

ADVANCED COOLING TECHNOLOGY HELPS INGENIO TRES VALLES INCREASE CAPACITY

By

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Abstract

IN 2006, Ingenio Tres Valles S.A. wanted to increase their plant production capacity and considered various ways in which this could be accomplished. Increasing the capacity in the drying and cooling sections was one of the requirements to ensure a top quality product. The challenges they faced were to select efficient technologies that would fit in the available space, utilise existing equipment where possible and offer the most cost effective solution. To increase the drying capacity of refined sugar, the decision was made to convert the existing rotary drum cooler to a rotary dryer. The next step was to add a stand-alone cooler. Tres Valles evaluated several options for the cooler; a fluid bed cooler, a rotary cooler and an indirect plate cooler. The indirect plate cooler operates on the principle of mass flow of sugar through a vertical bank of water cooled plates. After a thorough evaluation, Tres Valles selected an indirect plate cooler from Solex Thermal Science since the vertical configuration and small cross section fit easily into their existing facility. The indirect plate cooler also offered the most cost effective and energy efficient solution. The equipment was installed and commissioned in January 2008 in time for the seasonal operating campaign. The new drying/cooling configuration is now in the second operating campaign and has successfully played a role in increasing sugar production capacity at Ingenio Tres Valles. Quality objectives have been fully achieved and the equipment has met and exceeded the energy efficiency targets.

Introduction

The Ingenio Tres Valles S.A. plant in Veracruz, Mexico was operating with the conventional arrangement of two rotary dryer/cooler drums, each operating at the maximum capacity of 35 t/h. Tres Valles set plant objectives to increase capacity to a production rate of 75 t/h and improve product quality. From a quality perspective, they wanted to reduce 'lumping' of the product that was occurring due to moisture and temperature upsets which, in the 2006/2007 operating campaign, resulted in six quality claims against them from customers.

A technical and economic analysis was carried out to determine the best way to increase drying and cooling capacity as well as improve the quality and consistency of the product at the desired increased production rates.

With the deregulation of the sugar industry in Mexico, quality is becoming an increasingly important consideration with customers. Customers may require final product quality to be certified according to (among others):

- ISO 9001–2000;
- Hazard Analysis and Critical Control Point (HACCP);

- FDA (Federal Drug Administration);
- Kosher.

With this in mind, Ingenio Tres Valles required their production process to be able to meet these standards as this would help to differentiate them in the Mexican sugar market. In the short term, it was planned to ship some product in 1500 kg super sacks where there is an increased tendency for caking if the sugar is not fully dried and cooled.

Tendency for caking

The mechanism for sugar forming a 'cake' or 'lump' is caused by moisture migration through the sugar as illustrated in Figure 1. The moisture migration causes a 'cement' to form between adjacent crystals where they touch, forming a weak bond which leads to 'lumping'. Moisture migration through the sugar is caused by the temperature gradient between the sugar and the ambient conditions. These conditions exist when sugar is stored or put in bags at too high a temperature. The requirement is to store the sugar close to ambient temperatures. Typically sugar is cooled to a temperature within 5°C of ambient which minimises the risk of agglomeration.

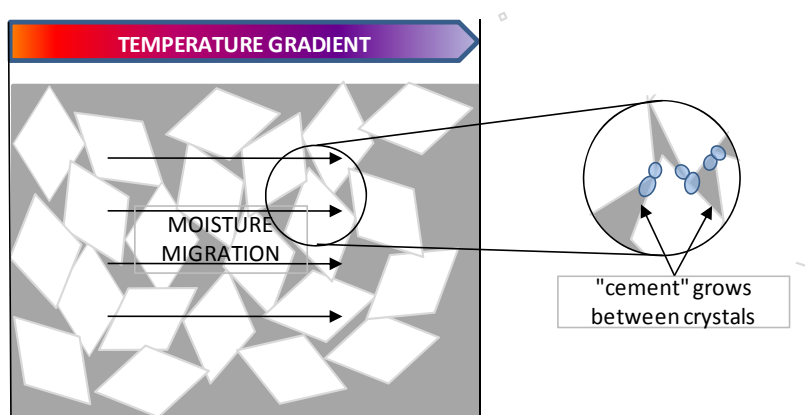


Fig. 1—Micro crystal growth leads to caking.

Evaluation of available technologies

The starting point of the study was to consider the possible alternatives. Following the study, three possible solutions were identified:

- Adding another rotary dryer;
- Changing to a fluidised bed cooler; and
- Converting the existing rotary cooler to a dryer and installing an indirect plate cooler to meet the cooling duty.

The first two options (rotary dryer and fluidised bed cooler) used equipment well known to the sugar industry in Mexico. The third option, using an indirect plate cooler, was not familiar to the Tres Valles engineers and had not been installed in any of the sugar factories in Mexico, although the technology had been extensively used in sugar factories in Europe.

Description of the indirect plate cooler technology

Plate heat exchanger technology has been applied to the bulk solids industry for approximately 20 years. The technology was first introduced in the fertiliser industry to cool bulk fertiliser and was quickly introduced to other bulk solid industries. Plate coolers have been used to cool crystalline sugar (beet and cane) for 10 years.

The idea behind the technology is simple: the bulk solid, in this case sugar crystals, flows slowly by gravity between water cooled plates as illustrated in Figure 2. The sugar crystals are cooled by conduction.

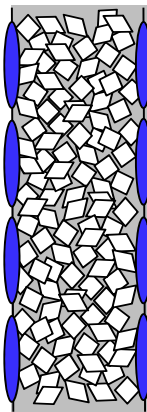


Fig. 2—Sugar crystals flow slowly between water cooled plates.

The heat exchanger plates are stainless steel and are of fully welded construction, with no gaskets; this design ensures very high mechanical integrity.

Water flows through the plates in counter-current flow with respect to the product flow, achieving high thermal efficiency. The plates are installed as a bank in a stainless steel casing.

Uniform velocity

The second requirement of an indirect plate cooler is that the sugar must flow at the same velocity over the full cross section of the heat exchanger to ensure an equal residence time which will result in uniform cooling as illustrated in Figure 3.

Uniform flow is achieved with a vibrating feeder discharge comprising overlapping shallow angled louvres. Product flow is proportional to the frequency of vibration and, when the feeder tray is stationary, there is no product flow due to the angle of repose of the sugar.

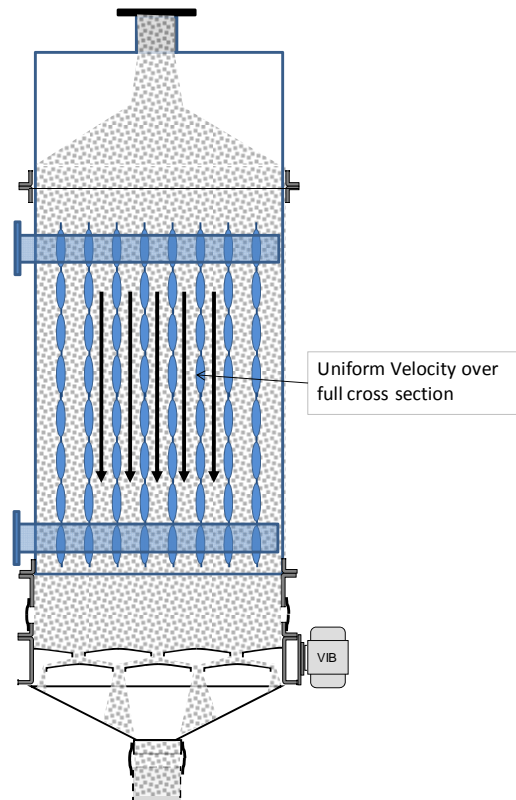


Fig. 3—Illustration of uniform velocity with full cross section vibrating feeder.

The advantages of indirect cooling

Indirect cooling with water results in several significant cost and quality advantages compared with direct cooling with air-sugar contact:

Air coolers require a large quantity of air for the cooling duty. This is inefficient, requiring a chiller and reheater, large fans and a dust collection system to prevent emissions to the atmosphere. This additional equipment adds to both installed capital and operating costs. In comparison an indirect plate cooler operates on a chilled water circuit.

- Direct cooling with air introduces the risk of contamination of the sugar crystals if there are micro-organisms present in the air.
- The slow gravity flow of the sugar through the indirect plate cooler is 'gentle' compared to a fluidised bed or rotary drum cooler. This gentle handling reduces degradation and breakage of the sugar crystals.
- The floor space required for the indirect plate cooler is small since cooling occurs in the vertical direction whereas, in a fluidised bed or rotary drum cooler, the product flow is horizontal, thus requiring a much larger floor space. This is a particular advantage in retrofit projects where floor space is usually very limited.

Water chillers use approximately 40% less energy than air chillers for the same heat load. This is explained by the fact that with an air chiller, the air must first be cooled to supersaturation, typically 10°C and 100% relative humidity and then reheated above the saturation point, typically 15°C and 70% relative humidity.

This requires energy to condense the moisture present in the air, plus the energy required for the reheat. With a chilled water system the only energy requirement is the sensible heat load to chill the water.

Technical and economic evaluation of alternative technologies

A comparison was made of the available technologies and summarised in Table 1.

Table 1—Technology and economic comparison.

Factor/Technology	Rotary dryer/cooler	Fluidised bed dryer/cooler	Indirect plate cooler
Dependency on air for cooling	Yes	Yes	No
Use of peripheral equipment	Yes	Yes	Small
High level of automation	No	Complex	No
Installation	Simple	Complex	Simple
Operating Simplicity	Simple	Complex	Simple

The energy consumption for each option was also evaluated. The results are shown in Table 2. The power consumptions quoted for the rotary and fluidised bed cooler are for the fans and drives for the drum. Table 2 does not include the power requirement for the chillers in either the rotary dryer, fluidised bed or the indirect plate cooler.

Table 2—Power consumption comparison.

Capacity/ Technology	Rotary dryer/ cooler	Fluidised bed	Indirect plate cooler
45.5 t/h	150 kW	140 kW	13 kW
91 t/h	300 kW	277 kW	54 kW

Reference plants

The next step in the evaluation for the Tres Valles engineers was to visit reference plants in Europe where there were a number of plants using the indirect plate cooler technology. The objective of the visit was to see the installations and discuss operating experience, equipment reliability and maintenance issues with the plant technical and operating personnel. Table 3 lists the plants visited.

Table 3—Reference plants.

Plant	Product	Country	Technology
Toury	Refined sugar	France	Indirect plate cooler
Nordstemmen	Refined sugar	Germany	Fluidised bed
RAR	Refined sugar	Portugal	Indirect plate cooler

Results of technology evaluation

Each of the three methods of cooling was considered technically viable and mechanically reliable. After careful evaluation, the choice between the different technologies was made on two principal criteria:

- Ease of installation
- Energy savings

On this basis, the indirect plate cooling technology was selected for the plant upgrade. Tres Valles plant engineers chose the heat exchanger technology offered by Solex Thermal Science.

System design and process control

Tres Valles specified the following design conditions for the indirect plate cooler:

- Capacity: 80 t/h
- Product in: 60°C
- Product out: 35°C
- Water temperature in: 25°C (from chiller)

To meet this duty, Solex configured the indirect plate cooler as a double bank design, with the water flow in series. A simple process flowsheet of the system is shown in Figure 5.

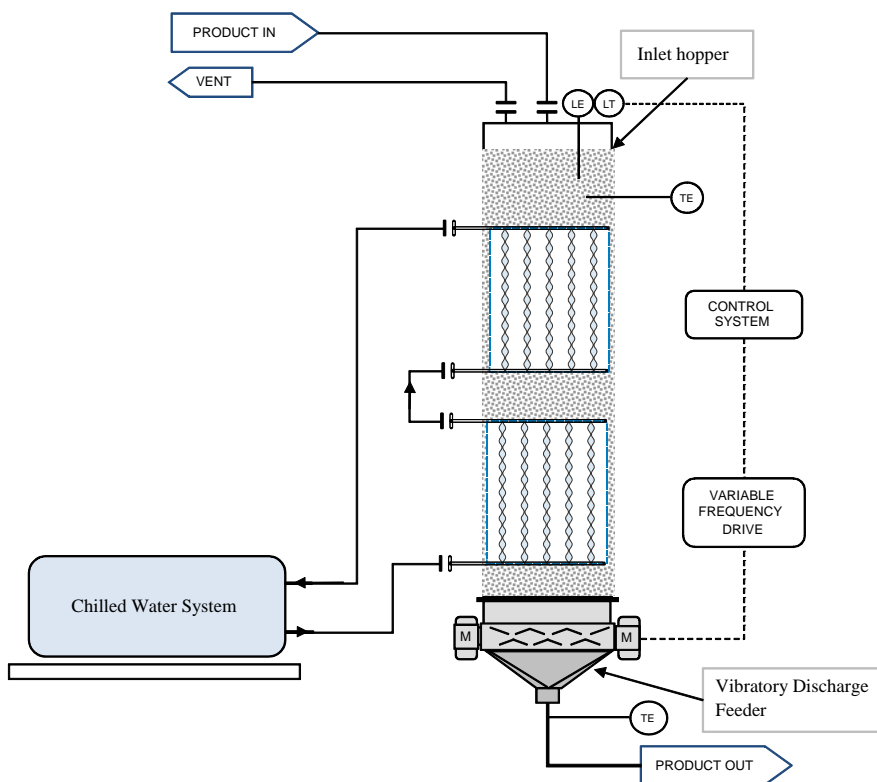


Fig. 5—Tres Valles process flowsheet.

Commissioning

Commissioning took place in November 2007 and the cooler was quickly on stream, meeting the required cooling performance. The Solex commissioning team was on site to assist with set up and calibration of the equipment and to observe the first few days of operation. In addition, on-site training was provided to the Tres Valles operations team.

Performance review 2007/2008 operating campaign

After operating the plate cooler through the 2007/2008 operating campaign, the following observations were made:

- Tres Valles was able to consistently maintain the product temperature to storage at the target temperature of 35°C
- The claims associated with lumping decreased from six in the 06/07 campaign to two in the 07/08 campaign. It has been identified that the two claims in the 07/08 campaign were the result of failures with the chilled water supply where they were unable to maintain the required cooling water temperature.
- The plant was also able to achieve the goal of increasing production capacity and did so in the 07/08 campaign by 20 000 tonnes from the previous campaign.

Conclusions

Ingenio Tres Valles needed to increase their sugar crystal cooling capacity to meet higher production targets and improve quality. They investigated alternative technologies including an additional rotary cooler, a fluidised bed and an indirect plate cooler for this duty. The indirect plate cooler had not previously been used in the Mexican sugar industry, so more in-depth study was required to understand both the advantages and disadvantages of the technology. They needed to ensure that this type of equipment could achieve reliable operation with a high on-stream factor and low maintenance cost.

Following the evaluation of the three possible technologies, the indirect plate cooler was selected since it most closely met the plant objectives.

The equipment was installed in the fall of 2007 in time for the 2007/2008 operating campaign. Operating experience through the first campaign proved the equipment fully met the objectives of the project. The equipment has now operated through the second season 2008/2009 and has again proven to achieve effective cooling and reliable operation.

Acknowledgements

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UNE TECHNOLOGIE AVANCÉE DE REFROIDISSEMENT CONTRIBUE À L'AUGMENTATION DE CAPACITÉ À INGENIO TRES VALLES

Par

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Résumé

EN 2006, Ingenio Tres Valles S.A. voulait augmenter la capacité de sa production et a considéré différentes possibilités. On a trouve nécessaire d'augmenter la capacité dans les sections de séchage et de refroidissement, afin de garantir un produit de qualité supérieure. Les problèmes confrontés

ont été la sélection de technologies efficaces pour l'espace disponible, l'utilisation de l'équipement existant dans la mesure du possible et une solution efficace au point de vue du coût. Pour augmenter la capacité de séchage du sucre raffiné, on a converti le refroidisseur a tambour rotatif en sécheur rotatif. L'étape suivante a été l'addition d'un refroidisseur autonome. Tres Valles a évalué plusieurs options pour le refroidisseur; un refroidisseur a lit fluidisé, un refroidisseur rotatif et un refroidisseur a plaques. Dans le refroidisseur a plaques un débit massique de sucre passe a travers une bande verticale des plaques refroidies a l'eau froide. Après une évaluation approfondie, Tres Valles a sélectionné un refroidisseur a plaques de Solex Thermal Science qui s'intègre facilement dans leurs installations existantes. Le refroidisseur a plaques offre un coût et une demande d'énergie économiques. L'équipement a été installé et mis en service en janvier 2008, a temps pour la campagne. La nouvelle configuration de refroidissement/séchage est maintenant dans sa deuxième campagne d'exploitation et a permit une augmentation de la capacité de production du sucre à Ingenio Tres Valles. La qualité a été atteinte; l'équipement a atteint, et même dépassé, les objectifs d'efficacité énergétique.

TECNOLOGÍA DE ENFRIAMIENTO AVANZADA AYUDA AL INGENIO TRES VALLES A INCREMENTAR SU CAPACIDAD

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PALABRAS CLAVE: Secadora de Azúcar, Enfriadora de Azúcar, Azúcar Refinado, Enfriador Indirecto de Placa, Flujo Másico.

Resumen

EN EL 2006, Ingenio Tres Valles S.A. deseó incrementar su capacidad de producción y consideró varias rutas para lograrlo. El incremento de la capacidad en secado y enfriamiento de azúcar fue uno de los requerimientos para asegurar un producto de alta calidad. Los retos que ellos enfrentaron fueron la selección de tecnologías eficientes que pudieran acomodarse en el espacio disponible, el uso de equipo existente donde fuera posible y ofrecer la solución más costo-efectiva. Para incrementar la capacidad de secado de azúcar refinado, la decisión fue convertir el tambor rotatorio de enfriamiento existente en una secadora rotatoria. El siguiente paso fue adicionar una enfriadora independiente. Tres Valles evaluó varias opciones para la enfriadora: una de lecho fluidizado, una rotatoria, y una enfriadora indirecta de placas. La enfriadora indirecta de placas opera bajo el principio de flujo másico de azúcar a través de un banco vertical de placas enfriadas por agua. Después de una evaluación exhaustiva, Tres Valles seleccionó una enfriadora indirecta de placas de Solex Thermal Science dado que la configuración vertical y la pequeña sección transversal se acomodaban al espacio disponible. Este equipo también ofrecía la solución mas costo-efectiva y la mas eficiente energéticamente. El equipo fue instalado y puesto en marcha en Enero 2008 a punto para la zafra. La nueva configuración de secado/enfriado se encuentra ahora en su segunda zafra y ha desempeñado exitosamente un rol en el incremento de la capacidad de producción de azúcar en el Ingenio Tres Valles. Los objetivos de calidad han sido completamente alcanzados y el equipo ha cumplido y superado los objetivos de eficiencia energética.