BENCHMARKS FOR CANE SUGAR MANUFACTURE TO ENSURE GLOBAL COMPETITIVENESS

By

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KEYWORDS: Sugar Manufacture, Operating Cost, Technical Performance, Production Costs, Energy Consumption.

Abstract

After reviewing and discussing operating data with sugar technologists from more than 40 countries around the world, it became obvious that technical performance varied significantly from company to company. Reasons given for poor performance, often not justified, are regional in nature, such as differences in social structure and culture. Also, the need for adequate training of operators/engineers/chemists in technologies and mid-level supervisors in management, which requires no capital expenditure, is often overlooked. To compete in a global economy, it is important to establish performance criteria/benchmarks for the purpose of achieving lowest cost sugar production. This paper discusses benchmarks for the sugar industry in order for the industry to compete in the global market.

Introduction

As we entered the 21st century, the sugar industry found itself at the cross roads, facing many difficult challenges e.g., nutritional values of sugar are under attack; uncertainty in governmental sugar programs; environmental pressure; global competition (WTO, NAFTA); and a constantly changing new economy. We must change with the business environment and needs if we are going to survive and prosper in this new millennium.

In the past two decades, many of the sugar industries' strategies were characterised by emphasis in risk management, downsizing, restructuring, reengineering and computerisation, including automation and the use of information technology to drastically reduce the cost of operation. Yet the sugar industry, as a whole, has not kept pace with productivity improvements of some.

We must re-evaluate and improve our conventional practices, simplify manufacturing processes, automate operation for efficiency and consistency in product quality, and finally capitalise on best available technologies.

Excellence in manufacturing

It is well understood that the objective of a business entity is to enhance shareholder value via:

a) increasing profitability;
b) minimising risk to business; and
c) fulfilling social responsibilities.

A company must maximise efficient use of available resources with existing technologies, invest in environmentally friendly new technologies that improve manufacturing efficiencies, produce new functional products, and meet customer requirements. These goals can best be achieved by establishing manufacturing excellence in its operation.

The key factor in this approach is the implementation of a benchmark for each and every element of the manufacturing process. Benchmarking is a process that measures manufacturing performance against best achieved or achievable performance in the world.

There is the argument that a benchmark for one company is not necessarily applicable to another because of differences in local economies, or social and political conditions. However in a competitive world, price is the major driver regardless of other considerations.
Manufacturing excellence should establish achievable and measurable targets or goals, and these should include but not be limited to, the following:

1. Organisation.
4. Operators per shift.
5. Energy consumption.
7. Sucrose recovery.
8. Sucrose loss.
10. Capacity utilisation.
11. Environmental quality.

Since this writer has no expertise in or access to all the above areas, the focus of this paper will be mostly on processing technologies.

Benchmarks or targets established in this presentation are based on data available to the writer. In the following Tables, the data for the best and the worst performing factories are not based on citable information but on observations of the author and data collected during visits to sugar factories around the world.

The benchmarks given in the Tables are based on the author’s calculations and experience and are considered by the author to be achievable. As an example, based on data collected during the 2000–2001 crop season from sugar factories in several countries, the % sucrose recovery value is from 89.65 to 80, with corresponding juice purity of 87.5 and 77.54 respectively. The difference in performance efficiency for these factories is astonishing. With a juice purity of 86, the % sucrose recovery should be at least more than 88%.

For a company with a production capacity of 450 000 tonnes raw sugar, a 5% increase in sucrose recovery (from 80% to 85%) would increase raw sugar production by 22 500 tonnes a year. Assuming a price of US$400/t of sugar, this amounts to US$9 million additional income a year. An increase of 10% recovery, which is definitely achievable, would give additional income of US$18 million. It should be pointed out that this goal can be achieved without much capital cost. The key to performance improvement of this type is:

a) follow the basics;
b) pay attention to detail;
c) do it now; and
d) do it right the first time.

The same data also show that the sucrose lost to molasses ranged from 11.65% to 6.2% at a juice purity of 77.54 to 87.5 respectively. It is obvious that improvement in juice quality will result in an increase in the % of sucrose recovered.

(1) Organisation

The organisation of a company in a global economy should be as flat as practically possible. The bloated organisational structure with many officers and many layers of middle managers is no longer desirable in the new economy. Responsibility, accountability and authority should be clearly defined.

Individual skill should be broadened and job requirements upgraded. Flexibility is also a key element in productivity improvement.

(2) Manufacturing cost

Table 1 shows the production cost of refined and raw sugar around the world. The refinery cost is from a low of US$25/t of sugar to a high of $185/t of sugar. The benchmark should be US$40/t of sugar. Local regional conditions play a big role in cost of production. For raw sugar, a benchmark of US$200/t of sugar should be achievable.
Table 1—Production cost (US$/t sugar).

<table>
<thead>
<tr>
<th>Type of sugar</th>
<th>Higher performance</th>
<th>Lower performance</th>
<th>Bench mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw</td>
<td>$140</td>
<td>$400</td>
<td>$200</td>
</tr>
<tr>
<td>Refined (cane)</td>
<td>$25</td>
<td>$185</td>
<td>$40</td>
</tr>
</tbody>
</table>

(3) Maintenance cost

Back in the 1970s, before the onset of automation, operators were the major cost in production, excluding the raw material. In the 1980s, maintenance cost became the major component in the cost structure, up to as high as over 35% of production cost.

With automation/computerisation, and improved reliability of equipment/instruments, the goal should be 15% maintenance as percentage of total production cost.

(4) Operators per shift

With increased automation, the effect of plant capacity on number of operators per shift is not significant.

As shown in Table 2, for a daily grinding capacity of 10,000 t cane factory, the number of operators per shift varied from 7 operators in industrialised countries to over 100 in developing countries for government-owned plants. The benchmark should be 7 operators/shift. For sugar refineries, the number of operators ranges from 6 to 12 per shift. A benchmark of 6 operators/shift is easily attainable.

Table 2—No. of operators per shift.

<table>
<thead>
<tr>
<th>Type of factory</th>
<th>Higher performance</th>
<th>Lower performance</th>
<th>Bench mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw sugar I</td>
<td>7</td>
<td>100</td>
<td>7</td>
</tr>
<tr>
<td>Cane refinery</td>
<td>6</td>
<td>12</td>
<td>6</td>
</tr>
</tbody>
</table>

(5) Steam consumption

Table 3 lists the steam consumption in terms of tonnes of steam per tonne of sugar for raw cane sugar, refined cane sugar and refined beet sugar which ranged from 3.2 to 6, 0.75 to 1.8 and 2.8 to 5.4. The benchmarks have been set at 2.5, 0.9 and 2.5 tonnes in the aforementioned order.

It should be noted that 1 tonne of steam/t of sugar can be saved, if refined sugar is directly produced from cane sugar factories in a one-step operation.

Table 3—Energy consumption (ton steam/ton sugar).

<table>
<thead>
<tr>
<th>Type of sugar</th>
<th>Higher performance</th>
<th>Lower performance</th>
<th>Bench mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw</td>
<td>3.2</td>
<td>6</td>
<td>2.5</td>
</tr>
<tr>
<td>Refined</td>
<td>0.75</td>
<td>1.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Beet</td>
<td>2.8</td>
<td>5.4</td>
<td>2.5</td>
</tr>
</tbody>
</table>

(6) Electricity and water usage

Tables 4 and 5 give the electricity and water usage for the cane sugar refining industry. The average electrical usage for the existing refineries is 85 kWh per tonne of sugar. For a modern refinery incorporating best available and established technology, 40 kWh/t of sugar should be the standard.

With respect to water usage, the writer has seen 30% of water consumed for raw sugar melted. For existing refineries, the water usage can be as high as 225% of sugar processed. For a newly designed refinery, 40% of raw sugar should be the goal (Table 5).

Table 4—Electricity usage (kWh/ton sugar).

<table>
<thead>
<tr>
<th>Type of sugar factory</th>
<th>Higher performance</th>
<th>Lower performance</th>
<th>Bench mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw</td>
<td>N/A</td>
<td>N/A</td>
<td>–</td>
</tr>
<tr>
<td>Refined</td>
<td>45</td>
<td>90</td>
<td>40</td>
</tr>
</tbody>
</table>
(7) Sucrose recovery

Table 6 shows the % of sucrose (pol) recovery based on the sucrose content of the incoming cane. For raw sugar factories the percentage of recovery ranges from 80 to 89.65 and for plantation white sugar plants 81.35 to 83.6%. The benchmark for both is set at 90% recovery.

<table>
<thead>
<tr>
<th>Type of sugar factory</th>
<th>Higher performance</th>
<th>Lower performance</th>
<th>Bench mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw</td>
<td>89.65</td>
<td>80</td>
<td>90</td>
</tr>
<tr>
<td>Plantation white</td>
<td>83.6</td>
<td>81.35</td>
<td>90</td>
</tr>
</tbody>
</table>

8) Sucrose loss

Percentages of sucrose lost in bagasse are shown in Table 7 and are between 3.15% and 10%, for raw sugar mills and between 3.85% and 5.80% for plantation white sugar factories. The benchmark for both has been set at 3.5%.

<table>
<thead>
<tr>
<th>Type of sugar factory</th>
<th>Higher performance</th>
<th>Lower performance</th>
<th>Bench mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw</td>
<td>3.15</td>
<td>10</td>
<td>3.50</td>
</tr>
<tr>
<td>Plantation white</td>
<td>3.85</td>
<td>5.80</td>
<td>3.50</td>
</tr>
</tbody>
</table>

As shown in Table 8, the unknown loss is between 0.2% and 2% for raw sugar mills and between 0.4% and 1.5% in plantation white sugar. The benchmark is predicted to be less than 0.5%.

<table>
<thead>
<tr>
<th>Type of sugar factory</th>
<th>Higher performance</th>
<th>Lower performance</th>
<th>Bench mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw</td>
<td>0.20</td>
<td>2</td>
<td>0.50</td>
</tr>
<tr>
<td>Plantation white</td>
<td>0.40</td>
<td>1.50</td>
<td>0.50</td>
</tr>
</tbody>
</table>

As given in Table 9, percent of sucrose lost in final molasses is in the range of 6.2% to 9.53% in raw sugar mills, and 8% to 11.65 in plantation white sugar factories. The percent of sucrose lost to final molasses greatly depends on the purity of the incoming juice. The benchmark should be 7.5% with juice purity of 85%.

<table>
<thead>
<tr>
<th>Type of sugar factory</th>
<th>Higher performance</th>
<th>Lower performance</th>
<th>Bench mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Sugar</td>
<td>6.20</td>
<td>9.55</td>
<td>6</td>
</tr>
<tr>
<td>Plantation white sugar</td>
<td>8</td>
<td>11.65</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 10 gives the values of % sucrose lost in carbonation cane sugar refineries. The % sucrose loss is defined as sucrose in the incoming raw sugar less sucrose in the products and final molasses. A good carbonation refinery should have a sucrose loss of less than 0.5%.

This writer does not have data on the % sucrose lost on phosphatation refinery. A higher sucrose loss is to be expected as compared to a carbonation refinery. This is due to the fact that a) carbonation destroys invert sugar which is known to form acid that causes sucrose hydrolysis, and b) sucrose
destruction is lower with carbonation because of the higher pH of the liquor used for sugar boiling. The sucrose loss benchmark for a phosphatation refinery should not be more than 0.65%.

**Table 10**—Percent sucrose loss (cane sugar refinery).

<table>
<thead>
<tr>
<th>Type of refinery</th>
<th>Higher performance</th>
<th>Lower performance</th>
<th>Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphatation</td>
<td>N/A</td>
<td>N/A</td>
<td>0.65</td>
</tr>
<tr>
<td>Carbonation</td>
<td>0.45</td>
<td>1</td>
<td>0.55</td>
</tr>
</tbody>
</table>

Table 11 shows that the % sucrose carried to final molasses in a carbonation cane sugar refinery, with average raw sugar polarisation of 98.3, is between 0.85% and 1.2%, with target/goal of 0.85%.

The writer did not have data on phosphatation refineries, but the loss would be slightly higher than that of a carbonation refinery. A phosphatation refinery creates more non-sucrose compounds (invert etc.) and removes less non-sucrose compounds as compared to a carbonation refinery.

**Table 11**—Percent sucrose lost in final molasses (cane sugar refinery).

<table>
<thead>
<tr>
<th>Type of refinery</th>
<th>Higher performance</th>
<th>Lower performance</th>
<th>Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphatation</td>
<td>N/A</td>
<td>N/A</td>
<td>0.95</td>
</tr>
<tr>
<td>Carbonation</td>
<td>0.80</td>
<td>1</td>
<td>0.85</td>
</tr>
</tbody>
</table>

(9) Safety records

Safety should be the number one priority of any manufacturing company. All work related injuries are preventable and avoidable. The writer has seen a sign at the entrance to a refining facility back in the 1980s, which stated that the company has operated for over 1500 days without an injury.

The key to success is involvement and commitment of all employees. In addition, accountability, benchmarking auditing and recognition are also essential parts of a safety program.

(10) Capacity utilisation

It is obvious that productivity, as measured by unit cost, improves significantly as plant utilisation goes up. Some managers have the tendency to emphasise plant utilisation at the expense of technical/processing/engineering improvement.

This practice has been particularly common during the drive in the last decade to reduce manning. In fact, capacity utilisation, manning reduction and process efficiency all can be properly managed to maximise the long-term profit of a company.

(11) Environmental quality

Cost effective green manufacturing is the ultimate goal for the 21st century. A company with vision should invest in economically justifiable and environmentally friendly technologies which improve process efficiency and produce value-adding products with zero effluent discharge. Investment in monitoring, remedial, and control technologies just to meet regulatory mandates alone is shortsighted.

**Conclusion**

The cane sugar industry needs to do three things in order to be competitive.

First, produce standard food grade white/refined sugar directly from sugar mills using new processing methods. These new methods, based on well established technologies, is the subject of discussion in a paper, entitled ‘Direct Production of Refined Sugar and Value Added Products from Sugar Cane Mills’, presented at the Sugar Industry Technologists 63rd annual technical conference in Vancouver, Canada, May 16–19, 2004.

Second, significantly increase sucrose yield by investing in newer technologies.

Third, establish performance criteria or benchmarks for the industry for the purpose of achieving the lowest cost sugar producers in the world in order to prosper in the global economy.

This paper focuses on benchmarking for the sugar industry.

STANDARDS POUR LA PERFORMANCE DES SUCRERIES DE CANNE
AFIN D’ASSURER LA COMPÉTITIVITÉ
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MOTS CLEFS: Fabrication, Sucre, Coût d’Opération, Performance Technique, Coût de Production, Consommation d’Énergie.

Resume
En discutant les opérations avec des technologistes sucriers représentant plus de 40 pays, il est évident que la performance technique des sucreries varie considérablement de compagnie à compagnie. Les raisons, souvent discutables, données pour expliquer les performances pauvres comprennent les différences sociales et culturelles. La formation des opérateurs, ingénieurs et chimistes, qui nécessite un investissement de capital, est souvent ignorée. Pour faire face à la compétitivité mondiale, il faut avoir des standards pour atteindre une production de sucre au coût le plus favorable. Ce papier présente des standards pour guider l’industrie sucrière vers cette compétition mondiale.

PUNTOS DE REFERENCIA EN LA MANUFACTURA DE LA CAÑA DE AZÚCAR PARA ASEGURAR UNA COMPETITIVIDAD A NIVEL GLOBAL
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Palabras clave: Manufactura del Azúcar, Costo de Operación, Desempeño Técnico, Costos de Producción, Consumo de Energía.

Resumen
Tras revisar y discutir los datos operativos con tecnólogos del azúcar de más de cuarenta países alrededor del mundo, resultó obvio que el desempeño técnico variaba significativamente de una compañía a otra. Las razones dadas para un pobre desempeño, frecuentemente no justificadas, son de naturaleza regional, tales como diferencias en la estructura social y la cultura. Asimismo, con frecuencia se deja de lado la necesidad de una adecuada capacitación de los operadores/ingenieros/químicos con respecto a las tecnologías y de los supervisores de nivel medio con respecto a la administración, lo cual no requiere de un gasto de capital. Para competir en una economía global, es importante establecer criterios/puntos de referencia del desempeño, con el propósito de lograr una producción de azúcar a un menor costo. Esta ponencia trata sobre los puntos de referencia para la industria azucarera a fin de que ésta pueda competir en el mercado global.