Treatment of Evaporator Thick Juice With Pittsburgh Activated Carbon

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Introduction

The use of granular activated carbon as a decolorizing medium in the processing of sugar beet syrups has been adopted in several factories in this country and abroad. However, from the data available, no clear-cut economic advantage was indicated and the Holly Sugar Corporation felt further investigation was necessary.

The Carlton Plant of Holly Sugar Corporation in southern California was chosen for our installation for two reasons: the quality of beets in the Imperial Valley yield syrups with poor color and, in addition, the stored juice arrangement allowed us to process half of each tank of stored thick juice with carbon treatment and half without carbon treatment. In this manner, an accurate comparison could be made for economic purposes of evaluation.

CAL, a granular mineral carbon, manufactured and sold by Pittsburgh Activated Carbon Company, was used in this test. The unit, illustrated in Figure 1, employs the patented Pittsburgh moving bed system in which the syrup flows upward through a packed bed of granular carbon. Some modifications, to be described later, had to be made on the original unit to make it operable. Briefly, the present scheme is as follows: The syrup from the factory, or storage, passes through a heat exchanger where the temperature is raised to 85° C, into the column feed tank. A level is automatically maintained in this tank to avoid pumping air into the columns. The syrup is then pumped into feed rings that encircle the column bases and thence through six equally spaced bayonets into each column. The feed to the columns is maintained automatically at 64° to 65° Brix and the flow is regulated by flow controllers being divided as evenly as possible between the two columns. The syrup flows up through the columns and out via screened outlet bayonets into collector launders. From the launders the syrup flows by gravity into a treated juice bumper tank and thence into the

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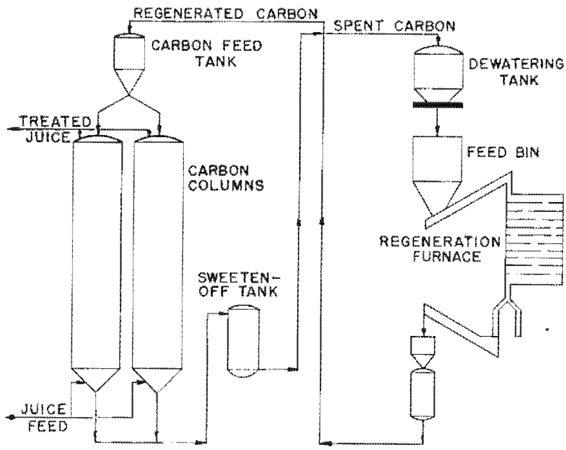

Figure 1.—Pittsburgh moving bed system.

plant for processing. A small amount of treated thick juice is drawn off at this point for the transport of regenerated carbon back to the columns.

The carbon flow through the columns is semi-continuous, down flow, counter current to the juice flow. Periodically, at a frequency of about 4 hours determined by the rate of carbon regeneration, a slurry of spent carbon and juice is removed from the bottom of a column into the sweetening off tank. This is referred to as a slug of carbon and during removal the flow of juice to the column is stopped, allowing the bed to collapse for refilling with regenerated carbon. When the column is completely refilled, it is once again placed on stream. This slugging operation is performed manually and is usually completed in 15 to 20 minutes.

The slug of spent carbon is sweetened-off with hot water at a rate of 16 gal/min. The sweetwater is returned to the column feed tank until 40° Brix is obtained: from 40° down to approximately 0° Brix it is returned to the plant raw juice bumper tank; then the sweetening-off stream is diverted to waste for continued washing. When space is available the carbon is transported up the de-watering tank in a water slurry and remains there till it is nearly drained of water. It then drops into the furnace feed hopper at an average moisture content of 38%.

The spent carbon is fed by variable feed scroll into a Hereshof type furnace, built by Bartlett Snow Pacific, for regeneration. The variable speed screw is capable of delivering between 500 and 1,200 pounds per hour. The furnace has eight hearths varying in temperature from about 400° C at the top to 975° C at the bottom. The reactivation furnace is fired on hearths 4, 6 and 8 with natural gas and has an air blower that supplies supplemental air to the hearths as well as primary air to the gas burners. Hearths Nos. 3, 5 and 7 are also equipped with lines to provide steam for the water gas reaction. The furnace stack has an automatically controlled damper to maintain near neutral pressure in the furnace. This is necessary to minimize carbon losses in the furnace.

The reactivated carbon drops out of the furnace through a chute, equipped with internal water sprays. The chute extends below the surface of the water in the quench tank sealing the furnace from the atmosphere at this point. The quenched, reactivated carbon is conveyed up an inclined scroll, which has a screened bottom for de-watering purposes, into the blow-case feed hopper. The carbon, containing about 48% moisture, is slurried in treated thick juice, fed into the blow-case and transported by air pressure up to the carbon feed tank above the columns where it is stored until after the next slugging operation when it can be fed back into the column.

Results

The unit was built and placed on stream during the summer of 1964, but mechanical difficulties delayed an accurate evaluation of the system until the thick-juice run of the 1965 campaign. Some of the difficulties worthy of mention involved the quenching and de-watering system, the regenerated carbon transport mechanism, and the bayonets for the flow of juice in and out of the adsorption columns.

Originally the carbon fell from the furnace into a cone bottomed quench tank equipped with a water jet at the vortex of the cone intended to transport the carbon onto a vibrating screen for de-watering. However, the water quite often failed to move the carbon out of the quench tank and carbon would build up in the chute from the furnace, releasing periodically in a red-hot geyser. To compound the situation, the vibrating screen soon blinded over causing excessive dilution of the treated thick juice. After various corrective measures failed, a combination inclined de-watering screw and quench tank was installed and has performed quite well to date. This system is illustrated in Figure 2.

The blow-case, a vessel for transporting the reactivated carbon thick juice slurry up to the column feed tank hydraulically, replaced an air-driven diaphragm pump, which plugged fre-

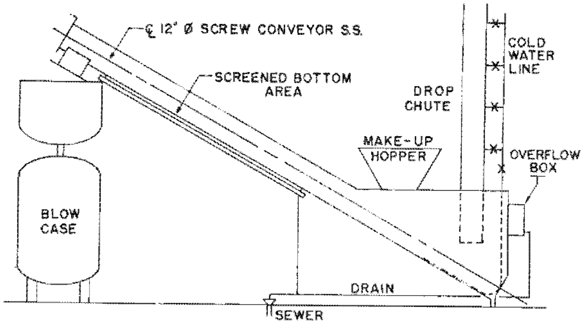

Figure 2.—De-watering screw.

quently and ruptured numerous diaphragms. The transport system is automated and operates with very little trouble.

The problems with the bayonets have been only partially resolved. The screens on all but one of the inlet bayonets on each column have been removed. Scale build-up on the screens made frequent backwashing necessary to maintain proper flow of syrup into the columns. The one screened bayonet in each column was maintained to allow for draining and sweetening-off purposes at the end of the operating season. The outlet bayonets are subjected to severe hydraulic forces from the movement of the carbon bed as it expands against the top. These forces have, on occasion, bent the bayonets, torn screens and even, in extreme cases, completely broken them loose from their flanges, allowing them to become lost within the carbon bed. This trouble with the upper bayonets has been only partially alleviated by extra sturdy construction and is quite serious since the carbon loss is intolerable and obvious difficulty with filtration is encountered when the carbon slurry enters the mill.

With the above changes instituted, the system operated fairly well and the results obtained during the 1965 campaign will probably be indicative of what may be expected in future operation. The major expense of this operation is, of course, the replacement of CAL carbon. The inventory of carbon is large, roughly 6300 ft^3, or 173,000 lbs of carbon is in the system, but this is of secondary importance to the losses.

During the 1965 juice run, a loss of 6.32% on carbon regenerated was experienced with a regeneration rate of slightly over 900 lbs/hr, or a burn ratio of 2.2 lbs carbon per bag of sugar produced. In order to determine where the formation and loss of ultra-fine carbon particles (−60 mesh) were occurring, samples were caught in various points in the system and analyzed for their fines content. The fines were backwashed out of the main body of carbon and both fractions were washed, dried, and weighed. The results of this study are shown in Tables 1 and 2.

Table 1.

Sample point	% Fines on carbon
Top of column	2.91
Bottom of column	1.70
Sweeten-off tank	1.30
De-watering tank	1.08
Furnace feed screw	1.15
De-watering screw	0.41
Column feed tank	0.40
Virgin carbon	0.67

Table 2.

Operation	Loss as fines % of total carbon loss
Sweetening-off	6.67
De-watering	3.02
Quench overflow	2.61
Juice to mill	38.10
Furnace loss	49.60

Of special interest is the fact that the majority of the carbon attrition occurs within the columns. Also, only about half of the total carbon loss can be attributed to the furnace with the majority of the non-furnace losses accounted for as fines in the treated juice stream.

Sugar losses have been estimated and under normal operation appear to be reasonable. The average of all tests made on the waste water from the carbon unit indicates that it contains about 0.013% of total sugar fed to the unit. The only other loss is the sugar remaining in the spent carbon fed to the furnace. This has been determined and amounts to about 0.019% of sugar treated.

During the test period a consistent upgrading of the syrup was achieved. Table 3 summarizes the analytical results on the treated and untreated juices, and the white sugar produced from each. Other analyses which were performed include: invert sugars, amino nitrogen, total nitrogen, betaine, sodium, potassium, calcium and iron. No change was detectable in any of these.

Table 3.

	Influent	Effluent	% removal
A. Average thick juice results			
Thick juice apparent purity, %	85.78	86.30	
Specific color	493.3	342.8	30.5
pH	7.3	7.4	
B. Average white sugar results		**Treated**	**Untreated**
Solution grade, color/turbidity		92.4/98.5	91.0/99.8
Floc test		0	2.2
C. Molasses produced			
Molasses true purity		60.4	61.2

The specific color is the adsorbance at 425 μ on a filtered juice sample divided by the product of the cell length in cm and the concentration in gm/cm^3. The white sugar solution grade is the transmittances of a 50° Brix solution in a 5 cm cell at 425 μ and 650 μ for color and turbidity, respectively.

The lower color and saponin levels in the juice allowed the production of floc-free sugar meeting the standards set for color and turbidity with less recrystallization. However, the turbidity of sugar from treated juice was somewhat poorer than from juice without carbon treatment.

Of prime concern is the extraction and the cost of the extraction. An accurate account of all costs and production was made during each phase of the test period. These data are shown in Table 4.

Table 4.

		Treated	Untreated
Cwt sugar produced/ft^3 juice		0.4008	0.37590
Lbs carton used/cwt sugar		0.1526	0
Cost of carbon	— $/cwt sugar produced	0.04822	0
Added sugar loss	— $/cwt sugar produced	0.00244	0
Cost of labor	— $/cwt sugar produced	0.19591	0.24076
Cost of fuel	— $/cwt sugar produced	0.14480	0.15648
Cost of materials	— $/cwt sugar produced	0.07108	0.05846
Total cost	— $/cwt sugar produced	0.46245	0.45570
Extraction	— % of total sugar fed	76.42	72.43

Thus Table 4 is the crux of the discussion; there is a 4 point increase in the actual extraction of total sugar fed at an additional cost of only 6.75 cents per bag of sugar produced. It is apparent that the costs of labor and fuel are lower for processing treated syrup, even though each of these include the extra expense of an operator and fuel for regeneration, because there was considerably less reboiling necessary to obtain quality sugar. The extraction gain is not entirely due to molasses purity reduction and juice purity difference but probably is due also to the considerable reduction in reboiling. The higher cost of materials for processing the treated juice is due to higher filtration costs arising from shorter filter cycles and higher filter aid addition. All things considered, it is apparent that for this particular case, the use of carbon is indeed a paying proposition.

A good evaluation of the process was achieved and most of the operating problems have been resolved satisfactorily. It is hoped that refinements in the operation will decrease the carbon loss, but even as is, the economics are quite favorable. It should be emphasized that the data reported here are only applicable to the Carlton mill, which is unique in many respects and may not be as attractive elsewhere.

Summary

In conclusion we feel the use of activated carbon columns is economically justified at our Carlton, California plant. There was a definite lowering of juice color as well as an elimination of floc in the sugar produced. An increase in actual extraction of total sugar fed to the system was realized, although it is our feeling such increase was not entirely due to molasses purity reduction or juice purity difference, but the result of considerable reduction in reboiling requirements. These benefits also resulted in both labor and fuel cost improvements, despite an added operator and extra fuel for carbon regeneration.

Economically the carbon column installation is justified at the Carlton plant, although its benefits elsewhere may not be as attractive.