

Urea Process Improvements,

Workshop of JSC NIIK (Research and Design Institute of Urea), Russia

"Urea process improvements" workshop was organized by JSC NIIK on 13-14 July, 2009 in New Delhi, Clarion Collection hotel. This event was organized specially for Indian urea producers.

JSC NIIK – is a Russian engineering company specialized in development and realization of technical solutions aimed at improvement of urea plants operation. JSC NIIK was established in 1952 and since that has realized more than 120 construction projects of commercial scale units for urea, melamine, isocyanides and other syngas products.

Within last five years, JSC NIIK has developed and realized more than 20 capacity revamps of urea units in Russia, CIS and other countries. This gained experience appeared to be very interesting for Indian urea producers as well. Representatives of 12 urea producing companies participated in the workshop organized by JSC NIIK in New Delhi.

The agenda of this workshop included the following very important topics:

- ✓ Urea capacity revamping technologies
- ✓ Grass root construction of urea plants by proprietary technology
- ✓ Prilling towers modification and construction
- ✓ Design and construction of melamine production units and their integration with existing urea plants
- ✓ Corrosion inspection and on-site repair of high-pressure vessels
- ✓ Production of compound fertilizers in drum granulator
- ✓ Development of urea process simulator for efficient personnel training

The versatility of technical solutions offered by JSC NIIK raised a great interest. The uniqueness of JSC NIIK approach is subjected by its experience of construction almost 30 urea units in

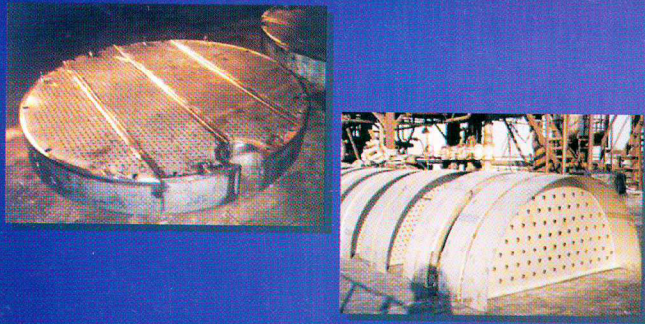
the former USSR by technologies of all known urea licensors. The experience gained by JSC NIIK over more than half a century ensures significant energy and environmental improvement of urea units operating by total liquid recycle or stripping technologies.

Workshop delegates showed great interest to JSC NIIK experience of capacity increasing revamps and modernization of urea synthesis reactor in particular. JSC NIIK has developed a set of internal devices for modernization of reactor. This set consists of high efficiency trays, longitudinal sectioning element and vortex mixer. Installation of such set into existing reactor or integration of a new reactor already equipped with such set of internals ensure conversion rate increase by 3%, capacity increasing by 20-50 mtd and steam saving of 0.04 Gcal. Within last five years JSC NIIK has realized more than 10 revamping projects with synthesis reactor modernization all with

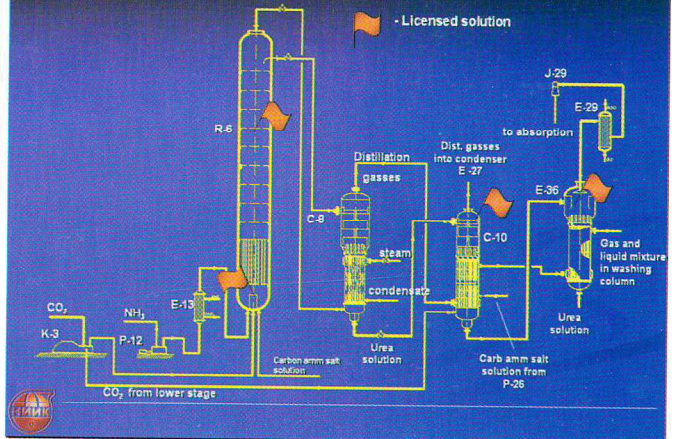


Picture 1. Efficient reagents mixing in urea reactor after modification by JSC NIIK technology

HIGH EFFICIENCY TRAYS BY JSC NIIK DESIGN



Principal diagram of synthesis and distillation units



Picture 2. Longitudinal sectioning element for urea reactor and high efficiency trays for improvement of conversion rate. Developed by JSC NIIK

beneficial results. Detailed description of modernization and operation principle of new internals were represented at the workshop and explained when answering numerous questions afterwards.

The extensive revamping experience enabled JSC NIIK to develop and license its own technologies for low and medium capacity urea production units. These technologies were also represented at the workshop in details. JSC NIIK has patented total liquid recycle technology with capacity of 1000 mtd and stripping process technology with capacity of 2000 mtd. Both technologies have modern and very beneficial energy, feed stock consumption and environmental indices.

Consumption per tonn of urea – 568 kg; CO₂ – 737 kg.

Energy consumption (for 1 tone of urea):

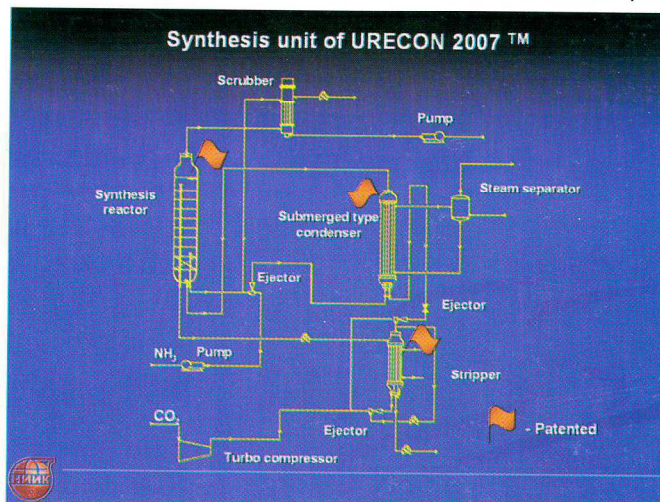
- urea unit with total liquid recycle by JSC NIIK technology:

- steam 0,8 – 0,85 Gcal;
- electric energy 150 kWt/h
- recirculation water 80 M3
- urea unit with stripping process :
 - steam 0,65 Gcal;
 - electric energy 30 – 120 kWt/h (depending on the type of compressor drive);
 - recirculation water 80 M3
- static strength of granule 1,0 – 1,3 kgs/granule
- product temperature at prilling tower outlet 45 – 50 C
- urea fraction : 2 – 4mm - not less 96 %
- moisture content (by Fischer method) less than 0,5%
- nitrogen content, not less 46,3%
- biuret content less than 0.9%

Quality of the final product:

- crumbiness 100%

JSC NIIK technologies enable very good environmental performance.



Effluents : ammonia 5ppm, urea – 5ppm,

Atmospheric emissions from prilling tower: ammonia 40 mg / M3, urea 20 mg / M3.

JSC NIIK is ready to provide full-scale engineering services for construction of urea plant: from

feasibility study up to performance guarantee testing.

JSC NIIK has presented its own urea prilling technology in towers by proprietary design as well as prilling towers modernization methodology. The offered simple technical solutions ensure improved product quality, reduce emissions and enhance capacity.

Improved product quality is ensured by new urea melt dispergator by JSC NIIK design and increasing of granules' falling height. Besides, the bottom part of the tower is equipped with fluidized bed, ensuring sufficient cooling of final product with minimum energy consumption. JSC NIIK has realized within recent decade more than 10 grass root and modernization projects for urea prilling towers in Russia, CIS and other countries. These projects were realized for towers operating with urea units of various technologies and capacities.

Urea produced in prilling towers by JSC NIIK design meets world quality

standards which is proved by sustainable market demand for this product.

Very active discussions followed JSC NIIK presentations about corrosion diagnostic experience and HP equipment repair methodologies. JSC NIIK has corrosion laboratory since the time of its establishment. This vast experience of curing corrosion

problems allowed to develop efficient methodologies and special instruments for repair and diagnostic of equipment, piping, valves and other critical elements in urea production flow chart.

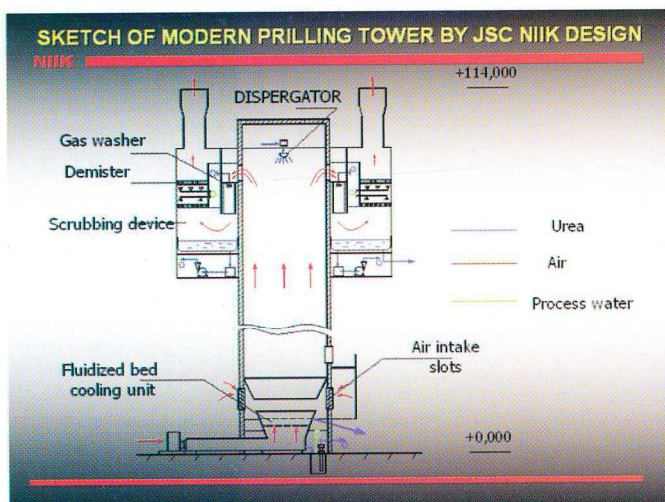
Technical solutions developed by JSC NIIK specialists allow high

pressure vessel repair with relining or tube sheet rehabilitation on site without relocation to workshop.

The delegates obtained detailed answers to their numerous questions regarding welding when repairing of tubeshett in high pressure carbamate condenser and relining without cutting of top and bottom spheres of vessels.



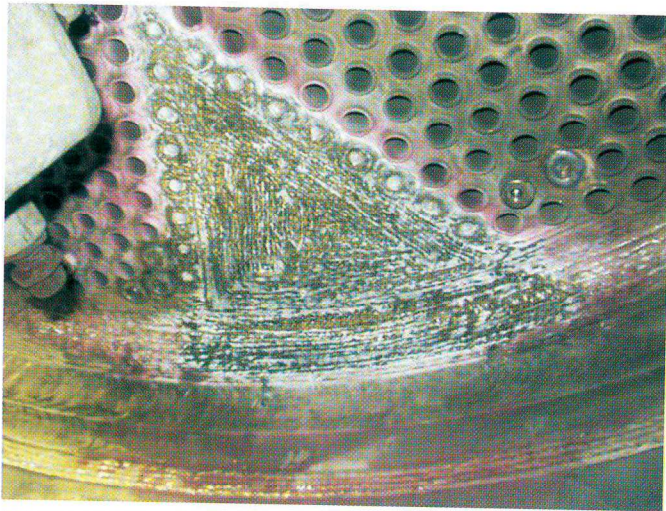
Picture 4. Jigging tool developed by JSC NIIK for relining of spherical parts of vessels



Picture 3. Modernization of prilling tower by JSC NIIK technology



Picture 4. Rolled lining ready for insertion into the neck of a vessel.



cooler, while those that less are left in the drum for further fattening. The drum has classifying unit, mechanism of returning undersize granules into spraying section, granules loading and unloading chambers, and water cooling system.

Picture 5. Rehabilitation of tube sheet in carbamate condenser by JSC NIIK methodology

One of the recent developments of JSC NIIK represented at the workshop – drum granulator. This development has a universal application. Drum granulator developed in JSC NIIK enables production of granulated urea with higher granules strength with different fraction as well as urea based compound fertilizers with various additives like Sulphur, zinc or ammonium sulphate. The operation principle for this case is the following:

Prior to the start up granulator is loaded with small size urea granules. When loading is finished the drum starts rotating, creating, thus, a “curtain” of small granules which is sprayed with 95-98% urea solution. Granules are fattening due to simultaneous crystallization of urea solution on granules surface and granules cooling while flying and palletizing. This process is multiple and final cycle is finished with granules size classification. Granules exceeding 3mm are loaded out into the

The design of all the items is patented know-how of JSC NIIK.

The drum is cooled by recirculation water with temperature of 28 °C, which is returned into the water loop by pumping via collecting tank.

The produced granules with temperature of not more than 100°C are loaded out onto conveyor and than by means of bucket elevator may be send to bulk flow cooler.

Cooler ensures decrease of final product temperature down to packaging value of 45 ± 5 °C and is sent to loading or storage.

Capacity of drum granulator may be adjusted in the range of one hundred twenty - two hundred forty tones a day or five – ten tones per hour. Overall capacity of the unit is unlimited, it is defined by client's requirements and the number of drums to be installed.

Shortly the advantages are the following:

- flexible capacity;
- low volume of air needed;
- formaldehyde free process;
- low energy and operational cost;
- wide range of capacity.

Another advantage of drum granulator is that it does not have external recycle, all undersize fraction is returned for further fattening via internal recycle loop. Drum granulator is very flexible for adjustment for production of different products with different fractions of granules.



Picture 6. Drum granulator by JSC NIIK design successfully integrated with existing urea unit.

Very strong interest of delegates was shown to the possibility of compound fertilizers production.

The last presentation at JSC NIIK workshop was dedicated to urea process

PC based simulator developed for efficient training of operation personnel.

The simulator is an interactive software application based on mathematic models describing particular process conditions. Training with simulator ensure preserving of qualification and even developing of personal sensory motor and intellectual as well professional skills such as operators' actions in process emergencies and generation of process control strategies for normal operation mode.

PC based simulator has the following structure

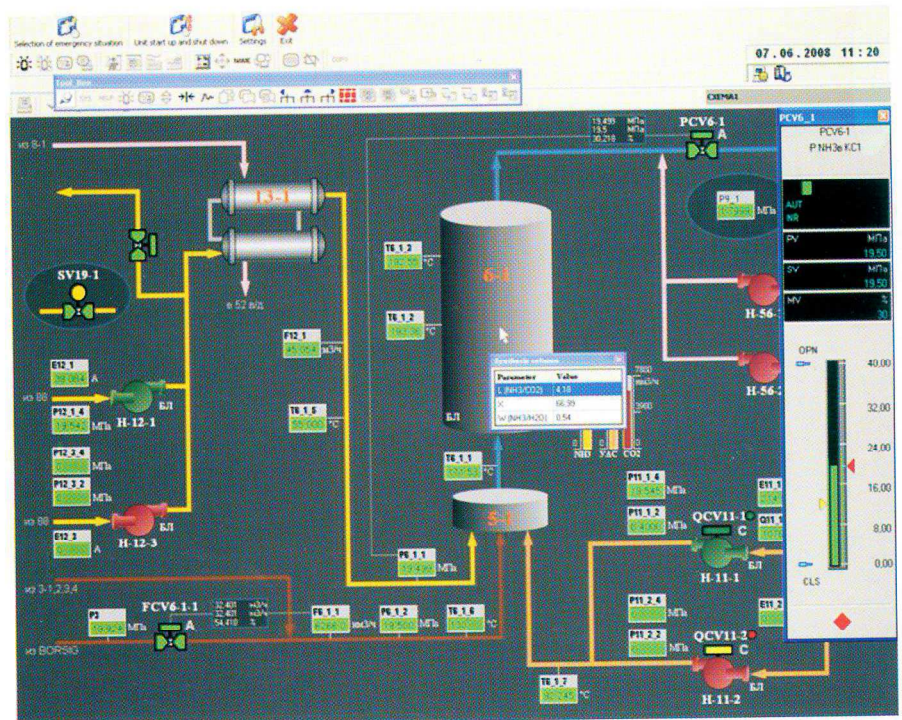
Functionally it is divided into:

- Theoretical knowledge data base or electronic documentation;
- Training subsystem for operating personnel;
 - Normal process operation and control;
 - Failure process operation and control;
 - Start up and shut down control;
- Subsystem of testing and certification.

The interface of simulator exactly reproduces interface of existing at the plant distributed control system and mathematic models are based on real heat and material balances. These features ensure virtual effecting the process: to start up and shut down unit, to generate and correct emergency situations, to control the process in normal and emergency modes.

JSC NIIK has developed and realized in 2007 a full scale urea process training and simulation complex at JSC NAK AZOT production plant of Eurochem company (Russia). Development, realization and commissioning took 1 year.

Practically the simulator can be organized as training class with single



Picture 7. Simulator interface completely reflects interface of existing control system

information center or server, teacher workstation (from where a prospect coordinator of training can issue tasks and control answers) and workstations of trainees.

Basic stages of simulator development are the following:

- approval of technical requirements and development of technical order for simulator;
- development of electronic data base (electronic documentation);
- development of process and DCS imitators;
- development of interface server software;
- development of teaching and certification system.

The most attractive and useful features of such simulator are the following:

- full scale dynamic mathematical model;

- calculation of parameters that are not controlled automatically;
- calculation of component consumption in gaseous and liquid process flows.

The simulator may be realized not only for urea production plant but also for ammonia complex as well as different others chemical products and fertilizers.

The workshop delegates found JSC NIIK technologies and solutions represented at the workshop very interesting, despite the fact this Russian company demonstrates its capabilities in India for the first time.

The first close acquaintance with Indian urea producers appeared to be very positive and it is a good sign for building future cooperation on trustworthy and mutually beneficial conditions.

The complete set of workshop materials may be received free of charge upon inquiry by email: kmv@niik.ru and kargaeva@niik.ru