SOLEX THERMAL SCIENCE

World leaders in the science of heating and cooling bulk solids.

CASE STUDY

The SOLEX COOLER for Fertilizer

GENERAL INTRODUCTION

The rotary drum and fluid bed have been the Fertilizer Industry standards for cooling fertilizer prills and granules for many years. Solex Thermal Science Inc., a former technology group of Cominco Engineering Services Ltd., designs equipment for heating or cooling bulk solids using the indirect heat transfer technology developed approximately 15 years ago. This technology has been developed by Cominco Fertilizers, (now Agrium Inc.), at their Carseland plant near Calgary, Alberta, Canada.

The driving force behind this development was the high cost of retrofitting a fluid bed cooler, particularly to provide the air handling and wet scrubbing system.

The Solex Heat Exchanger technology has found a niche in the Powder and Bulk Solids Handling Industry and particularly the fertilizer industry where it is recognized as one of the most significant technological developments of the last few years. Some of the reasons for the use in more than 60 fertilizer plants are:

- Innovative, yet very simple technology.
- The Solex Heat Exchanger offers technical advantages at lower capital and operating costs.
- It is the ideal solution for retrofitting.

TYPICAL DOUBLE BANK FERTILIZER COOLER

VIBRATING FEEDER

DESCRIPTION OF TECHNOLOGY

The Solex Heat Exchanger is a simple piece of equipment designed for cooling fertilizer prills and granules. This technology combines mass flow of bulk solids with conventional plate heat exchanger design.

In the Solex Heat Exchanger, the material passes in mass flow through vertical banks of hollow stainless steel plates. The cooling water is circulated through the plates in counter-flow for better thermal efficiency. The plates are connected to the inlet and outlet manifolds with flexible stainless steel hoses. All screwed connections are outside the product flow to avoid any contamination of the product.

Below the plate bank a mass flow discharge device creates mass flow and controls the product flowrate through the exchanger. This can be a gate feeder (mass flow cone with a gate) or a vibratory feeder.

The product moves slowly by gravity through the unit to create a sufficient residence time to achieve the required cooling. The slow material movement ensures that there is no dust formation and no product degradation. The unit is always full of material when it is in operation to ensure better heat transfer control and to prevent condensation. A level control system ensures that the unit operates at its optimum configuration.

IMPORTANCE OF THE STORAGE TEMPERATURE

Fertilizer prills and granules are hygroscopic products, MAP and NPK more than AN or Urea, but for all products it is important to store and package at the appropriate temperature to prevent caking during storage or long term bulk transportation. Caking can be a severe quality issue, resulting in breakage, fines, handling difficulties, a lower selling price and ultimately unhappy customers.

It is the tendency in the fertilizer industry to boost the plant capacity over the name plate capacity and all plant managers are proud to report a significant increase in production. This results in increasing temperatures after the prilling tower or after the cooler and the product arrives at the warehouse with a higher temperature than designed.

Another market trend is to produce bigger prills and granules. Bigger prills do not cool as much in the prill tower and additionally there is a larger temperature gradient within the granule: the outside is cooled well whereas the inside still has a higher temperature including a higher content in moisture. During storage, the temperature will be equalized between the inside and the surface of the granules and also between the center and the outside of the bulk, i.e. the temperature at the outside increases and evaporated water in the surrounding air can migrate to the granule surface: caking will take place.

This can be avoided by:
1. Low moisture content - max 0.25 % for prilled urea
2. Low storage temperature, - typical 40-50°C depending on the product

The moisture content is determined by the quality of the dryer or the prilling bucket in the prill tower. The temperature can be controlled by installing an additional cooler in granulation plants or a cooler in prilling plants where usually no cooler is included in the original design.

Especially for these retrofitting applications, the Solex cooler is the preferred choice with the unique indirect heat exchange technology for solids. It offers many significant advantages compared to the rotary drum and fluid bed type coolers using air in direct contact with the product:

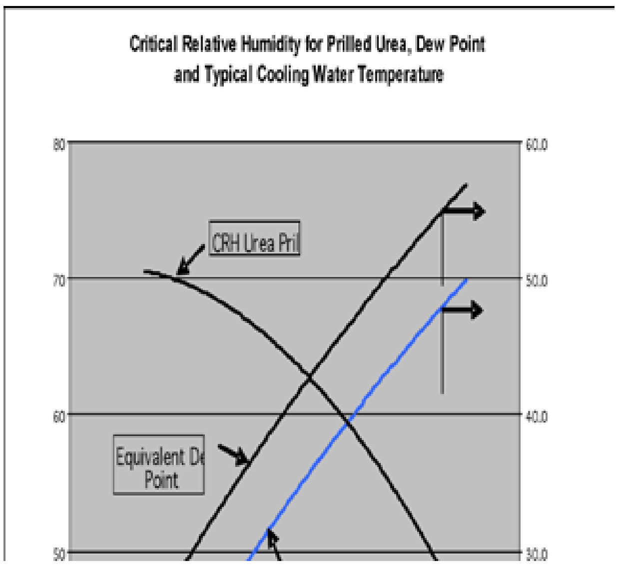
- No air conditioning unit to produce dry and cool air is needed.
- No additional or new wet scrubber system is needed
- Small additional load on the cooling water system
- Very little additional power consumption
- Little floor space required
- Easy to install – very simple instrumentation and control
- Almost no moving parts – no mechanical maintenance
- Smooth gravity flow: no product degradation and dust formation. The gentle product handling also makes it ideal for soft grades.
- Thermally high efficiency and large capacity - up to 150 tph in one single cooler

THE DANGER OF CONDENSATION

Especially in hot and humid ambient conditions as found in India, the danger of condensation on the cold plates has to be considered as a real threat. Condensation can lead to caking on the plates reducing the thermal performance of the exchanger. However Solex has many successful applications in tropical areas such as Brazil, Florida, The Philippines, Malaysia and Northern Australia. Tests and the experience of our customers have shown that condensation can be avoided by a combination of two “tools”:

1. Use of "warm" cooling water in the upper plate bank.

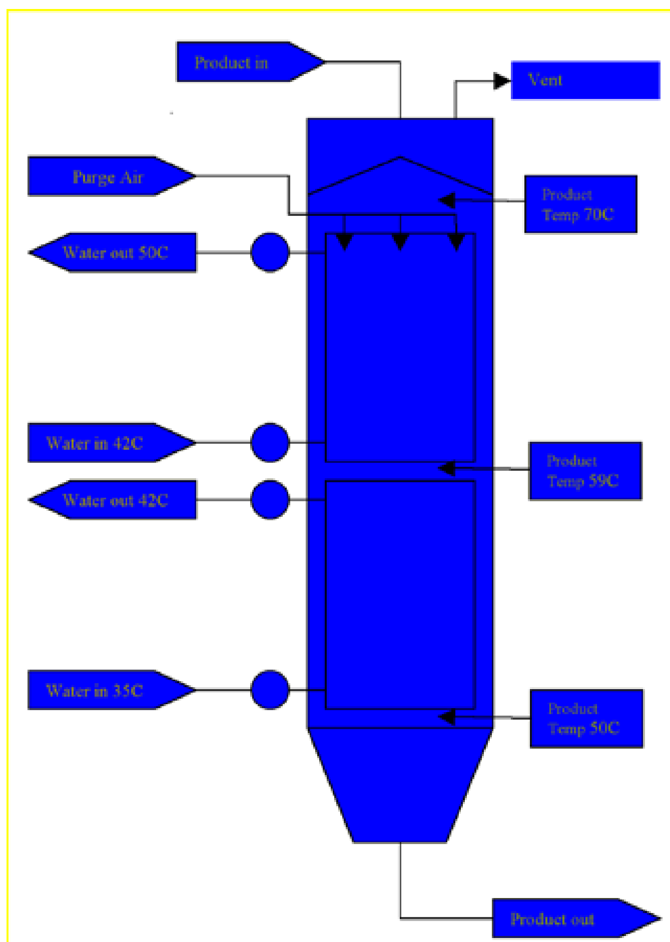
Condensation will not occur if the temperature of the exchanger plates is above the dew point of the entrained air. The dew point of the entrained air can easily be determined from a Critical Relative Humidity[1] (CRH) graph of the product. The following graph shows the CRH for freshly prilled urea. Plotted on the same graph is a dew point curve for air that corresponds to air at the same temperature and RH as the urea prills. The dew point curve represents a theoretical minimum water temperature curve to ensure that there is no condensation.



[1] *CRITICAL RELATIVE HUMIDITY IS THE VALUE OF THE RELATIVE HUMIDITY OF THE SURROUNDING AIR ABOVE WHICH A FERTILIZER WILL ABSORB MOISTURE AND BELOW WHICH IT DOES NOT. THE DEW POINT IS HIGHEST AT THE TOP OF THE EXCHANGER CORRESPONDING TO THE MAXIMUM PRODUCT TEMPERATURE AND SLOWLY FALLS AS THE PRODUCT TEMPERATURE FALLS.*

2. Use of Dry Purge Air at the Top of the Plate Bank:

A small volume of dry air is injected at the top of the exchanger where the condensation is most likely to occur. The purge air replaces the moist ambient air that enters the Cooler with the product; it also "dilutes" the entrained air, thereby lowering the dew point and the corresponding water temperature. By adding a small volume of purge air, (typically in the range 200 – 300 NmP3P/h) water temperatures can be reduced which improves the thermal efficiency of the exchanger. The typical water temperature with Purge Air is also shown on the graph.



Typical Schematic for Double Bank Urea Prill Cooler

We design the exchanger with a water temperature profile over the height of the bank, warm water at the top and progressively cooler water towards the bottom. This is easily achieved in the Solex fertilizer coolers since they are designed as multiple bank units with 2, 3 or even 4 banks of exchanger plates mounted in series. This design with multiple banks in series allows each bank to operate on an independent water circuit, with temperature control for each circuit. In addition the water flow in each bank is counter-flow which further helps to achieve the desired temperature profile. This way water temperature is optimized to prevent condensation and caking but maximize the thermal efficiency. The multiple bank design has the added advantage of higher thermal efficiency than a single bank, this is achieved by horizontally off-setting the plates between each bank.

PRODUCT ABRASION, DUST FORMATION, CLEANING

The product flows through the Solex cooler by gravity with a very low velocity. This is important to guarantee a long residence time for sufficient and even cooling. The typical residence time is 5-10 min. The slow movement avoids any product degradation and dust formation. Tests have shown no measurable quantity of fines are created as the product flows through the cooler, correspondingly no fines have to be removed after the cooler.

The flow pattern is laminar and there is no mechanical handling and moving of the particles. Therefore the Solex cooler is ideal also for soft and friable grades.

Certain grades of product may cause a slow build up of product on the inside of the cooler and on the exchanger plates. Over a period of time this will slowly reduce the cooling performance of the exchanger (although a fouling factor is incorporated into the thermal design of the exchanger). At some point cleaning will be necessary, this is easily done by washing with water and drying with a counter-current of warm air. Typically the exchanger can be washed and dried in a 4 to 8 hour period and can easily be fitted into a normal plant maintenance schedule

CAPITAL & OPERATING COST

INSTALLED CAPITAL COST

It is essential when carrying out the cost comparison between different methods of cooling to include the entire system. Typical system requirements for fluid bed compared to Solex Cooler are as follows:

Fluid Bed Cooler System	Solex Cooler System
Fluid Bed Cooler	Solex Cooler
Fans	Bucket Elevator *
Air chiller	Cooling Water Pump
Air preheater	Dry air system (if not existing)
Scrubber + ancillary equipment	Cooling water piping
Large diameter air ducting	

** DEPENDING ON PLANT LAYOUT*

It is difficult to give accurate capital cost data comparing the 2 systems since there are so many variables, particularly in a plant retrofit. However several case studies show that a installed capital cost will be approximately 2/3 of the cost of a comparable fluid bed system.

Based on a very rough rule of thumb showing installed capital cost as 2 times the Solex Cooler cost, the installed capital cost for the urea prill cooler vs. the fluid bed cooler sized for the process conditions described above is shown in Fig. 5.

OPERATING COST

A fluid bed cooler requires large horsepower fans, typically 2. One a forced draft fan supplying air to the fluid bed cooler, a second induced draft fan is required following the scrubber.

Additional energy requirements in a fluid bed system are for the air chiller, recompressing ammonia, and steam for the air pre-heater.

The Solex Cooler eliminates the majority of this energy demand, with small horsepower requirements for the cooling water pump, bucket elevator and purge air system. Typically a urea granulation plant fitted with a Solex Cooler will save 4 –5 kW.h/tonne, see graph of energy consumption.