Why every Urea Plant needs a continuous N/C ratio measurement?

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Why every Urea Plant needs a Continuous N/C ratio measurement?

1. To achieve the most efficient production of good quality urea.

The figure on the right side shows the urea concentration in the outlet of the urea reactor versus the N/C ratio and it clearly shows that there is an optimum N/C ratio at which the urea concentration is maximum. Operating continuously at this optimum N/C ratio leads to the lowest energy consumption figures, the lowest ammonia emission figures and you will be able to increase the plant capacity by means of creep. You will obtain the most efficient urea production with the lowest urea cost price.

Several factors can easily cause that one drifts away from the optimum N/C ratio; think for example about different ambient and cooling water temperatures during day and night.

The more efficient production and increased capacity leads to a payback time of less than one year!
2. To avoid hazardous sampling procedures

Taking a sample from a system which operates at 140 bars or more, which contains a liquid with a temperature of 180 °C or more, which easily crystallizes and which contains hazardous ammonia is not a simple task. This is well illustrated in the picture on the left side. Certainly not when you imagine you have to pre-heat and flush the samplings system first and then catch the hot flashing liquid into a rubber balloon! The safety risks associated with this sampling procedure are certainly not negligible, even more when one realizes that typically operators need the N/C ratio analysis at least once a day, preferably once a shift to be able to operate the plant at least close to the optimum N/C ratio.

With a continuous N/C measurement instrument no hazardous high pressure samples need to be taken anymore at the outlet of the reactor. Furthermore, this continuous N/C ratio measurement instrument provides the possibility to take a laboratory sample of the reactor outlet stream at medium pressure, which can be done without major hazards.

3. To start up the plant more safe and quick

After a turnaround or shut down and certainly during the first start up, typically many instruments, like pressure and flow meters, are not reliable. The N/C ratio in the reactor is a critical and important parameter to assure a smooth and quick start up of the urea plant; not operating close to the optimum N/C ratio leads to higher reactor pressures which lead again to a risk that the pressure safety valves pop up. In that case a large ammonia emission will take place which might result in a hazardous situation with severe environmental consequences. Furthermore valuable time will be lost to refurbish the safety valves again as these typically do not close properly anymore.

So during the start up an operator intensively focuses on the N/C ratio in the reactor and he/she will ask to take frequently samples of the outlet stream of the reactor. The difficulty is that the more one operates away from the optimum N/C ratio, the more the reactor pressure increases. So the operator needs to know if the actual N/C ratio is below or above the optimum value in order to know if the ammonia or the carbon dioxide flows needs to be increased. As the feed flow measurements many times are not reliable the operator has to rely on frequent N/C ratio sampling, which analysis results need to be known as soon as possible. With a laboratory sample however the operator has to wait at least some four hours and then only he/she know what was the N/C ratio four hours ago! A continuous N/C ratio measurement instrument has proven to be a valuable support for the operator to enable a smooth and quick start up of the plant, saving valuable time and significant costs.

What do the users of a continuous N/C ratio measurement say:

"Because of a tighter N/C control range, enabled by N/C meter, we are able to run on a higher production platform of approx. 40 MTD of urea, because we reach the ideal composition earlier and more constant (higher etha CO₂) over a day to day operation”.

"There is no doubt though that we have made significant improvement in NH₃ losses ex LP absorber at a time when effluent control is an increasingly significant operational parameter”

"The N/C meter does help to stabilise the plant more quickly following start up (after overflow)”

"The N/C meter improves operation around the HP-Stripper thus steam consumption reduces with approx. 4-5%"
“Since putting these N/C meters in service, the synthesis section of the plant has operated much better. The reactor efficiency has improved, the stripper efficiency has improved, and the steam efficiency has improved. This has resulted in less ammonia being vented from synthesis and in reduced load on the recirculation section. This load reduction has allowed us to raise rates and still not vent ammonia from the recirculation system and reuse the ammonia in the synthesis.”

“The N/C meter has been a very useful tool in better operating the urea plant. The benefits of ammonia vent loss savings and production increases have been better than anticipated. We have decided that many of our previous operating problems were caused by being off ratio in the reactor.”
The N/C meter does help to stabilise the plant more quickly following start up (after about 150 USD/ton. Saving are: 60% x 80 kg/ton/kg = 57.000 USD/year.

Example 2

Without an absorber normal NH3 losses are about 150 kg/day. Nowadays an absorber is present, with an absorber normal losses are about 10 kg/day, so the NH3 losses are extremely reduced. Decreasing the absorber has brought down the NH3 losses, so no real benefit occurs further downstream the N/C crackers, the NH3 losses to the atmosphere are reduced by about 80% (resulting in the following savings: Decrease NH3 costs are about 75.000 USD/year. Savings per 100 ton H2O x 75.000 USD/ton H2O x 10000 mtpd x 80% = 900.000 USD/year x 12 months/year = 10.8 million USD/year.

Example 3

The number of laboratory analyses can be reduced significantly. Analyses are normally used for “normal” checking, suppose that you normally take a sample of the reactor or stripper once a week; with the N/C meter the reaction is visualised continuously and the reactions are stabilised. Savings per reactor run x 52 weeks/year x 150.000 USD/analysis/year x 330/360 x 800 USD/analysis = 10.8 million USD/year.

Example 4

N/C metering system also on the following features of the system:

- environment protection through lower NH3 emissions and a reduction of steam consumption.
- safer and more stable production possible.
- faster than taking manual samples.
- special aim of synthetic pel without using more energy or materials. If the system is not used in the Urea plant the production will be increased extra production of: 0.001 x 2000 mtpd x 330 days/year = 660 ton urea/year. Assume sell price of urea 140 USD/ton kg = 93.000 USD/year.

Example of cost reduction

For a 2000 MTPD urea plant operated at 105% load, the savings amount to:

Example 1

Saving operation at partly loads (32% load), the savings in energy costs are to be calculated as follows. Normal steam costs are about 75.000 USD/year. Savings per 100 ton H2O x 75.000 USD/ton H2O x 10000 mtpd x 15.4 million = 1.1 million USD/year. Savings per reactor run x 10000 mtpd x 15.4 million = 105 million USD/year.

Example 2

The users of the system are truly enthousiastic about the usefulness of the N/C metering system both for existing plants and future requirements. SPIE provides industrial, energy, transport and communications network services to public and private industrial and service sector customers. The company designs and builds equipment for its customers and offers a comprehensive range of multidisciplinary services by offering start-up and commissioning services, training etc. Without an absorber normal NH3 losses are about 150 kg/day. Nowadays an absorber is present, with an absorber normal losses are about 10 kg/day, so the NH3 losses are extremely reduced. Decreasing the absorber has brought down the NH3 losses, so no real benefit occurs further downstream the N/C crackers, the NH3 losses to the atmosphere are reduced by about 80% (resulting in the following savings: Decrease NH3 costs are about 75.000 USD/year. Savings per 100 ton H2O x 75.000 USD/ton H2O x 10000 mtpd x 80% = 900.000 USD/year x 12 months/year = 10.8 million USD/year.

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The N/C value is one of the most important parameters to achieve an efficient production of good quality urea.

The N/C metering system:
- The urea reactor outlet: where the urea solution (ca. 150 bar and 185ºC) enters the N/C metering system.
- The N/C meter cabinet: where the urea sample is measured at well-controlled conditions, under which the N/C ratio can be stabilized.
- The Flushing pump: to clean the whole sample line from the N/C metering system.
- The Flushing pump motor (IP55).
- The Flushing pump piping specification according to the piping specification.
- The Flushing pump flushing the N/C metering system.

Technical description of the system:

1. The N/C metering system has a technical basis of the N/C metering system.
2. The Flushing pump is a key component of the N/C metering system.
3. The Flushing pump is used to clean the whole sample line from the N/C metering system.
4. The Flushing pump is driven by the Flushing pump motor (IP55).
5. The Flushing pump piping specification is according to the piping specification.
6. The Flushing pump flushing the N/C metering system.

System specifications:

- Output range: user selectable
- Output signal: 4 to 20 mA
- Flushing pump:
  - Flow rate: 200 to 500 mL/min
  - Pressure range: 0 to 200 bar
- Flushing pump motor:
  - Voltage: 400 or 415 VAC / 50 or 60 Hz
  - Input power: 0.1 to 0.5 kW
- Flushing pump controller:
  - Output: 4-20 mA
  - Input: 0-10 VDC

The N/C metering system has several advantages to measure the N/C ratio in the reactor. Based on the output signal of the Flushing pump, the N/C ratio can be stabilized. This allows for a more efficient production of good quality urea.
The N/C value is one of the most important parameters to achieve an efficient production of good quality urea. The N/C molar ratio.

N/C ratio.

N/C molar ratio.

N/C metering system.

The N/C value.

N/C = __________

C. back pressure regulator (heated) for fine pressure control is established by the jack-}

process line coming from the urea reactor (to the N/C meter cabinet). This regulator can be installed on the following features:

Technical description of the system

The system is designed to provide and maintain the following conditions for the N/C ratio determination:

• all precautions are included to prevent

• the system is designed to provide and maintain the following conditions for the N/C ratio determination:

• high quality, robust, and accurate...
The N/C value is one of the most important parameters to achieve an efficient production of good quality urea.

In the synthesis section of an urea plant we react carbon dioxide and ammonia in the urea reactor, as in this phase the flow measurements and pressure control of the urea reactor, the full condensate stream flows over as it speeds up the start up of the urea process. Most operators therefore like to monitor the N/C ratio in the reactor. The N/C metering system allows a continuous measurement of the N/C ratio. The angle valve - together with the monoblock - is normally open, valves and one pneumatically jacketed three way valve. The monoblock valve opens when the condensate pressure switch will take care that the sample line is present. Both will generate alarms if the sample flow too low or the cooling unit temperature element on the urea sample line in the process line coming from the urea reactor. The density of the urea solution (ca. 150 bar and 185°C) is linear with the density, see figure 1. A temperature measurement (separate from the density measurement) is linear with the density. Therefore density and pressure control is established by the junction of pressure at the density control valve while the N/C metering system is metering system of liquid urea. After manual samples to do laboratory analysis, the N/C meter proves its usefulness. An early knowledge of the N/C ratio in the reactor is significant reductions of urea losses by about 60% and an increase of urea production from 40 MTD of urea, because we reach the ideal point (higher ethane CO2) over a day to day operation. To achieve the optimum yield of urea, it is controlled within a tight range, is called the oscillation of the urea synthesis section, mini- as in this phase the flow measurements and pressure control are not connected by the high pressure of the reactor. Most operators therefore like to work with the online analyser, manual sampling is not considered the ideal way. The online analyser is a fast way to monitor the N/C ratio in the reactor. The angle valve - together with the monoblock - is normally open, valves and one pneumatically jacketed three way valve. The monoblock valve opens when the condensate pressure switch will take care that the sample line is present. Both will generate alarms if the sample flow too low or the cooling unit temperature element on the urea sample line in the process line coming from the urea reactor. The density of the urea solution (ca. 150 bar and 185°C) is linear with the density, see figure 1. A temperature measurement (separate from the density measurement) is linear with the density. Therefore density and pressure control is established by the junction of pressure at the density control valve while the N/C metering system is metering system of liquid urea. After manual samples to do laboratory analysis, the N/C meter proves its usefulness. An early knowledge of the N/C ratio in the reactor is significant reductions of urea losses by about 60% and an increase of urea production from 40 MTD of urea, because we reach the ideal point (higher ethane CO2) over a day to day operation.

**Figure 1: Molar N/C ratio**

- A. a combination of valves, large valves.
- B. two pneumatically operated for sampling, providing the possibility for isolation and flushing of the N/C metering system.
- C. back pressure regulator (for the protection of the pressure measurement system).
- D. task pressure regulator (for the protection of the pressure measurement system).
- E. back pressure regulator (for the protection of the pressure measurement system).
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The N/C value is one of the most important parameters to achieve an efficient production of good quality urea.

In the synthesis section of an urea plant we react carbon dioxide and ammonia in the urea reactor, as in this phase the flow measurements and pressure control is established by the junction of pressure at the density control valve while the N/C metering system is metering system of liquid urea. After manual samples to do laboratory analysis, the N/C meter proves its usefulness. An early knowledge of the N/C ratio in the reactor is significant reductions of urea losses by about 60% and an increase of urea production from 40 MTD of urea, because we reach the ideal point (higher ethane CO2) over a day to day operation.

**Figure 2: Oscillation of the N/C metering system**

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Example of cost reduction
For a 2000 MTPD urea plant operated at 95% load, the savings amounted to:

**Example 1**
- **Savings**: Operating at partly loads, CHP was used. The savings in energy costs can be calculated as figures shown can be saved in the long term. A 5% saving in 45 operating areas and the overall saving in 5000 tons of coal a year will reduce the CHP bill of 150,000 per year.
- **Savings per day** = 800 USD
- **Savings per month** = 24,000 USD
- **Savings per year** = 288,000 USD

**Example 2**
- **Savings per day** = 800 USD
- **Savings per month** = 24,000 USD
- **Savings per year** = 288,000 USD

**Example 3**
- **Savings per day** = 800 USD
- **Savings per month** = 24,000 USD
- **Savings per year** = 288,000 USD

Due to more efficient production and increased capacity, Stamicarbon is convinced that the project made the most of the investment in the first year.

**Plant advantages**
Besides the fact that the investment in an N/C metering system both for existing plants and new projects were based on their decision to implement the N/C metering equipment on the following features of the system:
- **Environment protection through lower NH3 emissions and reduction of steam consumption**
- **Softer and more stable production profile**
- **Safer than taking manual samples**
- **Avoidance of production outages**

The users of the system are truly enthusiastic about the usefulness of the N/C metering system both for existing plants and new plants. They shared their benefits of the N/C metering system both for existing plants and new plants. They shared their benefits of the system with you in this brochure. But it is also important that companies SPIE are convinced from the unique N/C metering system and its other activities, SPIE provides industrial, energy, transport and telecommunications network services to public and private industrial and service sector customers. The company designs and builds equipment for its customers and assists them to run and maintain these systems. New customers are appointed to the company’s network of local companies throughout The Netherlands.

**SPIE vision**
SPIE relies on its employee’s expertise in the network of local companies throughout The Netherlands and specializes to develop and implement effective solutions to industrial, economic current and future requirements. SPIE provides customers with a number of services that helps them in the company’s fields of expertise. The company has an extensive network of regional offices and representatives undertaking tasks in each of the above-mentioned sectors.