Steam Consumption at Sulphitation / Raw Sugar Factories (Boiling House - Recent Trends)

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There is tremendous potential to reduce the steam consumption further by installing energy efficient equipments in the boiling house.

In co-generation era and increase in electricity demand, the conservation of energy in sugar factory becomes vital important. Working on the above lines few factories have achieved one of the milestones in the order of 32-35 % on cane.

Considering the importance of reducing steam consumption, we will discuss various alternatives to reduce steam consumption.

Steam / vapour requirement at Pan:
(Impact on Steam % Cane: 18.0 % - 25.0 %Cane)

The major energy consumption in sugar industry is at pan boiling station.

Factors which contribute to the steam consumption at Pan Floor are as stated:-

- Quality of Sugar to be produced
- Massecuite Boiling Scheme
- Massecuite % Cane
- Pan Start up Time
- Washing Steam Quantity and Type
- Type of massecuite
- Type of Pan (Continuous / Batch type)
- Design of Pan
- Amount of movement water used in Pan Boiling
- Temperature / Pressure of Vapour.
- Injection water temperature and pressure
- Type of Condenser used in Pan.
- Feed Liquor brix
- Feed Liquor temperature.
- Automation and recording system.

However we generally assume following figures in Sulphitation / Raw Sugar Factories

A m/c	-	0.30- 0.35 MT vapour / MT massecuite (Continuous Pan)
A m/c	-	0.40- 0.45 MT vapour / MT massecuite (Batch Pan)
B m/c	-	0.30- 0.35 MT vapour / MT massecuite (Continuous Pan)
B m/c	-	0.35- 0.40 MT vapour / MT massecuite (Batch Pan)
C m/c	-	0.35- 0.40 MT vapour / MT massecuite (Continuous Pan)
C m/c	-	0.40- 0.45 MT vapour / MT massecuite (Batch Pan)

For Refineries Steam consumption is calculated on basis Pan Boiling Scheme assuming 10% extra of total water to be evaporated see Steam Balance for Refinery

Use of flash vapours of Clarifier Flash Tank
(Impact on Steam % Cane: 0.2% - 0.5%Cane)

The sulphited juice enters in flash tank of clarifier at about 103-104^{o}C. Due to venting of flash and further vapours in clear juice box, the ultimate temperature of clear juice reduces to 96-97^{o}C. This temperature loss (7-8^{o}C) accounts for 1.2 % vapour / steam demand. By eliminating radiation losses, we may recover 3-4^{o}C temperature loss by using direct contact JH for sulphured juice /clear juice.

Justification Calculations: 0.22% Cane is calculated on the use of Flash tank Vapours in Example

1. With use of Flash Vapours from Clarifier Flash Tank
2. Witnout use of Flash Vapours from Clarifier Flash Tank

Use of Direct Contact Juice Heaters
(Impact on Steam % Cane: Almost Negligible)

The use of tubular JH for juice heating is a common practice in Sugar Industry. But tabular juice heaters are having disadvantages such as scaling, higher ΔT in between two fluids. In direct contact juice heater one could achieve 2-3^{o} ΔT while in tubular juice heater it shall be of the order of 8-10^{o}C other wise very large HS is needed. Due to this advantage of direct contact JH the low temperature vapours may be easily used which will lead to have better steam saving.

The one of the major disadvantage of direct contact juice heaters is addition of condensate in juice. Due to this quantity of juice increases and brix % of juice decreases. This needs higher heating surface at evaporator. Considering all these drawbacks, due to the advantage of the use of lower pressure vapours the practice of using direct contact juice heaters for final sulphited juice heating and clear juice heating is becoming popular. This is also helping reducing in steam consumption.

If the DCH operates on vapour which is one stage further down the multi-effect stage that a tubular heater on the same duty, the overall change in Steam % Cane by switching to a DCH is almost negligible. As the approach temperature with DCH can be quite small, and that of a tubular heater is often ~10oC, this is often possible. We can verify this in our evaporator modeling.

Generally, though, the HS area saved by eliminating the tubular heater has to be put into the evaporator vessels at stages higher than that of the vapour bleed stage, or else the evaporator capacity is impeded.

As mentioned earlier it is better to have fewer heaters to clean than to have a slightly larger evaporator HS for cleaning.

The use of DCH for heating maceration waters, sugar melters, molasses conditioners etc, where the condensed vapour is not a process problem is a good technical solution.

Separation of water and sugar solids from juice can only happen by indirect heat transfer in Pans, Evaporators and Surface heaters. Direct Contact Heater do not contribute in water removal rather it dilutes the juice but generally used with one or two step lower vapors.
Any Major improvement in Steam Economy and higher Power Generation in Sugar manufacturing can only happen by efficient heat exchange indirectly. However DC Heaters brings following benefits to the user:

- When operated under vacuum conditions juice is aerated perfectly and need of flashing before clarifier can be minimized or avoided.
- As fouling creeps in surface heaters one has to take safety of higher bleed and compromise economy. Presence of additional Direct contact heater brings comforts of operating regularly without deviation in performance from lower bleed itself.
- Dilution in many factories makes it easier to operate pans on third vapors. Dilution also brings better clarity in juice and reduces problem of clarifiers.
- Presence of DC heater does not reduce heating surface requirements of the factory. However number of heat exchangers that needs cleaning is reduced with each additional DC Heater. Juice Heaters typically needs 15-20 % heating surface in a plant and same can easily be added in evaporators in form of additional effect to get same or usually better economy coming by way of additional effect.
- DC heaters are more efficient in absorbing heat from NCG as it is difficult to corner it in Tubular Heat Exchangers.
- DC heater helps to brings economy only when it is used with one or two step lower bleedings or Partial heating after a surface heater as correction heater.

Technological development can bring more methods to reduce or eliminate the use of thermal energy in sugar making. Filtration may remove both impurities and water without much energy cost. Evaporation at low temperature can make regenerative juice heating by PHE possible to almost eliminate the use of steam. All new developments will have initial adoption and quality related problems.

Justification Calculations:

1. With use of Direct Contact Heaters.
2. With use of Tubular Heaters.

Use of condensate flash heat recovery system:

Normally condensate is collected individually from evaporator / juice heater or pans and sent to overhead tanks at pans or used as boiler feed water. The condensate going to overhead tank looses its temperature by flashing vapours in atmosphere. The use of flash effect of condensate is age-old

practice but as it needs well preventive maintenance to avoid leakages, this was not preferred. But due to energy crisis and its economy, many sugar factories installed this.

The vapour condensate from juice heater, pans and evaporators is collected in flash tank depending upon pressure and temperature, the flash vapour is used back in evaporator (next vessel) at corresponding temperature pressure. This may result in saving 1.5 to 2% steam % cane.

Use of non condensable Gases for Molasses Conditioning
(Impact on Steam % Cane: 0.25 % - 0.5 %Cane)

The use of 7-kg/cm^2 live steam for molasses conditioning is general practice. During the sugar quality era the 7 kg/cm^2 steam is replaced by exhaust steam (1.5 kg/cm^2) to avoid destruction of reducing sugar and to avoid caramelisation and melanoidin formation.

The temperature needed to condition the molasses is less than 80^{o}C. To take advantage of this, recently some molasses conditioners are available which work on Non condensable gases of last effect. The temperature of these gases is in the range of 80 $\pm$ 2^{o}C. The quantity of non-condensable gases may not be sufficient to condition the molasses. To attain the conditioned molasses some vapours along with non-condensable gases may be used. But this will avoid use of exhaust steam /high pressure vapours and helps to reduce steam consumption. This may help to reduce steam consumption by 0.25 to 0.5% on cane.

Justification Calculations: 0.34% Cane is calculated on the use of #4 Body vapours for Molasses conditioner instead of Exhaust Steam

1. With use of #4th Body vapours for molasses conditioners
2. With use Exhaust Steam in molasses conditioning

Venting of Non Condensable gases:
For achieving better evaporation rate, it is common practice to remove/vent out non-condensable gases in atmosphere by venting in case high pressure vapours. In case of vapours below atmosphere pressure, it is vented by separate line to condenser. While practicing this, some vapours are also vented out along with non-condensable gases and leads to valuable heat loss.
To recover this heat, the non-condensable gases of calendria may be connected to the vapour space of same body, which is always under lower pressure. Due to pressure difference, the non-condensable gases may be easily vented out and the energy may be used in next body. The non-condensable gases of pans may be used for third body of evaporator. This will also help to reduce steam consumption of the order of 0.5 – 1.0 % on cane depending on venting of non-condensable gases.

Use of low temperature vapours for pan washing:

During last two decade almost all factories are using exhaust steam for pan washing in place of high-pressure live steam of 7 kg/cm^2 pressure. Recently few factories tried 1st / 2nd effect vapours for pan washing. With low-pressure vapours, the time required for pan washing is high (20-30 min). If sufficient pan capacity is available, the use of second body vapours may be safely used. In other case the exhaust steam may be replaced by 1st body vapour for pan washing. This may save steam % cane of the order of 0.5% on cane.
In addition to above the harm of high temperature to sucrose molecule will also reduced considerably.

Use of exhaust condensate for heating of condensate used for centrifugal wash water:

The superheated wash water used at centrifugal is of 115-120^{o}C and obtained by heating of condensate by using 7 kg/cm^{2} live steam. In view of reducing steam consumption, few factories are heating this water in PHE with the help of exhaust condensate of 122-124^{o}C. The idea of using exhaust condensate will help avoiding total high-pressure live steam (7 kg/cm^{2}) at centrifugal station. The use of exhaust condensate for obtaining superheated wash water may help to reduce steam consumption of the order of 0.50 to 0.75 % on cane.

Use of low pressure steam for seed melting:

The use of water for B & C melting is being avoided by number of factories. However to ensure complete melting the exhaust steam is commonly used. To reduce steam consumption, second body vapours may safely replace the exhaust steam.

To have one step further, some manufacturers designed seed melter under vacuum to use further low-pressure vapours. This will also help further reduction in steam consumption.

Use of condensate for Raw / Sulphited juice heating:
(Impact on Steam % Cane: 0.5% - 1.2%Cane)

The excess hot condensate is now a common thing in Indian Sugar Industry. Number of factories installed cooling towers for cooling of this excess condensate. To recover this heat few factories tried to heat RJ first heating by using condensate going to hot water condensate tank. This practice may save steam % cane of the order of 0.5 to 1.2 % on cane.

Justification Calculations: 1.02% Cane is calculated on the use of Condensate Heaters in Example

1. With use of Condensate heaters for RJ and SJ
2. Without use of Condensate heaters for RJ and SJ

Some factories also tried to use continuous pan vapours for RJ first heating. When the vapour going to evaporator condenser are less than 0.5% on cane, in such cases the use of continuous pan vapour for RJ first heating may be thought.

Heating of low temperature condensate by flue gas and using the same in flash effect:

Few factories tried heating of low temperature condensate by boiler flue gases. The heated condensate is mixed with appropriate condensate depending on temperature in condensate flash tank. This will give flash vapours to next body and the condensate after flash effect may be again re-circulated for heating by boiler flue gases. By using such system the flue gas temperature may be considerably reduced to 110^{o}C.

Use of surplus condensate for heating F.D. air:

Few factories tried to heat the air going to F.D. fan by excess condensate. This helps to increase boiler efficiency.

Heating of air by hot condensate at sugar dryer / hopper:

Normally steam of 1.5 or 7 kg/cm^2 pressure is used for heating the air at sugar hopper/ dryer. The air is to be heated by 10-15^{o}C. i.e. up to 45-50^{o}C. To achieve this temperature, hot condensate of 85^{o}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 0.3 to 0.5 % on cane.

Heating of sulphited juice in multistage:

In general sulphited juice heating is followed by 1st & 2nd effect vapour. In place of this one may have sulphured juice heating in four stages such as 3rd body vapour, followed by 2nd body vapour followed by direct contact heating with flash from clarifier and if needed last heating by 1st body vapours.