Recent Advances in Molasses Exhaustion

K. W. R. SCHOENROCK AND J. R. JOHNSON[1]

Background and History

The extraction of sugar from sugar beets has been very closely related to the development of beet varieties with a high sugar content. The early pioneers of this industry realized the importance of this relationship. From the annals of history it is evident that men such as Archard placed as their main objective first the development of beet varieties which made industrial sugar extraction from sugar beets economically feasible.

Results of the efforts in the direction of high sugar content seem to have reached a plateau although tremendous gains have recently been made in other directions of beet development.

More recently some areas even show a slow but alarming deterioration of beet processibility and a declining sugar extraction. A number of investigators have studied and reported on the subject of beet processibility and sugar extraction as a function of beet quality. The reader is referred to the extensive literature coverage on this subject.

According to this literature the extraction of sugar begins with beet breeding and is followed by appropriate agricultural practices. In some European areas the level of so-called melassigenic constituents such as potassium and sodium is considered in the beet contract. Farmers are advised as to the agricultural practices favoring low potassium and sodium content and are rewarded or penalized according to the deviation from the established standard.

However, the processor cannot always change the basic raw material to comply with the concept of ideal beet quality. Processing of the beet must consequently be adapted to prevailing beet quality to attain optimum results from the material available. In this light molasses exhaustion begins in the diffusion process.

Schneider, Reinefeld and Schliephake discuss the fundamentals and the practical application of sugar extraction from beet cossettes (24)[2]. The behaviour of nonsugars during extraction was investigated by Schneider and Schliephake (17). Rounds and Rawlings (15) reported their findings on the change in nonsugar elimination in diffusion due to temperature and

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[1] Research Chemist and Research Laboratory Manager, respectively, The Amalgamated Sugar Company, Twin Falls, Idaho.
[2] Numbers in parentheses refer to literature cited.

draft variations. Henry, Vandewijer and Piek (7) evaluated the effect of diffusion temperature and pH upon beet juice quality. Asselbergs, Van Der Poel, Verhaart and Visser (1) studied the extraction of nonsugars as a function of sucrose extraction and its relationship to sugar losses in molasses.

The primary objective of beet juice purification via the treatment with lime is to prepare a clear filtrate of sufficiently high purity from which sucrose can readily be crystallized. A voluminous literature testifies to the vigorous activity in the field of beet juice purification. It is commonly agreed that 1 pound of nonsugars not eliminated in purification will prevent about 1.5 pounds of sugar from being recovered as salable sugar. A nonsugar elimination of about 30% is very common for most good defecation systems. Strenuous efforts are continuing to improve nonsugar elimination and increase sugar extraction by this route.

Ion exchange has also been revitalized in the beet sugar industry in recent years to increase extraction of salable sugar. Reportedly, at least one ion exchange installation in Japan features nearly total nonsugar removal with complete elimination of molasses production.

Some ion exchange processes such as the Quentin process are designed to replace so-called highly melassigenic cations such as potassium and sodium with less objectionable cations such as magnesium.

The sole purpose of all processing operations in a beet sugar factory is to increase sugar extraction and molasses exhaustion at a reasonable cost level.

Purification via crystallization is the final step in a refinery processing sugar from sugar beets. Research activities in the field of crystallization have been especially lively in recent years. An extensive literature coverage of work performed prior to 1957 in the field of sugar technology with particular emphasis on crystallization has been prepared by Honig (8).

More recently Brieghel-Mueller (2) reported on super-saturation and the velocity of crystallization. Moller and Schmidt (12) developed a laboratory method to determine velocity of crystallization under conditions allegedly adapted as accurately as possible to those prevailing in the factory. Schlienhake (16) investigated the structure of aqueous sucrose solutions. Tonn (27) published his assertions of empirical nature concerning the rate of crystallization in supersaturated sugar/water systems.

Although the findings of Emmerich and Forth (5) with

crystallization of sucrose from weakly supersaturated solutions are based on pure solutions its value might well extend into the range of impure solutions. Their observations with damaged and so-called healed crystal surfaces may explain in part the reason for Carolan's (3) failure to exhaust molasses when starting with a higher purity mother liquor (compare chapter 7, Tables 7 and 8 with chapter 6, Tables 5 and 6) in spite of sufficiently high supersaturations.

Wagnerowski et al. (30); Pidoux (14); and Vavrinecz (28) among others reviewed the solubility of pure sucrose in water.

A large share of attention has been focused on the influence of the various nonsugars represented in beet liquors upon the solubility of sucrose (salting out effect). In a series of publications Schneider et al. (18, 19, 20) reported on sucrose solubility and crystallization as a function of individual nonsugar fractions. They also published their work on the influence of beet non-sugars on molasses formation (21, 22, 23). Mantovani investigated the individual effect of potassium chloride (9), betaine (10) and raffinose (11) on sucrose solubility and crystallization. He found a significant salting out effect for potassium chloride and a small decrease in sucrose solubility with either betaine or raffinose.

The results Mantovani obtained with raffinose were confirmed in our studies. According to Mantovani sucrose crystallization was only impaired to the extent of the salting out effect for potassium chloride or betaine while raffinose inhibited sucrose crystallization to a much larger extent than its salting out effect would justify. Carolan (3) essentially confirmed Mantovani's findings for potassium chloride and betaine, respectively, alone but found a decrease in sucrose crystallization for a combination of the two main nonsugars in molasses in excess of the combined salting out effect.

Grut (6) described a method for the determination of molasses exhaustion. Wagnerowski and coworkers (29) proposed a simple laboratory method for the estimation of specific sucrose solubility in pure and impure systems. In subsequent publications (31, 32, 33) Wagnerowski et al. proposed a system for evaluating and guiding molasses exhaustion under optimum conditions. Dobrzycki (4) reported also on these findings.

Development and Summary

Inconsistencies in low purity crystallization on a factory level prompted the authors to suspect a variable deviation of sucrose solubility from the values in established solubility tables.

The method of Wagnerowski et al. appeared to be well suited to allow the quick and simple determination of sucrose solubility

in specific low purity liquors. The basic findings of Wagnerowski *et al.* may be summarized as follows:

1. The saturation equilibrium for sucrose in low purity liquors is approached in about two hours. Schneider and coworkers have published similar results.
2. The coefficient of saturation[3] remains constant under temperature change for a given nonsugar/water ratio. This discovery has been credited to Wiklund (34).
3. For low purity liquors with a nonsugar/water ratio > 1.5 the coefficient of saturation is a linear function of the nonsugar/water ratio.

These findings were basically confirmed by our work. Solubility diagrams such as proposed by Wagnerowski *et al.* were prepared from time to time to see whether a shift in sucrose solubility did occur as campaign advanced. Sucrose solubility in molasses from different factories as well as sucrose solubility in molasses from different processing periods was determined and compared against each other, as well as against the values from established solubility tables. It was apparent that differences in sucrose solubility did occur between different beet liquors. These differences were however, relatively small for the test program thus far. A calculated least square straight line relationship between the coefficient of saturation and the nonsugar/water ratio representing all solubility values thus far established appears to suffice for normal factory operation.

Observed differences between determined values and values taken from established solubility tables were however very large. An accurate knowledge of actual solubility minimizes the chance for either undersaturation or excessive supersaturation during low raw massecuite curing. Dilution and reheating during the various crystallizer stages may be scheduled to conform with the actual solubility range. This will minimize danger of redissolving already crystallized sugar or of inadequate exhaustion of the molasses.

Alignment charts are presented which show the relationship between brix, purity, temperature and supersaturation on the one hand and the relationship between massecuite brix, purity, final nonsugar/water ration, pan size and total water addition on the other hand. Additional alignment charts may aid operators to further optimize the operation of the entire low raw side by knowing the total available time for operation under a specific set of conditions.

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[3] The coefficient of saturation expresses the ratio of dissolved sugar between impure and pure solutions at the same temperature and at saturation.

A large number of complete crystallizer cycles were continuously sampled. Viscosity, brix and purity were determined on the massecuite and the respective mother liquor throughout the cycle to determine the rate of crystallization. The cumulative crystallization rate[1] was found to be a log function of the log of time. Only the slope varied with a change in the conditions.

In another phase of this investigation the role of viscosity in low raw crystallization was studied. Opinions are somewhat divided on the relationship between viscosity and rate of crystallization. For all practical purposes in factory operation, however, viscosity is the controlling factor in low raw massecuite curing. For the practitioner it is of no immediate concern whether viscosity effects the crystallization rate directly or indirectly. Viscosity dictates the cooling rate, required dilution of mother liquor, and the conditions for—and results of—final purging on the low raw side. A thorough understanding of the role of viscosity in crystallization is therefore vital.

Recently Schneider, Schliephake and Klimek (25) reported their findings on the viscosity of pure sucrose solutions. Tikhomiroff, Pidoux and Filippi evaluated the effect of viscosity on crystal formation in super-saturated aqeous sucrose solutions (26). Wagnerowski, Dabrowska and Dabrowski (33) investigated the relationship between foaming, viscosity and molasses exhaustion. Pidoux (13) made a significant contribution when he developed a simple formula for expressing the temperature/viscosity relationship in sucrose solutions. His discovery has been applied to our work with molasses exhaustion. In so doing it has been possible to predict proper viscosities for purging by adjusting conditions to conform with optimum results. Massecuite as well as mother liquor viscosity was found to be a linear function of temperature although air entrainment and nucleation of fines may be responsible for certain deviations. In any event, cooling and dilution rates may be programmed on the basis of anticipated viscosities rather than solely on the immediate power requirements of the crystallizer.

Experimental Methods

Solubility determinations were carried out according to the procedures suggested by Wagnerowski et al. A fully jacketed three neck flask with one liter capacity was used for our determinations. The center neck received the stuffing box with stirrer

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[1] Cumulative crystallization rate is here expressed as % sugar crystallized per minute on total sugar in original mother liquor and disregarding available crystal surface area.

assembly. The two side necks were used for a reflux condenser and a thermometer, respectively. Constant temperature water was circulated through the jacket of the flask. The flask was placed in a full size electric heating mantle to minimize radiation loss, and to support the output of the constant temperature water bath if needed. Temperature of recirculation water was controlled through a thermistor regulated constant temperature water bath.

The flask was charged with the appropriate molasses sample of a predetermined nonsugar/water ratio. Temperature was maintained at $\pm$ 0.01°C. When thermal equilibrium was reached an adequate amount of coarse sugar, — 16 + 34 mesh, was added to provide a safe excess of sugar at saturation. The molasses/sugar mixture was then agitated for at least two hours at the test temperature. The necessary high nonsugar/water ratio in the molasses was either obtained by distilling off excess water from normal molasses or by sampling a crystallizer early in the cycle when nonsugar/water ratios were still sufficiently high to avoid evaporation of excess water. The latter method was finally adopted since a host of problems was associated with the former procedure.

A Carver Press fitted with a home made jacketed cylinder assembly was used to separate the mother liquor from excess crystals. The Carver press assembly was equipped with controlled electric heating platens. Constant temperature water from the water bath was also circulated through the jacket of the cylinder to keep the massecuite at temperature equilibrium during the pressing operation. The heavily supported screening section allowed the use of any filtering media. Tightly woven linen cloth was normally employed as a primary filter. The expressed mother liquor was collected in a jar and aliquot parts were used for the purity and viscosity determinations. Viscosity was determined with the Brookfield-Synchro-Lectric Model RVT viscometer and purities were determined via the single acid true purity method.

Results and Discussion

The differences in solubility between the values of Grut; Brown & Nees; and Twin Falls material for the 62-63 campaign are illustrated in Figure 1. It is easily seen that the Twin Falls material dissolves more sugar for a given nonsugar/water ratio than either the Grut or Brown & Nees values would indicate. The solubility values were applied to an actual crystallizer run to show the difference in supersaturation. Figure 2 illustrates the difference in supersaturation when using either Grut's solubility values and actually determined solubilities respectively.
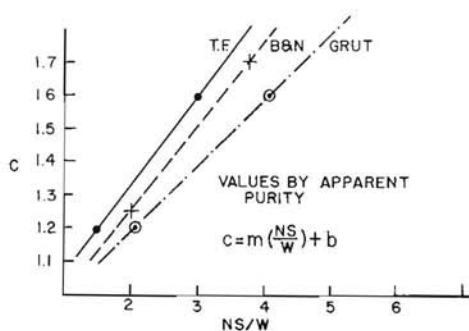
Figure 1.—Difference in sucrose solubility between the data of Grut, Brown and Nees and actual values for low purity liquors. Twin Falls area, 1962.
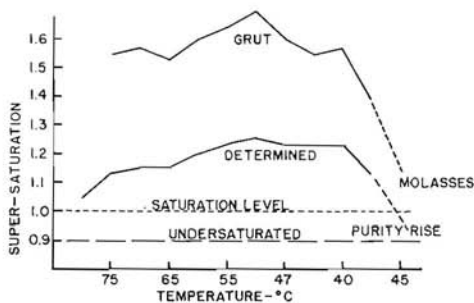

Figure 2.—Difference in supersaturation between Grut's tables and actual values. Twin Falls 1964, complete cycle.

The interesting part of this comparison is that the high supersaturation when based on Grut's tables made it difficult to properly schedule crystallizer operation and to justify in particular the purity rise in mother liquor which is usually experienced during the reheating period at the end of the crystallizer cycle. On the assumption of being sufficiently safe, operators raised temperatures and added water to improve purging. As we see from the actual supersaturation the mother liquor was already undersaturated at that point and sugar was redissolved. A second deception is the belief that a supersaturation of 1.5 or so should be maintained in low raw massecuite to secure acceptable crystallization velocity. It was found by testing a large number of crystallizers that a supersaturation of 1.25 was maximum for smooth operation.

The results for sucrose solubility in beet molasses from different areas are shown in Figure 4.

Although variations of sucrose solubility in nonsugar/water systems from different areas have been observed within the territory of the Amalgamated Sugar Company, these variations were relatively small when compared against the differences with established solubility tables heretofor used.

A least square line representing all values for the 62-63 campaign was identical to a least square line calculated from the solubility values of the 63-64 campaign. Figure 3 shows these results.

Only 2 solubility determinations at different nonsugar/water ratios are required to attain a complete solubility spectrum for the sample in question. However, more than 2 such determinations were carried out to gain confidence in the method and to provide sufficient data for statistical analysis. The 1962-63 campaign values in Figure 3 represent 49 different solubility determinations from 12 different mother liquor samples gathered from 4 factories at up to 4 different sampling periods. The same
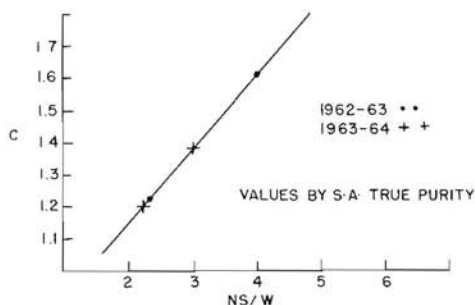

Figure 3.—Difference in sucrose solubility for low purity liquors between 1962-63 and 1963-64. Twin Falls area.
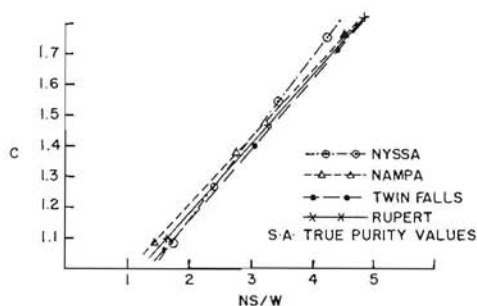

Figure 4.—Difference in sucrose solubility for low purity liquors from different areas. 1962-63 campaign.

4 factories are represented in the 52 solubility determinations carried out for 2 sampling periods during the 63-64 campaign. An average of 4 solubility determinations at different nonsugar/water ratios were performed for each molasses sample. Linearity between the coefficient of saturation and the nonsugar/water ration was evident in all cases. Table 1 shows the statistical correlation coefficients and least square equations for each set of data.

Table 1.—Solubility regression equations and correlation coefficients.

Factory and sample time	Equation	r (xy)
Rupert 1962-63	Y = 0.722 + 0.230 X	0.984
Rupert Early 1963-64	Y = 0.724 + 0.232 X	0.998
Rupert Late 1963-64	Y = 0.699 + 0.240 X	0.996
Rupert (All Combined)	Y = 0.713 + 0.234 X	0.991
Twin Falls 1962-63	Y = 0.704 + 0.228 X	0.976
Twin Falls Early 1963-64	Y = 0.697 + 0.241 X	0.989
Twin Falls Late 1963-64	Y = 0.809 + 0.167 X	0.987
Twin Falls (All Combined)	Y = 0.722 + 0.220 X	0.955
Nampa 1962-63	Y = 0.777 + 0.212 X	0.988
Nampa Early 1963-64	Y = 0.750 + 0.218 X	0.995
Nampa Late 1963-64	Y = 0.804 + 0.201 X	0.943
Nampa (All Combined)	Y = 0.780 + 0.210 X	0.984
Nyssa 1962-63	Y = 0.802 + 0.186 X	0.952
Nyssa Early 1963-64	Y = 0.702 + 0.225 X	0.998
Nyssa Late 1963-64	Y = 0.717 + 0.218 X	0.992
Nyssa (All Combined)	Y = 0.741 + 0.211 X	0.989
All Data Combined 101 =	Y = 0.745 + 0.217 X	0.979

   Differences are not significant @ 19:1 odd in Y-intercept or slope between factories or sample time.
   Observe Twin Falls for 1963-64 which has a lower slope than normal and the same for Nyssa 1962-63. Even with these values included we find the curve for combined data to possess a high degree of correlation C vs A. According to this we can assume that a single curve will suffice for solubility work without a high degree of error.

The most stable relationship in crystallizer operation is the nonsugar/water ratio. While sucrose in solution, brix and percent purity of the mother liquor as well as crystallization rate and viscosity are continuously changing, the nonsugar/water ratio may be controlled at will through water addition. Needed water dilution may be easily calculated for a final nonsugar/water ratio in the molasses if pan brix, pan purity and pan size are known. An alignment chart has been prepared in Figure 5 to illustrate graphically the relationship between these variables. It was necessary to assign an average density to the massecuite to convert volume values into its respective weight. The changes in water addition due to a small change in the massecuite
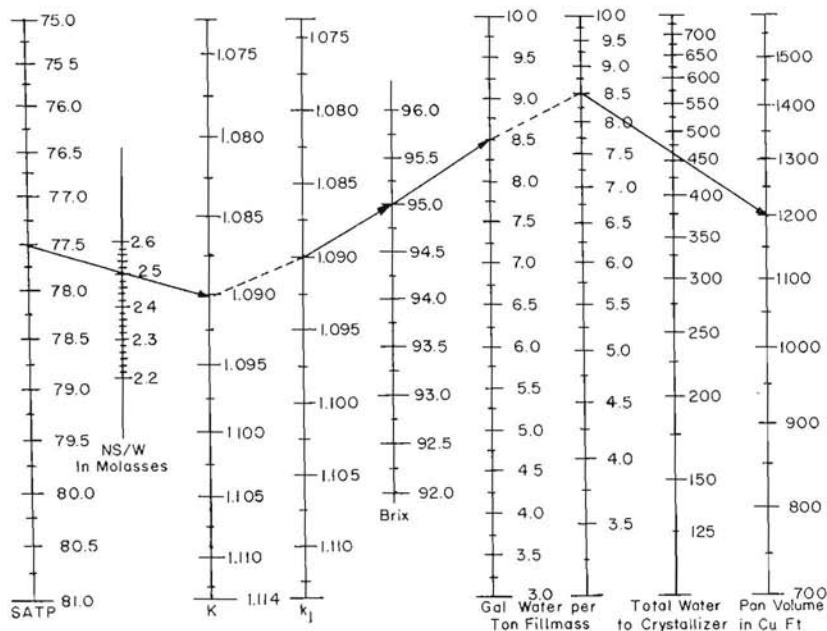
Figure 5.—Nomograph showing the relationship between pan size, pan RDS, pan SATP, desired nonsugar/water in molasses and required total water addition in gallons to the crystallizer.

specific gravity are small and may be neglected.

A simplified nomograph may be used according to Figure 6 by stabilizing the pan size and the nonsugar/water ratio in final molasses. For most factories this latter alignment chart is adequate.

In the example shown in Figure 5 a straight line is projected between the single acid true purity of the massecuite at pan drop (in this case 77.5%) on the far left scale through the selected nonsugar/water ratio in molasses (in this case 2.5), to obtain a K value of 1.09. A like K value is found on the adjacent K_1 scale and connected via a straight line over the determined massecuite RDS (in this case 95°) to find a water addition of 8.5 gallons/tons massecuite. This value of 8.5 may be connected from the second scale graduated in gallons water/ton fillmass with the pan volume on the scale at the far right (in this case 1200 cu ft) in the third part of the nomograph by a straight line to show a total water addition of 480 gallons. Or the value of 8.5 may be multiplied mentally with the total tons of fillmass at pan drop to obtain total water addition.
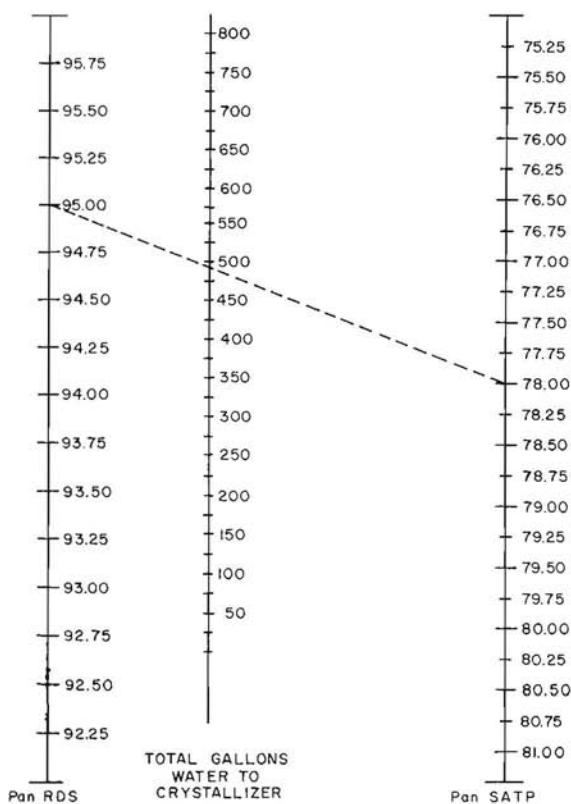
Figure 6.—Nomograph illustrating the relationship between pan RDS, pan single acid true purity and required total water addition to the crystallizer in gallons. Pan size 1300 cu ft. Projected final nonsugar/water ratio in molasses - 2.5.

Of primary importance to successful crystallizer control.is the proper timing for needed water addition. The scheduling for water addition must be a compromise between desirable super-saturation and tolerated viscosity. Supersaturation may be easily calculated for any set of conditions of brix, percent purity, temperature and coefficient of saturation for a specific mother liquor. Figure 7 illustrates this relationship graphically for the average of all determined solubilities as shown in Figure 3. The example given in Figure 7 shows a K value of 0.355 for a mother liquor purity of 59% and an RDS of 86°. This K value of 0.355 is projected in the second part of the nomograph through a temperature of 57° C to reveal a supersaturation of 1.0. Water addition may thusly be properly scheduled and purging tempera-tures may be conveniently selected without the danger of either
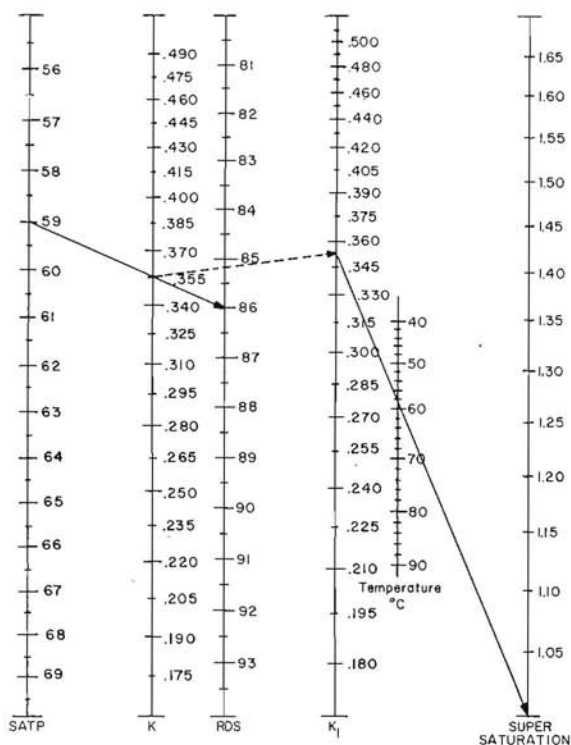
Figure 7.—Nomograph illustrating the relationship between single acid true purity, RDS, temperature, and supersaturation for low purity liquors. The Amalgamated Sugar Company.

dissolving sugar or exceeding the upper safe limit for supersaturation respectively.

Under normal conditions of factory operation it is impractical to obtain mother liquor brix and purity during the crystallizer cycle. A uniform pan boiling procedure will, however, produce very consistent mother liquor composition at pan drop. We found a stable 92.5° RDS and 63% purity for the mother liquor at a massecuite RDS of 95° at pan drop for one of our factories. Under these conditions and at a pan drop temperature of 85°C the mother liquor has a supersaturation of only 1.14. Supersaturation is the driving force for crystallization and should be held as high as clean crystallization permits.

The crystallization rate was determined from the change in sucrose concentration for the mother liquor of low raw massecuite subjected to carefully controlled curing. Figure 8 illustrates the declining crystallization rate towards the lower temperature scale.
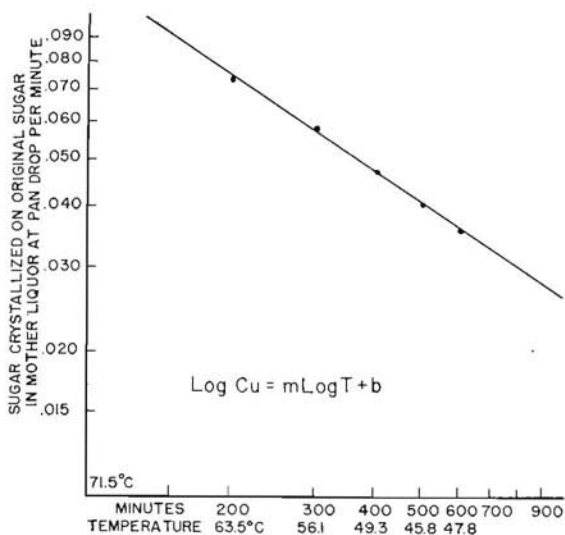
Figure 8.—Relationship between rate of crystallization and time for low-purity massecuite in commercial crystallizer, Twin Falls factory, campaign 1960-61. Mother liquor purity 65-70% (AP), supersaturation - 1.2.

It remains to be established though, to what extent the declining rate may be charged to temperature and to what extent to other influences such as proposed by Emmerich and Forth (5).

The values in Figure 8 represent a total of 160 different purity determinations from 23 complete crystallizer cycles. Linearity of the relationship as expressed in Figure 8 was observed in all cases although a shift in the slope was evident with a change in the massecuite and curing conditions respectively. The influence of surface area was purposely neglected for practical reasons.

To approach ideal conditions one would have to program the cooling rate and water addition to the crystallization rate within a favorable supersaturation limit to maintain an acceptable viscosity. The dominating role of viscosity is perhaps best illustrated by comparing the change in viscosity and supersaturation respectively during the cooling cycle. Below 70°C the viscosity increases more than twofold for every ten degree drop in temperature and triples below 40°C for every 10 degree centigrade drop. If a solution of sugar in molasses is assumed to be saturated according to the coefficient of saturation for Twin Falls material at 70°C, its supersaturation will be 1.13 at 60°C, assuming that sucrose crystallization was dormant during that period. The values are from 1.0 to 1.09 supersaturation for a temperature drop from 40° to 30° C. The inference is

that the rate of gain in supersaturation decreases during progressive cooling while the rate of gain in viscosity increases on a nearly logarithmic scale over the same temperature range.

Thusly, viscosity and not supersaturation becomes the controlling factor in the lower temperature range because continued crystallization does not allow a significant build up of supersaturation during a normal cooling cycle. Water addition need
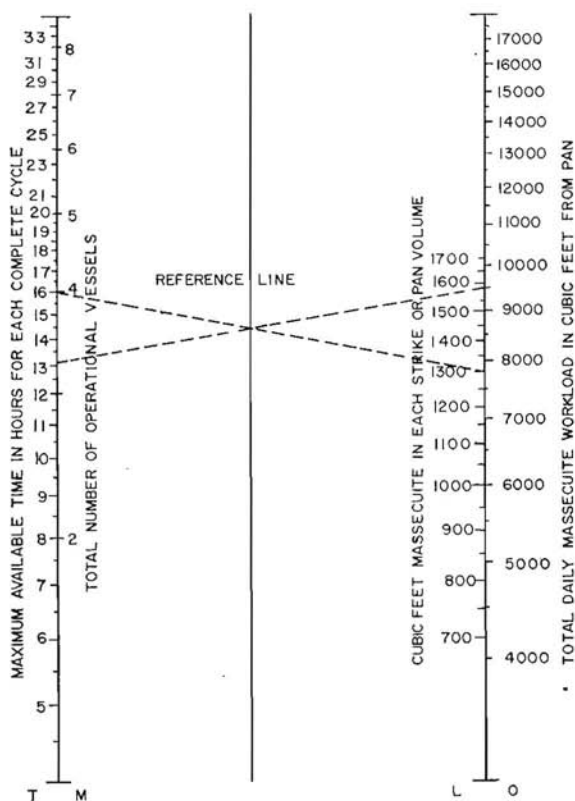
To solve for the unknown: Connect points on the inside scales via a straight line; A second straight line connecting points of the outside scales must intersect the first straight line on the reference line.

Example:

Number of vessels	=	4		(Scale M)
Maximum available	=	1300	cu ft	(Scale L)
Daily workload	=	9500	cu ft	(Scale O)
time	=	13.1	hours	(Scale T)

Figure 9.—Nomograph illustrating the relationship between available crystallizer vessels, capacity for each vessel, daily fillmass from pan in cu ft, and total time available for each complete cycle.

not be started then until the viscosity increase demands a dilution for reasons of handling and purging limitations. The only other factor which must be considered in scheduling the beginning and the rate of water addition once the total amount of water to be added has been established according to Figure 5 or 6, is the available curing time which in turn dictates the cooling rate.

The alignment chart in Figure 9 illustrates the relationship between daily low raw massecuite workload discharged from the pans, number of vessels, vessel capacity and maximum available time for each respective cycle. To solve for the unknown, points on the inside scales are connected via an imaginary straight line. Another straight line is projected between points on the outside scales to intersect with the first straight line on the reference line. The chart may be used for establishing maximum crystallizer or pan boiling time, or for finding the number of crystallizers or pans needed if a predetermined cycle time or daily workload or vessel capacity is to be maintained. Figure 10 shows an alignment chart at constant pan capacity, in this case 1300 cu ft. Similar alignment charts may be prepared for the centrifuge station.

After fixing the total time available for each respective crystallizer cycle it is feasible to project a specific cooling rate. Figure 11 shows an alignment chart which predicates the cooling rate in °C/hour if the available cooling time and the temperature
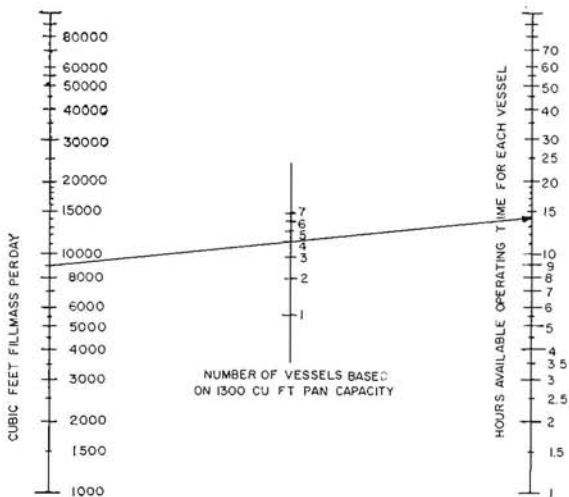

Figure 10.—Alignment chart showing the relationship between daily fillmass workload, number of vessels and total operating time.
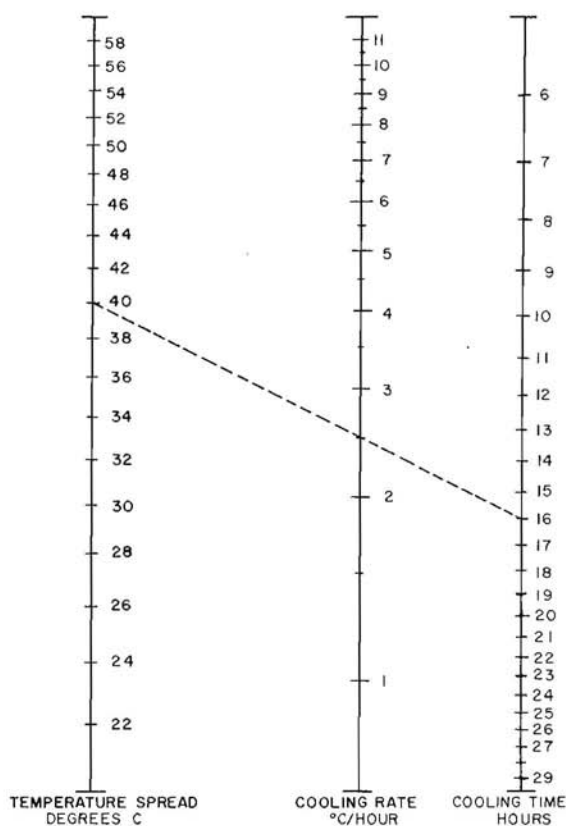
Figure 11.—Alignment chart illustrating the relationship between cooling rate in °C/hours, available cooling time, and temperature spread between highest and lowest temperature.

spread between the highest and the lowest desired temperature has been assigned.

On the basis of these findings a complete program may be projected for low raw massecuite curing under optimum conditions. The fundamental requirements of any such program are predicated upon reliable control equipment. This step by step program may be outlined as follows:

1. Obtain daily workload in cuft low raw massecuite from the laboratory. For a uniform operation this value is relatively stable from day to day and fluctuates only significantly with the daily slice.

2. Obtain total pieces of equipment such as low raw pans, crystallizers and low raw centrifuges.

3. Secure equipment load capacity for the facilities under 2.

4. Establish characteristic composition of mother liquor at pan drop. This composition is relatively specific for that particular factory and need be re-established only if a deviation from normal boiling practices occur.

5. Decide on the final nonsugar/water ratio in molasses. An optimum ratio of 2.5 is recommended for most operations.

6. Consult Figure 9 to establish the maximum time available for pan boiling. If the pan size is consistent use Figure 10. To maintain uniformity stick to the time schedule thusly found.

7. Again consult Figure 9 or 10 to establish total available crystallizer time and adhere to the found value.

8. Resolve the lowest temperature to be reached during the crystallizer cooling cycle. If the operation under 7 projects adequate time e.g. 15 hours or more than the massecuite may be cooled as low as 40°C, provided that the reheating may be accomplished in the mixer rather than in the crystallizer. However, if the total cooling time is limited to 12 hours or less, then do not cool below 50°C.

9. (a) Subtract from the total time as found under 7 the combined time needed for filling and draining of the crystallizer to arrive at a fixed cooling time.
   (b) Subtract the value established under 8 (lowest temperature) from the temperature of the massecuite in °C at pan drop to fix the temperature spread in °C.

10. Project an imaginary straight line in Figure 11 between the values as found under 9a and b respectively to establish a fixed cooling rate.

11. Obtain pan RDS, pan single acid true purity and total pan size from the laboratory. Together with the value resolved under 5 (nonsugar/water ratio in molasses) determine total water addition to the crystallizer by consulting Figure 5. If pan size and nonsugar/water ratios in molasses remain constant for every strike use the simple nomograph in Figure 6.

12. Determine supersaturation at pan drop by using values derived as under 4 (mother liquor brix and % purity) in Figure 7. If supersaturation thusly determined does not exceed 1.2, do not add water until the gradual viscosity increase demands dilution. For crystallizer with 12 or more hours cooling time the water addition need not begin above 70°C. The rate of water dilution should be held as low as total remaining crystallizer time permits. Total water must dissipate in the massecuite before the fillmass has to be dumped. This is an area where indi-

vidual judgment of the operator is still the deciding factor until a satisfactory viscosity and brix sensing device may control this function automatically. Temperature of dilution water should be at least as high as the temperature of the massecuite.

13. Determine purging temperature by using brix and percent purity of molasses in Figure 7. For a uniform operation these values will remain fairly constant from day to day. Massecuite should be reheated in the raw mixer to the temperature thusly found prior to purging.

Acknowledgment

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