fluitec
mixing + reaction solutions

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Flow models and static mixers for
DeNOx plants

Fluitec Georg AG began designing flow channels for the catalytic elimination of NOx back in 1995. Today, having implemented and systematically evaluated eleven large-scale DeNOx flow models (plant throughput: 50’000 to 2’000’000 Nm^3/h), the company is no longer forced to create a complex model from scratch every time. With a combination of CFD calculations and mikromakro® technology, it is possible to achieve a uniform distribution of velocity, temperature and the ammonia concentration comparatively simply.

Design principle of a DeNOx plant
During an incineration process – especially at high temperatures – nitrogen bonds with the oxygen in the air to form nitrogen oxides (NOx). Flue gas denitrification plants, also referred to as DeNOx plants, reduce the amount of nitrogen oxides present by adding ammonia (NH_3) to the flue gas before it enters the DeNOx catalytic converter. The following chemical reactions take place:

$4\ NO + 4NH_3 + O_2 \rightarrow 4\ N_2 + 6\ H_2O$
$2\ NO_2 + 4NH_3 + O_2 \rightarrow 3\ N_2 + 6\ H_2O$

Ammonia gas, ammonia water or urea is injected into the gas stream to permit the selective thermal reduction of NOx. Aqueous ammonia with a concentration of 25% has proved to be the optimal solution in many cases.
Two SCR methods can be differentiated. In the first method, the ammonia water is atomised directly into the flue gas duct and homogeneously distributed in the Fluitec mikromakro® mixer.

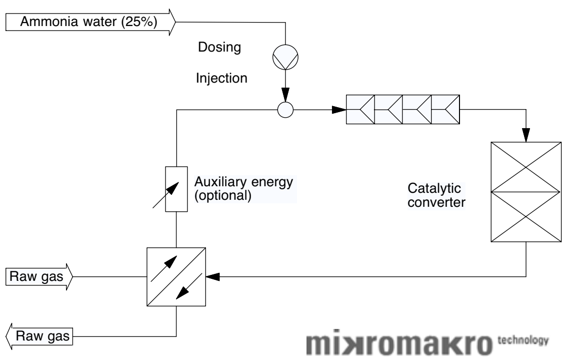


Fig. 1 SCR method with direct injection

In the second method, the ammonia water is evaporated in a bypass gas stream. The gas mixture is then pre-distributed via macro nozzles and homogeneously mixed in a micro mixer.

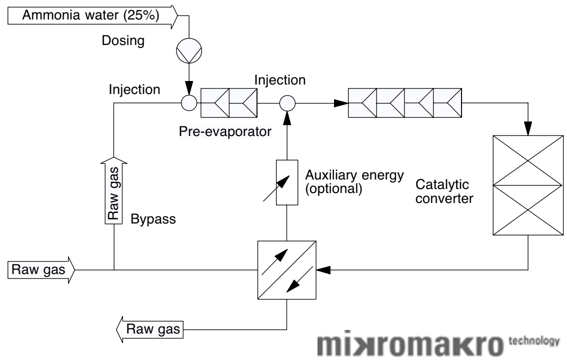


Fig. 2 SCR method with pre-evaporator

The decision for or against a particular SCR method depends on the quantity of gas to be treated, the required degree of denitrification, the geometry of the plant, the flue gas temperature and the amount of ash particles. The efficiency of the DeNOx plant can subsequently be improved by optimising the degree of mixing and the velocity distribution upstream of the catalyst layer. Flow models used to be built for this purpose to facilitate a qualitative statement about the flow channels. Today, Fluitec Georg always designs these channels with the help of CFD analyses.

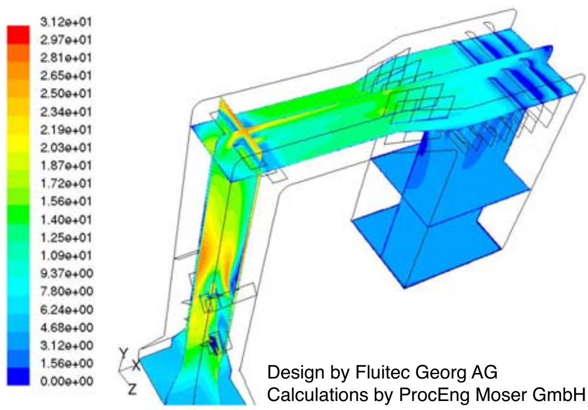


Fig. 3 CFD analysis of a DeNOx plant

Real models – are they scientifically founded?
Flow models were originally intended to provide qualitative information about the flow channels. However, real flow models for DeNOx plants are not considered to be scientifically founded because a constant Reynolds number cannot be guaranteed.

$$Re_{dh} = \frac{w \cdot \rho \cdot d_h}{\eta} \qquad \text{Equation 1}$$

A scale-up factor of 10, for example, means the hydraulic diameter also changes by the factor 10. The flow velocity must consequently be increased tenfold because it is not possible to change the density and viscosity in a real flow model.
If the flow velocity is generally between 3 and 20 ms^{-1}, velocities of 30 to 200 ms^{-1} must be realised in the model, leading to very high pressure losses and presenting an insurmountable challenge for the blowers.

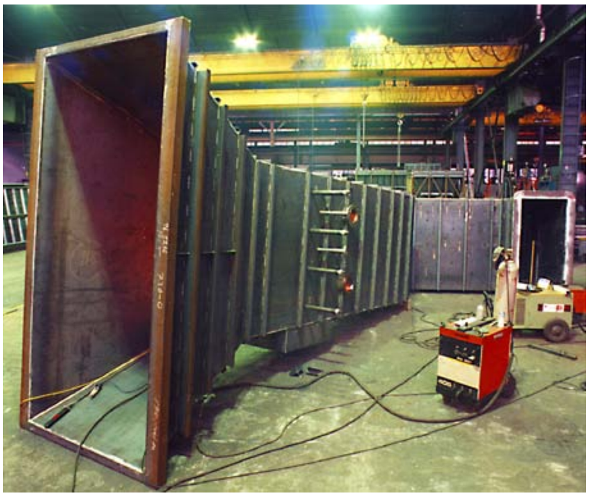
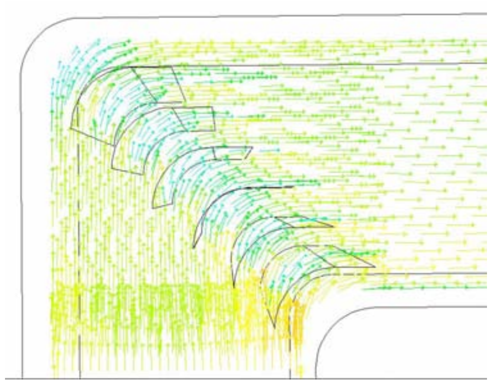


Fig. 4 Flue gas duct of a DeNOx plant

CFD analyses with high reproducibility
Experienced design experts are a must when it comes to optimising flow channels.
In addition to production and process engineers, an important role is played by specialists who are capable of verifying the design by means of CFD calculations. Fluitec Georg can draw on longstanding experience with flow models and evaluations of existing DeNOx plants, and thanks to intensive collaboration with ProcEng Moser is excellently qualified to develop scientifically founded and highly reproducible flow channel designs.
ProcEng Moser is our contract partner responsible for the CFD calculations for DeNOx plants. Efficient DeNOx designs are achieved today based on know-how that has been systematically built up over the years. Real flow models have become obsolescent owing to their inherent inaccuracies and the high costs involved.



Design by Fluitec Georg AG
Calculations by ProcEng Moser GmbH

Fig. 5 Flow vectors in a bend

Supply concept for DeNOx plants
The scope of supply for a modern DeNOx plant can be summarised as follows:

- Fluid dynamic design of the flue gas ducts
- Design and manufacture of the static mixer
- Design and manufacture of baffle plates and rectifiers
- CFD analysis of the flue gas duct and optimisation of the mixing quality, flow profiles and pressure loss
- Installation supervision for the static mixing elements and the baffles
- Design and manufacture of the atomising nozzles
- Design and manufacture of the ammonia water dosing stations, incl. installation or installation supervision

Fluitec Georg AG is in possession of approvals according to EN 729, HP-0, SVTI and PED.

Fig. 6 Flue gas duct with static mixers

Applications
Fluitec static mixers and dosing systems are traditionally used to evaporate ammonia water and to add ammonia to the flue gas. They are found in the following branches of industry:
- Waste incineration plants
- Chemical plants
- Cement production plants
- Fuel fired boilers
- Sludge / hazardous waste incineration plants
- Flue gas cleaning plants for large engines