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Finally Atomised

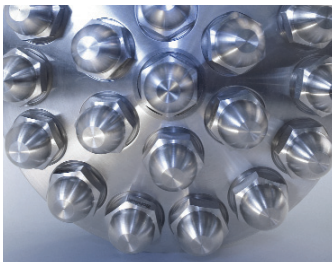
Efficient cooling of process gases

Published in "Chemietechnik" 4/2009,
 Publishers Hühthig GmbH, Heidelberg,
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In a multitude of industrial fields, such as paper mills, glassworks, cement works, power plants, steel works, waste incineration, etc., cooling process gases in an economical and above all energy efficient way is becoming increasingly important. Evaporative cooling is the most effective way to cool and condition exhaust gases. By cooling the gases, a defined reduction in volume is achieved.

As an important part of the cooling process, atomising lances are necessary for the defined positioning of the cooling water. A greater reduction in the gas volume reduces the required energy costs. The necessary drop size distribution and the related nozzle technology prevent unwanted condensation of cooling water. The liquid is converted into drops, in order to increase the surface area and therefore facilitate complete evaporation with the exhaust gas. Naturally formed sprays inherently strive for a minimal surface area and therefore the synthesised spray is unstable. Either a spray evaporates or lots of tiny drops merge into fewer big drops, causing the surface area to decrease. The nozzle system must fulfil a multitude of conditions for a complete evaporative process of the atomised liquid.

The choice of material is adjusted according to the chemical stability and the prevailing temperatures. In this case heat-resistant stainless steel is used; if the lifespan of the nozzle lances is reduced due to chemical corrosion, other materials will be used. It is therefore essential that the nozzles are not susceptible to blockages due to the continuous operation that is generally required.



Nozzle head with removable hollow cone nozzles

Small, even droplets desired

The following requirements for the nozzle spray are:

- small, even and reproducible drop size;
- flexible setting of the drop size;
- complete evaporation before the drop collective reaches the wall;
- spray jet forming;
- spray impulse adjusted to the system design;
- even distribution of liquid across the spray width;
- no condensation or
- change in the flow rate with consistent atomisation quality.

Often, the aim of atomisation is to greatly increase the free surface in order to facilitate 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 sized individual drops can be easily calculated with regard to the entire surface. Drop collectives with a broader 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. A dynamic drop measuring device (dual PDA= Phase Doppler Anemometer) is used 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 (e.g. exhaust gas speeds 10 m/s), corresponding atomising nozzles have been developed which achieve optimum mixing with the required process reliability.

By observing the nozzle systems, pressure nozzles or two-substance nozzles used when cooling an exhaust gas, it is clear that the aforementioned requirements are met only to a limited extent. It is possible to differentiate between pressure nozzles, external and internal-mix two-substance nozzles.

DECISIVE FACTS**For users**

- In a multitude of industrial fields, cooling process gases in an economical and above all energy efficient way is becoming more and more important.
- As a result of case-dependent design under consideration of the decisive technical and economic influencing variables, the atomisation nozzles are individually adapted to the existing features.
- The nozzle system must fulfil a multitude of conditions for a complete evaporative process of the atomised liquid.
- The separate feeding means that two-substance nozzles with external mixing are significantly less susceptible to blockages than pressure nozzles or two-substance nozzles with internal mixing.

Pressure nozzles are susceptible to blockages

Hollow cone nozzles are used with pressure atomisers. The expected drop size depends on the nozzle cross-section and 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 small liquid control ranges of a maximum of 1 : 3 are possible. Average drop sizes below 70 µm require hole cross-sections < 1.2 mm and pressures of up to 40 bar. The average drop increases to 130 µm when the pressure is reduced to 4 bar. Unfortunately these small nozzle cross-sections are susceptible to blockages and cannot achieve long-term process reliability.

The liquid is fed to the nozzle under pressure and enters the swirl chamber through tangential slits or holes. In the swirl chamber, the energy in the pressurised liquid is converted into rotational energy or kinetic energy. A rotating film of liquid forms around an air core and emerges through the hole as a hollow cone jet.

After overcoming the surface tension, the cone disperses into a myriad of fine droplets. The quality of the atomised spray and the drop spectrum are related to the diameter of the hole, the pressure, the scatter cone, the density, the viscosity, and the surface tension. Continuous operating reliability is no longer provided, due to the necessary swirl chamber with very small swirl slits or swirl holes inside the nozzle.

As a result of case-dependent design under consideration of the decisive technical and economic influencing variables, the nozzles are individually adapted to the existing features.

Two-substance nozzles with external mixing

In external-mix systems, the liquid and the atomisation medium – mostly compressed air – are mixed together intensively shortly after leaving the front side. The outlet cone of the two-substance nozzle is positioned at 30 to 40°. 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 desired drop size can be set individually via the mass ratio of air to liquid. In order to navigate large liquid control ranges, it is imperative to integrate a pre-atomisation on the liquid side. This fluidically prevents blockages. As a result, a three-slotted swirl chamber was developed, which has a lower deflection angle in comparison with other liquid swirl chambers. When using a liquid control range of 1 : 10, a pressure control range of 1 : 100 is required. In practice, the minimal capacity is designed to be 0.1 bar and the maximum capacity to be 10 bar.

The performance spectrum of two-substance nozzles with external mixing is between 1 and 6000 kg/h. The atomisation quality of the nozzle unquestionably decreases with an increasing flow rate. In spite of everything, drop sizes less than 200 µm are possible through corresponding measures with the help of the pre-atomisation.

Two-substance nozzles with internal mixing

Replacing the air cap with the interior mixing air cap reduces the drop speed to 45 %. The exchange surface between the exhaust gas and liquid increases by a factor of 2 to 2.5. With the internal-mix 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 broken down into 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 two-substance lances ranges from 10 to 1500 l/h per single nozzle.



Push-in tube with two external-mix two-substance nozzles

The basic concept of the development was to change to the geometry of the internal mixing zone. The aim was to achieve a more intensive mixing of atomising air and liquid by changing the geometry and particularly by avoiding installations susceptible to blockages. In this way 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 spraying angle should also be greatly enlarged as a result of the arrangement of the holes. The nozzle lances are frequently exposed to extremely high temperatures, aggressive gases and high amounts of dust. A reliable process is guaranteed by a maintenance-friendly design with a removable protective tube and a correspondingly robust nozzle design.