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THERMAL SCIENCE

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CASE STUDY

The Solex Heat Exchanger for Cooling Sugar Crystals.

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The rotary drum, fluid bed, and water-cooled screw conveyor have been the powder and bulk solids handling industry standards for heating or cooling bulk solids for many years. In this article Claudio Forniciov takes a look at specialty designed equipment for heating or cooling bulk solids with technology developed approximately ten years ago by Cominco Fertilizers, (now Agrium Inc). 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 innovative yet very simple technology of the Solex Heat Exchanger has enabled it to find a niche in the powder and bulk solids handling industry worldwide.

The Solex Heat Exchanger is a simple piece of equipment designed for heating or cooling powder and bulk solids. This technology combines mass flow of bulk solids with conventional heat exchanger design.

DESCRIPTION OF TECHNOLOGY

In this heat exchanger, the material passes in mass flow through a vertical bank of hollow stainless steel plates. For cooling applications, water is circulated through the plates. For heating duties, steam is commonly used, but hot water or a heat transfer oil can also be used. The plates have welded connections to inlet and outlet manifolds. As with conventional liquid or gas exchangers, the heat transfer fluid and product flows are counter-current to gain greater thermal efficiency. Below the plate bank is a mass flow discharge device termed a vibratory feeder, which creates mass flow and controls material flowrate through the exchanger.

The material moves slowly through the unit to create a sufficient residence time to achieve the required heating or 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 formation. A level control system ensures that the unit operates at its optimum configuration.

Indirect heat exchange, a feature of this heat exchanger, offers several advantages over the rotary drum and fluid bed type coolers that use air in direct contact with the product.
These advantages include:

- **No air handling requirements** – Eliminates emissions.
- **Gentle product handling** – No product degradation, low abrasion, mass flow design.
- **Low operating cost** – Substantial reduction in operating costs as the only drive required is for a water pump.
- **Low installed capital cost** – Much simpler system without ancillary equipment such as fans, scrubbers, or ductwork.
- **Low space requirement** – Equipment is compact and operates by means of gravity flow resulting in a small ‘floor space’ which makes it easier to install in an existing plant

Heating or cooling a powder or a bulk solid material is a common step in many chemical processes. Cooling is generally one of the final steps in the process, and frequently follows drying. Heating

is less common but would often be to preheat a raw material or intermediate product prior to a chemical reaction. The chemical industry is very diverse and there are countless situations where heating or cooling is required.

Powders and bulk solids must often be cooled prior to packaging to allow safe handling and storage in bags or safe loading into rail cars trucks or ships. Many solid materials are hygroscopic and must be cooled before storage. This prevents moisture migration from the ambient air and stops material from lumping and caking.

PROBLEMS FACING THE POWDER AND BULK SOLIDS HANDLING INDUSTRY

Some of the problems the powder and bulk solids handling industry is faced with using traditional cooling and heating technology can be described as follows:

- **Emissions** – Powder and bulk solids manufacturing facilities are recognized as having relatively high air emissions. Permissible limits of emissions from stacks are being reduced around the world. The major sources of emissions are from prill towers, granulators, dryers and air coolers.
- **High retrofitting costs for fluid bed coolers and drum coolers** – This occurs particularly in providing or upgrading air handling systems and the wet scrubbing system associated with it.
- **Quality issues** – It is important to have effective cooling of powder and bulk solids prior to storage or packaging. Many powders and bulk solids have a tendency to cake in storage if they are stored at elevated temperatures. If the product is not effectively cooled it can lead to rejection of the product by customers, create production loss, or it can cause a decrease in potential production capacity.
- **Increasing production** (debottlenecking) – When retrofitting existing plants, space is at a premium, which makes it difficult to install large equipment. In addition, new equipment imposes extra loads on plant utilities which significantly increases overall power consumption. In the case of rotary drum or fluid bed coolers, the fan motors do draw high electrical loads. It may also require upgrading the electrical distribution system and finding space in a frequently overcrowded MCC room.
- **Installation costs of new equipment can be very high** – Standard cooling and heating equipment such as rotary drums, fluid bed coolers, water cooled trays and screw conveyors have relatively high installed capital costs. In some cases, there is the need for associated pollution control equipment which increases costs.
- **Operating costs** – Large horsepower fans used in fluid bed coolers and drum coolers have high associated operating costs.

SOLUTIONS OFFERED BY THE NEW TECHNOLOGY

The new technology offers effective solutions to all of the above-mentioned problems that are normally associated with heating or cooling powder and bulk solids.

- **Emissions** – Changing to a Solex Heat Exchanger eliminates emissions from the cooling step as it does not use air in direct contact with the product. As such, there is no need for pollution control equipment and tight emission limits can easily be met.
- **High retrofitting costs for fluid bed coolers and drum coolers** – The heat exchanger does not require any ancillary equipment. Therefore, it provides a cost-effective solution in comparison to drum or fluid bed cooling equipment.
- **Quality issues** – The heat exchanger provides efficient heat transfer performance incorporating mass flow design without product degradation or abrasion. For cooling applications, the product is cooled by indirect heat transfer with water-cooled plates allowing for low product temperatures even in hot summer months. Lower temperatures provide safe handling and packaging as well as preventing caking or lumping of material in storage.
- **Increasing production** (debottlenecking) – The only significant utility that the Solex Heat Exchanger requires is cooling water, (for cooling), or steam, (for heating). In both cases, the heat transfer load is relatively low. In cases where cooling water is required, existing cooling towers are usually sufficient to accommodate the extra load.
- **Operating costs** – The only power consumption associated with operation of this heat exchanger is the drive for the cooling water pump. The water pump yields a very low annual electrical cost in comparison to a fluid bed cooler or drum cooler.
- **Installation costs of new equipment can be very high** – Due to simple vertical construction and high modularity, this heat exchanger can be erected in a timely and cost-effective manner. Without the need for ancillary equipment, the unit can offer considerable savings when installed in a new or existing facility.

WHERE DOES THE HEAT EXCHANGER FIT IN THE PROCESS?

In a typical process for plastic pellet manufacturing, the heat exchanger would find its place after the drying step and before packaging or bulk storage. It can also be used as a heater for odour removal in conjunction with an air purge system or for pre-heating powders prior to extrusion so as to enhance the overall efficiency of the process.

CONCLUSION

The new technology offered by this particular heat exchanger is an alternative method for cooling or heating bulk plastic products. It offers many advantages over traditional technologies, particularly zero emissions, small space requirements and very low energy costs.

The technology can also be used effectively for cooling or heating various plastic products (pellets or powder) in a variety of different applications. Some typical products would be: HDPE, LDPE, LLDPE, ABS, TPU, PVC, PP, NYLON-66, EPR, to cite just a few.

CASE STUDY

When a project is conceived, the objectives to be considered in new plants or debottlenecking projects can include improving product quality, eliminating emissions, and/or attaining lower operating costs.

Elastogran GmbH decided to install a Solex Heat Exchanger at their plant in Lemförde, Germany in order to obtain effective cooling of its TPU plastic product before storage. It was decided that the Solex Cooler offered an efficient way of cooling the product producing the required residence time in the unit in order to obtain the correct product consistency and quality required by the Elastogran specification.

The unit was installed downstream of a Fluid Bed Dryer in order to cool the hot product from approximately 90°C down to approximately 30°C. The product is pneumatically conveyed to the inlet hopper of the cooler and the batch addition is controlled such that the plates are always covered with product. This ensures full use of the existing heat transfer area and prevents humid ambient air from coming into contact with the cold plates. Cooling water at 20°C is circulated through the cooling plates, countercurrent to the product flow.

The cooled product is discharged from the exchanger via a Mass Flow Discharge Hopper that ensures uniform product flow through the unit thereby maintaining even temperature distribution. The product is then directed to a rotary valve, which regulates product flow rate and provides the required residence time in the unit. The valve also provides a pressure seal between the exchanger and the pneumatic transport system, which conveys the cooled product from the outlet of the unit to the location of the storage bins. The unit has been operating well within design parameters and to the full satisfaction of Elastogran.

ABOUT THE AUTHOR

Claudio Forniciov graduated with a BSc in Chemical Engineering from the University of Alberta, Edmonton, Canada in 1989. He is a member of APEGGA (Association of Professional Engineers, Geologists and Geophysicists of Alberta, Canada) and of AIChE (American Institute of Chemical Engineers -- US). Prior to 1990 when he joined Cominco Engineering Services, whose Bulkflow division later (in 1999) became Bulkflow Technologies Inc, he was Reservoir Engineer at Alberta Energy Company where he was responsible for reservoir simulations.Since 1994 he has been Technical Manager at Cominco Engineering Services in Calgary, Alberta, & Cominco Engineering Services Europe, Winterswijk, The Netherlands. He is now responsible for developing the European Market for The Solex Heat Exchanger and for the design, start-up and commissioning of the various bulk solids exchangers installed in Europe in the chemical process industry as well as other industries.