NEW IDEAS FOR IMPROVING EFFICIENCY IN THE PACKAGING AREA

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Abstract

LOOKING for more efficiency in the packaging area where the final product is handled, the performance of different machines for screening was studied, conveying the final product and also the milling of the overs separated by screening. In making the study of these unit operations, information was collected in different sugar mills and the different alternatives for screening the sugar were compared. A higher efficiency was achieved by using a gyratory reciprocating screener and losses of between 1 and 3% of the on-spec sugar were avoided when compared with the performance of other technologies for this operation. The possibility of milling the overs obtained in the screening process was also studied and compared with the traditional dissolution of this material. A milling test was conducted using plantation and refined sugar and 10–20% of the sugar that would normally dissolve and goes to molasses was recovered. Finally, some results obtained in conveying using vibrating conveyors as opposed to screw conveyors are discussed. It was found that recoveries of sugar between 0.5–3.0% were obtained with vibratory conveyors, as opposed to belt conveyors. In the case of screw conveyors, degradation in the order of 1–3% of the size was found. It is concluded that there is an opportunity for the technologist to recover more sugar in this area using the most efficient technology.

Introduction

For many reasons related to the constant increase in capacity of the sugar mills in the Mexican sugar industry and in other countries, the factories have shown a preference to make investments to lower energy consumption and in process equipment like centrifugals, crystallisers, vacuum pans, etc.

This situation has postponed for years projects in the sugar packaging area, and only in the last decade with the increased requirements of the customer concerning the final product and the reprocessing of sugar has the packaging area been looked at (Urrutia, 2000; Mathlouthi and Roge, 2004; Hartmut and Burkhards, 2008; Reichling, 2008).

To improve the particle size distribution it is necessary to reduce the overs and fines in the sugar especially the fines that can cause hardening (Lu *et al*., 1977). An efficient screener with gyratory-straight line motion offers a more efficient separation and low maintenance cost system for the sugar industry (Bergerhoff, 2006; Thouvard, 2006).

In analysing this situation, the packaging area of the plant could be a real opportunity to improve the plant efficiency.

Materials and methods

Screening of overs

Samples were taken in different sugar mills where various technologies were being used to screen the sugar before packaging. The machines being used were as follows:

- A static screen positioned at the end of the drum dryer.
- A high slope vibratory machine positioned at the dryer discharge.
- Other vibratory machines that were circular, flat or rectangular with an angle of 30° to the horizontal and positioned at the dryer discharge.
- Machines with gyratory motion at the feed end and straight-line motion at the discharge end with a little slope and low frequency motion and positioned at the dryer discharge.

In all cases, three samples were taken at the overs outlet during an hour of stable operation and then composited. The composite was then subdivided into three portions and analysed using a laboratory sieve machine and a 10 mesh (1.7 mm) screen.

Screening of overs and fines

Samples were taken in the non-screened inlet and the product outlet at Ingenio Tres Valles and Ingenio El Potrero where high efficiency screeners are used on the dryer outlet to eliminate the overs (>20 mesh, 0.85 mm) and fines (<80 mesh, 0.18 mm). In both cases, the machines have gyratory motion at the feed inlet and straight-line motion at the discharge end with a little slope and low frequency motion.

Milling of overs

During these tests, samples were collected at the overs outlet screener in two sugar mills where one mill produces refined sugar and the other plantation sugar. In both cases, the machines use gyratory motion at the feed inlet and straight-line motion at the discharge end with a little slope and low frequency motion.

A milling test was conducted with a Pin Mill model Simpactor 3B equipped with an 11 kW motor and operated at 1000 r/min for refined sugar and 2000 r/min for the plantation sugar samples.

Sugar conveying

Belt conveyor

In this case, data were collected from three factories by weighing the amount of sugar collected from the floor that had been spilt by the conveyors.

Screw and vibratory conveyors

Sugar samples were collected at two sugar mills from the inlet and exit of a 10 m long screw conveyor. Samples collected every 10 minutes for one hour were composited and sub-sampled. The samples were then sieved through a 70 mesh (0.212 mm) sieve. Similar samples were collected from 10 m vibratory conveyors at two other sugar mills.

Results and discussion

Screening to separate the overs

In the case of the screening to eliminate the overs, we collected the sugar retained in 10 mesh screen in several different sugar factories that used different screeners and we measured the fraction passing at 10 mesh screen that represents on-spec sugar that was retained or lost with the overs. Results of the sieve analyses for the three different machine types are shown in Table 1. The data are the proportion of on-spec sugar removed with the overs portion in relation to the total screened sugar.

Table 1—Comparison between the separation efficiency of overs using three different screener types.

Screener type	Sugar mill					Weight of on-spec sugar dissolved in a crop (t)*
	1	2	3	4	Mean	
Fixed static	2.3	4.0	3.5		3.2	103.7
Vibratory	1.2	2.5	2.0	2.6	2.1	67.9
Gyratory reciprocating motion, low frequency	0	0	0.1	0	0	< 0.1

* Note: Assumes a factory with 50 t/h sugar and an overs fraction of 1.5%.

Table 2 shows that the investment could be recovered in less than one crop for a factory with a minimum output of 50 t/h of sugar. In the case of factories that produce 20 t/h, the investment is recovered in 1.3 crops. To replace an existing fixed static screen, the recovery of the investment is faster.

Table 2—On-spec sugar lost by dissolution using vibratory screeners versus gyratory reciprocating motion machines.

Capacity (t/h)	On-spec sugar dissolved in one crop period (t)	Cost of the high efficiency machine (USD)	Time to recover the investment of high efficiency screen *
20	27.2	17 299	1.3 crops
50	67.9	28 722	0.85 crops
100	102.9	39 518	0.77 crops

* Based on a crop of 180 days and a sugar price of USD500 /t

The gyratory reciprocating motion screener shown in Figure 1 is commonly used in the USA sugar industry, and in Mexico they are used in 25 sugar mills and in eight factories in Colombia and three factories in Peru.

Fig. 1—Gyratory reciprocating motion screener.

Screening to separate overs and fines

Table 3 shows the data of the screening of the sugar from two sugar mills that produce refined sugar using a gyratory reciprocating screener. The data represent the percentage of sugar in each size fraction. The efficiency of the screener allows the mills to output sugar containing overs and fines of about 2% only.

Table 3—Results of sieve analyses of screened and non-screened sugar product at two mills.

Screen size range (Mesh #)	Ingenio El Potrero		Ingenio Tres Valles	
	Non-screened sugar (%)	Screened sugar (%)	Non-screened sugar (%)	Screened sugar (%)
+20	5.97	0.5	4.2	2.2
–20 / +70 mesh	87.79	97.50	92.1	95.1
–100	6.24	2	3.7	1.7

In both cases the final product is ready to:

- Fulfil the requirements of the companies that produce mixtures with flour of similar size for making bread, cereals, cookies and need sugar with a little overs and fines.
- Supply this sugar to any market with little risk of lumping during storage and transportation.

Ingenio Tres Valles did not receive any claim for lumps during the last campaign, because the sugar met every test with temperature between 32 and 35°C and with a very low content of fines. In the 2007–2008 crop a plate cooler was used without a screen and they received few claims (Urrutia *et al.*, 2008), and finally in the last crop the product was sent to many places through an agreement with Cargill.

Reichling (2008) established that, when sugar with low fines content is packaged at temperatures near the storage environment, no lumping will occur during storage and transportation.

The results in the elimination of overs shown in Table 1 indicate that the machine with the gyratory motion at the feed end and straight-line motion at the discharge end is more efficient at maximising the compliance level than the other screener tested. Since these results were obtained in the easier application, it did not justify making a test using the other screeners for the more difficult and expensive application to eliminate both the overs and fines.

Handling the overs of the sugar

Taking into account that by using a high efficiency screener, the separation of the overs without any on-spec sugar is guaranteed, then options to handle the overs can be evaluated. Normally almost all the sugar mills dissolve the overs obtained by screening of the product. It is common in the industry to dissolve the overs in several places of the factory depending on whether it is refined or plantation sugar being produced and the criteria of management. The effective sugar loss depends on where in the process the sugar is dissolved and can be between 10–20%. A 10% loss is a reasonable assumption for this discussion.

In any calculation, a loss of 10% of overs is an area of opportunity since this represents about 1% of the sugar and the loss of 0.1% of the sugar produced.

A second option is to mill the overs to produce a sugar with a similar size to the product sugar. A pin mill made in mild steel and equipped with a 11 kW motor was investigated for this option (see Figure 2).

Fig. 2—Pin Mill model Simpactor 3B with 11 kW motor.

Refined sugar

A sample of overs separated in a high efficiency screener was obtained from Ingenio Tres Valles and processed through the milling machine. The sieve data for both the sample of overs collected and the sample after milling are given in Table 4. The milled material had a very good particle size distribution with 66.7% in the size fractions between –16 mesh and +80 mesh.

Table 4—Sieve analysis of refined sugar overs and after milling.

Mesh size	Sugar in each size fraction (%)	
	Overs	Milled overs
+ 6 (3.35 mm)	36.5	
–6 / + 16 (1.18 mm)	63.5	29.4
–16 / +25 (0.71 mm)		13.8
–25 / +35 (0.5 mm)		11.9
–35 / +60 (0.25 mm)		32.3
–60 / +80 (0.18 mm)		8.7
–80		3.9
Total	100	100

Plantation sugar

When the oversized plantation sugar was milled, the results in Table 5 indicate that only 16% of the original sample remained outside the acceptable size range.

Table 5—Particle size distribution of the overs fraction of plantation sugar before and after milling.

Mesh size	Sugar in each size fraction (%)	
	Overs	Milled overs
+ 6 (3.35 mm)	79	
–6 / + 10 (2 mm)	21	13.1
–10 / +25 (0.71 mm)		77.8
–25 / +35 (0.5 mm)		3.0
–35 / +60 (0.25 mm)		2.5
–60 / +70 (0.212 mm)		0.7
–70		2.9
Total	100	100

Handling the milled sugar

In view of the results obtained through milling, it is worthwhile considering options to use the milled sugar. These options include:

1. Given that the overs are only 1% of the total sugar produced the best way to handle the milled sugar is to mix all the milled sugar with the screened on-spec sugar. The new overs and fines represent only a very small proportion of the total product.
2. The milled sugar could be sent to the inlet of the screener and, in this way, remaining overs will be separated and the milled sugar and the fines will pass with the on-spec sugar.
3. Send the milled sugar to a separate bin based on its quality. The technologist can mix the sugar according to the product specification required at the time.

Table 6 shows the increase in colour when 1% of milled sugar is mixed with 99% of on-spec sugar. The increase is within the error range of the method.

However, there are at least another two ways to utilise this material to allow the sugar technologist to select the most appropriate choice according to the particular conditions.

Table 6—Colour of milled overs.

Sugar type	Colour standard	Nominal values	Milled overs	Colour increase in the mix 1/99 (IU)
Refined	35	22	135	+1.13
Plantation	600	500	1335	+8.35

In an exercise to examine financial implications of milling the overs fraction, the only consideration was the loss related to the dissolution of the sugar and not other costs such as water consumption or additional energy used.

The investment recovery time of this project is very fast as is seen in Table 7. In the worst case for a sugar mill that produces about 20 t/h, less than one crop is needed to pay for the machine, using a very conservative estimate of the loss of sugar by dissolution.

This is a real opportunity area to improve the efficiency in the packaging area with only a minimal investment.

Table 7—Feasibility of milling the overs sugar fraction.

Capacity, (t/h)	Overs dissolved, (t/h)	Loss of sugar by dissolution, (USD/week)	Investment recovery time (weeks)
20	0.2	1680	18
50	0.5	4200	7.2
100	1.0	8400	3.6

Note: 1% of overs in the sugar, 10% loss of sucrose by dissolution, price of sugar is USD500/t, and price of the mill is USD30 000 FOB for a sugar mill in the zone of Cordova, Veracruz, Mexico.

Sugar conveying

For this test, three types of conveyors (screw, belt and vibratory) of a similar 10 m length were tested. Since this is the final step in the product handling system, careful handling is required.

With belt conveyors it is possible to lose a substantial portion of the sugar to the floor. Tests showed losses of up to 1 t per 8 h in sugar mills producing 1000 t/day of sugar.

This loss represents 0.3% of production. In other mills, losses of up to 0.6% were measured.

Closed conveyors like screw or vibratory conveyors do not experience this magnitude of loss. A saving of up to 500 kg for each 1000 t of sugar is possible and represents USD45 000 in one crop.

In looking at the problem, an exercise was undertaken under the assumption that only 0.1% of sugar is lost using belt conveyors.

Table 8 shows that if vibratory conveyors are used to replace belt conveyors, the investment is recovered in less than one crop, and in the future years no financial losses will be realised.

Table 8—The cost of 0.1% losses using belt conveyors.

Capacity, (t/h)	Tonnes lost per hour	Tonnes lost in a crop	Monetary loss (USD)	Cost of a vibratory conveyor for same job (USD)	Investment recovery time (crop)
20	0.02	86.4	43 200	40–50 000	1–1.25
50	0.05	216	108 000	55–70 000	0.5–0.65
100	0.1	432	216 000	80–100 000	0.37–0.46

Screw and vibratory conveyors

Screw and vibratory conveyors are closed conveyors that usually do not create any loss by spillage. An example of a vibratory conveyor is shown in Figure 3.

Fig. 3—Example of a vibratory conveyor.

Tests were conducted on two screw conveyors and two vibratory conveyors to assess whether either type of conveyor could cause crystal damage and increase the fines content in the sugar. The results in Figure 4 show that both screw conveyors that were tested caused crystal damage while the vibratory conveyors caused no damage.

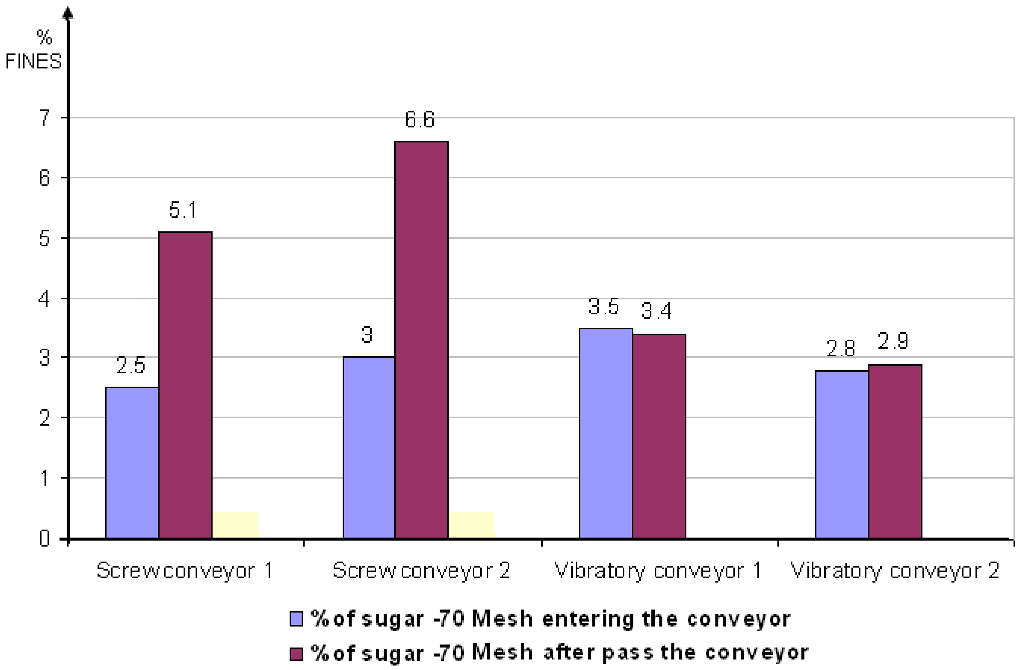

Fig. 4—Creation of fines during sugar conveying in screw and vibratory conveyors.

In this case the disadvantage is not related with a loss of sugar, but the lower quality sugar through the particle size characteristics of the product because the sugar conveyed by screw has an increased quantity of fines.

Conclusions

There are new opportunities for improving the efficiency in the packaging area that include:

- Using gyratory reciprocating screeners, 70 t of on-spec sugar can be recovered if a vibratory screener is used or 100 t of sugar if a fixed screen is replaced. The cost of the investment would be recovered in less than one crop.
- Compliant sugar with good grain size and low fines becomes available to send to any place without the risk of lumping when high efficiency screeners are used to eliminate overs and fines.
- The milling of overs instead of dissolution is a project with a fast recovery time. In the worst case for a sugar mill that produces about 20 t/h, the recovery time is less than 18 weeks. This is a real opportunity area to improve the efficiency in the packaging area with only a small investment.
- Using vibratory conveyors, it is possible to eliminate losses of 0.1% that represent a loss of 80–400 t of sugar per crop compared with belt conveyors because the vibratory conveyor does not produce fines during the conveying of sugar. If existing screw conveyors that can generate up to 3% fines are replaced, then the benefit is much more significant.

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NOUVELLES IDÉES POUR AMÉLIORER L'EFFICACITÉ DANS LA STATION D'EMPAQUETAGE

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Résumé

ON A étudie la station d'empaquetage pour améliorer la performance des tamis, du transport des sucres et des traitements pour les gros grains retenus sur les tamis. Pendant l'étude on a recueilli les informations de plusieurs usines a sucres et les différentes alternatives pour le tamisage ont été comparées. Une efficacité supérieure a été réalisée par un tamis giratoire; les pertes d'entre 1 et 3% du sucre ont été évitées en comparaison avec les performances des autres technologies pour cette opération. La possibilité de broyer les grains retenus a été également étudiée et comparée à la dissolution traditionnelle de ce matériau. Un test de broyage a été mené avec du sucre de plantation et du sucre raffiné; 10 à 20% du sucre qui serait normalement dissout et perdu avec la mélasse a été récupéré. Des résultats obtenus pour le transport à l'aide de convoyeurs vibrants par opposition aux convoyeurs à vis sont présentes. On trouve que des récupérations de sucre entre 3.0 de 0.5% sont obtenues avec les convoyeurs vibrants, par opposition aux convoyeurs a courroie. Dans le cas des convoyeurs à vis, une dégradation de l'ordre de 1 à 3% de la taille a été trouvée. On peut conclure que la récupération du sucre peut être améliorée grâce à la technologie la plus efficace.

NUEVAS IDEAS PARA EL MEJORAMIENTO DE LA EFICIENCIA EN EL ÁREA DE EMPAQUE.

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Resumen

EN LA búsqueda de mejores eficiencias en el área de empaque, donde se maneja el producto final, se estudió el desempeño de diferentes equipos de tamizado, de transporte de producto final y de molienda de los materiales retenidos en los tamices. Para el estudio de estas operaciones unitarias, se reunió información de varios ingenios y se compararon diferentes alternativas para tamizado de azúcar. La mayor eficiencia se obtuvo con el uso de un tamiz giratorio y reciprocante, eliminando entre 1 y 3% de las pérdidas de azúcar dentro de especificaciones comparado con el desempeño de otras tecnologías para esta operación. Se estudió la posibilidad de moler el material retenido en el proceso de tamizado y se comparó con la disolución tradicional de este material. Se efectuó una prueba de molienda con azúcar blanco y refinado y se recuperó un 10–20% del azúcar que normalmente se disuelve y va a las mieles. Finalmente, se discuten algunos de los resultados obtenidos en el transporte de azúcar usando conductores vibratorios en lugar de transportadores de tornillo. Se encontró que se recuperó entre 0.5–3.0% del azúcar cuando se usaron conductores vibratorios en lugar de conductores de banda. En el caso de los transportadores de tornillo, se encontró una degradación de tamaño de cristal del orden de 1–3%. Se concluye que hay una oportunidad de recuperar más azúcar en esta área usando tecnología más eficiente.