Evaluation of Affination at the Manteca Factory

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Introduction

During the 1985 intercampaign period, equipment for affination of final remelt sugar was installed at the Manteca, California factory of the Spreckels Sugar Co., Inc. Justification of the installation was based on Fall campaign operations where beet quality was generally the poorest, usually requiring significant amounts of wash water application to the raw centrifugals as well as significant cutback of production sugar to maintain adequate standard liquor quality for white sugar production.

The system was put on line during the 1986 Spring Campaign. The immediate effect on operations was a large reduction in standard liquor color allowing significant increases in wash syrup separation to standard liquor. There also appeared to be a reduction in molasses produced purities. Since wash water was generally not added to the raw centrifugals during Spring operations, the reduction in molasses purity is attributed to the increased wash separation and a lowering of the intermediate and raw fillmass purities.

In the 1986 Fall Campaign thick juice quality, both purity and color, was the worst encountered in recent history. As a result, comparison of the 1986 Fall period to other similar operating periods to determine operational benefits of affination were somewhat clouded by the more severe operating conditions experienced in the 1986 campaign. Comparison of operating data from the most similar periods suggest that affination allowed the factory to maintain similar throughput rates and molasses purities at similar production sugar cutback rates as experienced with thick juice of much better quality.

Desiring a more definitive analysis of the impact of the affination station on the Manteca operations, particularly during this very severe operating period, a computerized model of the Manteca sugar end was developed and subjected to various processing variations including changes in raw sugar quality and operation with and without affination. The results of this evaluation tend to confirm, although somewhat conservatively, the observations made from actual operations. In addition, a valuable tool was developed for the testing and evaluation of virtually any hypothetical processing condition.

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Evaluation Procedure

For the evaluation it was necessary to construct a reasonably precise computerized sugar end model. This was a means of achieving control over the many variables affecting the performance measurements and assure conclusions independent of uncontrolled, unrelated variations in operations. For the model to be precise and representative of actual operation at the factory, it was necessary to accurately determine the operating characteristics of the equipment involved as well as the operating parameters imposed on the equipment by operators and management.

The study utilizes the "P.C. Sugars" software marketed by Equipment Sales Company, Englewood, Colorado. This software offers a "building-block" concept allowing the user to customize the model to the specific equipment arrangement utilized in the process under study. Further, each unit process in the model is tuned to perform in the model as it does in actual operation. Unit processes can then be altered, added, or deleted from the process and flows redirected to determine the effect of the change on the overall operation. The possibilities for studying various process scenarios and conditions are nearly endless.

Each centrifugal and vacuum pan station was specifically designed to simulate actual performance during the evaluation period. Process flows including: wash syrup separations, seed footing transfers, centrifugal wash water, production sugar remelt, thick juice, molasses, and production sugar were carefully evaluated and inserted into the model. Finally, the basic model was tuned by relatively minor adjustment of fillmass rds and wash water flow to the white, intermediate, and affination centrifugals to yield production and molasses sugar outputs equivalent to actual operations. Comparative statistics for the basic model and actual performance are given in Table 1.

Table 1. Comparison of Model to Actual Performance

Manteca Factory

	P.C. Sugars Balance	Actual Operations
Standard Liquor Purity	90.91	90.78
Intermediate Fill. Purity	82.71	82.50
Intermediate Sugar Purity	97.91	97.80
Raw Fillmass Purity	74.07	73.90
Raw Sugar Purity	93.99	94.80
Molasses Produced Purity	57.06	57.30

The basic model simulates typical operations at 94 purity raw sugar with affination in place. To determine the impact of poorer raw sugar quality the raw sugar purity was changed in the model and white centrifugal wash separation adjusted to achieve a similar standard liquor purity.

For evaluation of the nonaffination modes, at both raw sugar purities studied, the following steps were taken:

1. Wash water was added to the raw centrifugal.

2. Process flows redirected to appropriate points. Standard liquor purity was then adjusted to the value of the basic model by:

    a) Reducing/eliminating white centrifugal wash recycle.

    b) Increasing production sugar remelt.

Discussion of Actual Operating Data

Comparing actual operating data for Fall Campaign periods with and without the affination process offers some insight into the possible benefits of the affination process. Table 2 gives relevant data comparing one Fall campaign period without affination to the Fall campaign with affination. These two periods had the most similar operating conditions.

Table 2. Comparative Operating Data

Affination	No	Yes
Thick Juice Purity	86.8	85.1
Standard Liquor Purity	91.0	90.8
Molasses Produced Purity	56.9	56.8
Sugar Produced cut-back	18.6%	20.1%
Thick Juice Color	36	47
Standard Liquor Color	33	35
Sugar Produced Color	26	28
Sugar Produced, Cwt/day	98%	100%

Even though thick juice quality was significantly worse in the affination period, factory production rates, molasses purity, and sugar quality did not suffer. When affination was put on line, the factory generally experienced an initial reduction in sugar produced color on the order of 25-30% allowing significant reduction in production sugar remelt to maintain standard liquor quality.

During the 1986 Fall Campaign with affination, factory throughput was limited by the capacity of the intermediate and raw sugar crystallization operations. Raw sugar quality, due to throughput pressures, tended to deteriorate and add to the processing difficulty.

Discussion of Computer Simulated Operations

The model was tested at 94 and 90 purity raw sugar for both affination and nonaffination schemes. These purities being representative of actual operations during the selected period. The respective models were then evaluated for extraction efficiency, process flows, and color balance and compared to each other to determine the relative differences between affination and nonaffination modes of operation.

Extraction Performance

Affination schemes yielded a small extraction improvement at both raw sugar purities studied. Table 3 summarizes the results of the material balances.

Table 3. Comparative Sugar End Extraction

	Affination		No Affination	
Raw Sugar Purity	94	90	94	90
Standard Liquor Purity	90.91	90.90	90.91	90.91
Molasses Produced Purity	57.06	57.62	57.49	58.15
Variation in Extraction	-	(0.56)	(0.41)	(1.01)

Using the affination model at 94 raw sugar purity as the base, the extraction improvement over nonaffination at the higher raw sugar purity was found to be 0.41 units. Comparing affination to nonaffination at the lower raw sugar purity, affination gave a better extraction of 0.45 units. Lowering the raw sugar purity caused a reduction in extraction in both the affination and nonaffination models with slightly less difference in the affination model.

Lacking comparable operating data, it was not possible to confirm an extraction improvement in factory operations. However, it can be said that under more severe operating conditions than previously encountered, molasses purity was apparently unaffected or just slightly improved with affination.

Sugar End Operations and Capacity

The elimination of wash syrup separation and a considerable increase in production sugar cut-back was required in the nonaffination models to maintain standard liquor quality. Using the affination model at 94 raw sugar purity as the comparative base, the differences in the relative amounts of cut-back and wash separation are shown in Table 4.

Table 4. Cut-Back and Wash Separation Data
% on Basic Model

	Affination		No Affination	
Raw Sugar Purity	94	90	94	90
White Sugar Cut-Back	100%	99%	142%	203%
White Cent. Wash Separation	100%	45%	0%	0%

In the affination mode, only white centrifugal wash required adjustment to maintain standard liquor purity at the lower raw sugar purity. In the nonaffination modes, no white centrifugal wash recycle to standard liquor could be tolerated and from 1 1/2 to 2 times as much production remelt, as in the affination mode, was required to maintain standard liquor purity. These data confirm the observation that production sugar cut-back was considerably reduced when affination was put on line. The impact of affination on remelt requirements had a significant effect on unit process flows in the sugar end. Sugar end flows increased significantly when affination was eliminated from the model.

Again using the affination model at 94 raw sugar purity as the base, the relative sugar end flows are shown in Table 5.

Table 5. Sugar End Flow Comparison
% on Basic Model

	Affination		No Affination	
Raw Sugar Purity	94	90	94	90
White Fillmass Flow	100%	99%	108%	120%
Intermediate Fillmass Flow	100%	102%	110%	121%
Raw Fillmass Flow	100%	107%	98%	108%
Sugar Produced	100%	99%	99%	99%

White and intermediate fillmass flows were significantly higher in the absence of affination while approximately the same volume of sugar was recovered. Given the capacity constraints on the intermediate and raw operations experienced during this period, it is likley that sugar output would have been further restricted during the 1986 Fall Campaign in the absence of affination resulting in poorer process efficiency in the areas of fuel economy and throughput.

Sugar End Color Balance

Using process flow data from the models, actual process colors for thick juice, white centrifugal wash, and standard liquor and assuming constant intermediate sugar and standard liquor color for all models, raw and affination sugar colors were calculated and a sugar end color balance established for each model using the method of Broughton, Houghton and Sissons[2]. This method uses a simple calculation to derive a dimensionless value, "color quantity", for each process flow making up standard liquor.

$$\text{Tons Sugar or Juice} * \frac{\%\ \text{Solids}}{100} * \text{Color} = \text{"Color Quantity"}$$

Color rise in the melters and heaters was held constant for all models at 10% of total standard liquor color. Table 6 summarizes the results of this evaluation.

[2]Factors Affecting White Sugar Color. Part II, The Sources of White Sugar Color", Zuckerindustrie III (1986) Nr. 11.

Table 6. Color Component of Standard Liquor
Contribution of Components, %

Raw Sugar Purity	Affination 94	Affination 90	No Affination 94	No Affination 90
Thick Juice	75.5	75.9	69.1	63.1
Production Remelt	0.1	0.1	0.1	0.1
White Centrifugal Wash	2.4	1.1	-	-
Intermediate Sugar	7.7	8.0	8.0	8.0
Raw/Affination Sugar	4.3	4.9	12.8	18.8
Total Color Recycle	14.5	14.1	20.9	26.9
Color Rise in Melter System	10.0	10.0	10.0	10.0
Total Color	100.0	100.0	100.0	100.0

Depending on raw sugar quality, sugar end color recycle is reduced by 30% - 48% when affination is employed. The "color quantity" attributable to raw sugar is reduced three to four fold with affination allowing more efficient processing of higher color thick juices or increased recycle of white centrifugal wash syrups to standard liquor. In the absence of affination, large amounts of production sugar are required to maintain equivalent standard liquor and production sugar quality at the given thick juice quality.

Comparing the results of the color model to the actual changes in standard liquor color experienced in the factory when affination was put on line, only about 50% of the impact is represented in the model. This is partially explained by the fact that upon start-up of affination, no raw remelt flows to standard liquor until the equipment is filled with affination magma. The steady state color balance is not achieved until several hours after affination is put on line.

Summary

The results of computer analysis may be summarized as follows:

1) Extraction improvements of 0.41 to 0.45 units were noted when affination is employed. As raw sugar quality deteriorates, extraction benefits increase from the use of affination.

2) Requirements for production sugar remelt to standard liquor are reduced from 30% to 50% depending on raw sugar quality when affination is used. In the absence of remelt requirements, greater amounts of wash syrups may be recycled with affination.

3) White and intermediate fillmass flows are reduced from 10% to 20% when affination is employed. Raw fillmass flows are affected by only 1-2% depending on raw sugar quality.

4) Internal sugar end color recycle is reduced by 30% to 48% depending on raw sugar quality when affination is used.

With the exception of the extraction benefits noted, conclusions of the computer model are confirmed by process observations during the evaluation period.

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