A DUSTY DILEMMA

Graeme Cousland, Begg Cousland Envirotec, UK, explains the benefits of using a dust control or emission abatement system in a fertilizer plant.

The industrial production of solid fertilizers, whether phosphate-based, nitrogen-based, or a complex fertilizer combination of these materials, involves gas/air passing through reaction and other process stages, where additional gaseous elements and/or solid materials are entrained with it. By using a dust control or emission abatement system, the producer can often recover valuable product while reducing the atmospheric emissions, both visibly and measurably.

The topic here is dust control/emission reduction and such dust solids could be captured mechanically by filtration, if the gas is essentially dry. For example, in certain cases, bag filter systems are used to collect the fugitive dust around bagging stations. However, many process gas emission abatement systems will involve a wet contact of gas and a scrubbing solution to neutralise contaminant gases, such as fluorine and ammonia, which are present along with the solid materials. These technologies therefore operate chemically through absorption and mechanically through liquid contact, and, along with wet gas filtration, these will be the focus of this article.

Formation and nature of dust particles

Prilling

The production of prilled fertilizers, using a liquid solution that is sprayed or otherwise ejected from a

Figure 1. BlueFil® structured PP mesh pads treating granulator and cooler emissions to <30 mg/Nm³.

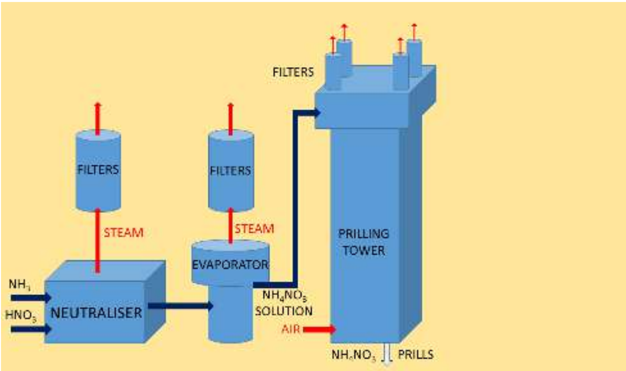

Figure 2. Typical AN prill tower and roof level system.

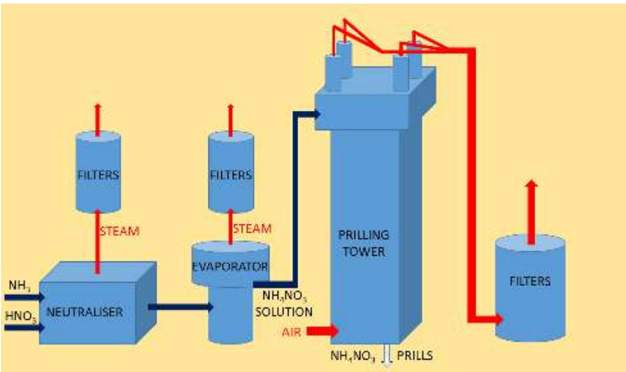

Figure 3. Typical AN prill tower and ground level system.

static, rotating or vibrating central point inside the top of the open column of a high tower, is a long-established method of forming spherical fertilizer, e.g. urea, ammonium nitrate (AN), calcium ammonium nitrate (CAN) and NPK. The prills form as the liquid droplets fall down against the forced, or fan-induced, draft air rising upwards. The method of spraying, the internal design of the tower, and the condition of the equipment used largely determine the amount and size of the particles that are emitted, and sub-micron AN fume can add to the atmospheric emissions. The air volume can be less than 100 000 Nm³/hr or more than 1 million Nm³/hr.

Granulation

Increasingly, granulated fertilizers are being produced using a variety of granulation technologies. These include fluidised bed and rotating drum/spray concepts, sometimes agglomerating or coating a seed-feed of prilled product. There is a major economic benefit for granulation plants with respect to environmental emissions – the gas volumes are much lower; therefore, the cost of abatement can be greatly reduced. Where a product is cooled or dried, dust emissions will also be created, which need to be treated before exiting to the atmosphere.

Opacity

The quantity of particles that are emitted with a size below 3 µm, and particularly below 1 µm (which includes sub-micron fume), will significantly influence the visibility of the tower or stack emission. A content of more than 30 – 50 mg/Nm³ of such small sized particles is visible, and is easily identified by the length of the dark or off-white plume that continues after any steam vapour has evaporated.

Some technology challenges

Blockage/maintenance

It is not always considered at the project stage, when the priorities are keeping equipment size, energy requirement and costs low. However, blockage of filtration or scrubbing equipment can be a major headache and a significant demand on maintenance resources if the system design has been 'optimistic' or simply unrealistic.

The competing demands are from five sides: CAPEX; efficiency; energy; space; and maintenance. The balance is normally reached after a series of compromises. For example:

- More efficiency usually means more energy and more space.
- Less space usually means less efficiency.
- Minimum maintenance usually means less efficiency, and sometimes more energy.

It is unfortunately a frequent occurrence to find that the operating reality does not meet the intended performance outcomes. Again, for example:

- The efficiency is not good enough below 2 µm and there are visible emissions.
- The scrubbing solution is not correctly sprayed onto the packing media and the rate of blockage is unacceptable.
- The demands of production overrule the 'good intentions' of efficient emissions reduction.

Solubles/insolubles

Soluble materials entrained by the process gas should be removed in a wet scrubbing system, where they are forced into contact with the scrubbing solution (see Figure 1). The reality is that unless the system is well designed, well maintained and well operated, some materials are not properly or consistently wetted. They remain undissolved and then adhere to the scrubbing system equipment.

CAN has limestone or dolomite added and these insoluble calcium carbonate materials will block in high density filtration or scrubbing media.

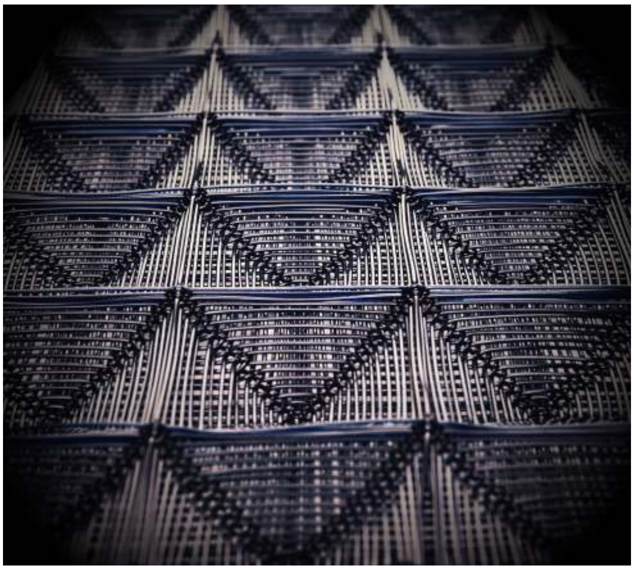

Figure 4. BlueFil MX095 mesh in PP.

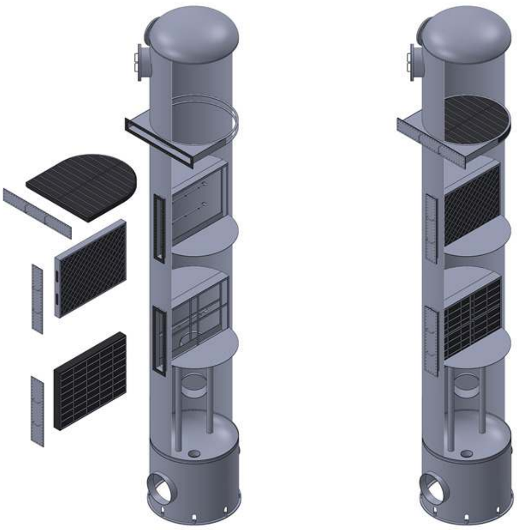

Figure 5. Schematics of vertical vessel retrofit with BlueFil mesh packing and demister.

Emission/opacity reduction

When the product is AN, the exit content can easily be reduced below 30 mg/Nm^3 and a maximum of 10 mg/Nm^3 is practical with high efficiency candle filters. For CAN and urea, where Benvitec Environment's BlueFil® (or equal) irrigated mesh pad scrubbing technology is used, it is reasonable to expect 30 – 50 mg/Nm^3 exit, depending on local requirements.

Of course, the allowable emission will vary from country to country, and sometimes there is also an acceptable difference in the limit for an old plant and a new plant. For example, in Europe, new urea prilling and granulation plants were required to emit less than 50 mg/Nm^3 of urea dust, while existing granulation plants were set a target of 70 – 80 mg/Nm^3 and existing prilling plants were set a target of 100 – 150 mg/Nm^3.

System location

When considering a prilling tower, there are two possibilities for the dust control system. On top of the tower is the obvious preference for the plant. However, there are major issues around space availability and (operating) weight that usually rule out anything other than a basic efficiency solution. For example, a simple irrigated BlueFil mesh pad system for urea prilling towers may satisfy emission limits in countries with less stringent pollution control requirements, or retrofit projects on old towers (see Figure 2).

Increasingly, and driven by environmental regulations, prilling tower dust control systems are located at ground level due to the size of the installation required to handle these large gas flows. That necessitates the long ducting down to the ground and the increased power fan + stack for final emission (see Figure 3).

Granulator and dryer emission abatement systems are not done at elevation, and this allows much more efficient tailoring of the design to optimise the efficiency and energy values against the actual process conditions and pollution regulations.

Good practices – good experiences

Wet gas filtration

Candle filters with irrigated mesh pad upstream

The company has a range of glass fibre bed media and, for AN plant emissions, the Brownian Diffusion types TGW15, B14W and B14 are those that will give the high efficiency sub-micron particle removal efficiency that is necessary for ensuring opacity and PM2.5 requirements are met. These mist eliminators can be made up to 6 m long to help manage the vessel footprint needed for treating large air volumes.

It is important to ensure that these filters are constantly wet, avoiding problems of crystal buildup in the fibre bed. This problem is resolved by the irrigated mesh pad stage below the candle filters. A 'Becoil' demister in 304L stainless steel is sprayed from above and below with a nitric acid solution to absorb NH_3, and the liquid carried over to the candle filters then ensures they are suitably saturated.

Absorption and liquid contact

Wet cyclones and venturi scrubbers

Two well known gas scrubbing technologies, from opposite ends of the efficiency spectrum, are wet cyclones and venturi scrubbers. Both have the benefit of a low-risk of solids blockage, and both can be found in P_2O_5 plants instead of cross flow fume scrubbers.

Wet cyclones have no internal contact media (e.g. no packings or mesh), and rely on large volumes of sprayed liquid contacting the dust particles inside the 'open' vessel body, with an internal tangential flow created to help knock out the entrained liquid droplets. It is a simple technology with a limited collection efficiency on small size particles.

A venturi, however, is able to collect small particle sizes by forcing contact between the dust particles and the contact liquid at the top part of the venturi throat. This requires a high liquid pressure and a high liquid volume. CAPEX cost and energy consumption factors can be a negative when considering this technology.

BlueFil meshpad scrubbers (cross flow or vertical)

The cross flow scrubber (horizontal vessel and air flow, through vertical packing stages) consists of a heavily sprayed open inlet section to remove as much of the larger dust particles as possible, before reaching the packing stages. In that regard, there is a similarity with a wet cyclone, although the orientations are different. It is normal to have a liquid recycle arrangement, where liquid from later stages is fed back into preceding stage sprays.

The significant amount of solids present in the exit air from urea, CAN and P_2O_5/DAP processes require the best packing materials in terms of:

- Maximum void space without negative impact on mesh efficiency.
- Maximum strength and resistance to damage in operation and during aggressive washing.
- Smoothest wire surface to discourage solids deposition.

Based on those factors, the company has chosen Benvitec Environment's BlueFil meshes for use in these cross flow systems following trial installations in comparison with other media. In particular, the MX095 mesh style (see Figure 4) can save pressure loss and avoid the need for extra layers of alternative packing mesh in many installations, but with no reduction on dust removal efficiency.

Where needed or preferred, a vertical version of this scrubbing system can be designed, and a recent retrofit installation by the company has both vertical and horizontal stages in a vertical vessel (see Figure 5).

'Becoflex' rotary brush scrubber

This Begg Cousland technology uses a polypropylene (PP) brush as an impeller inside a fan casing, and, by irrigating the rotating brush with water or a scrubbing solution, solids in the gas are immediately wetted and removed as an effluent slurry. This equipment generates suction, and often can operate as the sole air mover. This has been a successful innovation in handling AN granulator dryer emissions, with 16 already in continuous operation and reducing the AN exit to below 10 mg/Nm^3 and NH_3 to less than 5 mg/Nm^3.

It is also notable that the 'Becoflex' does not block with the solids, since the brush and volute are constantly irrigated and the wetted solids are thrown out by centrifugal action.

Conclusion

The range of dust emission sources in the fertilizer production industry is wide and diverse. Pollution control requirements vary by country, industry and age of plant. Each producer can select the most suitable technology and equipment from an array of filtration and gas scrubbing options, to ensure an optimised solution tailored to his conditions and limitations. WF

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