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THERMAL SCIENCE

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

CASE STUDY

The Solex Heat Exchanger – A Better Way to Cool Sugar Crystals

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INTRODUCTION

In order to prevent caking and maintain product quality in storage and packaging, sugar crystals must be cooled to a uniform temperature. The traditional ways of cooling sugar included drum coolers or fluid bed coolers that use large amounts of air and energy to provide the necessary cooling. Recently, the Solex Heat Exchanger was introduced to the sugar industry. This technology has been used successfully in the past 15 years for heating and cooling many types of bulk solids including fertilizer granules, plastic pellets, detergent powders and chemical products. Now, with 12 sugar coolers installed in Europe and North America, the Solex Heat Exchanger has quickly been established as a proven and cost effective method of cooling sugar crystals.

The paper will provide a description of this new technology as it applies to cooling sugar. Recent installation will be profiled, with particular reference to energy savings and product quality improvements.

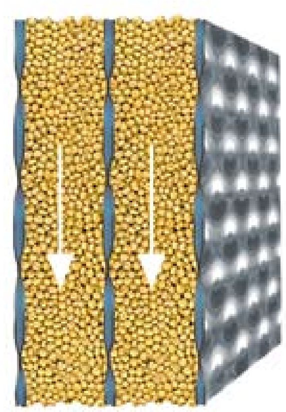
DESCRIPTION OF THE TECHNOLOGY

The Solex Heat Exchanger cools bulk solids by combining a welded plate heat exchanger with mass flow design.

The equipment includes a vertical assembly of welded stainless steel heat exchanger plates and a mass flow discharge feeder mounted below the plate bank. Instead of air, the exchanger uses cooling water passing through welded, hollow stainless steel plates. Free-flowing bulk solids pass slowly through the vertical channels between the heat exchanger plates. This 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.

MASS FLOW DESIGN

The heat exchanger plates are spaced to ensure reliable flow. With the mass flow design of the equipment, all of the material is in motion with uniform velocity over the full cross-section of the heat exchanger.



A specially designed feeder is mounted below the plate bank to control the discharge rate of the product and to achieve mass flow through the equipment. This results in a “first-in-first-out” sequence, an important element in the design of the Solex Heat Exchanger.

INDIRECT COOLING BY CONDUCTION

For cooling, water or glycol is circulated through the heat exchanger plates. For maximum efficiency, the heat transfer fluid flows counter-current to the product flow. The vertical configuration of heat exchanger plates provides a large heat transfer surface in a compact unit. Unlike rotary drum or fluid bed processors where air is in contact with the product, this indirect method of heat transfer maintains product quality while eliminating the need for costly air handling equipment.

Multiple plate banks can be mounted in a single piece of equipment. This configuration operates with a higher thermal efficiency by offsetting the heat exchanger plates in each bank.

HEAT EXCHANGER PLATES

The stainless steel heat exchanger plates are fully welded and require no gaskets. To make the plates, two panels are laser or resistance welded together in a preset pattern of spot welds. Perimeter and pass seam welds are completed, followed by installation of the welded inlet and outlet tube connections. Weld discoloration is removed by pickling.

The welded plates are hydraulically inflated under controlled conditions to provide uniform corrugations, or dimples. These dimples create turbulent flow inside the plate resulting in efficient heat transfer. The heat exchanger plates have a low profile with smooth and uniform heat transfer surfaces exceptionally resistant to fouling.

PLATE BANK AND COOLING WATER MANIFOLDS

The finished heat exchanger plates are installed in a stainless steel casing with access doors to allow easy cleaning and inspection. The connections to the pipe manifolds are made on the exterior of the casing with flexible stainless steel hoses. The completed assembly is then hydrotested before shipping.

MASS FLOW DISCHARGE FEEDER

The Solex Heat Exchanger is engineered with a mass flow discharge feeder that regulates the product feed rate through the equipment. The discharge feeder is mounted directly below the plate bank and material is fed uniformly over the entire cross section of the heat exchanger.

The vibrating feeder operates effectively for a wide range of free-flowing bulk solids. A suspended rectangular tray with fixed internal louvers controls the material flow. Two counter-rotating vibrator motors, controlled by a variable frequency drive, apply a small amplitude of motion to the feeder. The material feed rate depends on the feeder's vibration frequency—the higher the frequency of operation, the faster the discharge rate. There are no internal moving parts and therefore, no product degradation.

SOLEX HEAT EXCHANGER CONTROL SYSTEM

The Solex Heat Exchanger employs a simple, yet effective level control system. The inlet hopper distributes incoming product evenly into the heat exchanger plate bank, forming a conical pile. The bulk solids then pass slowly through the plate bank with sufficient residence time to obtain the specified product temperature. The discharge feeder regulates the product flow.
For continuous operation, the control system varies the rate of the discharge feeder to maintain a preset level in the inlet hopper. For batches, the Solex Heat Exchanger can also operate between high and low level switches maintaining the product level above the heat exchanger plates.

Product temperature is typically measured at the inlet and outlet of the heat exchanger. Recirculating or modulating the temperature of the heat transfer fluid can be used to control product temperature.

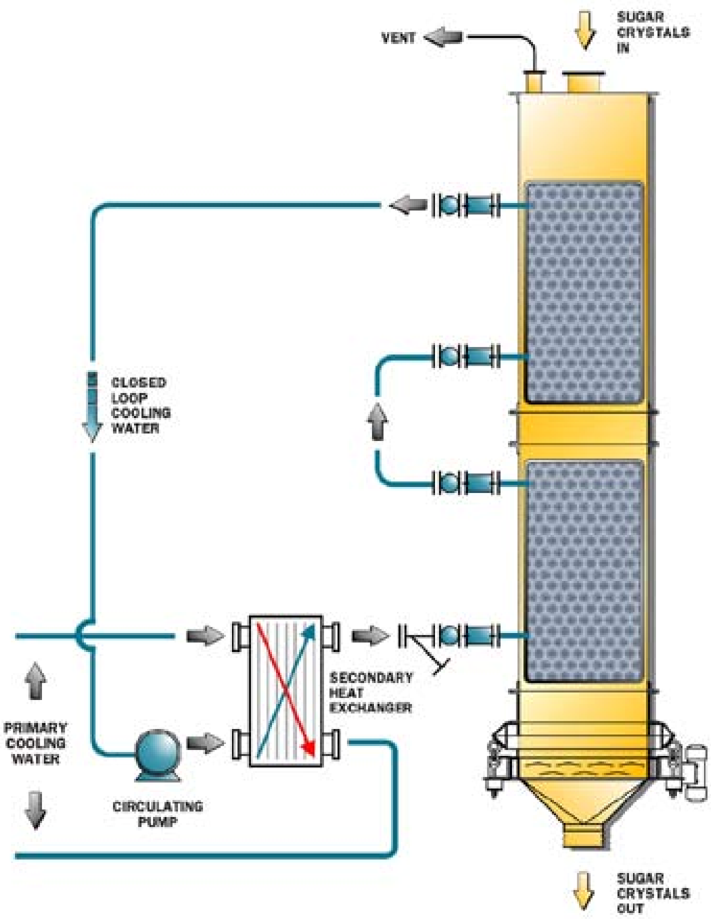


FIGURE – TYPICAL SCHEMATIC FOR DOUBLE BANK SUGAR COOLER WITH CLOSED-LOOP COOLING WATER

CASE STUDY 1 – DANISCO SUGAR, KÖPINGEBRO, SWEDEN

Danisco Sugar is the fourth largest sugar producer in Europe. From 1997-2000, the Danisco plant located in the small town of Köpingebro in the south of Sweden increased its capacity by 40 percent, producing 85,000 kg/hr of granulated sugar. With the increased rates, Danisco found that the cooling capacity of their existing equipment was no longer sufficient to meet their needs. The sugar temperature had increased to approx. 35-40°C which created a problem since the recommended temperature to prevent caking and maintain product quality in storage is below 30°C. The engineers at Danisco were on the lookout for a more cost effective solution and decided to evaluate the Solex Heat Exchanger.

An on-site pilot test was carried out at the plant in November of 2000, and after two weeks of positive trials, the management, engineering and maintenance departments of Danisco fully endorsed the selection of this equipment for their plant. The Solex sugar cooler was started up successfully in time for the next sugar campaign staring in September 2001.

DANISCO SUGAR, KÖPINGEBRO, SWEDEN

PROCESS DATA	
Design Flowrate	85,000 kg/h
Sugar Crystal Size	0.5 mm
Sugar Inlet Temperature	40°C
Sugar Outlet Temperature	25°C
Specific Heat of Sugar	0.31 kcal/kg.°C
Moisture Content	0.03%
Bulk Density	880 kg/m3
Cooling media	Dowcal/Water
Cooling Water Temperature	16°C
Cooling Water Flowrate	155 m3/h
FABRICATION SPECIFICATION	
Heat exchanger plates	SS316L
Cooling water manifold	SS316L
Heat exchanger casing	SS304L
Discharge Feeder	SS304L
Surface Finish	Pickle and passivate
Gasket Material	Food Grade Silicone

Based on a report provided to Solex by Mr.Bo-Anders Persson of Danisco, the following observations and conclusions were made after the first campaign:

Installation Costs: Compared to fluid bed and drum coolers, the investment cost for the installation was lower. The equipment is compact and is easy to install.

Cooling Performance: At full capacity, Danisco found that the equipment met or exceeded the expected cooling duty, cooling 85 mtph of sugar from 40°C to 25°C with cooling water supplied at 16°C.

Sugar Quality: Danisco found that the quality of the sugar was maintained or improved through the Solex Cooler. The product had a lower relative humidity in the outlet than theoretically expected. The Solex Cooler minimized abrasion of the product compared to other types of coolers, resulting in less sugar dust and higher quality product.

Maintenance and Operation: Danisco found that the Solex cooler had very low maintenance costs because there are few moving parts, and the equipment is easily operated. Operating costs were low with less than 100 kW installed electrical power, including equipment such as new conveyors, dry cooler fans and cooling water pump associated with the cooler installation.

No Emissions: Since the equipment does not use any air to cool the sugar, there are no emissions and there is no sugar sent to remelting.

BUCKET ELEVATOR TO TOP OF SOLEX COOLER

TOP VIEW OF INLET HOPPER

COARSE SCREEN INSIDE INLET HOPPER

SUGAR LEVEL INSIDE COOLER INLET HOPPER

VIBRATING DISCHARGE FEEDER

CHILLER FOR COOLING WATER

CASE STUDY 2 – SUGAR REFINERY OF R.A.R., PORTO, PORTUGAL

The main target at R.A.R. in Portugal was to reduce lump formation in the 1 ton bags and 50 kg bags. Before the sugar cooler was installed, sugar was cooled with ambient air, so the sugar temperature leaving the dryer was dependent on the ambient temperature (max. 45°C in summer and min. 20°C in winter; relative humidity is fairly constant at 60%). In same cases, during summer, the temperature difference between the sugar leaving the dryer and storage ambient was higher than 20°C. As a result, caking occurred at the warehouse and they received a lot of customer complaints, sugar returns and reprocessing costs.

The following cooling solutions were evaluated by R.A.R:

- Fluid bed dryer: not considered because of available space
- Cooling air conditioning system for the rotary dryer: not accepted because of high energy consumption (164 kW)
- Construction of a silo: not considered due to high capital cost
- Installation of a sugar cooler. Solex Cooler was selected due to low installed cost and low energy consumption in comparison to alternatives. Total electrical consumption by the Solex Cooler system is 15 kW.

R.A.R., PORTO, PORTUGAL

PROCESS DATA	
Design Flowrate	28,000 kg/h
Sugar Crystal Size	0.55 mm
Sugar Inlet Temperature	45°C
Sugar Outlet Temperature	30°C
Cooling media	Water
Cooling Water Temperature	20°C
Cooling Water Flowrate	43 m3/h
FABRICATION SPECIFICATION	
Heat exchanger plates	SS316L
Cooling water manifold	SS304L
Heat exchanger casing	SS304L
Discharge Feeder	SS304L
Surface Finish	Pickle and passivate
Gasket Material	Food Grade Silicone

R.A.R. – INLET HOPPER

R.A.R – SUGAR INSIDE COOLER AND LEVEL PROBE

R.A.R. – SUGAR COOLER

R.A.R – SUGAR COOLER AND VIBRATING FEEDE