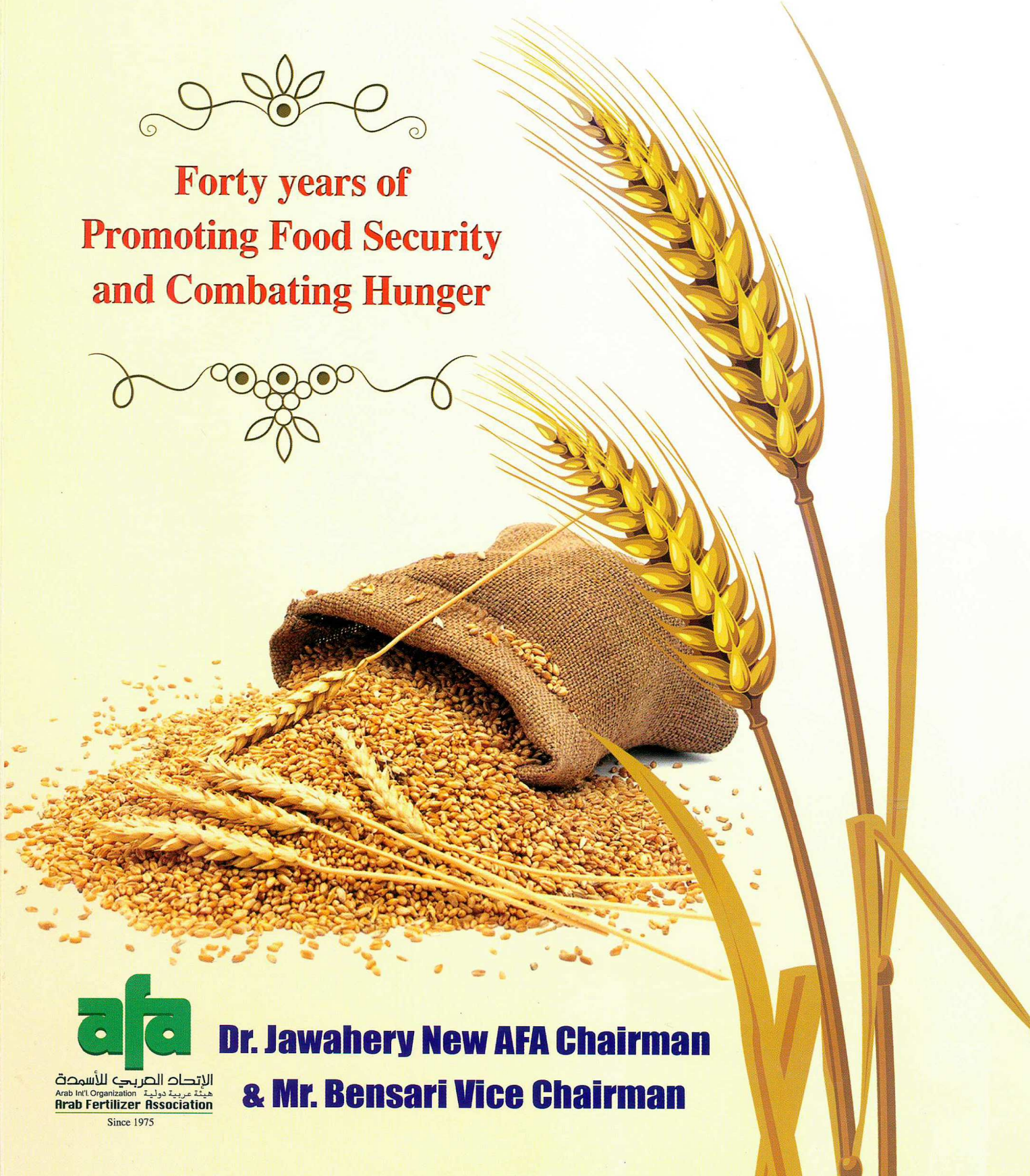
Arab Fertilizer

Issue Number (70) September - December 2014

Welcome to the 21st AFA Int'l. Annual Fertilizer Forum & Exhibition

Forty years of Promoting Food Security and Combating Hunger



Dr. Jawahery New AFA Chairman & Mr. Bensari Vice Chairman

afa
الإتحاد العربي للأسمدة
Arab Int'l Organization هيئة عربية دولية
Arab Fertilizer Association
Since 1975

INCREASING THE EFFICIENCY OF THE UREA SYNTHESIS REACTOR

NIIK
Research and Design Institute of Urea

NIIK (Research and Design Institute of Urea) has 60 years of experience in designing of new and revamping of old urea plants. Based on the accumulated experience NIIK can offer a number of activities aimed at increasing of urea unit capacity and improving of energy efficiency.

One of the key activities in the NIIK revamping concept is modernization of synthesis section. Efficiency enhancement of synthesis section would not only improve process parameters, but also increase final product output.

Efficient operation of synthesis section greatly depends on the amount of ammonia and %%2 recycle. Any change of this amount results in changes of energy consumption. So in a synthesis reactor it is very important to achieve the maximum conversion of original feedstock into the final product under required process conditions.

This measure is aimed at increasing efficiency of synthesis process and improvement of conversion rate of CO2 into urea. As a result, due to optimal hydrodynamics of flows inside of the reactor the efficiency of reacting volume is increased. Moreover, the increased CO2 conversion rate reduces amount of unconverted ammonia and %%2 in the melt and so there is a reserve to raise load of the urea unit.

It is important that such revamp can be done in the short time and within the scheduled shutdown of the urea unit.

Our synthesis section revamp concept starts with required calculations and designing of the equipment.

The urea synthesis reactor can be divided into three operating zones:

1. Mixing zone.
2. Carbamate formation zone.
3. Urea formation zone.

For each zone NIIK has developed a high efficient set of internal devices.

Mixing zone.

In the mixing zone the gas is dispersed into the liquid which results in formation of liquid-gas mixture.

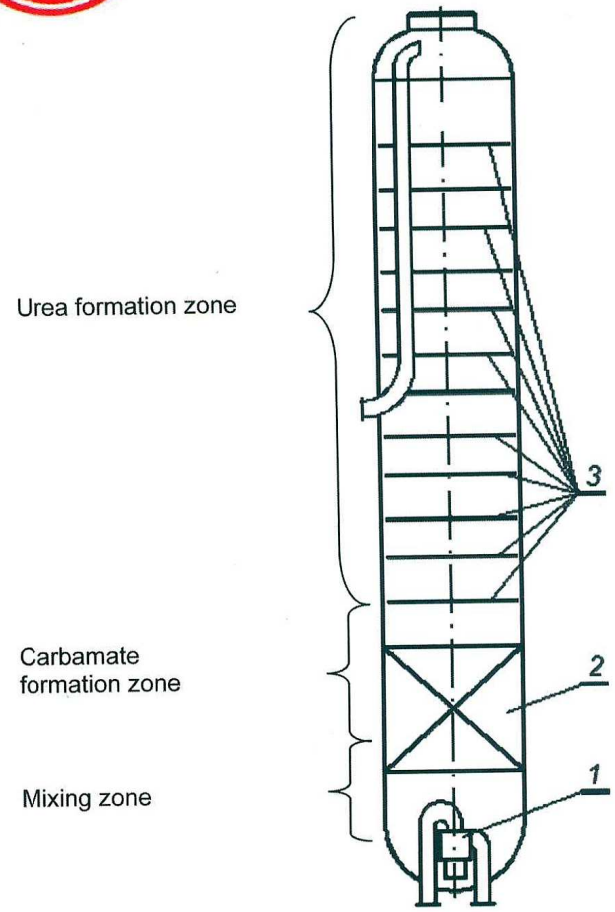


Fig. 1 - Sectioning of urea synthesis reactor

The area comprises existing feeding nozzles and a mixing device, which designed by the process licensor.

Design of the mixing device is very important as bounding of original feedstock into ammonia carbamate directly depends on its efficiency. So a mixer should have the following features:

- It must fill up the volume of the reactor with a gas-liquid mixture as much as possible;
- It must ensure the largest possible specific surface of media contact of components supplied to the reactor.

NIIK researches carried model trials of all types of conventional mixers applied in urea reactors in a specially designed scale-down laboratory urea reactor. Based on the tests we came to a conclusion that all conventional mixers do not ensure necessary mixing of the components. Gas in the form of large bubbles goes up reducing specific surface of media contact of gas and liquid. In this case the fill factor of the bottom part is low. This process results in extension of ammonia carbamate formation zone and further reduction of efficiency of entire synthesis process.

To ensure efficient mixing of feedstock at the reactor inlet NIIK offers a high efficient Vortex Mixer.

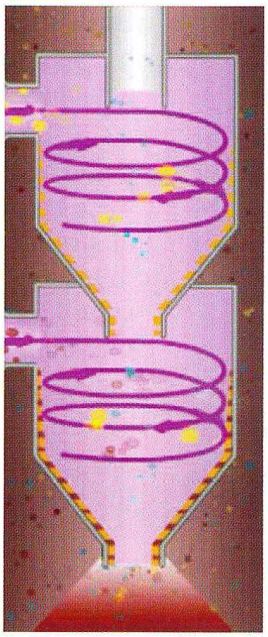


Fig. 2
Operation of the Vortex Mixer

The working principle of the mixer is based on the effect of intensive dispersion of gas resulted from breaking of a swirling gas-liquid jet with liquid at the nozzle outlet.

Due to the unique design of the Vortex Mixer dispersion of gas into liquid is carried more efficiently - the bubbles are much smaller than the ones produced in the conventional mixers. In this case specific surface of media contact generated by the Vortex Mixer is two times higher.

Location of the Vortex Mixer in the reactor and a special design of its outlet nozzle provide the largest mixing area in the same volume ; up to 90% (against 30% for conventional mixers). Moreover installation of the Vortex Mixer eliminates so called a«dead zones» in the bottom of the reactor which increases a useful volume for the reaction. So these two factors result in increase of CO2 conversion rate in the synthesis reactor and reduce the energy consumption in the distillation sections.

NIIK's patented Vortex Mixer technology has been used since 2005. By present eight urea plants of Total Liquid Recycle, Snamprogetti, Tecnimont technologies have been equipped with the Vortex Mixer. In each case installation of the Vortex Mixer resulted in performance enhancement of urea synthesis section. In some cases unit capacity enhancement and energy consumption reduction were among the guaranteed values. It both was achieved because the amount of recycle returned to the synthesis section has reduced by increasing of CO2 conversion rate in urea synthesis reactor.

Installation of the Vortex Mixer gives the following results:

- Increase of CO2 conversion rate in urea synthesis reactor by 0,5-1,0 % depending on the process technology;
- MS saving from 15 to 40 kg/t depending on the process technology Reference list of the internal devices with the achieved results are given in the table below :

The latest case study of the Vortex Mixer is given Below

On June, 30 2014 the Vortex Mixer was successfully installed into the reactor of Urea Unit ;II (Snamprogetti stripping process) at Nagarjuna Fertilizers and Chemicals Limited, Kakinada, India.

Base Case Test

Base case test was carried out from 29.06.2014 till 09.07.2014. The test was performed under stable process conditions. The load of the urea unit was 2330 MTPD (based on final product output). Process operating parameters and lab analysis of main streams were recorded during the test.

Assembly of the vortex mixer

The assembly works of the Vortex Mixer in the

References

Urea Plant and Process Technology	Type of Internal device and year of installation	Result of installation of internal devices
JSC «KuibyshevAzot», Togliatti, Russia Urea Plant-4,Urea Unit-2, Stamicarbon Total Liquid Recycle	Vortex Mixer, Conversion Booster, Mass Transfer Trays 2005	1. Conversion rate in urea synthesis reactor increased by 1,5 % (up to 69,0 %). 2. Urea Unit is operating stable at capacity 500 MTPD (design capacity 270 MTPD).
JSC «Togliatti Azot», Togliatti, Russia Urea Unit -1, Snamprogetti	Vortex Mixer, Conversion Booster 2007	1. Capacity of the urea unit increased up to 1650 MTPD (design capacity 1500 MTPD).
JSC «KuibyshevAzot», Togliatti, Russia Urea Plant-1,Urea Unit-4, Stamicarbon Total Liquid Recycle	Vortex Mixer, Conversion Booster, Mass Transfer Trays 2008	1. Conversion rate in urea synthesis reactor increased by 4,6%. 2. Total utility saving - 0,03 Gcal/t. 3. Urea Unit is operating stable at capacity 500 MTPD (design capacity 270 MTPD). * Other NIIK solutions were implemented during the revamp.
KJSC «Azot», Kemerovo, Russia Urea Unit-1 Tecnimont	Vortex Mixer 2008	1. Capacity of the urea unit increased from 1600 MTPD to 1650 MTPD (design capacity 1500 MTPD). * The Urea Synthesis Reactor has already been equipped with NIIK Conversion Booster.
«Azot» affiliate JSC« OHK «Uralchem», Bereznyaki, Russia Urea Unit Tecnimont	Vortex Mixer 2010	1. Conversion rate in urea synthesis reactor increased by 1,3 % (up to 58,5 %). 2. Capacity of the urea unit increased up to 1550 MTPD (design capacity 1500 MTPD). 3. Urea Unit is operating stable at capacity 1600 MTPD. * The Urea Synthesis Reactor has already been equipped with NIIK Conversion Booster.
JSC «NAK «Azot», Novomosskovsk, Russia Urea Plant-3, Urea Unit-1 Snamprogetti	Vortex Mixer 2011	1. Conversion rate in urea synthesis reactor increased by 1,1 % (up to 57,4 %). 2. Capacity of the urea unit increased by 50 MTPD. 3. Urea Unit is operating stable at capacity 1900 MTPD (design capacity 1500 MTPD).
JSC «Acron», Veliky Novgorod, Russia Urea Unit-5 Original process technology-Snamprogetti, modified by NIIK	Vortex Mixer, Conversion Booster, Mass Tranfer Trays 2012	1. Urea Unit is based on relocated equipment. After relocation the unit was then equipped with Vortex Mixer, Conversion Booster and Sieve Trays. 2. Capacity of the urea unit increased by 10 % compared to design capacity.
M/s Nagarjuna Fertilizers and Chemicals Limited, Kakinada, India Urea Unit -2, Snamprogetti	Vortex Mixer 2014	1. CO_2 conversion rate in urea synthesis reactor increased by 0,6 % (up to 57,8 %). 2. MS steam saving. Guaranteed value - 35 kg/t (achieved value - over 40 kg/t).

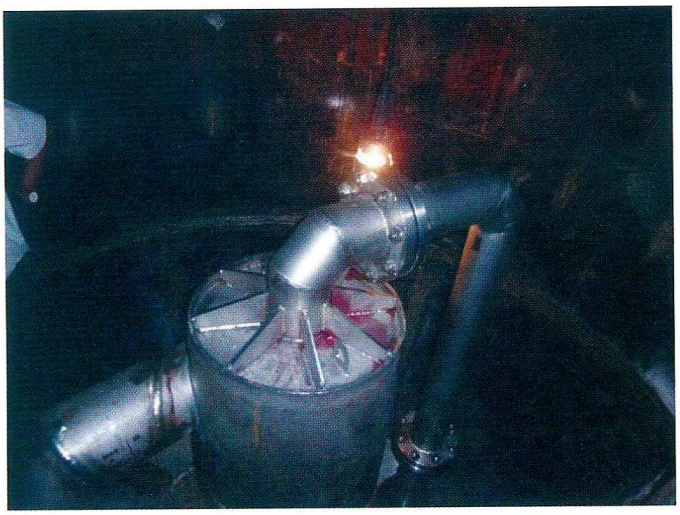


Fig. 4 – The Vortex Mixer

Urea Reactor of Urea Plant-II were carried out from 16.05.2014 till 24.05.2014 under a field supervision of NIIK. Installation work of the Vortex Mixer took 5 days. At the same time repair woks of liner welding joints were carried in the reactor.

Guarantee Test

Guarantee performance test of the Vortex Mixer was carried out from 26.06.14 till 29.06.1. At that time the average unit load was 2329 MTPD. During the test there were recorded the same process parameters and lab tests as at the base case test.

The following changes were observed during the test:

1. CO2 conversion rate in urea synthesis reactor increased by 0,6 % (from 57,2 % up to 57,8 %), which indicates efficiency enhancement of urea synthesis reactor with installed Vortex Mixer. Urea content in solution from urea synthesis reactor increased by 0,8%. Also CO2 conversion rate approached equilibrium by 0,9 % compared to the base case test. It shows that efficiency of synthesis section has been increased.

2. Achieved value of saving after installation of the Vortex Mixer was 39 kg/t of urea against guaranteed value of 35 kg/t of Urea. It should be noted that saving value reached 45 kg/t while maintaining optimal process mode.

At NFCL MP steam is supplied into stripper pos. %%-101, predecomposer pos. %%-102% and distiller pos. EMV-102. Steam saving was achieved in MP distillation section by reduction of steam supplied into predocomposer EE-102A and distiller pos. EMV-102. The amount of unreacted components that had to be removed from urea solution was decreased so the amount of steam required to remove these components is reduced as well. Operation of LP distillation, condensation and evaporation sections remained the same (or even improved) compared to the Base Case Test. It proves that saving is achieved not by increasing load on other sections but by efficiency enhancement of the synthesis section.

3. A rise of CO2 pressure before the reactor compared to the base case test was 0,6 bar. This is a result of slightly increased load of urea unit (the difference at similar loads is around 0,1%0,2 bar). In any case this increased value is negligible and within the measurement accuracy of the meter. It didnصt affect further increase of unit load up to 2400 MTPD.

No rise of pressure in ammonia HP pump was observed (in average, ammonia pressure before the ejector was maintained less by 1,0 bar compared to the base case test).

It should be noted that reduction of ammonia pressure before HP ejector was not accidental. The effective operation of synthesis unit resulted in decreased amount of recycle. So the energy consumed for transferring of the recycle was also reduced. It helped to maintain low pressure of ammonia flow before HP ejector.

4. The fact that opening rate of the recycle supply control valve changed also indicates that the amount of recycle in the urea unit has been decreased. Opening rate of E01-HV-09 control valve decreased at average by 1,3 % compared to the Base Case Test. The average consumption with installation of Vortex Mixer reduced by 39 kg/t. In this case the average payback period

of investments for the project is approximately 6 months.

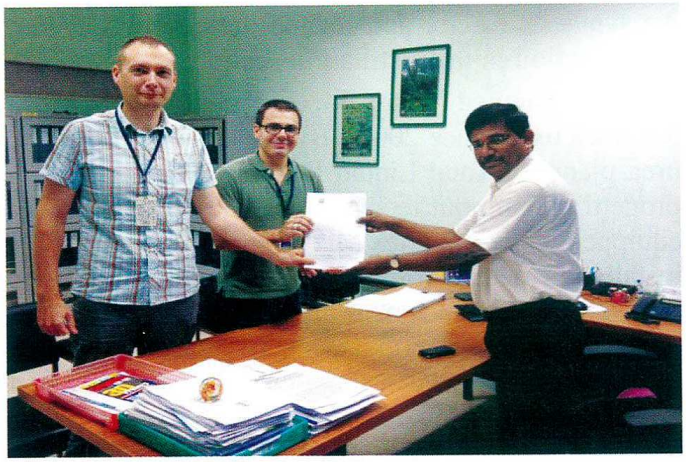


Fig. 5 – NIIK and NFCL signing the Guarantee Test Certificate