Sugar End Operation on Ion Exchange Juice

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THE OPERATION of a beet sugar factory consists of two separate and distinct processes: the beet-end operation and the sugar-end operation.

The beet-end operation consists essentially of three major steps; first, the extraction of the sugar-containing juice from the beet; second, the chemical elimination of a certain proportion of the impurities from this juice; and finally its concentration in multiple effect evaporators. The sugar-end operation is devoted almost entirely to the crystallization and separation of the practically pure sugar crystals from the thick juice obtained from the beet-end. However, purification may be said to take place on the sugar-end also because the remaining impurities are successively concentrated in the mother liquors by the various boilings until they eventually end up in the final molasses.

In the history of beet sugar refining, there has been used a wide variety of methods for removing impurities from the raw juice. The standard and most successful of the various methods has been lime defecation which is capable, when properly done, of removing approximately 45 percent of these impurities. Sulphitation is also almost universally used for impurity and color removal.

Ion exchange gives sugar technologists a new tool to more effectively remove impurities from sugar solutions. Through the use of this new tool, we are able to eliminate about 90 percent of the total impurities, giving us a more pure sugar solution than we have ever before obtained. Many of the worst salts not removed by old methods are removed by ion exchange, so that what is left is, practically speaking, an ash-free and sulphur-free sugar. In ion exchange juices there are none of the disagreeable tastes or odors that are present in regular beet operation.

Table 1 shows average values on some of the pertinent data on the influent (filtered second carb juice) and effluent juice from the exchangers.

Table 1.

	Influent	Effluent
Brix	12.95	11.81
Percentage sugar	12.13	11.61
Purity	93.76	98.60
pH	8.14	7.13
Invert	.13	.36

Our present sugar-end equipment is inadequate to obtain the ultimate extraction of sugar from the type juice put out by ion exchange. We have on the bottom floor of the factory, six machine syrup tanks, each with a

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capacity of 302 cubic feet. In addition, we have seven tanks on the pan floor. These, with their capacities and the manner in which they were used are shown in table 2.

Table 2.

Tank No.	Capacity	Syrup
	cubic feet	
1	502	Standard syrup
2	502	Standard syrup
3	502	High green
4	502	2nd boil green
5	251	Machine syrup
6	251	3rd boil green
7	283	Molasses

We started on a four-boil system, but found we had to add too much low purity syrup back with the high purities to get a final molasses of sufficiently low purity. We then put a charge line from the molasses tank into the low raw pan and were able to figure out a five-boil system. This still was not a desirable method because considerable inboiling of low purity syrups was yet necessary to bring the final molasses to the requisite low purity. The boiling of the high purity thick juices from the ion exchange process is very much the same as the similar working of thick juices from the conventional refining process. However, on the lower purity syrups this is not true. Here we found that we needed a very much better circulation in the pan than heretofore. In all cases, it was impossible to brix the pans as heavy as with regular beet juices.

At Layton we have three pans. The white and intermediate are coil pans, and the low raw is a calandria. In the regular white pan we boiled only the standard thick juice or the first boil pan. In the intermediate pan we boiled all second-boil sugar, which was made up of a mixed graining charge of high green and standard thick juice and finished on straight high green. This massecuite was dropped to the white mixer, spun out, dried, and sacked as white sugar. The intermediate pan was also used for third and fourth boil, which consisted of melted sugar coming back to the white side. The syrup from this third and fourth boil was taken to the low pan for a crystallizer boil. The crystallizer sugar was returned to the beet-end and the syrup discarded. We averaged a discard in about every 18 pans.

We found that we needed better pan circulation, especially on the low purity side of the sugar-end more particularly in the low raw pan. It was impossible to boil a low pan and hold it more than 4½ to 5 hours. This was due to the fact that the impurities giving high viscosities are removed by ion exchange; so that when the crystals reach a certain size, they settled out like sand. Before we learned this fact, we dug and melted out a few low raw pans of sugar. On the basis of the five-boiling system, indications are that a total of 93.5 percent extraction is feasible, with a probable true purity of 57.5 to 58.5 in final molasses. The campaign average at Layton, including 18 days of straight house operation, was 58.59 purity on molasses. For the ion exchange period we had 57.41 average.

Our thinking on possible changes to make a good balance on the sugar end for this new juice would be to: 1.—materially increase holding tanks so that we have enough tankage to handle syrups for a seven-boiling system, 2.—to improve and increase pan circulation, especially on the low raw pan so that all of our melt sugar could be boiled in this pan, 3.—to obtain three new centrifugals for white first and second boil and to move two of our present automatic machines to third and fourth boil service and the other two automatic machines to high raw service, and 4.—to so split our sugar mixers that we will have four instead of three mixers and to so arrange the sugar scroll that we can blend third and fourth boil sugar with first and second.

It is evident from our experiences this year that we can get four white strikes of sugar by using standard syrup with the various greens for graining charges. In doing this, however, it will be necessary to add a decolorizer such as activated carbon to the syrup from the second boiling and then to give it a careful filtration with filteraid before third boiling.

In order to more fully utilize the three pans we have, it seems that the feasible thing is to boil all the low and melt sugar in the calandria pan. In order to do this, we will have to add a heating coil under the calandria and one above to induce greater natural circulation and also to take advantage of vapor heat.

To get a better and more uniform sugar throughout, we think it important to have controlled cycles on all centrifugals except the low raw; so we think in terms of three new machines on first and second sugar with automatic wash and syrup separation, two of our old machines with automatics and heavier wash on third and fourth, and two automatics on so-called high raw.

We plan to have two white mixers in line so the two pans can work together, rather than separately. In having mixers, centrifugals, and scrolls in a straight line, it will be possible to more completely blend the sugars by a part blend in the scroll and finish in the sugar dryer without a lot of extra blending equipment.

The purity control we think we will try for, is a straight purity drop all the way through. In attempting to get four white strikes of sugar we are sure that the wash and green will have to progress together. In other words, we do not think it necessary to separate the green from the wash on any but fourth boil. For obvious reasons we figure on an extremely clean separation of wash and green on this boil. Wash, of course, will be returned to fourth boil storage. It would seem that on a seven-boiling system we could expect to get a low pan about every 25 to 26 pans, or from 40 to 48 hours apart.

Table 3 shows the approximate purities of each massecuite in a seven-boiling system:

Table 3.

Strike Number	Approximate Purity
1	98.6
2	96.0
3	93.0
4	90.0
5	83.0
6	72.0
7	60.0
Molasses	50.0

I have a report from Lynn Peterson, Peterson Filters and Engineering Company of Salt Lake City, on experiments conducted at Layton on filtration of raw juice without carbonation.

The possibilities shown by these experiments looked very promising. They were conclusive enough that it was decided to build equipment large enough for next year to filter approximately 400 gallons per hour, which we will run through our pilot ion exchange plant. It is hoped that we can run enough cycles to determine the feasibility of ion exchange filtration without carbonation.

I quote from Mr. Peterson's report:

"The filtration of the raw juice looks more economical than it has in the past, due to a combination of an old concept and newly developed liming and filtration equipment. It has been known for some time that the filtration rate is greatly improved at the iso-electric point. However, the point appeared to be too critical and to vary greatly with the juice so that controlling this point would not be feasible with known liming or carbonating equipment. Further more, the filter rate would be such that an uneconomical number of filters of standard design would be required to filter the juice if limed to the elusive iso-electric point.

"A new type limer, known as the Peterson Vacuum Limer and an improved type rotary leaf pressure filter known as the Conkey Rotary Pressure Filter have features which warranted additional experimentation to determine the feasibility of their combination in solving raw juice filtration.

"Tests using laboratory bench size equipment have just been completed at Layton.

"The data indicates that the iso-electric point, using the vacuum limer is not as critical as first supposed and that the number of filter units, using the new design, is not unreasonable if automatic timing and valve control is contemplated. An optimum iso-electric point for the juice at Layton was established between a pH of 10.6 and 11.5 which could be duplicated, and the filter tests on this juice indicate an economical filter rate. A filter area requirement of 3.0 to 3.5 square feet per ton of beets with not more than two men per shift for the limer and filter station is indicated.

"Ion exchange tests were made in the laboratory on juice clarified by the new combination without colloid formation in the resin beds, and at an exchange capacity comparable with ion exchange on second carbonated juice.

"For comparison of existing filtration equipment with the new filter, table 1 and table 2 are shown. The figures are more to show the over-all status and trend of filtration in beet sugar factories, rather than a detailed quantitative analysis of filter capacities. The trend has been toward filters which could operate on shorter cycles with a reduction of labor. The Kelly replaced plate and frame presses with not only 60 percent reduction in filter area requirement, but with at least a 50-percent reduction in labor. The combination of tray clarifier and rotary drum vacuum filter in conjunction with continuous carbonation replaced the Kellys in most factories, by again reducing the filter area and labor. The Conkey could be used to advantage on first carbonated juice since the tray clarifier could be eliminated and thereby minimize retention time.

Table 1.

	Sq. ft. area per ton beets	Filtering cycle in hours	Time between discharge	Men per shift 2000 ton house
First Carb Juice				
Plate and Frame	4.0 to 6.0	8 hours	1 hour Manual	10
Kelly Filter (Stationary Leaf)	1.5 to 2.0	2 hours	20 minutes Manual	4
Clarifier Plus Rotary Drum Filter (Vacuum)	0.4 to 0.6	Continuous		1
Conkey Rotary Leaf	1.0 to 2.0	1½ hours	15 minutes Automatic	1 or 2

"The same filtration equipment is considered in table 2, except on raw juice limed to an optimum iso-electric point. All figures, except for the Conkey, are estimates from other tests and observations by the Peterson Filters and Engineering Company.

Table 2.

On Raw Juice at Iso-Electric Point (Optimum)				
Plate and Frame (Est.)	5.0 to 8.0	1 hour	20 minutes Manual	20
Kelly Filter (Est.)	3.5 to 4.0	½ hour	10 minutes Manual	10
Clarifier Plus Rotary Drum Filter (Est.) (Vacuum)	1.5 to 3.0	Continuous		2
Conkey Rotary Leaf (Test Data)	3.0 to 3.5	½ hour	10 minutes Automatic	1

"Preliminary settling tests indicated that a thickener ahead of the rotary pressure filter is feasible. The juice temperature does not exceed 50 degrees Centigrade, and having a high pH, a retention time of only 20 minutes being required, this can be justified by a 30 to 40 percent reduction in rotary pressure filter area required over that shown in table 2. With this combination, plate and frame presses as "polishers" would be used on the thickener overflow. Activated carbon can also be used here to further improve the color.

"Using the Peterson Vacuum Limer in combination with the Conkey Rotary Leaf Pressure Filter for raw juice clarification, an operating cost of from 10 to 15 cents per ton of beets appears to be possible.

"Scaling up the bench laboratory equipment to pilot size for further investigation in the 1948-1949 campaign is now being prepared."

/signed/ Lynn Peterson