Chapter - II
Sugar Sector Profile

Background

The sugar industry is one of the ancient and still the largest amongst the food processing industries in the world. Sugar is the only processed food available in bulk at the highest purity, above 99.8% purity.

India has been the originator of the sugar industry. At present, India is the second largest producer in sugar- White sugar, crystal sugar and raw lump sugar (Jaggery) in the world. The production of sugar in India has grown from a few million tons in early fifties, to the present level (in 2004-05) of over 20 million tons of crystal sugar and about 18 million tons of Jaggery.

India has the largest number of modern sugar processing mills, nearly 500 in number. Almost 400 have been installed, since independence compared to the sugar mills abroad, the Indian sugar mills are a mix of large and small sugar mills distributed in state sector, co-operative sector and private sector. The average capacities of the sugar mills are only 2500 TCD, as against the average capacities of about 10000 TCD abroad.

The Indian per capita consumption of sugar is over 30 kg in comparison to the average per capita consumption of over 45 kg in the western countries. With the recent liberalization of the sugar industry and the increasing demand for sugar, the sugar industry is poised for tremendous growth.

Energy consumption scenario

The sugar industry is not only highly energy intensive, but they require energy in the forms of:

- **Mechanical/electrical energy**: Require to operate the mills, juice pumps, conveyors, boiler feed pumps. Boiler FD/ID fans, injection water pumps etc.

- **Steam (low pressure) / thermal energy**: For concentration of juice and controlled crystallisation.

A typical 2400 TCD (100TCH) sugar mill needs steam of about 45% on cane crushed and power of about 30 KWH per ton of cane crushed.
Process description

The typical process in a sugar industry is as described below:

Cane preparation

The cane preparation is the first operation in the production of sugar. The preparatory equipment includes kicker, leveler, cutter, fibrizers and shredders. The cane is unloaded using slings or hydraulic tippers and is cut to the desired length in the kicker and cutter. In the fibrizer and shredder, the cane is shredded for obtaining maximum surface area for juice extraction. From the fibrizer / shredder the cane is transferred to the mill section through chutes.

Milling

The mill is the heart of a sugar mill. A typical sugar mill has a 4 stage or 5 stage mill set up. The prepared cane is crushed in the mills, to separate the juice and bagasse. Imbition or masceration water is added in between the last two stages of the mill, to maximize the extraction process. The juice and bagasse flow is counter current in the mills. The juice obtained is taken up for the further processing in the boiling house (evaporators and pans) while the bagasse is dispatched to the boiler house.

Juice preparation

The raw juice received from the mill house is filtered in the strainers and transferred to the weigh scale. A weighed quantity of juice is tipped to the weighed juice tanks. The raw juice is heated from 30$^\circ$C to 65$^\circ$C in the raw juice heaters. The heated raw juice is sulphited to remove all suspended matter and improve the pH of the juice. This sulphited juice is passed through sulphited juice heaters to heat the juice from 65$^\circ$C to 105$^\circ$C. The heated sulphited juice is then clarified. After clarification, the clear juice is heated in clear juice heater up to 105 - 110$^\circ$C. This heated clear juice is then sent to the evaporators for concentration.

Evaporators

The juice is concentrated from about 14 – 16 Brix to about 60-65 Brix in the evaporators. Exhaust steam is used for the heating purpose. The commonly used evaporators are the quadruple and quintuple effect short tube evaporators. Further to the concentration to a higher level, the concentrated syrup is transferred to the vaccum pan section, for evaporation, crystallisation, to produce sugar.
Vacuum pans

The vacuum pans are used for further concentration of the Massecuite (thickened syrup) produced in the evaporators. The syrup is concentrated from 60 – 65 brix to about 90 – 100 brix. The heating of the Massecuite is achieved through vapour bleeding from the evaporators.

Centrifugal

The concentrated Massecuite is then cooled in either an air cooled or water cooled horizontal / vertical crystallizers. The cooled Massecuite is transferred to the centrifuges, where the sugar and the molasses are finally separated.

Block Diagram: Sugar Industry Process
Sugar drier

The final sugar obtained from A - centrifuges are passed through oscillating / vibrating hoppers. Hot air is used for drying of sugar in the first half of these hoppers, while cool air is blown over the sugar for cooling in the final stages. The cooled sugar is then graded and stored in hoppers. From the hoppers, the sugar is taken out as per the requirement, weighed and packed in bags.

Target specific energy consumption

The target electrical energy and steam (thermal energy) consumption of a new sugar mill (of 2400 TCD capacity and above only) should be as below:

- Specific electrical energy consumption (for electric driven mills) : 30 kWh / tonne of cane
- Specific steam (thermal energy) Consumption : 38% on cane

The break up of the target energy consumption is as below:
<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Section / area</th>
<th>Electrical energy (kWh / tonne of cane crushed)</th>
<th>Section / area</th>
<th>Steam (Thermal energy) (% on cane)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cane milling</td>
<td>5.0</td>
<td>Evaporators</td>
<td>34</td>
</tr>
<tr>
<td>2</td>
<td>Milling</td>
<td>10.0</td>
<td>Others</td>
<td>04</td>
</tr>
<tr>
<td>3</td>
<td>Juice preparation</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Evaporators, pans and crystallisers</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Pump house (evaporator &amp; pan condenser)</td>
<td>4.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Centrifugal</td>
<td>6.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Others(Workshops, lighting etc)</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Total</td>
<td><strong>30.0</strong></td>
<td></td>
<td><strong>38</strong></td>
</tr>
</tbody>
</table>

The above break up of specific energy consumption figures are based on sugar mills operating with the following features:

- Cane carriers with DC motors or AC variable speed drives.
- Conventional milling system comprising of cane kicker, cane knives, shredder and fibrizers.
- DC drives for mill prime movers
- High efficiency centrifugal pumps for juice transfer, imbibition water and boiler feed water pumps installed with a variable frequency drive (VFD)
- Quintuple effect evaporator with extensive vapour use
- Multi-jet condensers for evaporators and pans
- Cooling tower / mist cooling system
- High efficiency backward curved blade fans for boiler FD, PA, SA, and ID fans
- High capacity regenerative type centrifugal

**Co-generation potential**

Although sugar industry is energy intensive, the sugar cane has more than 30% fibre in the form of bagasse, which is used as a fuel for generating energy. The energy content of bagasse is much more than the internal requirement of the plant. The bagasse is used as
fuel, for generation of both steam and power. This simultaneous generation of steam and power is commonly referred to as Co-generation.

The Indian sugar industry has been adopting Co-generation right from the beginning for meeting the internal power and steam needs of the plant. Only in the recent years, with the increasing shortage of power, has it been found to be attractive to generate excess power and sell to the grid.

Depending upon the level of technology adopted, a 2400 TCD plant can produce about 6 MW surplus power. With larger mill capacities the surplus power increases more than proportional.

The estimated commercial co-generation potential in the Indian sugar industry is about 3000 MW, in addition to the existing co-generation plants. This huge potential can be further increased, if the energy consumption in the different sections of the plant can be minimized.

The implementation of energy conservation measures can be strongly pursued, as one of the attractive options for reducing the energy consumption, maximizing the saleable power and improving the profitability of the Indian sugar industry.

**Major factors that affect the energy consumption in all sizes of sugar mills**

The major factors that affect the specific energy consumption in the sugar industry are as follows:

- Plant layout and systems engineering
- Capacity of plant and level of capacity utilisation
- Quality of sugarcane available
- Type of mill drive – steam turbine, DC drive, hydraulic drive
- Type of process adopted
- Type of evaporator and number of effects
- Practice of extensive vapour use at evaporators and pans
- Type of condenser in evaporators and pans
- Nature of water cooling systems such as spray, pond, cooling tower, mist cooling etc
- Operating efficiency of pumps and fans / blowers
- Quality and type of sugar produced
- Co-generation system installed - high capacity & high pressure boiler & type of turbine
- Steam distribution and consumption pattern
- Condensate / flash recovery system
- Type of control system used

These are the various major factors, which affect the specific energy consumption in sugar mills. There are other minor factors, which are not highlighted in this thesis.
Benefits of energy savings

The major benefits of energy savings in a sugar industry can be broadly classified under steam savings & power savings.

Any savings in steam has a two-fold advantage:

❖ Bagasse can be saved, which can be directly sold in market

❖ Additional “saleable” power can be generated by passing steam through a condensing turbine, provided a commercial co-generation system is available

Similarly, any savings in power will reflect as additional power exported / sold to the grid, provided a commercial co-generation system is available

If commercial co-generation system is not available, there is still an incentive, small though for power saving. In such a case, any power saving can result in, an equivalent reduction in bagasse consumption.