“THE KAPP CO_2 CHILLER”

The Perfect Debottlenecking Tool of Any Urea Plant…

and Without Consuming Cold Energy from Your Existing Plant

Introduction

In most urea plants the CO_2 compressor is the bottleneck for further capacity increase. In summer conditions the CO_2 inlet temperature is typically higher than the design figure. Cooling back this temperature will increase the density and will increase the capacity of the CO_2 compressor. Some CO2 chillers make use of cold energy sources like existing the ammonia refrigeration compressor. In summer however many times also these cold energy sources form a bottleneck also.
KAPP Heat Transfer Engineers, together with UreaKnowHow.com developed **THE KAPP CO_2 CHILLER**, which cools the feed CO_2 temperature without using cold energy sources from the existing ammonia and urea plant. This paper will describe and evaluate three options for THE KAPP CO_2 CHILLER. All three options lead to extreme short pay back times as will be demonstrated below.

KAPP Heat Exchange Engineers is among the best and most innovative engineering agencies in the branch of heat transfer. The knowledge they have of the industry and its diversity allows us to go further than anyone else. Not only do they design and plan your heat transfer solution, they also take care of the total production, construction and maintenance of the installation. To do so, they have the best network of specialists and producers of components worldwide. For more information, refer to:
(http://www.ureaknowhow.com/ukh2/sponsors/1060-kapp.html)

Options

KAPP Heat Transfer Engineers and UreaKnowHow.com have detailed out and evaluated three options:

1. Cooling feed CO_2 with 20 bar feed ammonia
2. Cooling feed CO_2 with atmospheric feed ammonia
3. Cooling feed CO_2 with an external cold energy source

As a base case we take a 3500 metric tons per day (mtpd) Stamicarbon PoolCondenser urea plant with a CO_2 feed temperature of 45 ^oC in summer.
The optimum design for THE KAPP CO_2 CHILLER is a tube cooler as this type of heat exchanger leads to an extremely low pressure drop on the CO_2 side of only 600 Pa (0,06 bar), which is of course very important for a CO_2 chiller in order to maximize the density of the CO_2 at the inlet of the CO_2 compressor.

Option 1: Cooling feed CO_2 with 20 bar feed ammonia

The 80 TPH feed ammonia with a temperature of 17 °C will cool the 120 tons per hour (TPH) CO_2 feed of the urea plant from 45 °C to 26 °C. The CO_2 density will increase from 2,42 kg/m^3 to 2,60 kg/m^3 or an increase of 7%.

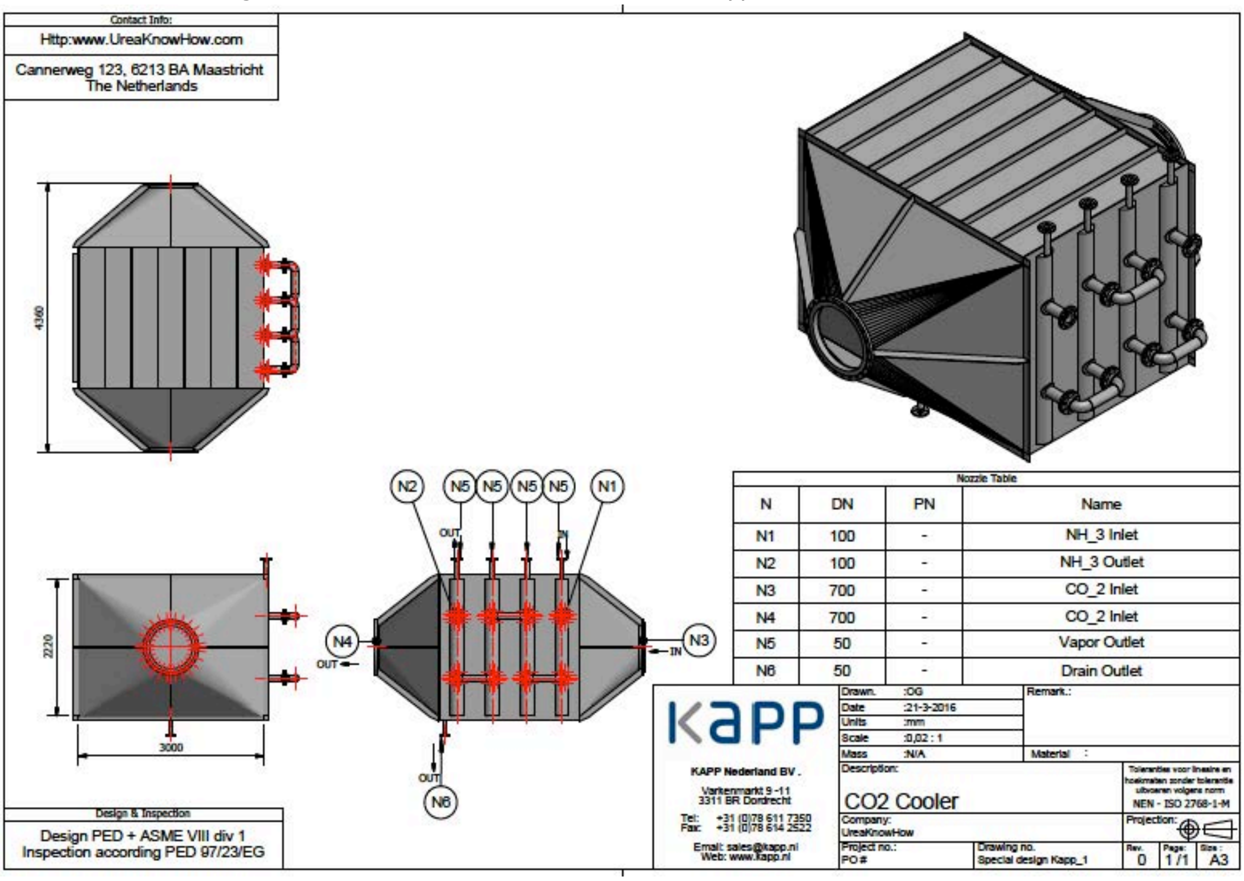
The higher CO_2 density will lead to the following benefits:

1. More load on the existing CO_2 compressor and more urea production capacity of some 5%. 5% more urea production during 6 months per year for a 3500 MTPD urea plant means an extra urea production of 31.500 metric tons per year (MTPA). Assuming profit margin of 100 US$/mt this means 3,15 mln US$ per year additional profit.
2. The higher CO_2 density will also lead to a lower steam consumption on the turbine when the plant load is not increased to a maximum extend.

Using the 20 bar feed ammonia as cooling medium leads to a further significant benefits:

3. No extra energy is required to cool the CO_2. On the contrary the CO_2 chiller provides energy as explained under the next point
4. The ammonia feed will increase from 17 °C to 28,5 °C, which leads to more LP steam production in the PoolCondenser. The extra duty is about 1260 kW, which equals some 2,1 TPH extra LP steam production. Low value heat is thus converted into high value heat.

Find below a drawing of the KAPP CO2 CHILLER with some typical overall dimensions.



Nozzle N1 and N2 are the NH_3 inlet and outlet, Nozzle N3 and N4 are the CO_2 inlet and outlet.
Nozzles N5 are the NH_3 vapor outlet on the NH_3 side, Nozzle N6 is the liquid drain on the CO_2 side.

Option 2: Cooling feed CO_2 with atmospheric feed ammonia

Atmospheric feed ammonia will first be heated up to 0 ^oC to avoid any ice formation on the CO_2 side of the chiller.
Then 80 TPH of atmospheric ammonia with a temperature of 0 ^oC will cool the 120 TPH CO_2 feed of the urea plant from 45 ^oC to 15 ^oC. The ammonia feed temperature will increase to 19 ^oC.
The CO_2 density will increase from 2,42 kg/m^3 to 2,72 kg/m^3 or an increase of 12%.

The higher CO_2 density will lead to the following benefits:

1. More load on the existing CO_2 compressor and more urea production capacity of some 10%. 10% more urea production during for example 6 months per year for a 3500 MTPD urea plant means an extra urea production of 63.000 MTPA. Assuming profit margin of 100 US$/mt this means 6,3 mln US$ per year extra profit.
2. The higher CO_2 density will also lead to a lower steam consumption on the turbine when the plant load is not increased to a maximum extend.

Using the atmospheric feed ammonia as cooling medium leads to a further significant benefits:

3. No extra energy is required to cool the CO_2.
4. The atmospheric ammonia will be freed from any inerts and hydrogen leading to higher temperatures in the urea synthesis section and to higher conversion figures in the urea reactor.
5. Plus minimized risks for any explosion.

Note: Ammonia delivered at about 18 bars contains inerts and hydrogen dissolved in it. Inerts decrease the conversion in the urea synthesis and hydrogen leads to explosion risks. Typical inert analysis figures are: Hydrogen content 0,01vol%, Nitrogen content 0,07vol%, Argon content 0,03vol%, Methane 0,09vol%. Ammonia from atmospheric storage does not contain anymore any inerts and hydrogen anymore as these are flashed off and thus is a better choice when going for max capacity and minimized risks for explosion.

Option 3: Cooling feed CO_2 with an external cold energy source

In the oil and gas industry it is quite common to rent an external cold energy source during summer conditions. With the continuously decreasing electrical power prices nowadays it becomes also very attractive to rent such a packaged unit in ammonia and urea plant.
The company AGGREKO (www.aggreko.nl) from the Netherlands for example provides these services worldwide. Find some picture of these units below.


These units can realise upto 1500 kW cooling capacity, sufficient the CO_2 chiller of a 3500 mtpd urea plant. KAPP Heat Exchange Engineers is very well capable to adapt the design of the CO_2 chiller to such a cooling unit and one can rent the unit and connect it to the CO_2 chiller during summer only.

For example, when renting two Aggreko WCC800 units at ambient conditions of 50 °C and 50 Hz power frequency the optimum chilled water temperature and delta-T is 15 and 6 °C. With this cooling capacity we can cool 120 TPH CO_2 from 45 °C to 22,8 °C with a density of 2,63 kg/m^3. This is a density increase of more than 8%, thus even better than cooling with feed ammonia.

The WCC800 air-cooled fluid chiller (refer to picture on the right side) has been specially designed for the demanding rental market, to meet the different temperature control needs of many industry sectors, including food and beverage, refining, chemicals, utilities and manufacturing.
The units, suitable for wide voltage (380 / 480 Volt) and frequency range (50 and 60 Hz), can operate in ambient temperatures ranging from -18 °C to +50 °C and deliver fluid from -12 °C to +15°C.
High cooling capacity and increased coefficient of performance (COP) were key drivers for this innovative unit, which achieves 742 kW cooling capacity at Eurovent normalised conditions and a COP of 3,10.
All fans are inverter controlled to save energy and reduce noise, with a built-in sound enclosure for compressors. As with any other Aggreko chillers, the WCC800 is fitted with Aggreko's own remote operating system and uses environmentally friendly R134a refrigerant.

This option minimizes the investment costs and requires only some power consumption, still realising a very short pay back time.
A budgetary average price for 1400 kW of chillers with associated hoses, pump, cables and manuals valves amounts to about 25 kUS$ per month. This is an average price based on the countries in the Middle East Aggreko operates in.

The higher CO_2 density will lead to the following benefits:

1. More load on the existing CO_2 compressor and more urea production capacity of some 5%. 5% more urea production during 6 months per year for a 3500 MTPD urea plant means an extra urea production of 31.500 metric tons per year (MTPA). Assuming profit margin of 100 US$/mt this means 3,15 mln US$ per year additional profit.
2. The higher CO_2 density will also lead to a lower steam consumption on the turbine when the plant load is not increased to a maximum extend.

Using the Aggreko chilling unit as cooling medium leads to a further significant benefits:

3. No impact on the existing cold energy sources
4. No additional investment costs required
5. Very limited rental costs only during summer
6. High flexibility to use the cold energy from the Aggreko chilling unit wherever needed.

As an alternative cold energy source, it is also possible to make use of a vapor absorption recovery (VAR) technology to produce chilled water instead of the compressor technology used by Aggreko. Also with VAR technology KAPP Heat Transfer Engineers can design for you an optimum CO_2 chiller design.

The KAPP CO_2 CHILLER finally has another significant benefit:
Many times CO_2 compressor internals gets fouled by carry over of washing solution from the CO_2 washing section in the ammonia plant. This fouling leads to lower capacities and vibration issues. The KAPP CO_2 chiller will condense the washing liquid reducing to a significant extent any future fouling problems.

For more information or a customised design for your plant, contact:

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