Analysis of particle growth time in TEC urea granulator

Author
Mr. Su Sheng
Tarim Petrochemical Branch Company
Korla 841000, Sinkiang

Summary
By means of analyzing growth time of urea granules in fluidized bed granulator, the effect of operating variables on residence time such as bed height, product size, seed size in crusher, granulation load. In case growth time of urea granules change less, ensuring high quality production in size distribution and water content of products, providing a basis for actual producing in bed height bed temperature and recycle ratio.

Foreword
TEC urea granulation technology combines spout bed granulation technology and traditional fluid bed granulation technology. The granulator consists of the spouted bed, perforated plate, fluid bed, spray nozzles and chambers. The urea solution with a concentration of 96% is pumped into the granulator by the urea melt pump, sprayed into the spouted bed through spray nozzles and attached to the recycle seeds in fluid state. The recycle seeds grow after the multi-stage spouted bed and fluid bed. The urea seeds from fluid bed are transported to the lower part of spouted bed from its upper part. The water in the urea solution is evaporated when the urea solution on the seeds surface cool down and solidify, so that the moisture content of urea granules will be less than 0.25%.

Spouting air is introduced by the spouting air blower and heated by the spouting air heater. Fluidization air is introduced by the fluidization air blower and heated by the 1st fluidization air heater and 2nd fluidization air heater. The temperatures of both kind of air are adjusted by their own heater to maintain the bed temperature at 110 ~ 120 ℃ for urea granules solidification and drying.

After solidification and drying, urea granules are cooled down to 90 ℃ in the 4th chamber of the granulator. The urea granules are settling to perforated plate (the lower part of fluid bed) by gravity and pushed out of the granulator by the horizontal thrust produced by the fluidization air through the inclined holes on perforated plate. Urea granules are lifted to the urea screens by the bucket elevator after the vibrating feeder and weighting device located at the granulator outlet. In the screens, the urea granules are classified into four fractions: agglomerates, oversize, on-size and undersize.

The agglomerates are collected into the dissolving tank through the chute, and dissolved into urea solution, which is pumped to the urea melt plant for recovery by dissolving tank pump. The oversize particles and a small part of products are sent to the crusher for crushing after cooling in the oversize particle cooler, and then the crushed product is recycled to granulator as seeds. The undersize particles also recycle to granulator as seeds. The recycle ratio is 0.5:1 (including the crushed oversize particles and a part of products, and undersize particles). Products are cooled down to below 50 ℃ in product cooler and then are packaged by the weighting device or sent to the bulk warehouse.

1. Introduction TEC urea granulation plant

The urea plant use TEC fluid bed granulation technology, and see Figure 1 for the process.

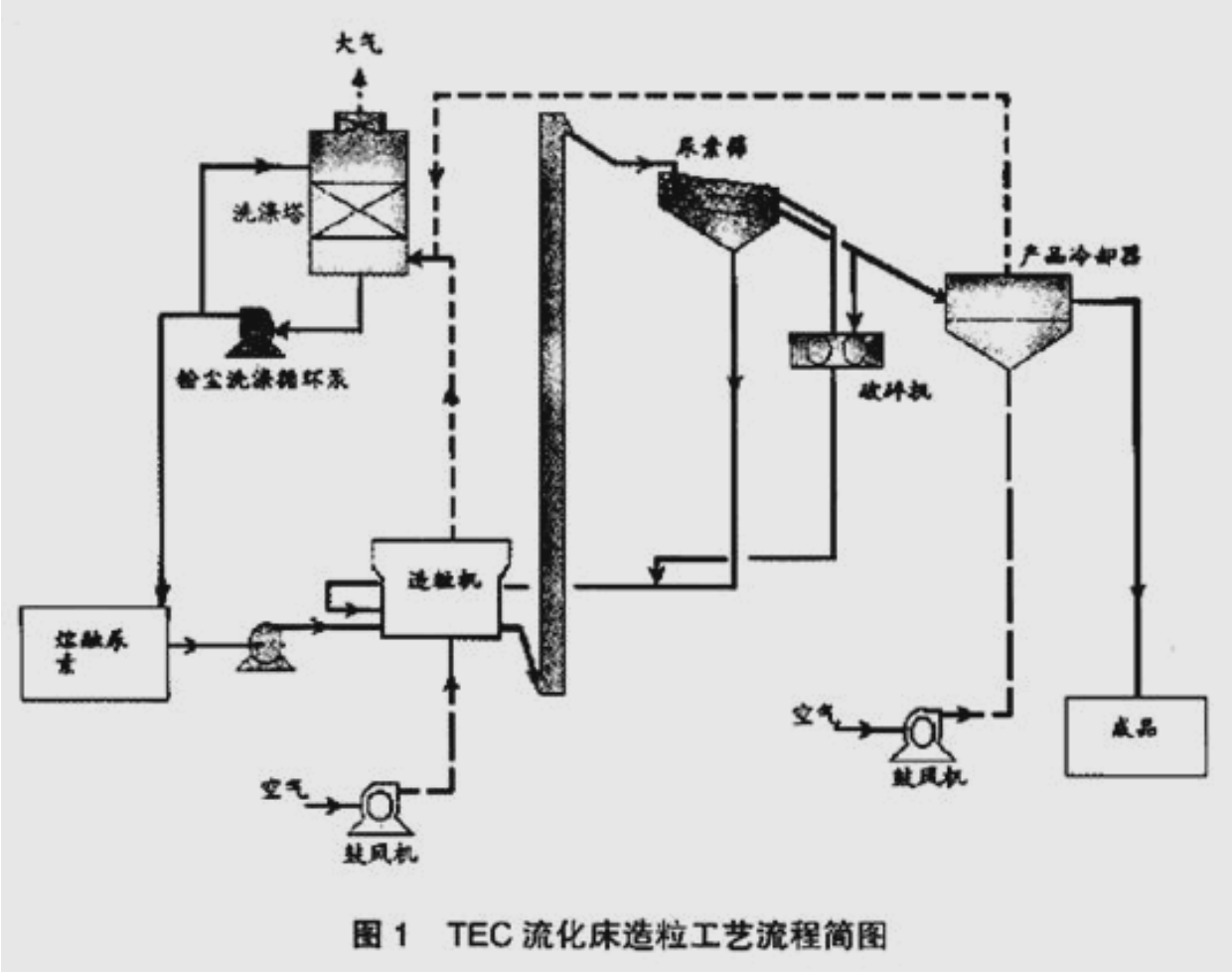

图 1　TEC 流化床造粒工艺流程简图

The growth path of urea product is as follows. The oversize particles and a small part of product from the screens are sent to the crusher for crushing after cooling in the oversize particles cooler. The crushed seeds are sent to the granulator, in which they are enclosed by the urea solution atomized by spray nozzles for the first time. Then urea granules are lifted to the urea screens by the bucket elevator after the vibrating feeder and weighting device located at the granulator outlet. The crushed seeds are sent to granulator again after screening. After such circulation for 3 or 4 times, the size distribution of urea particles can meet the product specification. Then the on-size particles are sent to packing section or bulk warehouse after cooling in product cooler.

2. Analysis of the growth time of urea granules

The operating temperature of fluid bed is 110~120 ℃. The urea solution from the evaporation system contains approx. 4% water. The water cannot be evaporated completely when the bed temperature of the granulator is low, and the amount of dust will increase significantly when the bed temperature is high. Under normal conditions of urea solution concentration, ambient temperature and humidity, when the load of granulation system is ≤100% and the bed temperature of granulator is between 110 and 120 ℃, the moisture content in product changes very little. But when the urea solution in tank shall be recovered to meet production needs, the load of granulation system is >100 %, and when the bed temperature of granulator is between

110 and 120 ℃, the moisture content in product changes greatly.

The crystallization rate of urea can be controlled by the bed temperature, but a high bed temperature is not wanted in the actual production. The 1st reason is high steam consumption, and the bucket elevator and urea screen load increase. The 2nd reason is serious dust production in the granulation system. Under high load production, to increase the crystallization rate of urea one can choose to raise the bed temperature or increase the urea seeds grow time in the granulator. The optimum operation is to choose the latter.

The residence time τ of seeds in the granulator can be expressed as follows.
That is: τ = m / （Qs + Qu）
Where: m——total mass of urea particles in the granulator
Qs——flow of recycle seeds into the granulator
Qu——flow of urea solution into the granulator (using product flow)

Total mass m of urea particles in the granulator is proportional to the area of the granulation area and bed height. Under production of urea granules, the ideal particle size distribution of the urea particles from granulator is shown as the 4th curve in the Figure 2. The seeds cycle number S of the TEC urea granulation system is controlled 3 to 4, as show in Figure 2.

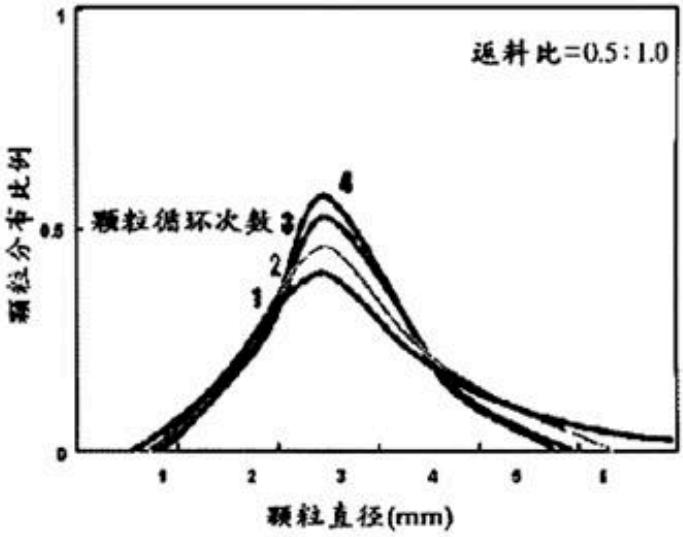

图 2　尿素粒径分布与晶种循环次数关系图

$$S=\frac{1.5\ln\left(\frac{D_u}{D_c}\right)}{\ln\left(1+\frac{Q_u}{Q_s+Q_u}\right)}$$

Where: S——seeds cycle number in the granulation system
Qs——flow of recycle seeds into the granulator
Qu——flow of urea solution into the granulator (using product flow)
Du——average particle size of product
Dc——average particle size of seeds at the outlet of crusher.

From the crushed by crusher to the product, the total seed growth time T in the granulation area can be expressed as:

$$T = \tau \cdot S = \frac{1.5m \ln\left(\frac{D_u}{D_c}\right)}{(Q_s+Q_u)\ln\left(1+\frac{Q_u}{Q_s+Q_u}\right)}$$

When the granulator bed height remains constant, that means a total mass constant of urea particles in the granulation area, and when the recycle flow increases or the granulation load increases, the total seed growth time T in the granulation system will be shorter and the moisture content in product will increase. When the granulator bed height increases, the total mass of urea particles in the granulation area will increase, and keeping the same recycle flow and granulation load, the total seed growth time T in the granulation area will be longer. But when the bed height is too high, the seed cycle number S will be smaller, that means the total seed growth time T will be shorter. So in the actual production, do not take the method of increasing bed height to prolong the total seed growth time in the granulator.

3. Application in the actual production

In the fluid bed granulator, the particle size distribution of product and the water content in product are related to the residence time distribution of urea particles in the bed.

(1) When the seed cycle number is too low, there will be more oversize particles in the urea particles at granulator outlet, and the water content in product will increase. Under production of urea granules, the ideal particle size distribution of urea particles from granulator is shown as the 4th curve in the Figure 2.

(2) When the seed were sprayed with the first urea solution layer (urea concentration is 96%) at the bed temperature of 110-120 ℃, assuming that the water in urea solution on the seed surface was not evaporated to the eligible content before solidification, it will cause the urea concentration below 99.6%. When such seed circulated in the granulator for the second time growing, the urea concentration will be still under 99.6%. Thus the water content in product will not satisfy the requirement until the seed leave the granulator. This situation is because of the lower bed temperature, we can increase the bed temperature appropriately to reduce the water content in urea granules to solve this problem.

(3) When our company's granulation plant is operated under the 100% load, total mass m of urea particles in the granulation area is 15t, recycle seeds flow Qs into the granulator is controlled at 80 t/h, product flow is 110 t/h, seeds cycle number S is controlled at 3-4, the total seed growth time in granulation area is 15-20 min, bed temperature is controlled under 110-117 ℃, and the moisture content in urea product is less than 0.4%.

In the process of urea solution recovery, the granulation load will exceed 100%, the bed temperature shall be controlled under 115-119 ℃. In order to avoid the dust production caused by too high bed temperature, recycle seed flow shall be reduced, that is to maintain the total seed grow time T in the granulation area. If 10 t/h load increased, 10 t/h of recycle seeds shall be reduced.

The following control scheme can be obtained based on the total growth time T in granulation area:
① properly increase the bed height
② properly add the number of sprayers to increase the granulation area

③ reduce the distance between the crusher rolls, and reduce the crushed size
④ decrease the crusher load, and increase the product size
⑤ reduce the recycle seed flow by above methods ①, ③and ④ and adjust the fluidization air flow

When the bed temperature can be controlled under 110～117 ℃ by the above methods, the moisture content in urea product will be less than 0.4%, the dust production caused by too high bed temperature can be avoided, and the water content in product will be not below standard.

4. Conclusion

The crystallization rate of urea can be controlled by the bed temperature in actual production, but the bed temperature is not wanted to be controlled between 115 and 119 ℃. Especially under high-load condition, to ensure product quality by increasing bed temperature will increase the load of equipment items and cause serious dust production in the granulation system. Reducing the flow rate of recycle seeds to maintain the total seed growth time T in the granulation area, that is how many load added, how many recycle seeds shall be reduced, to control the bed temperature under 110～117 ℃, avoid dust production caused by too high bed temperature and ensure the moisture content in product not below standard.

Translator notes:
This is a Technical Paper originating from our Chinese partner: www.Ureanet.cn. The paper was original in Chinese language and it is translated and interpreted into English with care and as much as reasonable possible accuracy, all to the best of our abilities