The TOYO Urea Granulation Technology

- The Challenges and Achievements in Producing Urea Granules -

SHUHEI NAKAMURA

Toyo Engineering Corporation
8-1, Akanehama 2-chome, Narashino-shi, Chiba 275-0024, Japan

INTRODUCTION

Since established in 1961, Toyo Engineering Corporation (TOYO), a global leading engineering contractor and urea process licensor, has licensed its technologies for over 100 urea plants including granulation units, sharing 1/4 of world urea production capacity as of May 2007.

In late 1970's, TOYO established a urea granulation process based on a Spouting Bed type urea granulator and expanded its own technical range to provide a variety of urea fertilizer products in addition to conventional Urea Prill Product and Urea Solution Product.

In late 1980's, TOYO further improved its design of the granulator by applying the Spout-Fluid Bed for the granulator, which is a combination of the spouting beds and fluidized beds and reduces energy requirements and improves the quality of the product granules.

The features of TOYO Urea Granulation Process are given below:

(1) High Energy Efficiency
(2) High Product Quality
(3) Low Emission

Photo.1: PIM2, Indonesia 1,725 MTPD with ACES Plant
Now, TOYO is known as the license owner of the Spout-Fluid Bed Urea Granulation Process to produce the high quality product which has been applied for 16 urea plants as of the middle of 2007 from 50 MT/D to 3,250 MT/D production capacities in single train. (Refer to Table-1).

In 2007 TOYO has completed basic engineering for a new 2,640 MTP Urea Granulation project and license its Spout-Fluid Bed Granulation technology for PetroChina Tarim Petrochemical Company.

To meet increasing demand for large scale urea units, TOYO has started licensing technologies for so-called “Jumbo Urea Plant” over 3,000 MTPD capacities. Design and engineering up to 4,500 MTPD have completed and a number of proposals of 3,000 – 3,500 MTPD single train plants have been carried out. In early 2007, TOYO was awarded an epoch-making contract to supply license and to perform basic engineering to build a 3,250 MTPD Urea Plant in Iran. TOYO ACES21® and Spout-Fluid Bed Granulation technologies are being applied to the project.
This paper reviews the advancement in TOYO Granulation technology in the aspect of product quality improvement, energy saving, environmental protection, and approach to Jumbo Granulation Plants.

### Table 1
List of TOYO Urea Granulation Plants

<table>
<thead>
<tr>
<th>Owner</th>
<th>Location</th>
<th>Capacity (MTPD)</th>
<th>On Stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mitsui Toatsu Chemicals, Inc.</td>
<td>Chiba, Japan</td>
<td>50</td>
<td>1975</td>
</tr>
<tr>
<td>2. Petrochem Ltd.</td>
<td>Kapuni, New Zealand</td>
<td>470</td>
<td>1983</td>
</tr>
<tr>
<td>3. Mitsui Toatsu Chemicals, Inc.</td>
<td>Osaka, Japan</td>
<td>100</td>
<td>1983</td>
</tr>
<tr>
<td>4. SKW Piesteritz GmbH</td>
<td>Piesteritz, Germany</td>
<td>1,200</td>
<td>1995</td>
</tr>
<tr>
<td>5. Petrochem Ltd.</td>
<td>Kapuni, New Zealand</td>
<td>750</td>
<td>1997</td>
</tr>
<tr>
<td>6. SKW Piesteritz GmbH</td>
<td>Piesteritz, Germany</td>
<td>500</td>
<td>1998</td>
</tr>
<tr>
<td>7. Ningxia Chemical Works of CNPC</td>
<td>Ningxia, China</td>
<td>1,740</td>
<td>1999</td>
</tr>
<tr>
<td>8. PT. Pupuk Iskandar Muda (PIM-2)</td>
<td>Aceh, Indonesia</td>
<td>1,725</td>
<td>2005</td>
</tr>
<tr>
<td>9. Lutianhua Group Inc. (CNTIC)</td>
<td>Sichuan, China</td>
<td>2,000</td>
<td>2000</td>
</tr>
<tr>
<td>10. Zhanyi Fertilizer Plant</td>
<td>Yunnan, China</td>
<td>600</td>
<td>2002</td>
</tr>
<tr>
<td>14. Confidential</td>
<td>CIS</td>
<td>2,000</td>
<td>(2007)</td>
</tr>
</tbody>
</table>
PROCESS FEATURES

1. Efficient Granulation Mechanism

TOYO’s urea granulation technology adopts Spout-Fluid Bed Granulator. In the Spout-Fluid Bed Granulator, spouting bed is formed by an upward stream of air introduced into the bottom of the granulator and fluidized bed is formed surrounding the spouting beds.

The air introduced into the spouting bed maintains that the particles remain in suspension. The droplets of urea solution fed to the bed through the spray nozzles are deposited on the surfaces of suspended seed particles. Thus the particles gradually grow up in layer-upon-layer.

Since air introduced to the granulator not only forms spouting bed and fluidized bed but also promotes cooling and drying the granules. 96% concentrated feed solution can be fed to the granulator to obtain a product with a moisture content of 0.3% or less. Thus biuret formation and steam consumption can be minimized.

Photo.4: Ningxia PetroChina No.1 Plant (1,740 MTPD) and No.2 Plant (870 MTPD)

Photo.5: Ballance, New Zealand (750 MTPD)
2. High Energy Efficiency

TOYO Urea Granulation Process consumes less utility.

Most of the energy for Granulation Process is consumed by fans, pumps and solid transportation equipment as electric power. Fig.2 shows the breakdown of power consumption for each user in Urea Granulation Plant. 80% of total power is consumed by fans. Therefore, the reduction of the power consumption by fans is essential for energy saving.
TOYO has succeeded to minimize power consumption of fans by introducing the following features:

(1) No compressed air for atomization

TOYO’s Urea Granulation Process utilizes single (liquid) phase spray nozzle combined with spouting air, eliminating the need of atomizing air compressor.

(2) Optimal bed depth in the granulator

The combination of spouting bed and fluidized bed is the feature of TOYO’s Urea granulation Process. It does not need to keep high bed depth in granulator, resulting in significant saving of electric power for fluidizing air fan.

(3) Smaller pressure drop in dust scrubber (See Fig. 3)

Packed bed type dust scrubber proprietarily designed by TOYO realizes both low pressure drop and high efficiency, reducing power for the induced fan considerably.

Following table shows the typical energy consumption of TOYO’s Urea Granulation Process.

<table>
<thead>
<tr>
<th>Table-2 Utility Consumption (typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam</td>
</tr>
<tr>
<td>Power</td>
</tr>
<tr>
<td>Cooling Water</td>
</tr>
</tbody>
</table>

In case Bulk Flow Cooler is applied instead of fluidized bed cooler for product cooling, the power consumption can be reduced by 4-5 kWh/T as shown in Fig.2.
3. High Product Quality

TOYO Spout-Fluid Bed Granulation Process produces the excellent quality product by the following functions:

(1) Cooling – low biuret formation

As the granulator rapidly cools the urea melt sprayed onto the granules, biuret formation is negligibly small.

(2) Drying – low moisture and high hardness

The granulator dries the granules so that the moisture content in the product become low enough to have sufficient hardness.

(3) Suspending – round and uniform product

Round and uniform product is obtained because the seed particles are suspended in the spouting bed during the granulating process.

As a result, the granular urea product is quite resistant against fracture and caking during storage and transportation.

Table-3 shows the typical product specification of TOYO’s Urea Granulation Process.

<table>
<thead>
<tr>
<th>Table-3 Product Qualities (typical)</th>
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</thead>
<tbody>
<tr>
<td><strong>Total Nitrogen</strong></td>
</tr>
<tr>
<td><strong>Biuret</strong></td>
</tr>
<tr>
<td><strong>Moisture</strong></td>
</tr>
<tr>
<td><strong>Formaldehyde</strong></td>
</tr>
<tr>
<td><strong>Size 2 - 4 mm</strong></td>
</tr>
<tr>
<td><strong>Hardness</strong></td>
</tr>
</tbody>
</table>
4. Production of Various Sized Granule

Various sizes of granular urea product can be produced in accordance with market demand and applications, simply by changing the screen mesh sizes as shown in Fig. 3.

![Figure 3: Flexibility of Product Size](image)

5. Environmental Protection

Urea dust in the exhaust air from the granulator is a major concern of air pollution in a urea granulation plant. Optimal air velocity for spouting bed and through free board area of granulator minimizes the dust formation in
the granulator. And the uniquely designed (Packed Bed type) low pressure-loss dust scrubber reduces urea dust to less than 30 mg/Nm³.

Dust scrubber is normally located on the ground level as shown in Photo.6. In case there is the limitation for available area, dust scrubber can be installed above the Granulator as shown in Photo.1 and 2.

![Dust Scrubber Diagram]  
**Fig.4: Dust Scrubber**

**Photo.6: Zhanyi, China (600 MTPD), Dust Scrubber on Ground**

**Process Description**

Fig.5 shows a typical process flow sheet for TOYO Urea Granulation Process.

The urea solution concentrated in the evaporator is supplied into the spouting bed through the single fluid spray nozzles to enlarge the recycle particles (seeds) in the granulator. The water content in the feed urea solution is evaporated in the spouting beds in the granulator to produce the
urea granules with 0.2 - 0.3 wt.% of moisture content. The enlarged granules are cooled in fluidized beds in the granulator.

Coarse granules produced in the granulator are screened to separate the product size granules from over and under size granules through the double deck screen (See Photo.7). Under size granules are recycled to the granulator as seeds and over size granules are crushed through the double roller type crusher (See Photo.8) and recycled to the granulator together with the under size granules as the seeds.
Exhaust air from the granulator and cooler is scrubbed in the wet type dust scrubber to recover the urea dusts as urea solution. Recovered urea solution is recycled to the urea plant for recovery.

**LARGE SCALE PLANT APPLICATION**

Nowadays the capacity of ammonia plant becomes larger and larger to be 2,000 MTPD as standard capacity. The required capacity of Urea Plant also becomes larger (more than 3,000 MTPD) to meet the increasing capacity of ammonia plant.

Since 1975, TOYO has scaled-up Granulation Plant successfully from 50 MTPD to 3,250 MTPD as shown Fig.6.

![Fig.6: Granulator Scale-up History](image)

Following design philosophy has been applied for former scale up of plant and it should be applied for the further scale-up of the plant (e.g. 3,500 MTPD or larger) in the same way, utilizing the state-of-the-art granulation process simulator, full knowledge and know-how on solid handling.
equipment and machinery, and incorporating the latest experience of the 3,250 MTPD at the same time.

(1) Increasing the number of spouting bed in proportion to the production capacity. (See Fig.7)

The capacity of Granulator is increased simply by adding required number of spouting bed under same condition. The sprayed capacity and air flow rate for one spouting bed is maintained for any plant capacity.

Therefore, large scale granulator is designed based on proven unit of spouting bed, extending the length of granulator from experienced size of granulator, considering following aspects:
- uniform transversal particle distribution
- avoiding back mixing
- uniform air distribution
- transportability of granulator

**Fig.7 : Granulator Scale-up Philosophy**
(2) Increasing Number of Screen, Crusher and Bucket Elevator

The capacity of solid handling section is also increased simply by adding required number of screens and crushers considering available capacity of machine.

<table>
<thead>
<tr>
<th>Required Number of Screen and Crusher</th>
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<tbody>
<tr>
<td>Plant Capacity [MTPD]</td>
</tr>
<tr>
<td>Screen</td>
</tr>
<tr>
<td>Crusher</td>
</tr>
</tbody>
</table>

Based on maximum capacity of present available machine

Fig.8: 3D Model of 3,250MTPD Urea Granulation Plant
Other transportation equipment such as bucket elevators and belt conveyors will not be the bottleneck even for the large scale plant e.g. 3,500 MTPD, in terms of their availability. Therefore, the number of trains of transportation equipment should be determined considering equipment layout and operability.

Above mentioned approach eliminates bottlenecks and risks due to large capacity Granulation plant. In fact, basic design for a 2,640 MTPD Urea Granulation Plant in China has been completed, and a 3,250 MTPD Urea Granulation Plant including synthesis section in Iran is now in basic design stage.

Further Improvements
TOYO continues R&D to improve its own Urea Granulation Technology. The improvements are:
- new spray nozzle design for granulator enhancing drying efficiency
- improved configuration of granulator enhancing high quality of granular urea product
The fruits of the above R&D are being incorporated in the granulator design of the latest projects.

CONCLUSION
TOYO’s Spout-Fluid Bed Granulation Technology has been applied to 16 urea granulation plants in 8 countries, including the latest two Jumbo units; 2,640 MTPD unit for PetroChina Tarim and 3,250 MTPD unit for NPC (Shiraz Petrochemical) Iran. Now, 3,500 MTPD of larger units are ready for implementation, and it is no longer “challenging” project for TOYO.

References