

ADVANCED TECHNOLOGY FOR REDUCING STEAM & POWER CONSUMPTION

by

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Introduction

India has been known as the original home of sugar and sugarcane. Indian mythology supports the above fact as it contains legends showing the origin of sugarcane. India is the second largest producer of sugarcane next to Brazil.

Apart from sugar, the sugar industry produces certain by-products, which can be used for production of other industrial products. The most important by-product is molasses, which is utilized for production of chemicals and alcohol. In addition, the other important by product is bagasse. It is mainly utilised as a captive fuel in the boilers but it is also used as a raw material in the paper industry.

Energy Profile

The energy requirements in a sugar mill are in the form of steam for process heating/turbo drives and electricity for running various drives. The sugar industry has the unique advantage of utilizing a captive fuel-bagasse, to meet its energy requirements. However, depending upon various factors like fibre content in the cane, quantity of juice, type of clarification process and evaporation effects, type of prime movers (steam driven or electric driven) etc., some sugar mills produce a small quantity of surplus bagasse while others are deficient by a small quantity.

These mills, therefore, have to depend in a very limited way on external fuels like fuel oil, LSH, coal etc to supplement their energy requirements. Likewise, some sugar mills during the season can produce a little surplus power while others would be deficient in power by a small margin and hence the dependence on grid power is minimal.

Energy consumption in Sugar Industry

Energy consumption in sugar plants depends on various factors such as its capacity, steam generation parameters, vintage, equipment used etc. Analysis of the energy consumption pattern in the sugar mills reveals that there exists significant scope for improving the energy efficiency in the Indian Sugar Industry.

The major reason for the high energy consumption in the industry is the presence of large number of old, small capacity sugar mills which have not invested much over the years in modernizing or upgrading various process equipment.

Apart from improving the end use efficiency in the plants, the other most promising energy conservation measure for the industry is to set up high-pressure cogeneration systems. This not only has the potential of opening up additional revenue streams for the sugar plants by way of sale of electricity, it can effectively contribute in reducing the ever widening gap between demand and supply of electricity in various power deficit regions in the country.

**Specific Electrical Energy
consumption**

**30 units/tonne of cane with
electric motors & DC Drives
24 units / tonne of cane with
diffusers**

**Specific Thermal Energy
steam consumption**

30 % on cane

The energy consumption in Indian sugar mills range from 0.7 to 0.87 GJ/ tonne of Cane against a world average of 0.5 to 0.6 GJ/Tonne of cane crushed.

Energy efficiency in sugar industry

Energy efficiency in sugar industry offers the following benefits:

- 1] In plants having cogeneration facility and where the state utility is able to purchase additional power generated from sugar plants, any improvement in energy efficiency levels of the plant results in increased export to the grid. This reduces the equivalent reduction in power generation from fossil fuel based power plants. This has a significant reduction in carbon emissions.

2] In plants having cogeneration facility, but the state utility is not ready to purchase power, improvement in energy efficiency in the plant results in saving in bagasse. This either could be exported to other sugar plants, having cogeneration facility with state utility ready to purchase power, or can be sold to paper plants.

3] In plants, which do not have cogeneration facility, energy efficiency directly results in reduced power demand from the state utility. This results in higher profitability to the plant as well as significant reduction in GHG emission. These plants, however, are very few in number.

The Indian sugar industry offers good potential for energy saving. The estimated energy saving potential in the Indian sugar industry is about 20%. This offers potential of about 650 MW of electrical energy.

Co- Generation in Sugar Mills

The sugar industry by its inherent nature can generate surplus energy in contrast to the other industries, which are only consumers of energy. With liberalization and increased competition, the generation and selling of excess power to the electricity boards, offers an excellent source of revenue generation to the sugar plants. This is referred to as commercial cogeneration and has been only marginally tapped in our country.

The sugar plants have been adopting co-generation right from the beginning. However, the co-generation has been restricted to generating power and steam only to meet the operational requirements of the plant. Only in the recent years, with the increasing power demand and shortage, commercial cogeneration has been found to be attractive, both from the state utility point of view as well as the sugar plant point of view.

The sugar plant derives additional revenue by selling power to the grid, while the state is able to marginally reduce the 'demand-supply' gap, with reduced investments.

Technologies & Measures for Energy Efficiency Improvements

Various technologies for energy efficiency improvement are discussed briefly. Some of these technologies are already in use in India while many are in the development phase or not yet commercialized in India. Besides these technologies, one very important step, Indian sugar mills can adopt is to produce smaller sized sugar instead of bolder sugar grains. Simply because of the bolder grain size, 2 to 3% more energy is consumed by the industry.

Energy Economy-Steam

The use of bagasse is increasing and therefore bagasse prices are high. Sugar factories can earn money on sale of saved bagasse and can reduce the production cost of sugar. Efficient utilization of steam is very much essential to save the bagasse for factories without cogeneration or cogeneration with back pressure route. In case of factories with cogeneration by condensing route, the steam saving in boiling house can produce more electricity for export. Therefore the subject “ Efficient utilization of Energy & steam Economy” is important for sugar industry.

POTENTIAL AREAS OF STEAM & ENERGY ECONOMY COMPETENTLY.

- **Boiler Station**
- **Clarifier Station**
- **Evaporator Station**
- **Pan Station**
- **Centrifugal Station**

BOILER SECTION

The Exhaust Steam consumption can be reduced to 0.5% by recovering the waste heat from the Boiler Blow down.

Process :

The blow down water released from the boiler is at the saturation temperature appropriate to the boiler pressure. In case of boiler at high pressure of 45 kg/cm², this temp. is 256 deg. C. the water can't exist at 256 deg.C. Under atmospheric condition, as there is an excess of enthalpy or energy in the blow down water. This excess energy evaporates a proportion of the water to steam, and the steam is referred to as flash steam.

Recovering System

“ Blow Down Heat Recovery” consist of flash tank that shall operate under a pressure of 1.2 bar abs. To generate flash steam at the rate of 0.5% on cane crushing approx. depending on the blow down temp.

For 350 TCH

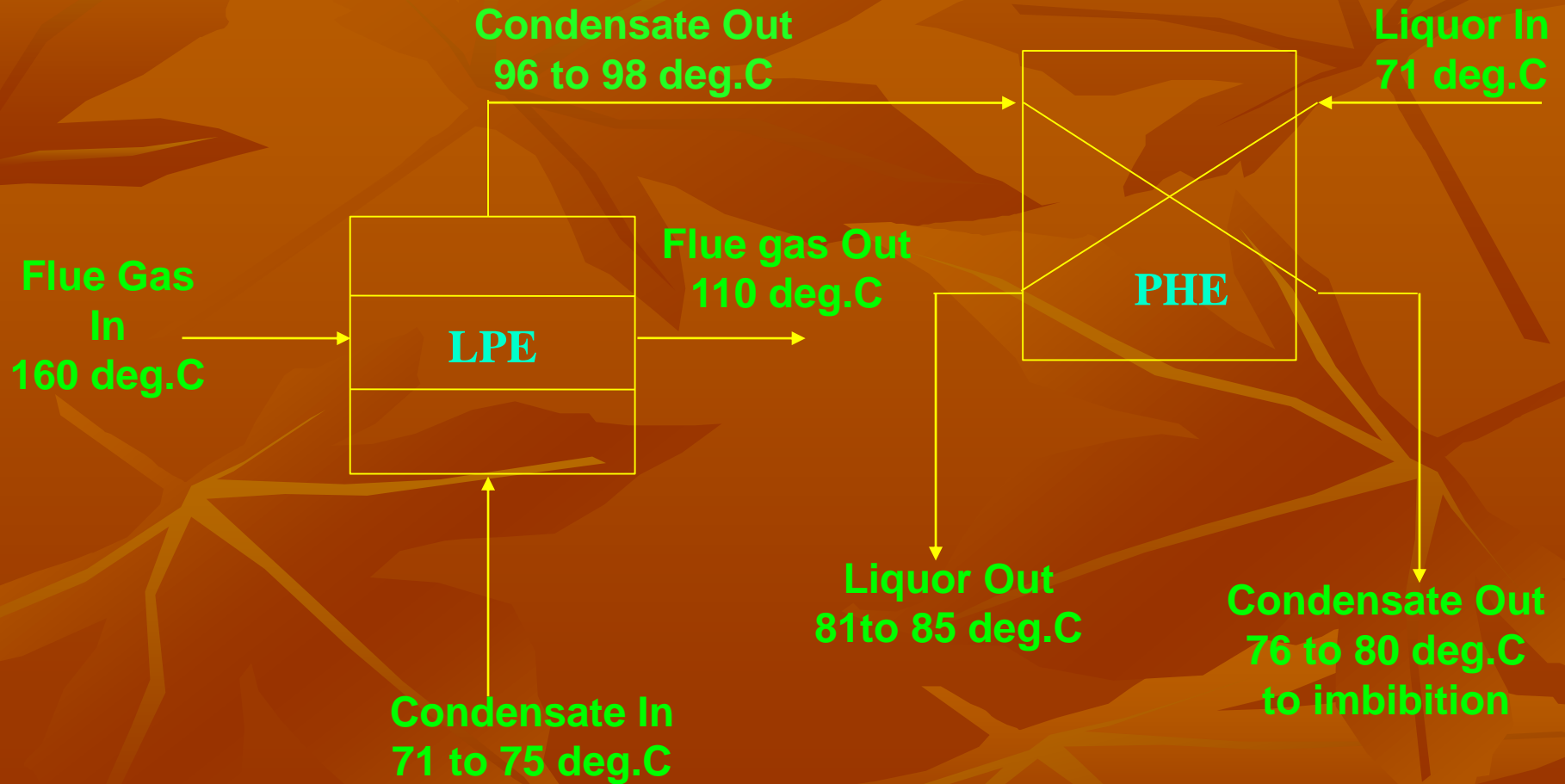
Parameter	% on Cane	Qty T/Hr.
Blow Down Qty	1.8	6.3
Flash Vapour	0.5	1.75

Boiler Flue Gas.

The Exhaust steam consumption can be reduced to 1.3% on cane by recovering the waste heat from Boiler Flue gas.

Process – The excess condensate shall be used to recover heat from flue gas in the Low Pressure Economizer (LPE). The heat gained by condensate shall be transferred to the other juice with help of liquid-liquid PHE.

Recovering System



JUICE CLARIFIER

The Exhaust steam consumption can be reduced to 0.4% on cane by recovering the waste flash vapours at juice clarifier flash tank.

Process – The defecated juice at 102 deg.C coming from defecated juice heaters is introduced to the flash tank before entering the clarifier to remove non-condensable gases from the juice. This flash tank is vented to the atmp. The qty. of flash vapours lost to atmp. Is about 0.4% on cane.

Recovering System

- By providing systematic vapour pipe line to recover the excess heat of clarifier flash vapours from flash tank.
- The vapour line shall be designed for minimum pressure loss.
- These recover flash vapours will be used at pan station.

EVAPORATOR STATION

The Exhaust steam consumption can be reduced to 2.5% on cane by flash heat recovery hot condensates.

Process – The evaporator set is operated with reducing pressure from 1st effect to last effect, therefore the condensate temp. is different in each effect and is decreasing towards the last effect. The hottest condensate from the previous effect can be flashed to following effect. Hence, an additional heat can be generated that will reduce the equivalent amount of exhaust in 1st effect.

Condensate Flash Recovery System

The flash steam becomes available for recovery at the flash tank. In essence, a flash tank provides a space where the velocity is low enough to allow hot condensate and flash steam to separate. The flash steam from flash tank is sent to following effect for use.

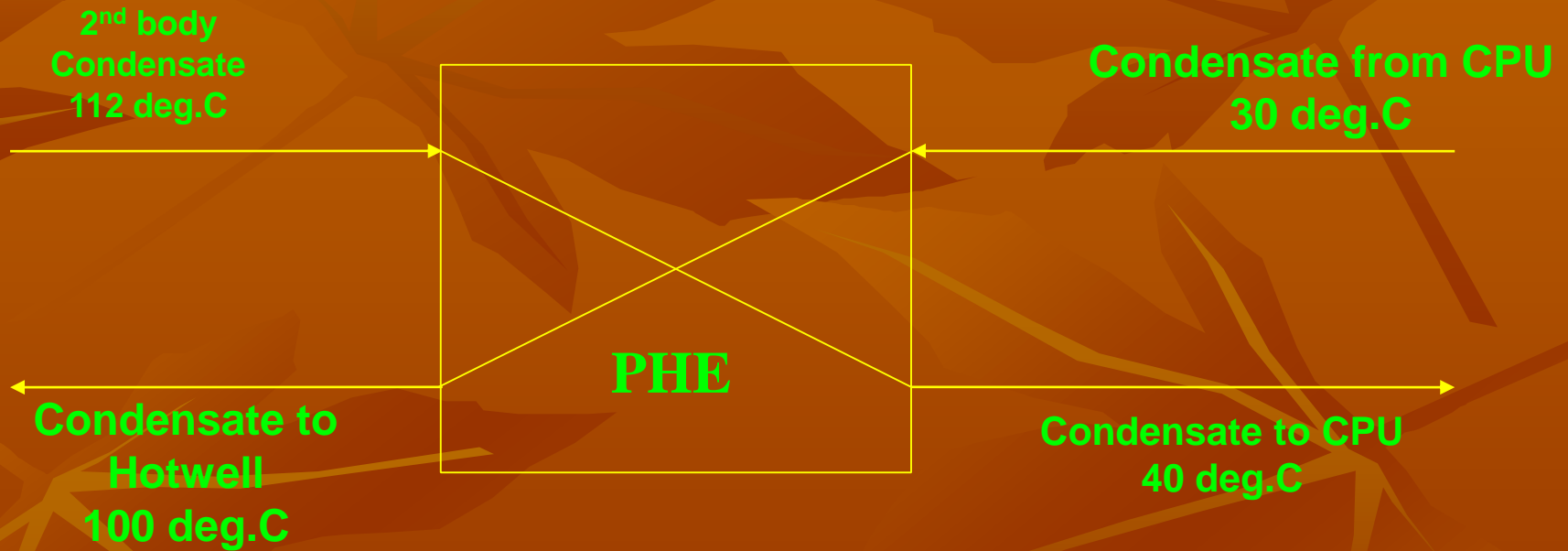
To use condensate of pans, juice heater and evaporator station in to flash system. This shall increase the flash quantity which is about 2.5% on cane.

Heat Recovery from 2nd Effect condensate

The Exhaust steam consumption can be reduced to 1.0% on cane by heat recovery from 2nd effect hot condensates.

Part of the evaporator 2nd effect condensate shall be diverted as boiler feed water after treatment through a condensate polishing unit (CPU). For this purpose the high temp. 2nd effect condensate need to be cooled down to around 40 deg.C The heat lost in cooling the evaporator condensate can be recovered by heating the treated condensate coming from the CPU unit.

Recovering System



Various alternatives for waste heat recovery at Evaporator.

- ❑ Use of hot condensate water of 90°C to heat raw juice in 3rd stage heating.
- ❑ Use of continuous pan vapours for RJ 1st heating.
- ❑ Venting of non condensable gases from each evaporator body calandria to vapour space of same body.
- ❑ Venting of non condensable gases from pan calandria to evaporator 3rd body vapour space.
- ❑ By using direct contact juice heater one could achieve 1-2 $^{\circ}\text{C}$ approach while in tubular juice heater it shall be of the order of 8-10 $^{\circ}\text{C}$
- ❑ Due to this advantage of direct contact JH the low temperature vapours may be easily used which will lead to have better steam saving.

PAN STATION

Molasses Conditioning

The exhaust steam consumption shall be reduced to 1.0% on cane by carrying out the molasses conditioning with NCG's of Evaporator set.

Process – The liquor separated out from the centrifugal is known as molasses and introduced to the pans for further exhaustion. This liquor should be free from sugar crystal unless it shall affect the boiling procedure. The dissolving of sugar crystal by raising its temperature up from 60 to 75 deg.C is known as molasses conditioning.

Recovering System

By using DCH direct contact heater which is minimum 1-2 °C approach, while in conventional system it shall be of the order of 6-8 °C

Due to this advantage of DCH low temperature vapours may be easily used which will lead to have better steam saving.

PAN WASHING

Conventional Practice:

It was routine practice to use 7 kg steam pan washing i.e. before start of new strike. During sugar quality era, 7 Kg steam is replaced by exhaust steam to avoid caramelisation.

The main purpose of pan washing is to remove left over massecuite crystals from pan body as well as top tube plate of calandria.

For pan washing, steam required is 0.25 % cane

Pan Washing

Modern Trend:

To use 120⁰c exhaust to achieve 90⁰c temperature is not advisable as major aim is condensation of vapours on metal surface for crystal removal.

Due to introduction of continuous pan, there is considerable decrease in pan washing steam.

For further reduction in steam consumption, exhaust shall be replaced by 1st /2nd body vapours or vapours near to 100⁰c temperature.

Other measures to reduce vapour consumption at Pan Station

- ❑ To use 1st / 2nd body vapours for Pan washing
- ❑ Use of continuous pans.
- ❑ Use of Clear Juice instead of movement hot water at A cont. Pan.
- ❑ Use of mechanical circulator for pans.
- ❑ To use syrup for B & C seed melting, melt brix % above 65 and temp – above 75.
- ❑ Pan shall not be used for seed melting.
- ❑ To minimize movement water by installing flow meters to hot water lines.
- ❑ Reducing low grade massequite grain hardening time below 20 minutes.

- ❑ **To reduce dry seed % cane and to improve uniformity of dry seed by using vibro screens.**
- ❑ **Use of syrup for CAW & BFW magma mixers.**
- ❑ **Use of CL molasses for CFW magma mixers**
- ❑ **Use of Pan & Condenser automation systems**
- ❑ **To increase the brix % of conditioned molasses and temperature of conditioned molasses so as reduce water intake.**
- ❑ **Massecuite level in pan shall not exceed the maximum strike level.**
- ❑ **Small size sugar production.**
- ❑ **To increase exhaustion in all massecuite to tune of 62%**
- ❑ **Re-circulation in pan boiling process shall be kept minimum.**

CENTRIFUGAL STATION

The LIVE steam consumption OF 7 bar shall be reduced to 2.0% on cane by carrying out the heating of centrifuge wash water with exhaust condensate in place of superheated wash water with 7 bar live steam.

Low grade sugar melter

Conventional Practice:

Similar to molasses conditioners, for low-grade sugar melter, 7 Kg steam was routinely used in earlier days.

During sugar quality era, 7 Kg steam is replaced by exhaust steam/ 1st /2nd to avoid caramelisation.

At present, use of exhaust steam with clear juice or syrup for low grade sugar melting, is common practice. For low grade sugar melting, exhaust /vapour required is 0.50 % cane.

Hot Air Blowers for FBD & Hopper.

Existing Practice:

Live steam is being regularly used. This quantity is very small and may vary from 0.10 to 0.15 % on cane. Though the quantity is small, radiation losses are on higher side.

The air is to be heated by 10-20°C. i.e. up to 65-75°C.

Low grade sugar Melter

Modern Trend:

For sugar melting, the maximum temperature required is 85⁰c. This target could be achieved by using 3rd body vapours in quadruple OR 4th body vapours in quintuple However for doing this, one has install sugar melter working under vacuum. For reducing the maintenance problems, the use of second body vapours may be made.

Hot Air Blowers

Modern Trend:

Exhaustor 1st Body vapours shall replace live steam. To achieve this temperature, hot condensate of 85°C may be used. For this purpose, some sugar factories installed radiator in front of air blower and hot water is circulated in radiator to achieve air temperature.

This will help to reduce steam consumption by about 0.10 to 0.15 % on cane.

Other measures help for Reducing steam & Power consumption.

- ❑ Cleanliness of evaporator HS. Prefer floating type bodies so that HS will be always clean.
- ❑ Better insulation cares so as to radiation losses.
- ❑ Perfect maintenance of all automation system.
- ❑ Development of skilled man power.

Adoption of Falling Film Evaporator

Advantages

- Reduced steam consumption
- High heat transfer coefficients & less ΔT .
- Increased throughput of the evaporator
- Minimal internal pressure drop.
- Minimum Inversion losses

Vertical Continuous Vacuum Pan for Massecuite Boiling

Advantages :

- **Reduction in steam consumption eliminates the fluctuations in the vapour demand thus steadiness of operation is achieved.**
- **Reduction in boiling point elevation avoids heat injury and colour formation.**
- **Maximum exhaustion of mother liquor.**
- **No fines and conglomerates.**
- **Facility of isolation of modules for cleaning during operation.**

Mill Drives (AC/DC)

Advantages

- Efficiency of AC motor is higher than DC motor
- Low maintenance cost than DC motor
- Less harmonics than DC motor
- Overall power saving of 3-5% is possible with AC drive for milling tandem in place of DC drives.

Variable Speed Drive (VSD) for the Juice Pumps

Advantages :

- Consistent and steady flow to the juice heaters.
- Improved quality of sulphitation, as the juice flow was steady.
- Reduced power consumption by an average of 11 kW (a reduction of about 30 - 40%).

Low Pressure Extraction (LPE) System

Advantages :

- Low capital cost (about 60%)
- Low power consumption to the extent of 35%
- Extraction comparable to 4-mill system (about 95%)
- Low maintenance cost
- No special skills required
- Very low retention time
- No chemical control.

Conclusions

With use of above modern innovative principles, Sugar mills can reduce the steam consumption and consequently able to achieve tremendous bagasse and energy saving.