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Edle Tröpfchen
Düsen und Injektionslanzen im Einsatz bei Rauchgasentstickungsanlagen

Brilliant Droplets

Nozzles and injection lances in use with flue gas denitrogenation installations

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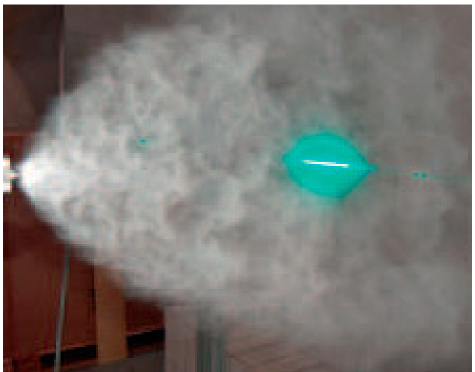
The SNCR and SCR procedures were developed for flue gas denitrogenation in order to meet the strict air purification requirements. Injection lances for the defined insertion of the reducing agent are an important component of both processes. These differ in their structural and procedural design depending on the application.


SCR injection lance with external mixing

The SNCR procedure is based on the insertion of a reducing agent in the hot exhaust gas stream, via which a selective NO degradation is brought about. The most important reactive component is ammonia. In practice, the temperature window here is between +850 and +1100 °C. The maximum NO_x reduction rate that can be reached is limited by the fact that there are only a few time windows in the process in which a reducing agent can be added at an optimum temperature of +950 °C. The gas residence time in the optimum temperature window for the reaction is also very short. The more reducing agent is added, the less complete its conversion. Reducing agent which has not been converted is discharged from the high temperature range of the process in the form of NH_3. Usually, large exhaust gas cross-sections are to be homogenously covered with the reducing agent when this happens. Low investment costs, direct injection into the boiler and quick retrofitting speak in favour of this technology.


The two-substance nozzle with flat-stream characteristics distributes the reducing agent evenly and extensively in the exhaust gas duct

The reducing agent is also injected into the flue gas stream during the SCR procedure which, with the aid of a catalyst, causes the nitrogen oxides to change into nitrogen (N_2) and water (H_2O). 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. Meanwhile, the reducing agent is injected in temperature ranges of +200 up to approx. +500 °C. If the reducing agent has been poorly pre-distributed, one or several static mixers are set up before it enters the catalyst housing. One advantage the SCR procedure has over the SNCR procedure is that higher denitrogenation rates can be achieved with minimal NH_3 escape. In the case of high denitrogenation rates, the catalytic SCR technology is superior to the SNCR procedure. 25% ammonia water or 40% urea solution is normally used. 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. However, urea has a tendency to crystallise within the nozzle during atomisation, meaning that trouble-free operation cannot be guaranteed for every atomising nozzle.

Atomisation technology

Atomisation technology is a discipline of mechanical process engineering and deals with the fragmentation of liquids or dispersions into fine drops. The aim of this often is to greatly increase the free surface to benefit substance or heat exchange processes. An ideal spray consists only of drops with an equally large diameter. This is known as a monodisperse spray. A drop collective with equally large individual drops can be easily calculated with regards the entire surface. Drop collectives with a wider drop size distribution, however, can only be calculated approximately at best. However, a pure monodisperse spray is very rarely achieved, but sprays with a narrow drop size distribution are feasible. However, as the size of the drop is only part of the assessment of a nozzle, it is crucial that other relevant criteria are also included in the evaluation. Schlick uses a dynamic drop measuring device (dual PDA= Phase-Doppler Anemometry) for this purpose. The evaluation of a spray includes drop size, drop speed and volume current density. The scatter cone of the nozzle, program-controlled via a traversing device, is now moved as a result of this measuring volume into two axes. The single drop now changes the direction of the laser beam. This change is registered by the incident lens and evaluated in the processor. Using details of the drop swarm and laboratory tests in simulation channels, corresponding atomising nozzles have been developed which achieve optimum mixing with the required process safety.

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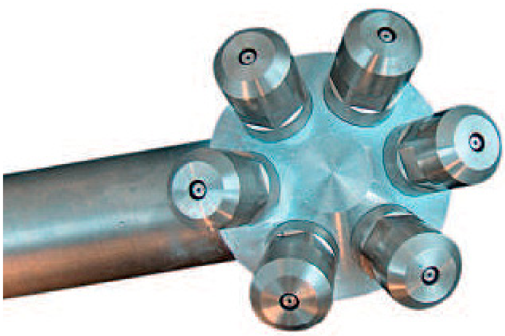
Injection lances

The nozzle foreparts used during the SNCR procedure are designed in heat-resistant stainless steel due to the high temperatures and resistance to corrosion. Suitable for use in continuous operation in air up to approx. +1150 °C, at a temperature change up to approx. +1000 °C. A straight lancing system with pipe-in-pipe technology is used here as standard. This measure prevents pre-evaporation in the inlet device, and therefore an undefined dosage of the reducing agent. The use of an additional protective pipe which is loaded with sheath air in the low pressure range is recommended to increase the service life of the nozzle tips. The fluid is inserted crosswise to the flow direction of the exhaust gas. The liquid spray formation is therefore imperative here for optimum mixing of the reducing agent with the exhaust gas stream. Up to 1500 l/h of liquid may be required. If there is bad permeation, the efficiency factor of the desired NOx reduction decreases and the liquid consumption increases. Large duct dimensions (e.g. 5 x 2 m), high speeds, changing exhaust gas quantities and turbulent flows require injection lances which produce average drop sizes in the region of 40 to 60 micrometers and distribute this drop collective extensively in the reaction chamber. The use of the two-substance nozzle technology means that a carrier gas absorbs the drop break-up (normally air) which atomises the reducing agent at the nozzle exit with sonic speed and therefore accelerates the escaping fluid lamella. A differentiation is generally made between internal and external mixing according to the location where the liquid and gas meet. The outlet cone of the two-substance nozzle with external mixing can be set between 10 and 40°. Both substances are fed separately through the mouth and only meet once outside of the nozzle. The separate feeding means that this nozzle technology is significantly less susceptible to blockages than pressure nozzles or two-substance nozzles with internal mixing. The two-substance nozzle with flat-stream characteristics distributes the reducing agent evenly and extensively in the exhaust gas duct. The option of adjusting the structure (the nozzle axis can be turned 360°) means that zones with NOx tips can be loaded due to a higher loading of the fluid. All NOx lances are designed with removable nozzle tips and can be replaced when there are signs of wear. The liquid spray formation can also be changed by replacing the nozzle tips. Due to the lower temperatures, angular NOx lances made from temperature and acid-proof stainless steel are used in the SCR process. Here, the atomising air protects the reducing agent to be dosed. The reducing agent is inserted in the continuous current in the flow direction of the exhaust gas.

Two-substance nozzles

Two-substance nozzles with external mixing are suitable for dosing quantities of 1 to 200 l/h. The high exit speed of the spray cloud demands long evaporation sections. Due to the small atomisation angle, it is recommended to use a pipe up to DN 600. Replacing the air cap with the patented interior mixing air cap from Schlick reduces the drop speed to approx. 45%. The exchange surface between the exhaust gas and liquid increases by a factor of 2 to 2.5. With the interior mixing Schlick two-substance nozzle, the liquid also escapes from a centric hole, however, this time into a mixing chamber. A cone in the mixing chamber causes the liquid jet which meets the cone tip centrally to be distributed to a film which is torn into single drops by the swirled atomised air. The flanks of this cone contour end in the nozzle holes of the air cap. The holes are inclined according to the cone gradient, meaning that the remaining liquid is blown out in a defined manner and the loaded surface is larger. The performance range of the SCR injection lances starts from 10 to 800 l/h. The basic concept of the development was to change to the geometry of the interior mixing zone. The aim was to achieve a more intensive mixing of atomising air and liquid, particularly by avoiding installations susceptible to blockages. As a result, it is possible to reduce the air requirement of the nozzle whilst maintaining the same drop size, and therefore to reduce the penetrating power of the spray jet. In parallel to this, the arrangement of the holes of the spraying angle has also been greatly enlarged. This technology is generally used with a pipe up to DN 1000.



The multiple nozzle head is fitted with two-substance nozzles with external mixing and is suitable for large duct diameters

Multiple head

Larger duct diameters (from DN 1000 onwards) are only loaded with the reducing agent in the centre using a lancing system. The drop speed of the interior mixing two-substance nozzles which is produced is too low to reach the outer area of the exhaust gas duct. The multiple nozzle head is fitted with two-substance nozzles with external mixing. The increase in the drop speed means that homogenous mixing of the two reactants is achieved. The outlet cone of each individual nozzle is 30 °. Changing the angularity and the number of nozzles means that the injection lance is dimensioned for the required duct dimension. The flow rate begins from a liquid load of 200 l/h. In practise, the maximum capacity currently lies at 1000 l/h. However, larger flow rates are technically feasible. As a result of case-dependent design under consideration of the decisive technical and economic influencing variables, the injection lances are individually adapted to the existing features.