Low Raw Sugar Crystallization in Connection With Affination

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Introduction

Since the advent of the modern sugar industry, crystallization has always been given major consideration. In recent years many investigators have studied the subject with reference to sugar boiling. The objectives have been many and varied such as: pan design, steam economy, sugar quality, pan yield, workability of low grade products and overall sugar recovery. In 1960, a sugar boiling program was started at the Utah-Idaho Sugar Company. The objective was to improve the quality and yield of low raw sugar with the final objective of affinating this sugar. The end result desired was to increase sugar end capacity without major expenditures for additional equipment. The plan was to standardize on improved graining and boiling procedures that would give higher purity sugar with larger and more even crystals. This better sugar should purge more readily and thus give the needed increase in plant capacity. The Moses Lake, Washington, factory was chosen for the initial experimental work on this problem.

Description of Equipment

The Moses Lake factory is equipped with two 11-foot diameter calandria pans of 1,200 cubic feet capacity (Figure 1) used to boil the low raw sugar. These pans are cross-connected with an 8-inch line and valve for splitting pans. Both are equipped with mechanical circulators driven from the bottom. The controls (See Figure 2) include an absolute pressure controller, a density controller, a BPR (boiling point rise) recorder, and a level recorder. Attached to the pan is a microscope so that the inside contents of the pan can be magnified and viewed during the whole boiling period. The microscope has a light source inside the pan that shines through the juice and crystals, giving an excellent illuminated field.

The massecuite is dropped into a surge tank where the RDS is adjusted to the crystallizer RDS before it is pumped into the continuous crystallizers. This requires that the pan RDS be determined in the laboratory and the amount of water to be added to the surge tank calculated from the RDS of the pan as dropped. After the proper amount of water has been added and mixed with the massecuite, the massecuite is pumped to the continuous

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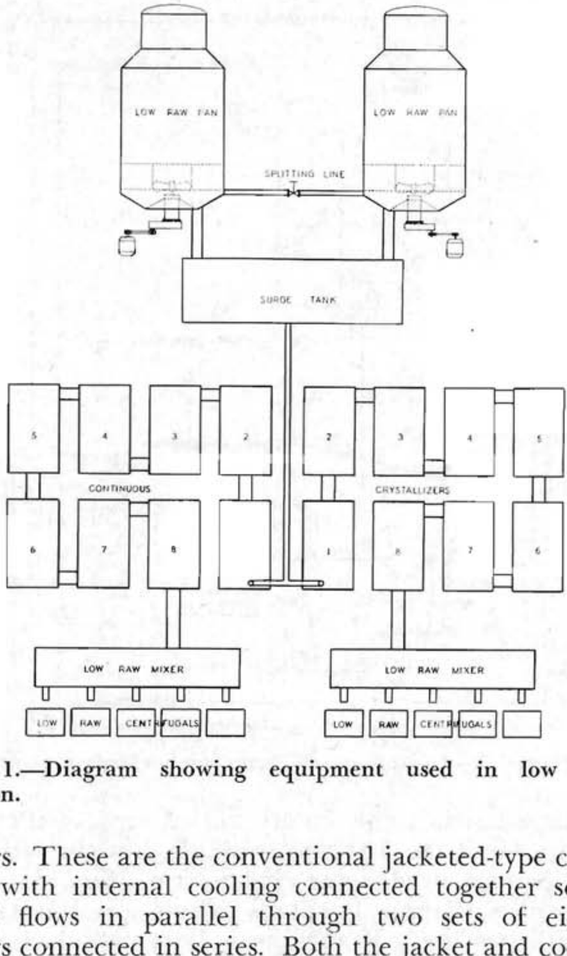

Figure 1.—Diagram showing equipment used in low raw sugar crystallization.

crystallizers. These are the conventional jacketed-type crystallizers equipped with internal cooling connected together so that the massecuite flows in parallel through two sets of eight single crystallizers connected in series. Both the jacket and cooling arms are used to cool the massecuite. The arms turn at 1 RPM and the cooling water is about 20° C. From the bottom of the last or eighth crystallizer on each side, the massecuite drops into two separate mixers—one for each set of crystallizers. Ten 42 inch × 24 inch Roberts centrifugals, five under each mixer, operating at 1,600 RPM, handle all the low raw massecuite.

Procedure

From the start of the sugar boiling program it was evident that in order to make each and every pan produce good low raw sugar, the proper amount of grain had to be established in each pan. The method previously used for graining - powdered sugar and air - left much to be desired. Several graining methods were attempted including: fondant and isopropyl alcohol, fondant and

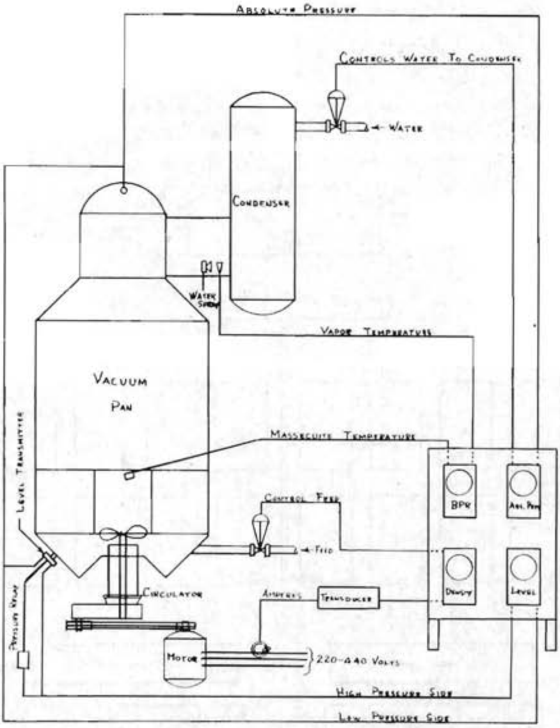

Figure 2.—Instrument diagram for calandria pans.

saturated liquid sugar, and finally milled seed. Gillett (2)[2] has explained in detail the first two methods, but the latter method mentioned perhaps needs some explanation. The idea originated in the Hawaiian Islands. It entails merely grinding two pounds of sugar with two liters of anhydrous isopropyl alcohol in a one gallon ball mill for twenty-four hours—hence the name milled seed. This mixture contains approximately 1.6×10^9 neuclei per milliliter which means that about 300 milliliters are required to seed a low raw pan or about 125 milliliters to seed an average white pan. Milled seed has the following advantages: 1. Is is a stable mixture. 2. It requires only a small quantity, 300 milliliters, to seed a pan. 3. It gives approximately the same number of grain each time. 4. It permits a very simple seeding operation.

The boiling procedure starts by taking a 400 cubic foot graining charge of high green into a clean tight pan. The amount of graining charge is constant from pan to pan by the use of the level recorder. By using high green, the seed crystals grow very rapidly in the graining charge resulting in a finished pan in which

[2] Numbers in parentheses refer to references.

the crystals are of maximum size. As soon as the charge is pulled into the pan, the agitator is started and the steam is turned on. The charge is boiled down until the boiling point rise reads 9° C. This supersaturation point can be observed through the pan microscope by putting a few coarse crystals in the graining charge just prior to the time when saturation is reached and noting when the crystals just develop sharp edges.

At this point the pan is seeded with 275 to 300 milliliters of milled seed (See Figure 3) and then as soon as the crystals take distinct shape as observed through the pan microscope (BPR 11° C), the steam valve to the calandria is turned back to ½

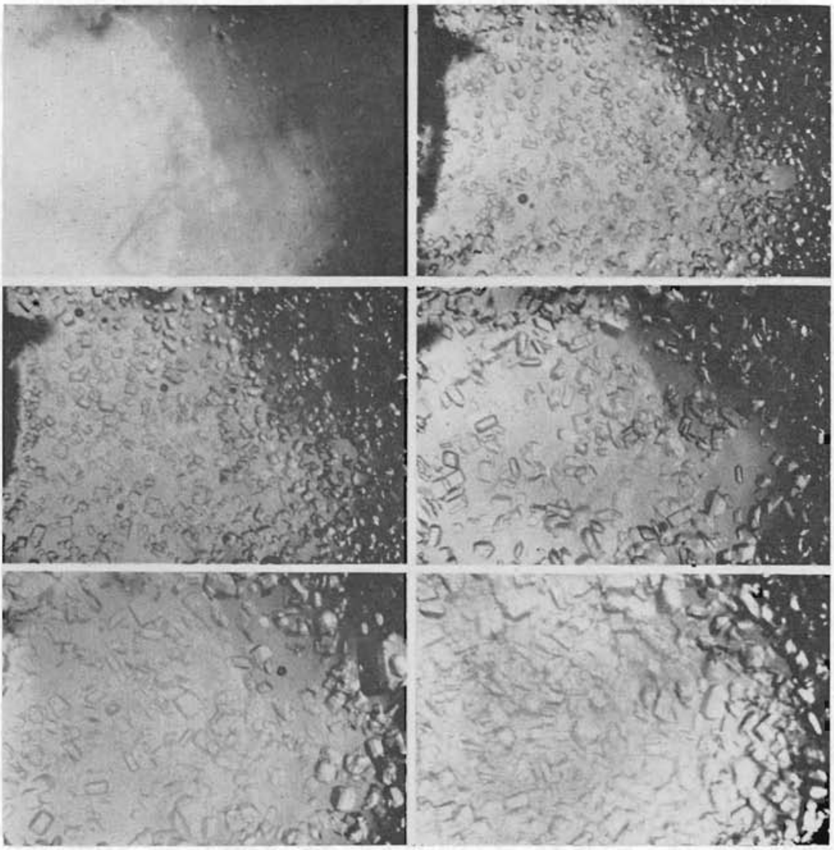

Figure 3.—Photographs of crystals as they appear through the pan microscope. Upper left—crystals at seeding time, upper right—crystals when steam rate is reduced, center left—crystals when feed is started, center right—crystals when pans are split, lower left—crystals when feed is shut off, lower right—crystals when pan is brixed.

round open. The crystals now are allowed to grow unmolested for approximately fifteen minutes until the BPR starts down. This point is verified through the microscope as being the time when the crystal width equals the distance between crystals. At this time the feed of intermediate green is started and the steam is turned back on the calandria. The pan feed is controlled by the load on the agitator motor operating the feed valve. When the massecuite volume reaches 1000 cubic feet, half of it is drawn into a second similar pan. The pan which is used for graining is fed at a fast evaporating rate while the other pan is taken up more slowly. The obvious reason for this is to balance the boiling schedule.

When the final pan volume is reached, the feed is shut off and the pan Brixed to the required RDS as indicated by the motor load. Both pans are boiled at a constant absolute pressure of four inches of mercury and the boiling time is approximately four hours per pan. This method of boiling requires a mechanical agitator to provide circulation while the pan is held at a slow evaporating rate. The purpose of this is to establish a good grain footing on which to build the sugar crystals. By slowing the pan down, the small crystals are allowed to get the growth and crystal area necessary to take more sucrose in the form of feed liquor.

Table 1.—Table showing results of low raw sugar boiling program.

Year	Cut	True purity low raw pan	Massecuites % on beets	Cubic feet/day	True purity molasses	Purity low raw sugar
1961-1962	4620	79.40	12.4	12,200	60.67	94.6
1960-1961	4069	78.36	12.2	10,700	59.95	93.0
1959-1960	3579	76.58	11.4	8,800	60.70	93.1
1958-1959	3539	76.74	11.7	8,900	62.25	92.0
1957-1958	3473	77.07	10.9	8,100	63.33	92.8
1956-1957	3415	77.41	11.5	8,400	62.76	92.4

To control grain size on low raw sugar is was necessary to know the MA and CV of this sugar. This could most easily be done by developing a practical method for wet screening the low raw sugar. It would also be helpful if such a method could be used to get an estimate of the MA and CV on the crystals in the massecuite as dropped from the pan. Such a procedure was developed (1). It is an adaptation of the method of Saint and Trott (3) and consists of washing the raw sugar or massecuite free of syrup with a sugar saturated alcohol solution and then wet screening in more of the same solution. The crystals become separate and distinct and may be photographed under magnification with a polaroid camera. The pictures and screen analyses give good guides to the sugar boilers and the result is a better quality of low raw sugar.

A table showing the MA and CV of the low raw sugar can perhaps best demonstrate the use of this control. A special chemist was employed during the sugar boiling work mainly to run the analysis on the low raw sugar for MA and CV. The results of one month's operation are shown in Table 2 for the Moses Lake Factory and the same table has the results of one week's operation at the Toppenish Factory. It is interesting that on about the 20th of October the MA went down and CV up, making the massecuite considerably harder to spin. These low MA's were caused by returning to the former sugar boiling practices. A return to the standard boiling procedure corrected the trouble as evidenced by the MA of .0128 on the 23rd of October.

From all indications the success of this method of boiling is dependent upon the use of a high purity graining charge and the growth of the crystals in this material as long as possible. The BPR will actually start down before any feed is added to the pan. This indicates that the sugar crystals have taken enough sugar from the mother liquor to actually lower the supersaturation. When the BPR starts down, more sugar must be made available for crystallization in the form of feed liquor. In actual practice, 60% or more of the crystal width may be attained in the graining charge before any feed is added to the pan. With the crystals firmly established, the remainder of the growth time can be spent getting as much sugar out of the molasses as possible.

Results

The standard boiling procedure increased the MA on the low raw sugar to as high as .0143 and an average of about .0115. At the start of the program the MA was about .0050. The plant capacity at Moses Lake increased from 3,579 tons per day in 1959 to 4,620 tons per day in 1961 using the same existing sugar end equipment. The purity of the low raw sugar increased from 93.1 to 94.6. These larger crystals and higher purity sugar permitted the affination of the low raw sugar to 99 purity and its return via the affinator to the white pan.

This program could not have been carried out or made successful without the cooperation and helpful suggestions of the sugar boilers, sugar end foremen, and particularly the factory supervisory personnel.

Table 2.—Table MA and CV of low raw sugars.

Date	Moses Lake: North Crystallizer MA	North Crystallizer CV	South Crystallizer MA	South Crystallizer CV	Toppenish: Date	Low raw sugar MA	Low raw sugar CV
1 Oct. 61	.0083	38	.0079	38	18 Jan. 62	.0093	24
2 Oct. 61			.0092	44	19 Jan. 62	.0090	34
3 Oct. 61			.0078	55		.0066	78
4 Oct. 61			.0085	46	20 Jan. 62	.0105	38
6 Oct. 61	.0107	45	.0097	53		.0102	38
7 Oct. 61	.0113	48	.0113	53	21 Jan. 62	.0125	33
9 Oct. 61	.0104	45	.0110	45		.0115	39
10 Oct. 61			.0117	36	22 Jan. 62	.0140	33
11 Oct. 61			.0117	39		.0144	22
12 Oct. 61	.0116	38	.0117	30	23 Jan. 62	.0115	37
13 Oct. 61	.0111	38	.0097	33		.0122	36
14 Oct. 61			.0113	32			
15 Oct. 61	.0143	31	.0124	29	24 Jan. 62	.0106	27
16 Oct. 61	.0143	31	.0143	31		.0130	41
18 Oct. 61	.0135	28	.0131	29	25 Jan. 62	.0143	37
19 Oct. 61	.0104	34	.0107	33	26 Jan. 62	.0130	34
20 Oct. 61	.0086	51					
21 Oct. 61	.0094	36	.0092	37			
23 Oct. 61	.0128	28	.0128	30			
24 Oct. 61	.0140	27	.0136	28			
25 Oct. 61	.0121	35	.0124	31			
26 Oct. 61	.0112	35	.0123	28			
28 Oct. 61	.0112	35	.0119	32			
29 Oct. 61	.0117	33	.0124	29			
30 Oct. 61	.0115	32	.0117	30			
31 Oct. 61	.0104	34	.0111	37			

Conclusion

A sugar boiling program of improved crystallization techniques and standard graining and boiling procedures, along with better pan instrumentation and controls, can give benefits by 1. increasing the capacity of the low raw sugar handling equipment, 2. increasing the purity of the low raw sugar, and 3. producing a quality sugar that is adaptable to affination.

References

(1) Gaddie, R. S. and R. R. West. Wet screening of sugar crystals from low purity massecuites and sugars. Private publication, Utah-Idaho Sugar Company.

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(3) Saint, John and R. R. Trott. 1960. Determination of size of crystals in massecuites and raw sugars. Sugar J. 23 (7): 23-27.