Affination of Low Raw Beet Sugar

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Introduction

Affination is a process by which sugar can be upgraded in purity without melting and recrystallizing.

The process of affination is used in the sugar refining industry as the first important step in the processing of raw sugar into its finished products. It is accomplished by mixing the raw sugar, which contains a thin layer of mother liquor on each of its crystals, with a saturated refinery syrup. The saturated syrup has little effect upon the sucrose crystals, but takes into solution all of the mother liquor surrounding the crystals. The resulting magma is then spun in centrifugals and washed up to a very high purity. This combination of affination and centrifuging gives almost complete separation of sugar from nonsugar.

Affination, as it is used in the cane sugar industry, is obviously a simple procedure. Its simplicity tends to obscure its value as a step in the process, but its effect upon the economy of refining raw sugar cannot be overlooked.

The advantages and simplicity of affination have not as yet found application in the beet sugar industry of this country. This is due perhaps to the fact that the domestic industry does not have a counterpart for raw sugar. Most raw sugar comes from sugar cane, but in many parts of the world is made from beets. It is a partially refined product that usually is produced in a raw sugar mill where a complete refining job is not attempted. It then has to be shipped to a refinery for further processing into its finished products.

Beet sugar, on the other hand, is manufactured into its finished products in the same plant where the beets are sliced.

Affination need not be reserved for raw sugar as described above. It can be used to process any grade of sugar that has suitable characteristics. For affination a sugar should contain a fairly large and even size grain that will permit washing in a centrifugal without some of the crystals passing through the screen. Also, its nonsugars should be such that they will be taken into solution by the affinating syrup. Low raw beet sugar is such a product except that in many plants, in this country, the crystal sizes are too small and too irregular in size to permit efficient washing in a centrifugal. It follows then, that if the crystals of

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low raw beet sugar could be enlarged sufficiently, affination and centrifuging could be used as a short cut step in the processing of beet sugar.

In 1960 a sugar boiling program was begun at Moses Lake, Washington, to improve the yield on all the pans and to thereby increase the capacity of the sugar end. This program was crowned with considerable success and from it was learned that with proper graining and boiling procedures a larger grain in low raw massecuite will result.

Encouraged by this knowledge, equipment to affinate low raw sugar on an experimental basis was installed in the plant for operation during the 1961-62 campaign.

It is the purpose of this paper to report on that work.

Objective

1. To upgrade low raw sugar to high raw sugar purity without recrystallization or excessive washing.
2. To reduce the amount of high raw massecuite boiled.
3. To improve high raw sugar quality by providing more boiling time.
4. Reduce circulating load on the sugar end.
5. To effect steam economy.

Machinery and Methods

The machinery used for affination of low raw sugar at Moses Lake is shown in Figure 1. Low raw sugar is boiled in the low raw pan (1) in the upper right hand corner of the figure.

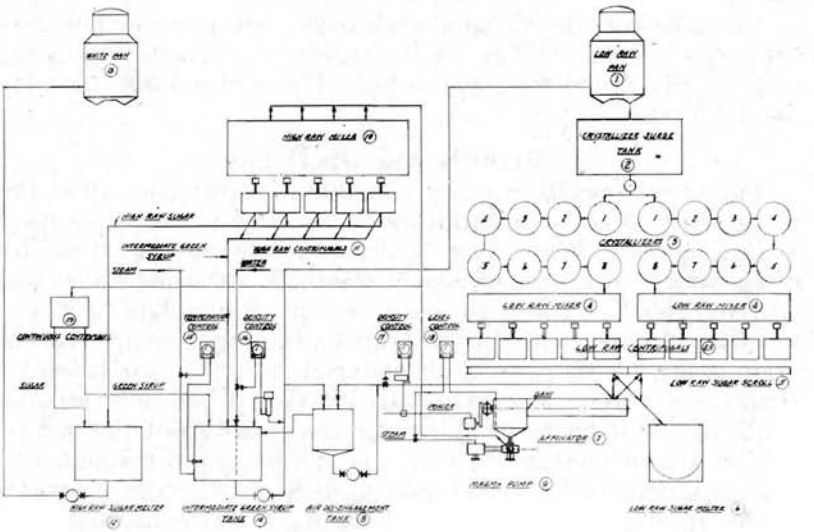

Figure 1

Massecuite from this pan is dropped into a surge tank (2) from which it is pumped into two banks of eight conventional crystallizers each (3) which are connected in series for continuous operation. From here the cured massecuite passes into two low raw mixers (4) each of which accommodates five 42" × 24" × 1600 RPM low raw centrifugal machines (4-a).

The sugar from these machines is discharged into the low raw sugar scroll (5) which brings the sugar to a central point between the two banks of machines. At this point the sugar can be directed from either or both sets of machines into the low raw sugar melter (6) or into the affinator (7) as desired.

In the affinator, which consists of a 24" scroll case 12 feet long attached to a surge tank and equipped with shaft and set of spiral paddles, the sugar is mixed with intermediate green syrup. In the end of the affinator, between the scroll case and the surge tank, is a dam designed to keep the paddles of the affinator submerged. From the affinator surge tank the resulting mixture is pumped by a magma pump (9) into the high raw mixer (10) which is equipped with a mixing apparatus. Here the magma is either spun on a continuous centrifugal (19) or mingled with the high raw massecuite and spun on the high raw centrifugals (11). The sugar from the high raw and continuous centrifugals is melted in the high raw sugar melter (12). The intermediate green syrup from these centrifugals enters the intermediate green tank (14) where it is heated and adjusted for R.D.S. before it is pumped through the air disengagement tank (8) on its way back to the affinator (7) and on to the low raw pan (1).

Controls for the affinator consist of: an intermediate green temperature control (15); an intermediate green density control (16); an affinator density controller (17); and a surge tank level control (18).

Methods and Operation

Successful operation of an affinator is contingent upon there being available a suitable saturated or near saturated syrup for mixing with the sugar. Not knowing which centrifugal machine syrup would work best, provision was made for using either intermediate green syrup, high green syrup, or standard liquor. It soon developed that the intermediate green syrup was best adapted for the purpose. This material, however, was laden with air as it came from the centrifugals and the air had to be separated before it could be used. This required heating of the syrup to 90°C in the intermediate green tank and passing it through an air disengagement tank. Before leaving the intermediate green tank the syrup was adjusted to 78 to 80 RDS which assisted in the removal of air and appeared to be the right range of density for

best operation. Through this range of density and temperature the syrup was slightly undersaturated, but when mixed with the low raw sugar and cooled to magma temperature the material was again saturated and there was no significant melting of sugar observed in the affinator.

The "mean aperture" (MA) of the low raw sugar affinated ranged from .0100 to as high as .0142 with the average around .0115. It seemed to mix well in the affinator except that it had a light golden color indicating that air was mixed with it. The RDS of the magma was 91.5 but when this material was mingled in the high raw mixer with the high raw massecuite which has a like density, and was fed into the centrifugals it appeared to have a density very much lighter than this. Further investigation showed the magma to have a weight of only 55 pounds per cubic foot compared to 93 pounds per cubic foot for a massecuite of this apparent density. The difference in the two weights was due to the entrapped air.

There was another effect from this air. It seemed to stay in the wall of the sugar in the high raw centrifugals and to prevent the wash water from passing through. The result was that the sugar would slump to the bottom of the basket as soon as the machine was stopped.

Laboratory work on methods of mixing low raw sugar and intermediate green syrup pointed the way for remodeling the affinator. After remodeling, the weight of the magma was increased to 76 to 80 pounds per cubic foot. This still was not good, but it made it possible to better load the centrifugals and to better spin the product. The low raw sugar could then be upgraded to a 99 plus purity either when spun by itself or when spun as a mixture with the high raw massecuite. There were times, however, when it was impossible to spin a full load of sugar in the baskets and to maintain the sugar quality at such a high point. There were indications that in addition to the trouble caused by air there was also trouble caused by the smearing action of two sizes of grain. This was confirmed in the laboratory and by the fact that troubles were less whenever the MA of the high raw and low raw sugar were near the same value.

At this point it was felt that both the trouble from air and the trouble from mixed grain sizes could be overcome if the magma could be spun by itself in a continuous centrifugal. The air would be easily disengaged as it spread over the screen of the machine to only a few crystals depth, and the problem of mixed grain size would be overcome if there were no mixing of high raw massecuite with the affination magma.

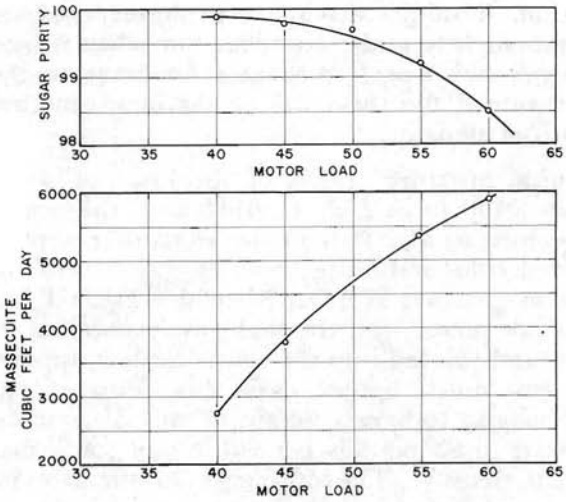

Figure 2

Another thing in favor of spinning this material on a continuous centrifugal is its density. Affination magma need not be as heavy as the massecuite dropped from a white or high raw pan—it can be anything from 88 to 92 RDS if saturated syrup is used, the difference being only in the amount of intermediate green syrup circulating between the centrifugals and the affinator. The amount of air entrapped in the magma is considerably less at the lower RDS.

For the final two weeks of campaign a Silver continuous centrifugal was used to process the magma from the affinator. After a few adjustments, this centrifugal handled the magma very well. The air in the magma did not seem to hinder the purging ability in any way and varying the magma RDS did not seem to have any effect either. The performance is best given in the form of Table 3 and Figure 2. The machine handled approximately 5000 cubic feet of magma per day, producing a green of approximately the same purity as the green going to the affinator and sugar of approximately 99.0 purity. If no wash water were used in the centrifugal, the purity of the green syrup from the machine would be lower than the purity of the feed syrup to the affinator. This is because the film of low purity syrup around the low raw sugar crystals is dissolved in the feed syrup, lowering its purity. When the sugar is washed in the continuous centrifugal, a small portion of the crystals is melted, tending to raise the green purity. This explains why the feed syrup to the affinator and the green from the continuous centrifugal end up approximately the same

purity—the impurities on the 95 purity sugar lower the purity, but the wash raises it back up again.

The amount of magma going to the machine was rather difficult to obtain; however, the figures shown in Table 3 were obtained by weighing the green from the machine and then from the amount of wash water, green RDS, and magma RDS, calculating the amount of magma.

Results

Affination was carried out continuously at Moses Lake for a period of thirty-five days. During parts of the first two weeks of this period, all of the low raw sugar from the plant was affinated. For the remainder of the time, only the sugar from one bank of centrifugals or slightly more than half of the low raw sugar from the plant was processed. Table 1 is a tabulation of the results.

Table 1.—Affinator

		Sugar purity		Color			Cubic feet per day	
Week	Slicing Rate	High raw	Low raw	Evap. thick	Standard liquor	Affinator magma	High raw mach. spun	High raw mass. boiled
20 Oct. 61	4688	99.0	94.4	71	40		23,800	23,800
27 Oct. 61	4736	99.2	94.4	62	40		23,400	23,400
3 Nov. 61	4675	99.0	94.7	67	43		22,100	22,100
10 Nov. 61	4766	99.2	95.1	59	41		22,500	22,500
17 Nov. 61	4773	99.1	94.8	70	52	7,730	16,720	24,450
24 Nov. 61	4661	99.0	95.0	74	53	5,620	16,590	22.210
1 Dec. 61	4664	98.8	95.3	80	55	5,660	17,450	23.110
8 Dec. 61	4711	99.3	95.3	76	54	5,120	18,470	23.590
15 Dec. 61	4642	99.2	95.2	80	58	5,270	19,760	25,030

It can be noted in this tabulation that the amount of high raw massecuita boiled was reduced by as much as 31.5%.

Table 2 shows a chronological comparison between slicing rate, high raw massecuite boiled, and purities of high and low

Table 2.—Affinator

Year	Slicing rate	High raw sugar	Purity low raw sugar	Cubic feet High raw filmas % on beets
1961-1962	4620	99.1	94.6	21.7%[1]
1960-1961	4069	99.0	93.0	33.4%
1959 1960	3579	98.6	93.1	36.0%
1958-1959	3539	98.3	92.0	34.9%
1957-1958	3473	98.7	92.8	30.7%
1956-1957	3415	97.6	92.4	30.8%

[1] To date for Campaign

Table 3.—Continuous centrifugal on affinator

Affinator			Ft³ per day	Feed Syrup			Machine Syrup		Sugar		
RDS	Purity	Temp		RDS	Purity	Temp	RDS	Purity	MA	CV	Purity
89.9	88.8	58	.....	75.9	80.7	88	76.4	80.1	.0115	37	99.3
89.9	90.0	56	4908	78.1	76.8	88	76.1	80.5	.....	....	99.8
90.0	89.9	60	4707	76.8	78.0	95	76.6	80.2	.....	....	99.3
90.8	88.8	56	6519	75.1	77.6	96	76.8	78.7	.....	....	99.4
89.4	89.4	56	5403	72.4	80.8	96	76.4	80.4	.....	....	98.5
92.1	88.7	60	.....	76.4	78.7	95	78.1	78.1	.0103	25	99.4
86.7	89.9	60	3806	65.8	82.8	96	75.1	81.2	.....	....	99.8
89.4	90.5	60	4861	75.5	82.2	95	75.9	82.0	.0114	33	99.7
89.4	89.3	60	5837	75.5	80.8	95	75.9	81.7	.....	....	96.8
89.9	90.2	60	6008	72.8	80.0	92	76.8	81.0	.....	....	98.5
89.4	89.2	62	5820	75.9	82.4	93	76.8	81.4	.....	....	98.4
90.3	91.0	60	.....	74.6	81.7	95	76.4	81.7	.....	....	98.8
90.3	89.2	60	2756	76.8	81.2	98	77.3	80.9	.0128	41	99.9
92.1	88.0	58	.....	72.8	81.8	98	74.1	81.5	.0126	43	99.8

raw sugar. Here again a decrease in the amount of high raw massecuite boiled can be noted for the year 1960-61 and 1961-62. The reduction for the 1961-62 campaign can be attributed mostly to the process of affination but for the reduction in both years some credit must be given to the over-all sugar boiling program that was carried on at the plant.

Table 3 shows the results obtained from using the continuous centrifugal on the magma.

Table 4.—Continuous centrifugal, effect of varying amounts of wash water.

Motor Load	Steam	Asp. Steam	Water	Purity Sugar
55	34	60	1.50	99.4
55	34	60	1.25	99.8
55	34	60	1.00	99.2
55	34	60	1.00	99.4
55	34	60	.75	99.5
55	34	60	.50	99.8
55	20	40	1.00	99.6
55	20	40	.30	99.3

Conclusions

1. That low raw beet sugar is a suitable product for affination and that it can be upgraded to 99 plus purity, provided the "mean aperture" (MA) of the sugar is kept above .0100 and the coefficient of variation is kept below about thirty.

2. That the amount of high raw massecuite boiled can be reduced by as much as 32%.

3. That the MA of high raw sugar can be materially increased by utilizing the additional boiling time made available by affination of low raw sugar.

4. That the circulating load on the sugar end can be reduced materially by affination. The low raw sugar, instead of being melted and reboiled, is short-circuited into the white pan.

5. That the amount of coloring matter returning to the white pan is no greater when affinating and continuous centrifuging is in use than when the low raw sugar is remelted and recrystallized in the high raw pan. The degradation of sugar is less due to the omission of one boiling step in the process.

6. That there are important steam economies associated with affination. These economies result from the reduction in the amount of high raw sugar boiled and from elimination of dilution and heating in the low raw sugar melter. With affination there is no need for operating the low raw melter.

7. Affination, as it was originally set up and tried at Moses Lake, left several things to be desired. First of all, the spinning of magma with the high raw massecuite was a mistake. Under

best operating conditions, variations of MA for both the high raw and low raw sugar were observed. When the values for the two were near the same figure, the results were very encouraging. When the values for the two were quite different the results were poor and discouraging.

Mixed grain and air in the centrifugal feed required light loading on the high raw machines and resulted in a reduction in capacity of the high raw centrifugal station. Since this station is called upon to handle the same amount of material, whether affinating or not, this reduction in capacity became a serious handicap.

8. Affination of low raw sugar was much more encouraging after the continuous centrifugal was put into operation. Consistently the machine handled around 5000 cubic feet of magma per day, producing a green of approximately the same purity as the green going to the affinator. The purity of the sugar coming from the centrifugal averaged over 99 purity, which was the desired result.