EVALUATION OF VACUUM PAN OPERATIONS

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ABSTRACT

Batch vacuum pans with little or no automatic control remain standard equipment in raw sugar factories. Considerable variation in performance is observed and a system has been developed for evaluation of the personnel and equipment involved. No non-standard analyses are required but detailed records are kept for each strike, including operator, analyst and pan identity and analytical data for all massecuites and molasses. The data are entered into a spreadsheet system for generation of statistical and graphical output. Typical outputs are pan utilization and performance and the abilities of pan boilers and analysts. The areas of weak performance for individual analysts and, especially, pan boilers were readily identified.

INTRODUCTION

The efficiency of the pan floor in a raw sugar factory is essential for good sugar recovery. The quality and utilization of the information from the laboratory is very important in optimizing the factory performance. Traditionally sugar factory process data, from the laboratory and other sources, has often been used for review of operations at the end of a set period such as a weekly run or yearly crop. There are distinct advantages to having on the run information to be able to make adjustments to operating conditions. Much of the data required for this is simply buried in the laboratory reports or can be obtained with minimal extra effort. The critical factor is being able to evaluate this information quickly and this can easily be done with modern data handling systems.

This paper describes a process developed for the evaluation of batch vacuum pan operations at a Louisiana factory. This was carried out over two crops (1988 and 1989) with collaboration between the Audubon Sugar Institute and Raceland Factory and for one crop (1990) by the factory staff alone. Only the standard factory data were used and gave useful insights into the performance of individual sugar boilers and analysts, and also the utilization and performance of each vacuum pan. On the run evaluations were made and, with targets for operational parameters decided upon, any deviation from target could be quickly determined. Since the
quality of the analytical data is critical, much effort in the first year was put into comparison of the performance of the individual analysts. The quality of analytical procedures has received much attention but their routine application in factory laboratories raises many more difficult questions. This approach also highlighted the limitations of the current system of chemical control, which is closer to stock-taking than control. Problems arise due to the limited data available and the time required, even if the sample can be obtained, for the analysis to be completed.

DATA COLLECTION AND EVALUATION

Due to the often high syrup purities, the boiling house scheme used at the factory is a modified three boiling system with all A-molasses being used to "top-off" some A-massecuite footings. The molasses from these strikes (identified as "T" in the paper) is used for production of B-massesuicites. A, T and B sugar are blended to give production raw sugar. The C-massesuicites were cooled in continuous crystallizers and the final molasses sampled at eight hour intervals. The nominal retention time in these crystallizers is 36 h. Five batch vacuum pans are used with pans assigned to each type of strike and the pan boilers assigned to either A and T strikes or to B and C strikes. There is little automation operation of the pans, this being basically automatic vacuum control.

Routine practice at the factory is for all massesuicites and their molasses to be individually analyzed, with no compositing of samples. The data available for each sample of massesuicite and molasses were as follows:

- Massecuite Brix, pol and purity;
- Molasses Brix, pol and purity;
- Identity of analyst (by initial in the paper);
- Identity of pan boiler (by initial in the paper);
- Pan number.

Syrup samples and magma samples (prepared with water) from the continuous low grade centrifugals were taken at 8 h intervals.

All Brix measurements were by refractometer on a 1:1 dilution. All pol measurements involved the use of lead subacetate as clarifying agent, and all purity data in the paper are therefore apparent purity.

Sampling of molasses from the batch centrifugals was done soon after beginning to purge the strike, but results from examination of molasses purities with varying time of the massesuicite in the receiver shows a significant drop in some cases. Since it is not possible to satisfactorily identify a final molasses sample with an individual C-massesuicite, the average value of final molasses purity over the period from 24 to
48 h after dropping the strike was used. A few samples were obviously mislabeled and were discarded from the data set.

All the data was entered into the SAS program on the mainframe computer or, in the last two years, into a spreadsheet system, either Microsoft Works or Lotus 123. The data output can be in tabular or graphical formats.

The calculated data consisted of the following:

- Seasonal trends in syrup purity, etc.;
- Purity drop for all strikes;
- Crystal content for all strikes;
- For each analyst:  
  - Total number of each analysis;
  - Mean and distribution of analytical values;
- For each pan boiler:  
  - Total number of each strike boiled;
  - Mean and distribution of massecuite and molasses Brix and purity, purity drop, and crystal content;
  - Performance with different pans;
- For each pan the mean and distribution of massecuite Brix, etc.

In some cases attempts were made to establish correlations between the different types of data obtained, e.g., between massecuite Brix and crystal content. Not included in the system described here, due to incompleteness of data, are the times involved in boiling the individual strikes, the origins of the strikes (how many cuts to make a C-massecuite, etc.) and any data on the quality of the sugar produced. Of particular interest in the last would be crystal size data.

RESULTS

There are many tables, graphs and combinations of data that could be illustrated. The following are a representative cross-section of the results which are intended to demonstrate the utility of the approach.

1. Utilization of analysts, pan boilers and pans

For the 1988 crop the rotation of shifts for the analysts (L, M and T) and pan boilers (A, E and F for A- and T-strikes; B, O and R for B- and C-strikes) were not in sequence and therefore each pan boiler had his material analyzed by all analysts. The analyst/sugar boiler/strike data are given (Table 1), and show that, although the analytical load is not even, it is reasonable to compare the performance of the analysts over the total sets of data for each strike type.
FIGURE 1. Analysis of analyst, sugar boiler and strike data.

<table>
<thead>
<tr>
<th>Strike type</th>
<th>Sugar boiler</th>
<th>Analyst L</th>
<th>Analyst M</th>
<th>Analyst T</th>
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<tbody>
<tr>
<td>A</td>
<td>A</td>
<td>106</td>
<td>42</td>
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<td>E</td>
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<td>F</td>
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<td>53</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>47</td>
<td>52</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>57</td>
<td>75</td>
<td>37</td>
</tr>
<tr>
<td>B</td>
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<td>59</td>
</tr>
<tr>
<td></td>
<td>O</td>
<td>38</td>
<td>53</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>43</td>
<td>51</td>
<td>48</td>
</tr>
<tr>
<td>C</td>
<td>B</td>
<td>41</td>
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<td></td>
<td>O</td>
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<tr>
<td></td>
<td>R</td>
<td>30</td>
<td>35</td>
<td>30</td>
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This data can also be summarized graphically (Figures 1a and 1b) which display the workloads of each of the individuals involved and show that each analyst performed about the same number of analyses and that each high grade pan boiler and each low grade pan boiler had boiled about the same number of pans.

The utilization of the vacuum pans is shown (Figure 2) with pans 3, 4 and 5 being used for both A- and T-strikes, with pan 5 being used for a disproportionate number of T strikes.

### 2. Seasonal trends

The Louisiana crop is short and there is a distinct change in the cane quality from the beginning to end of the crop. This is reflected in the syrup purities and all the 1989 crop data on syrup purity is shown (Figure 3a). The value of using all the data obtained is that it clearly shows how much daily and weekly variation there is in the data and this is ignored when daily and weekly averages are used. The width of the band that encompasses most of the syrup data is about 3 purity points. As expected there is the same trend in A-masseculate purity (Figure 3b) but the spread of purities is much wider – about 7 points. This is partly explained by the erratic operation of the low grade centrifugals for production of magma, for which the purities vary widely through the crop and even over the same day (Figure 4a). Although the
average magma purity is about 86, a reasonable value, there is too much variation due to inconsistent operation. The C-massecuite purity remains fairly constant through the crop (Figure 4c). The primary reason for this is the inability of the low grade crystallizers to operate under high Brix conditions and the management decision to operate at reduced massecuite Brix.

3. Comparison of analysts

Both massecuites and molasses are analyzed for Brix and polarization and both show some variation between analysts. The statistical data is given (Table 2) and shows little difference between them with the greatest variation being seen in Brix values (Figure 5a and 5b). The means and standard deviations given should be treated with caution since they are for materials changing with time (e.g. Figure 3b), but they do confirm little difference between the analysts and therefore more confidence can be given to evaluation of pan boilers.
FIGURE 3. Syrup purity and A-massecuite purity through crop day.
FIGURE 4. C-magma, C-Massecuite and final molasses purity through crop day.
FIGURE 5. Analysis of B-molasses for purity and A-massecults for Brix by analyst.

<table>
<thead>
<tr>
<th>Material</th>
<th>Data</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
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<td></td>
<td></td>
<td>L</td>
<td></td>
<td>M</td>
<td></td>
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<td>93.3</td>
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<tr>
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<td>72.2</td>
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<td>92.6</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>Purity</td>
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<td>41.2</td>
<td>1.7</td>
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</table>

4. Comparison of pan boilers

The statistical data on Brix values is given in Table 3 which shows relatively little difference between the individual pan boilers with the most significant difference being observed between A and F (Figure 6). A more detailed analysis of the purity drops and crystal contents achieved shows very great variation, not so much between individuals but in the performance of each (Figure 7). The same result is obtained, to varying degrees, for all pan boilers boiling all types of strikes. For the 1989 and 1990 crops this data has been given to the pan boilers on a weekly basis as a means of encouraging improved performance. Much of the time good purity drops and crystal contents are achieved, but the performance is inconsistent. This conclusion could not be drawn from daily or weekly averages. Also, it should be noted that the Brix values for the low grade massecuites are lower than desirable.

If strikes are well boiled, there should be some correlation between the Brix of the massecuite and the crystal content. This is plotted for T-massecuites (Figure 8) and there is no correlation. A particularly wide spread of data is shown by pan boiler F, a further demonstration of inconsistent performance.

<table>
<thead>
<tr>
<th>Material</th>
<th>Data</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
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<tr>
<td>A-Mass</td>
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<td>92.5</td>
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</table>

**T-MASSECUITE BRIX**

**BY PAN BOILER**

![T-massecuite Brix value between individual pan boilers.]

**FIGURE 6.** T-massecuite Brix value between individual pan boilers.
FIGURE 7. Variation of purity drops and A-massecuite crystal contacts by pan boiler.

FIGURE 8. T-massecuite Brix vs crystal content showing no correlation.
5. Comparison of pans

It is only possible to compare pans 3, 4 and 5 since they are used for production of the same massecuites (A and T). The purity values and crystal contents of the massecuites are a function of available materials and the decision of the pan boilers. The only significant difference between the pans would be the ability to go to higher Brix. Little difference was observed between pans 3 and 4 but pan 5 was usually boiled to a higher Brix.

SUMMARY

This paper describes an approach to the evaluation of batch vacuum pans and ancillary equipment by analysis of all strikes and other material, e.g. magma, and identification of the personnel involved. The manual operation leads to inconsistent performance and the principal conclusion is that much of the erratic performance could be removed with the appropriate automatic control systems being applied to the pans.

Some advantages of this approach for evaluation of the performance of batch vacuum pans are:

1. No unusual analyses are required;
2. The data can easily be processed in a simple spreadsheet;
3. It is readily understood by factory personnel and is a useful learning tool;
4. It indicates when special analyses are required;
5. Further statistical analyses can be performed, e.g. generation of cusum charts.

REFERENCES

EVALUATION DE LA PERFORMANCE DES APPAREILS À CUIRE

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RESUME

Les cuites discontinues avec peu, ou même sans automation sont trouvées dans beaucoup de sucreries. Les performances varient considérablement et on a développé un système pour évaluer le personnel et l'équipement. Le système ne reclame aucune analyse spéciale mais tous les détails concernant la cuite, l'analyste, et les résultats des analyses de massecuite et de la mélasse doivent être notés. Les données sont manipulées par un ordinateur et on produit des résultats statistiques et graphiques. Des resultats types concernent l'utilisation de la cuite, la performance de la cuite et l'abilité des cuiseurs et des analystes. Il a été possible d'identifier des performances en dessous de la moyenne chez des analystes et plus particulièrement chez des cuiseurs.
RESUMEN

Tachos de calandriar y operación intermitente equipados conpocos o sin controles automáticos continúan siendo equipos "standard" en fábrica de azúcar crudo. Considerables variaciones en los resultados pueden ser observado y un sistema ha sido desarrollado para la evaluación del personal y el equipo. No se requieren análisis fuera de lo standard, solo información detallada de cada "templa" o "strike", incluyendo identidad del operador, analista, tacho y datos analíticos de todas las masacocidas y mieles. Esta información es introducida en una computadora para generar las estadísticas y gráficos. Los resultados obtenidos incluyen la utilización y trabajo obtenido de los tachos y la habilidad de los "pullistas" o operadores de tachos y analistas. Las áreas débiles en la ejecución del trabajo de ciertos analistas y especialmente de operadores de tachos fueron rápidamente identificadas.