Cold recycle fluid bed granulation

K. Monstrey of Green Granulation Technology introduces a novel urea granulation technology where energy saving, low investment costs and high product quality are combined in a new layout and optimised production process.

Green Granulation Technology (GGT), a leading provider of fertilizer related process technologies in China, has developed a new urea granulation process that has been named cold recycle granulation or the CRG process. The essence of the process lies in handling cooling in a single step so that screening, crushing and recycling takes place with cold product. In this way, screens and crushers can be kept clean for longer and less dust is produced during processing. The CRG process has reduced the investment and operational costs of urea granulation, while optimising product quality and reducing dust emissions.

The first cold recycle fluid-bed urea granulation technology process was successfully applied in one of GGT’s projects in China in 2013 (3,000 t/d). Since then, over 11,000 t of daily capacity are under construction or being commissioned.

The CRG process combines energy savings, low investment costs and high product quality in a new layout and an innovative production process.

Building height

GGT has completely reworked the traditional idea of the layout of a urea granulation unit, resulting in a much lower building that offers convenient access to operators (Fig. 1). Not only does it make construction much cheaper, it also allows operators to move more quickly and efficiently throughout the plant.

The most drastic saving in height comes from the use of a single cooler that is in line with the granulator (Fig. 2). The cooler automatically operates at the same bed-level as the granulator. The granulator has no cooling compartments, only injection compartments. As a result, the product entering the cooler is at a temperature above 100°C. The cooler outlet temperature is set according to the client’s requirements. Since the cooler is operating at a relatively high bed level, the CRG process achieves the maximum polishing effect in the cooler.

A single cooler handles all cooling, down to product end-temperature, so screening of the product and crushing of the oversize granules takes place with cold product.

GGT has combined the screen feeder and safety screen into one single apparatus, resulting in a considerable saving in height. This is only possible due to the site layout in which the vibrating screens and crusher(s) are located below the granulator/cooler instead of the more conventional arrangement where the safety screen is located upstream of the bucket elevator.

Diverters traditionally require a lot of height, especially the additional diverters for forestry size. GGT is able to control the granulator seeding for big size, eliminating the need for this diverter. During design, GGT has spent a lot of time and effort in minimising the required height for the diverters, without compromising on the free flow through the device.

Building strength

Screens with horizontal gyratory screening movement, as well as other types of vibrating screens, are very demanding when it comes to the required strength of the building. A building has to be designed...
and constructed is such a way that it can not only withstand the weight of the different components, but also the rotating vibrations that some of the equipment produces. This implies that, for a urea granulation building, one should take into account the harmonic vibration of all (2, 4 or even 6) vibrating screens, when calculating the strength of the building. The laws of physics prescribe that a tall building with a strong source of vibrations in the top must be much stronger than a low building with the source of vibrations located in the lower part. By locating the vibrating screens directly below the granulator/cooler, GGT is reducing the need for a building that is extremely strong up to the top.

In addition, GGT has opted to locate the scrubbers on the ground using an integrated scrubber circulation tank so there is no need for an underground tank.

**Upstream related investments**

The CRG process is able to use a urea melt feed of 95-96% (at the sprayers). Therefore, there is no need for a second evaporation section in the urea synthesis plant, construction costs are reduced and power consumption is lower due to the high water content of the melt. Table 1 shows the effect of water content in the urea melt feed on the heat balance of a urea granulation. This makes the CRG process very flexible. It can be linked to whatever existing urea synthesis technology is currently marketed.

**Power consumption**

**Optimised internal dynamics in the fluid bed**

For fluid bed granulators it is vital to ensure proper flow of particles towards the sprayers. One solution is to use a thick bed layer (starting from 600 mm WC pressure drop over the bed and perforated plate). Such a thick fluid bed becomes a “bubbling bed”. This means that small air bubbles are formed at the perforated plate and, while rising, these bubbles grow in size until they explode when reaching the surface of the bed. It is this bubbling phenomenon that ensures a wild and uncontrolled movement in the bed and the product transport to the sprayers. This solution comes at a price, namely high fluidisation air pressure, since it only becomes effective from at least 600 mm WC pressure drop. If no other aid for circulation inside the bed is provided, this movement by bubbling is absolutely vital for a thick layer fluid bed. If no bubbling is obtained because of lack of air or bed thickness, the moisture of the end-product will automatically be high.

GGT has developed and patented technology which implies a fluid bed granulator in which the sprayer arrangement involves spraying zones and drying zones. Seed material is sucked towards the spray zone by the combined upwards action of atomisation and fluidisation air. During the pass through the spray area they grow by the sprayed-on urea melt. Once passed through the spray zone, the granule/seed will automatically flow into the still zone where the sprayed-on solution is given time to further evaporate while the granule/seed is sinking down for another pass through a spray zone. By optimising the movement in the bed in this way, the different spray zones are able to handle much more product, without overloading the spray zone which would lead to higher moisture. The principal of optimised movement in the bed has allowed GGT to lower the bed level of the fluidised layer down to 450 mm WC instead of the earlier mentioned +600 mm WC. This optimisation in combination with good spraying conditions has greatly reduced the need for residence time in the granulator.

**Deep vacuum in the granulator**

The lowered bed in combination with the low pressure drop scrubbers has made it possible for GGT to design a urea granulation plant without fluidisation air fan(s). The whole system (granulator and cooler) is operated under deep vacuum, pulling air through the system by means of the exhaust fan only. Not only does this eliminate the fluidisation air fan (and its heating of the air stream), it also creates a deep vacuum in the granulation section which enables better evaporation during the spraying of the urea melt.

Since GGT has placed the cooler on the same level as the granulator, with the same bed level as the granulator, the cooler can benefit from the deep vacuum. For the cooler, the effect is even stronger.

The cooler directly receives ambient air, since there is no fluidisation air fan heating the air by $6-9\, ^\circ\mathrm{C}$ or more. This results in more efficient cooling and reduces the amount of cooling air.

If a fluidisation fan is required, e.g. in the case that a chiller is used on the last part of the cooler or due to ambient design conditions, GGT uses a low pressure fluidisation air fan that heats up the air by no more than $3\, ^\circ\mathrm{C}$. The purpose of this fan is to compensate for the pressure drop caused by the chiller. The heating of the fan can help to dry out the chilled air.

**Patented double temperature scrubbing system**

The deep vacuum system is most attractive when the pressure drop over the ducting, granulator/cooler and scrubbers is limited to a minimum. Therefore, GGT has designed and patented the double temperature scrubbing system involving low pressure drop horizontal type scrubbers that are able to capture very fine dust particles by condensation of water on the dust particles.

The double temperature scrubbing process can only be realised by using two separate scrubbers, one for the granulator and one for the cooler.

The low pressure drop over the system is made possible thanks to the use of Mistrix BlueFi high efficiency mist eliminators. The close cooperation between GGT and Mistrix enables both parties to exchange knowledge and technology and offer a scrubbing system that has combined maximum efficiency with minimum pressure drop. The BlueFi technology enables a low pressure drop and a high efficiency since all the monofilaments are arranged at rectangular angles to the air flow to achieve the best possible separation of droplets. This unique weave (Fig. 3) stands in stark

<table>
<thead>
<tr>
<th>Water content in the urea feed solution</th>
<th>Heat removed by evaporation</th>
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<tbody>
<tr>
<td>0% (100% urea solution)</td>
<td>0%</td>
</tr>
<tr>
<td>1.5% (98.5% urea solution)</td>
<td>10%</td>
</tr>
<tr>
<td>3% (97% urea solution)</td>
<td>22%</td>
</tr>
<tr>
<td>4% (96% urea solution)</td>
<td>35%</td>
</tr>
<tr>
<td>5% (95% urea solution)</td>
<td>40%</td>
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</tbody>
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Table 1: Removal of crystallisation heat by water evaporation
contrast to the random orientation of a wire knitted mesh.

**Optimising ducting**
GGT has put a lot of effort into optimising the ducting throughout the urea granulation plant. Every turn or bend in an air duct creates pressure drop and may cause turbulence in the air flow. By eliminating turns where possible and limiting ducting to a minimum, pressure drop savings of over 100 mm WC are easily made.

**High performance hydraulic urea melt sprayers**
The in-house developed GGT Mark II hydraulic sprayer has a working pressure of 4 barg. This air-assisted urea melt sprayer has been developed during semi-industrial pilot plant tests, with the aim of lowering the atomisation air pressure to 0.3 barg. This goal has been reached and the sprayers are now being operated in full scale industrial units. The GGT liquid sprayer produces low moisture product due to the fine atomisation of the liquid, leading to very fast and efficient evaporation of the water.

The GGT Mark II sprayer not only produces very fine and homogenous droplets, but is also able to form seeds as a feed for the process in a controlled way. This seed formation can be controlled by regulating the pressure of the atomisation air, header per header and results in lower load to the crushers. In the CRG process, the crusher capacity is only half the capacity of other types of granulation units. If needed for maintenance reasons, the crusher(s) can even be bypassed without destabilising the process.

**Flexibility by optional components**
GGT offers the possibility to incorporate alternative cooling means to boost the cooling capacity of the fluid bed cooler. For example, water-cooled cooling plates can be added in the fluid bed. These cooling plates can be taken out of commission when ambient conditions do not require additional cooling.

The cooling plates make use of the plant cooling water circuit to boost the cooling of one or more compartments in the fluid bed cooler.

Using AirSieve technology, a stream of fine material can be extracted from the side of the cooler, at a location where the product has not yet been cooled down to end temperature. This stream is directly recycled in the stream of fines and crushed product to the granulator.