

In fine vapours

Atomisation technology in nitrogen oxide reduction using urea

During flue gas denitrogenation, the addition of a reducing agent is used to transform nitrogen oxides into a substance that can be emitted without causing any damage or can be used again.

The reducing agent ammonia is increasingly being replaced by innocuous urea.

However, urea has a tendency to crystallise during atomisation. When observing the nozzle systems used in urea atomisation, it can be seen that trouble-free operation is not always guaranteed.

UWE WEIB

NO_x is produced as a by-product of combustion

processes with high temperatures, not just in vehicle engines, but also in numerous industrial processes. As a result of legal regulations on emissions control, power station operators and fertiliser producers, among others, are therefore obliged to reduce their nitrogen oxide emissions using primary or secondary methods in line with state-of-the-art technology. While primary measures predominantly provide direct optimisation of the combustion process in terms of the air ratio, secondary measures related to exhaust gases transform the nitrogen oxides into a substance, which can either be emitted without causing any damage or can be used again.

Secondary measures to reduce NOX

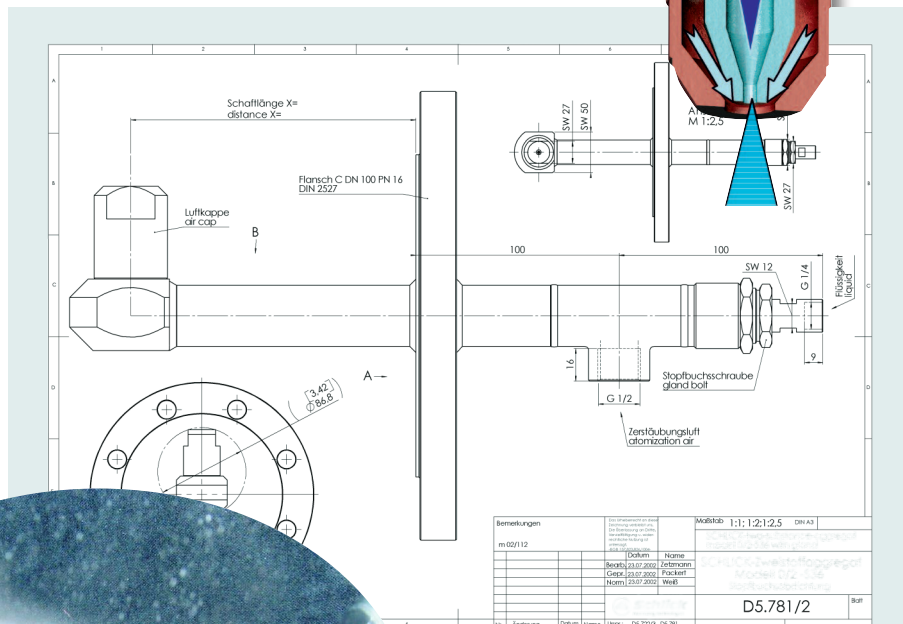
The dry secondary procedures such as the

■ SNCR procedure (selective non-catalytic reduction) and the

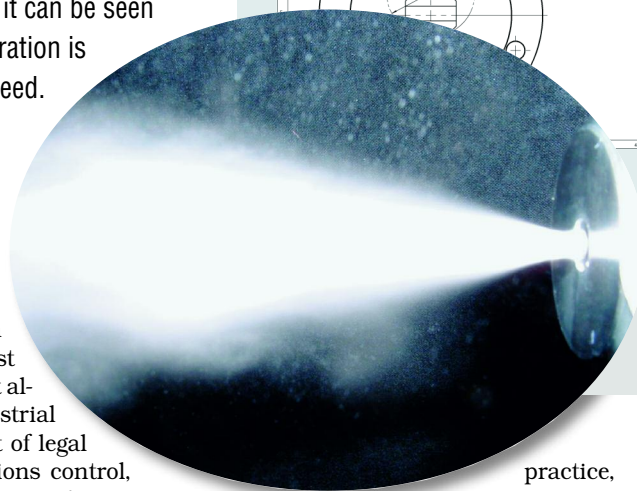
■ SCR procedure (selective catalytic reduction)

aim to reduce nitrogen oxides into nitrogen and water. Selective catalytic reduction has proved to be successful in

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The liquid jet which escapes through the hole is subjected to shearing strain and is broken up into fine drops. The compressed air escaping from the annular gap is responsible for this process in the external-mix two-substance nozzle.



practice, as this has been able to achieve the highest rates of reduction and clean gas concentrations of 100 to 200 mg/Nm³ at lower temperatures. The nitrogen oxides are catalytically reduced at a temperature of 380 to 450 °C (1000 °C in the case of the SNCR procedure) using ammonia or a urea solution. The amount of liquid required for the reduction is added to the flue gas before it enters the reactor, which means that the flue gases flow through several catalyst points that are evenly distributed throughout the cross-section. The vanadium pentoxide or tungsten trioxide catalyst in honeycomb or modular construction reduces the activation energy of the reaction that is to take place

$$4 \text{ NO} + 4 \text{ NH}_3 + \text{O}_2 \rightarrow 4 \text{ N}_2 + 6 \text{ H}_2\text{O}$$

$$2 \text{ NO}_2 + 4 \text{ NH}_3 + \text{O}_2 \rightarrow 3 \text{ N}_2 + 6 \text{ H}_2\text{O}$$

for at least one of the reactants (urea or ammonia / nitrogen oxides), which results in an accelerated conversion into nitrogen and water vapour. Today, an aqueous urea solution is being increasingly used in place of ammonia, as it is considerably simpler to handle. It is easy to transport and store urea, which is colourless, odourless,

non-toxic and biologically harmless. An example of its use, which proves this harmlessness, can be seen in agriculture, where urea is used as a fertiliser or an animal feed supplement.

Atomisation technology is not just a theory

However, urea has a tendency to crystallise within the nozzle during atomisation, meaning that trouble-free operation cannot be guaranteed for every pressure or two-substance nozzle. Nozzles used in flue gas denitrogenation with urea must

- not be susceptible to blockages,
- achieve homogenous liquid distribution in the exhaust gas stream,
- have an even speed distribution with sufficient exit speed so that the entire duct cross-section can be reached,
- be temperature resistant up to 1,000 °C (SNCR procedure) and/or 450 °C (SCR procedure),
- achieve volumetric average drop diameters of 20 to 30 µm,
- maximise the contact area between spray and exhaust gas and
- have a liquid control range of up to 1:10.

Images: Düsen-Schlick

The two-substance lance with external mixing has a homogenous spraying pattern with an even liquid distribution and a fine drop spectrum.

Pressure nozzles

Flat jet or hollow cone nozzles are used as pressure atomisers, in which the drop size depends on the nozzle cross-section and on the existing differential fluid pressure: the smaller the nozzle cross-section and the higher the differential pressure, the finer the drop spectrum. For this reason only liquid control ranges of a maximum of 1:3 are possible, and drop sizes under 50 µm require hole cross-sections smaller than 0.5 mm and pressure of up to 50 bar. Furthermore, a swirl chamber with very small swirl slits or swirl holes is needed inside the nozzle, meaning that continuous operating safety is no longer provided. In this case the urea would definitely crystallise and block the nozzle. Preliminary evaporation would also have to be impeded using a protective/cooling pipe, meaning that the nozzle type is unsuitable for this application.

Two-substance nozzles

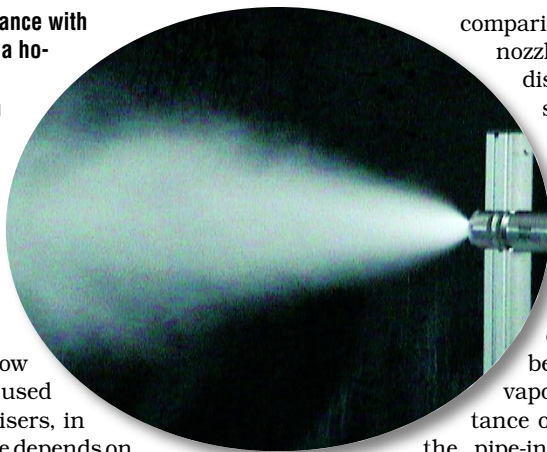
In the case of internal-mix two-substance nozzles, the urea is mixed with compressed air in the nozzle. The two-phase flow then leaves the nozzle through a hole with a scatter cone of approx. 10°. This means that the spray would only disperse over roughly 200 mm, meaning that homogenous distribution in the exhaust gas duct would not be achieved. Due to the internal mixing zone, this type of nozzle is also particularly susceptible to blockages and liquid control ranges of 1:10 are hardly possible, as the two components interact within the nozzle. In this case, if there are altered capacity values the compressed air and urea solution have to be adjusted to each other and then corrected.

External-mix systems are the most suitable for urea atomisation.

In these systems, the liquid and atomisation medium (compressed air) are mixed together intensively shortly after leaving the front side.

The smaller the drops, the larger the surface

The outlet cone of the two-substance nozzle is positioned at 30 to 40°. Combined with the increased outlet speed in



comparison with other nozzle systems, the dispersion of the spray is roughly 1,000 mm after a distance of 2 m. When using a volumetric average drop size of 20 to 30 µm, urea has already been completely vaporised after a distance of 1,000 mm. In

the pipe-in-pipe construction with a moveable bearing, the internal urea solution is protected by the external compressed air, meaning that premature evaporation is avoided. Furthermore, this type of nozzle is less susceptible to blockages due to the separated inlet, and the required drop size can be controlled very easily by adjusting the air/liquid ratio.

In addition, at Düsen-Schlick pre-atomisation has been integrated on the urea side. This impedes blockages and permits very large liquid control ranges. In the case of pre-atomisation, developed specifically for this task, which has a lower deflection angle in comparison with other liquid swirl chambers, a pressure control range of 1:100 is required when using a liquid control range of 1:10. In practice this means that the minimal capacity can be designed to be 0.1 bar, and the maximum capacity to be 10 bar. As a result of this, models with flow rates of 1 to 700 l/h are currently available. ■

Weitere Informationen über:

www.process.de

- Atomisation with two-substance nozzles in rapid access

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