Aid of Cleaner Air

**SLOBODAN JANCIC**  
**WERNER KOLLER**  
**ARNO SIGNER**  
**SULZER CHEMTECH**

Some 60 million tons per year of nitric oxides are released worldwide to the environment as the consequence of human energy consumption. Efficient technologies have been developed to treat flue gas, and Sulzer with some 50 plants is the technology leader. A recent example is AES Cayuga, a coal-fired power plant in Lansing, NY (USA).

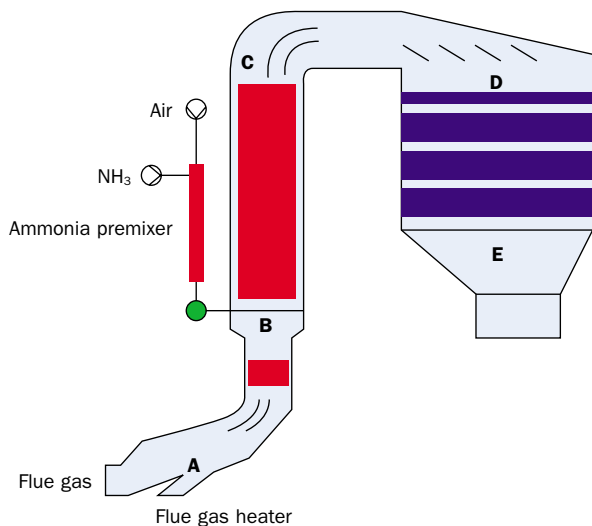


▶ The combustion of fossil fuels is often conducted at highest possible temperatures in order to secure highest thermal efficiency in power generation. At these conditions, several forms of nitric oxides (NO<sub>x</sub>) are generated. Nitric oxides are extremely reactive and exert the formation of the ground ozone. For these reasons the nitric oxides belong to the most harmful pollutants.

## **NO<sub>x</sub> Removal by Using Ammonia**

A method to abate nitric oxides is to admix ammonia to flue gas at 300–400 °C and pass the mixture over a fixed bed of catalyst to reduce the harmful substances to harmless nitrogen (Fig.1). This DeNO<sub>x</sub> process is called “Selective Catalytic Reduction” and has gained wide acceptance. The size of the reactor – and there-





**3** Schematic representation of a typical DeNO<sub>x</sub> plant. After the temperature has been adjusted at point A, ammonia is admixed at point B, and the flow of the mixture is guided by vanes between point C and D, where it enters the bed of catalyst and leaves at point E.

► Large-scale duct configurations allow for the transport of some 1000 tons/h of very hot flue gas carrying dust. Under such conditions, the mixing and flow optimization is difficult due to large dimension of the ducts, the rectangular shape of cross sections, the strong bends, and the varying cross-sectional area. Furthermore, the duct length available for homogenization is usually short and amounts only to several hydraulic duct diameters.

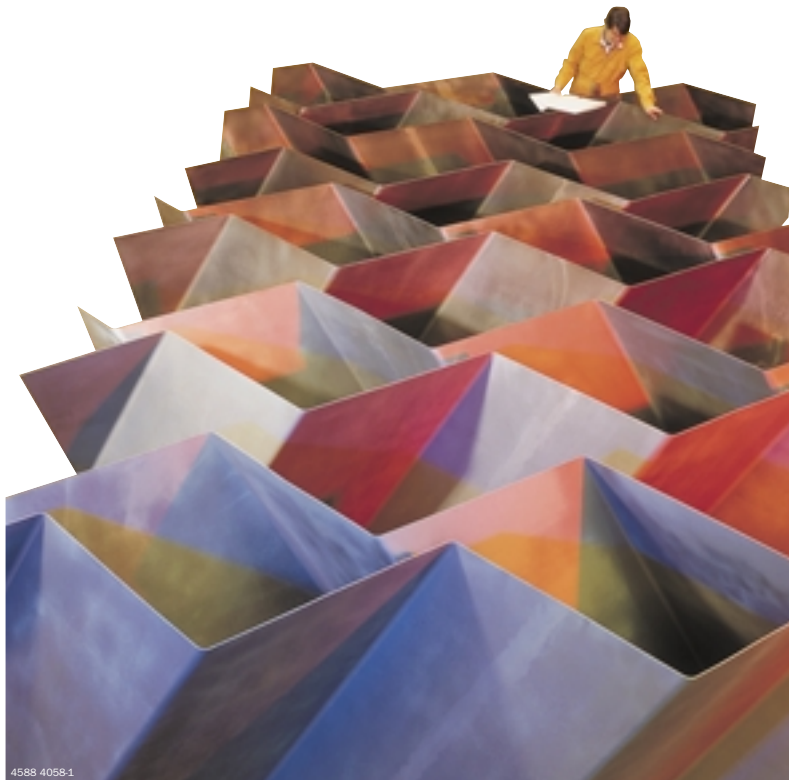
### Relying upon Fundamentals in Mixing

After the temperature conditioning and primary flow stabilization (Section A to B in Fig. 3), a small amount of ammonia has to be admixed, evaporated, and dissipated to a very large volume of flue gas. In a specially devised pre-mixer,

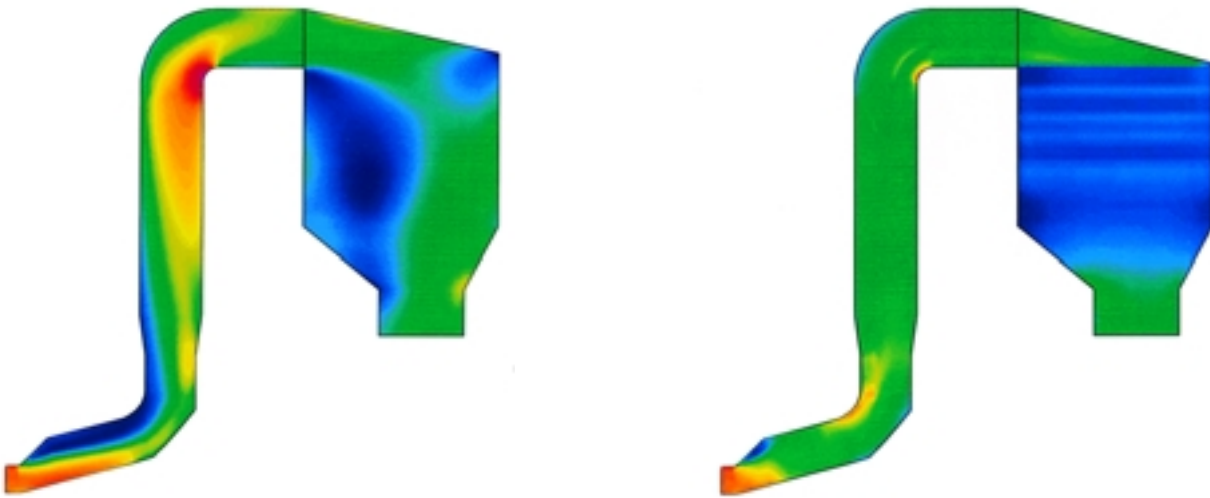
the ammonia is diluted in a side stream of flue gas or fresh air in order to secure a more favorable mixing ratio and ease the mixing task. An injector at point B dissipates the ammonia and spreads it upon the internal plate surfaces of the subsequent static mixer (Fig. 4). The perfect mixing at low pressure drop is possible due to the understanding of mixing fundamentals and the utilization of shear forces caused by the passage through the mixing to generate a special dynamics of micro and macro turbulence.

### Finalizing Design by Numerical Flow Simulations

The conditioned flue gases have to be passed through the reactor hood whilst maintaining constant velocity profiles and strict downward flow orientation at the reactor entry point. This is no easy matter in practice since the geometry of flue gas ducts and reactor hoods varies greatly. In order to prevent empirical approach and educated guesswork, Sulzer Chemtech relies upon Computational Fluid Dynamics (Fig. 5) performed at Sulzer Innotec (the innovation, R&D, technical and production services business within Sulzer) by a team of world-class specialists. The ap-



**4** A Sulzer Chemtech SMV mixer secures intensive mixing over the entire duct cross section and combines short mixing lengths with very low pressure drops.



**5** Computational Fluid Dynamics simulation for the flue gas duct and reactor hood (left: without static mixers; right: with static mixers). With static mixers the velocity distribution becomes even (same color), leading to perfect reduction of the nitric oxides.

proach is based on the solution of Navier-Stokes equations for three dimensions and two turbulence equations using a finite-volume procedure.

#### Process Guarantees Granted

As a result of the computations, the optimized hood geometry is found. It must be confirmed in carefully designed model test units. The goal is to verify the calculations, to optimize the mixers' efficiency, and to improve the velocity distribution by finalizing the design of guide vanes in the reactor hood.

The models are generally one tenth of the full size. The flow conditions remain very similar to reality since the Reynolds Number in the model could be maintained at only one third of that in real plant and still in turbulent regime. The velocities are adjusted to match those used in full-scale plants. The test generally enables fine tuning of the final design so that process guarantees can be granted to the plant user.

Sulzer Chemtech relies upon the experience of 50 plants to provide customized solution to every new application. In order to avoid time and capital consuming model tests, Sulzer Chemtech combines the knowledge of the fundamentals in mixing, the capability to simulate flow, and the infrastructure to perform convincing confirmation tests in models of workable size. ◀

#### ▶ CONTACT FOR USA

Sulzer Chemtech USA Inc.  
Mughis Naqvi  
6501 Coventry Way  
Mount Laurel, NJ 08054  
USA  
Phone +1 (1)856-642 72 03  
Fax +1 (1)856-642 72 04  
E-mail mughis.naqvi@sulzer.com

#### ▶ CONTACT FOR OUTSIDE USA

Sulzer Chemtech AG  
Werner Koller  
Postfach 65  
CH-8404 Winterthur  
Switzerland  
Phone +41(0)52-262 61 49  
Fax +41(0)52-262 00 69  
E-mail werner.koller@sulzer.com