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Research Article

Analysis of the Volume of the Main Water and Wastewater in a Sugar Manufacturing Process followed by the Suggestion Regarding the Reutilization of the Waste Water

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Abstract

Sugar industry is one of the most important agro-industries in India. Cane Sugar Industry has an important role in the Indian economy as well as in the foreign exchange earnings. Since cane consists of about 70-75% water, cane sugar mill processes more water than sugar. All the water entering a mill must also leave it in one form or another. So why the sugar industry is a major water user and wastewater producer. Water is most essential but scarce resource in developing countries. Recycling of condensate, segregation of high strength and low strength effluent, proper operation of ETP (Effluent Treatment Plant), etc. leads to a well maintained water managements in the sugar industry and leads to reduction in the requirement of fresh water. In this study we quantified the volume of the main water and wastewater in a sugar manufacturing process followed by the suggestion regarding the reutilization of the waste water. For study the data is collected from The Kaithal Cooperative Sugar Mills Ltd. (2500 TCD) which is situated in Kaithal District of Haryana State.

Keywords: *Sugar industry, Water recycling, Reduction in fresh water requirement, Water management,*

1. Introduction

1.1 Sugar Manufacturing Process

Sugar is manufactured in following stages

1. Extraction of juice from sugarcane milling.
2. Clarification of juice.
3. Concentration of juice by evaporation to syrup.
4. Crystallization of sucrose by vacuum pan distillation.
5. Centrifugal separation of sugar & molasses from the massecuites.
6. Drying & cooling of sugar.
7. Sugar grading & packing.

1.2 Factory Water Balance

Sources

(1) Water comes from outside such as river, canals, well, dam borewell etc.
(2) Water comes along with sugarcane.

Use

The water utilized in the sugar industry can be classified in to two categories.

(1) External Water (Cold Water): The external water does not generally come in contact with the sugar does not generally come in contact with the sugar manufacturing process directly. The external water such as cooling water used for condensing and cooling power turbines, mill turbines, mill bearings, crystallizes sulfur burners, air compressors, vaccum pumps, hot liquor pumps etc. and water used for floor washing, vessel washing and domestic use.

(2) Internal Water: The internal water such us the water from the cane itself imbibition water, clarification water, boiling water and purging water which is directly involved in the sugar manufacturing process. Clean cane containing about 70% water, wherefore the water coming from the cane itself is a primary source for sugar manufacturing process. The water from cane itself in the form of condensate is more than sufficient for the internal process of sugar manufacturing such as condensate water used for imbibition, boiler, filter, cake washing, milk of lime preparation movement water at pans, molasses, dilutions, centrifugals, melting etc.

Sources of Effluents

The waste water generated from different substreams can be classified as follows

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(1) Mill House: The effluent consists of water used for cleaning the mill house floor which is liable to be converted by spills and pleased sugar juice (This clearing up operation will prevent growth of bacteria on the juice-covered floor).Water used for cooling of mills also forms part of the waste water from this source. Basically this water contains organic matter like sucrose, bagacillo, oil and grease from the bearings fitted in to the mills.

(2) Waste Water from Boiling House: The waste water from boiling house results from leakages through pumps, pipelines and the washings of various sections such as evaporators, juice heaters, clarification, pans crystal is action, and centrifugation etc. The cooling water from various pumps also forms part of water.

(3) Waste Water from Boiler Blow-down: The water used in boiler contains suspended solids dissolved solids like calcium salts, magnesium salts, sodium salts, fatty salts etc. These salts get concentrated after generation stream from the original water volume. These solids have to be expelled time to time to save the boiler being covered up by scales.

(4) Excess Condensate: The excess condensate does not normally contain any pollutant and is used as boiler feed water and the washing operations. Sometimes it gets contaminated with juice due to entertainment of carryover of solids with the vapours being condensed in that case if goes in to the waste water drain. The treatment requirement in this case is almost negligible and can replace fresh water or let out directly as irrigation water after cooling it to ambient temperature.

(5) Condenser cooling water: Condenser cooling water is recirculated again unless it gets contaminated with juice, which is possible due to defective entrainment separators, faulty operation beyond the design rate of evaporation etc. if gets contaminated, the water should go into the drain invisibly. This volume of water is also increased by additional condensing of vapour of trained from the boiling juice the pan.

(6) Soda and Acid Wastes: The heat exchangers and evaporator are cleaned with caustic soda and hydrochloric acid in order to remove the formation of the deposits of scales on the surface of the tubing. In India, most of the sugar factories let this valuable chemical go into drains. The soda and acid wash contribute considerable amounts of organic and inorganic pollutions and may cause shock loads to waste water treatment once in a fortnight or so.

A scheme showing the water flows in a sugar process production appear in Figure 1.

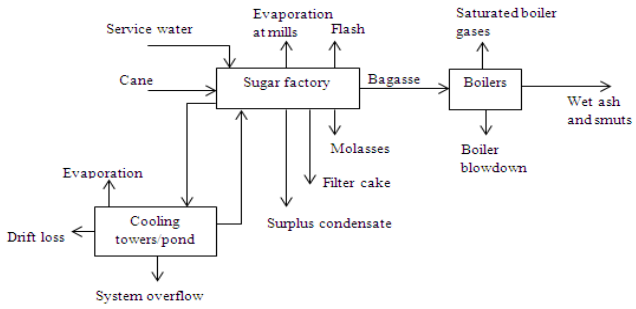

Figure 1.1: Streams containing water entering and leaving a sugar mill.

In sugar process production water leaving the mill does so in the following ways

1. Together with the products of the mill: in molasses and in filter cake.
2. In the form of vapor in: boiler gases, which may or may not be saturated, depending on whether a wet scrubber is used; vapor evaporated in cooling towers or spay pond; flash vapor from the heated juice flash tank; evaporation from diffuser or mills.
3. In liquid form as: surplus condensate; overflow from the cooling water circuit; boiler blow down; drift loss from the cooling towers or spray pond; effluent (wash down or spillage) from drains.

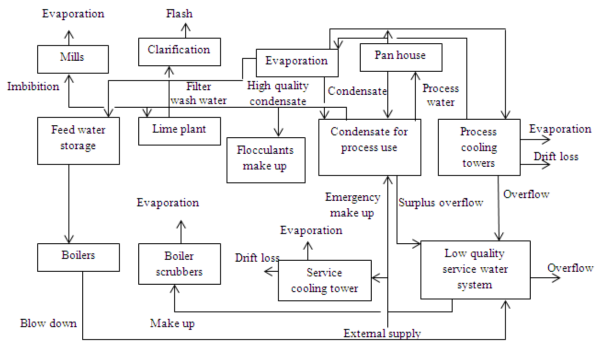

Figure 1.2: Major water flow in a sugar mill

2. Literature Review

2.1 Meilyn González Cortés, Harry Verelst (2010)

Since cane consists of about 70-75% water, cane sugar mill processes more water than sugar. All the water entering a mill must also leave it in one form or another. The sugar industry is a major water user and wastewater producer.

In this work are identify the structure of the main water and wastewater circuit in a sugar manufacturing process. It is analyzed using graphical techniques, and the structure of the main water and wastewater circuit can be optimized by the inspection of feasible options. By analyzing the combined effect of all the operations at given impurity contents in fresh water taken in and wastewater discharged, water pinch makes it possible to evaluate the water consumption at optimum utilization of circuit components. Both circuit structure, that is, set of connections between its components (considered as 'sources' and 'sinks'), and water flows in these connections were optimized.

2.2 Mauro F. Chavez-Rodriguez a, Klever Joao Mosqueira-Salazar (2013)

Sugarcane is one of Brazil's most important industries, mainly because of ethanol, one of its products. Ethanol has a low production cost and low GHG emissions per unit of energy produced, as compared to other fossil fuels. However, several authors have expressed concern about the high water consumption expected in the coming years for biofuel production. This work presents a proposal to reduce water consumption in the industrial stage, taking into account demand and supply quality restrictions. A water supply mix is suggested, with direct reuse of 648 L/t of cane, and another 176 L/t of cane covered indirectly by recycled streams. This reduces the required external withdrawal to 405 L/t of cane — a value within the limit mandated.

2.3 Jadhav P.G., DR. Vaidya N.G., Dethe S.B (2013)

Sugar industry is one of the most important agro based industry segment in India. Cane Sugar Industry being an important role in the Indian economy as well as in the foreign exchange earnings and also plays a very vital part in polluting the environment with its waste discharge. With expansion of Sugar plants, pollution due to inadequate and it becomes threat for environment .In this study four Sugar Industries were selected for the analysis of the composition of their effluents, which are the primary source of water pollution. The results of the study showed that the effluents in general exceed the limits specified in CPCB with reference to parameters a such as BOD, COD, Oil and greases , total suspended solids. The effluent level found through the analysis can be reduced if suggested recommended measures are worked upon.

2.4 Harush D P and Hampannavar U S (2014)

Sugar is one of major product in India. Water management in the industry is one of major problem. Due to this there is lots of effluent generated to effluent treatment plant and thus efficiency getting reduced for the treatment to be achieved. Industry can be well maintained if proper water management activities can practice and applied in the required area. Recycling of condensate, segregation of high strength and low strength effluent, proper operation of ETP (Effluent Treatment Plant), etc leads to a well maintained water managements in the industry and leads to reduction of cost on water. Well Operated and maintained ETP will not have any problem and can achieve the prescribed norms by statutory board. The Paper is completely prepared based on my personal experience as consultant in sugar industry and by review of few of related articles.

2.5 Pradeep Kumar Poddar and Omprakash Sahu (2015)

Wastewater from sugar industries is one that has complex characteristics and is considered a challenge for environmental engineers in terms of treatment as well as utilization. Before treatment and recycling, determination of physicochemical parameter is an important mechanism. Many different types of techniques are introduced and modified for the purpose, but depend upon the water quality parameters. The main aim of this study is to determine the physicochemical characteristics of sugar industry waste water by the standard method and minimize the fresh water consumption in sugar industry by water pinch methodology.

3. Analysis and Result

The analysis on material wastage has been carried out keeping the following points in mind

1. The material balance on the basis of total cane crushed per annum, yielding different byproducts like bagasse, filter cake, final molasses and their constituents have been quantified.
2. The process loss of sugar content has been worked out on annual basis from laboratory test report (as taken in appendix A).

Table 1 Water Balance in Boiling House

Sr. No.	Particulars	Quantity (tons/hr)
1	Water input through mixed juice (M.J.)	93.09
2	Water input through the milk of lime (M.O.L.)	1.52
3	Water in M.O.L.	1.406
4	Moisture in filter cake (F.C.)	2.45
5	Water loss through juice flash [1% M.J.]	1.167
6	Water in clear juice (C.J.)	90.879

Table 2 Water Balance at evaporator station

Sr. No.	Particulars	Quantity (tons/hr)
1	Pol. in clear juice	10.37
2	Brix in M.J. [13.02 % MJ]	13.02
3	Brix in F.C	0.087
4	Brix in clear juice (C.J.)	12.933
5	Quantity of clear juice	103.812
6	Water evaporated in (Evaporator & Vapour Cell)	79.52

Table 3 Steam required at various stations

Sr. No.	Particulars	Quantity (tons/hr)
1	Steam required for pan boiling	30.27
2	Water to be evaporated in evaporator	49.25
3	Steam required for raw juice heating	6.05
4	Steam required for sulphited juice heating	5
5	Steam required for clear juice heating	2.38
6	Steam required for evaporator station(for 1,2,34 & 5th body)	49.25

Total quantity of Clear Juice (C.J.)=103.812 tons/hr
Water evaporated in evaporator and V.C.=79.52 tons/hr
Syrup quantity= 103.812 – 79.52 =24.29 tons/hr
Total water going to pan condenser = Water in C.J.– Water evaporated in evaporator 90.879–79.5 =11.359 tons/hr
i.e. Quantity of syrup - quantity of solids in syrup = 24.29 -12.933=11.36 tons/hr

Table 4 Balance of Water in Clear Juice

Sr. No.	Particulars	Quantity (tons/hr)
1.	Total water in clear juice	90.879
2.	Water evaporated in vapour cell (Condensate)	30.27
3.	Water evaporated in evaporator (Condensate)	49.52
4.	Water evaporated in pans (Condensate)z	11.36
5.	Total water evaporated	90.879

3.1 Total Condensate Water Balance

A. Sources of condensate

(a) Exhaust Condensate

Sr. No.	Particulars	Quantity (tons/hr)
1.	Vapour cell Condensate	30.27
2.	Evaporator 1st body condensate	17.48
3.	Clear juice heating condensate	2.38
4.	"C" Pan condensate	7.24
5.	**Total (a)**	**57.37**

(b) Vapour Condensate

Sr. No.	Particulars	Quantity (tons/hr)
1.	Sulphited juice heater condensate	5.00
2.	Raw juice heater condensate	6.05
3.	2nd body of evaporator condensate	12.48
4.	Condensate from 3rd body(x)	6.43
5.	4th body (x)	6.43
6.	5th body (x)	6.43
7.	Pan condensate	30.27
8.	Condensate from last body	6.43
9.	Vapor condensate from pans	11.359
10.	**Total (b)**	**90.879**
11.	**Total Condensate Available (a+b)**	**148.249**

B. Consumption of Condensate

Sr. No.	Perticulars	Qty. ton/hr
(a)	**For boiler feed**	
(i)	Exhaust condensate	57.37
(ii)	Vapour condensate (from R.J. heater)	6.05
(b)	**For imbibition water**	
(i)	"A" pan condensate	14.71
(ii)	"B" pan condensate	8.325
(iii)	2nd body condensate	6.43
(c)	For M.O.L preparation	1.406
(d)	Net pan movement water	1 .00
(e)	Centrifugal washing	3.28
(f)	Water for miscellaneous use	2.00
(g)	Water loss through flash	0.80
	Total	**101.371**
	Therefore, excess condensate water (148.249 – 101.371)	**46.878**

3.2 Cold Water Balance

Water requirement during running

(i) Make recirculation water @ 5% of that required for cooling of bearings of mills and turbines = (0.05×5×3600)/1000
=0.9 tons/hr

(ii) For sulphur furnaces, So_2 gas cooling, air Compressors = 3 tons/hr

(iii) Pumps gland cooling = 2 tons/hr

(iv) Laboratory and miscellaneous washing = 1 tons/hr

(v) Spray pond make up water circulated using 2 Nos. of 681LPS and 2 Nos. of 315LPS capacity.
Total capacity of spray pump required (1992 LPS)= (1992×3600)/1000= 7171.20 tons/hr

Assuming 1% spray loss on total capacity = 71.71 tons/hr

Total water requirement = 78.61 tons/hr

Excess condensate received = 46.878 tons/hr

Net cold water required = 78.61 – 46.87 = 31.73 tons/hr

Conclusions

4.1 Hot water balance (Fig. 4.1) indicates the usage of total water content introduced in the juice and recovered back to produce solid sugar crystals. Total water content of 60.13 tons/hr is got from sugar cane crushed to which 1.406 tons/hr is added through M.O.L and 35.10 tons of hot water is added at last mill. This is recovered back in various stages such as 30.27 tons/hr in vapour cell, 49.25 tons/hr in evaporators, 11.359 tons/hr in pans and sent to hot water tank through condensers for recirculation and use. The excess 46.878 tons/hr condensate water is sent to spray pond, where it is cooled by spray and addition of 31.73 tons/hr net cold water to makeup for spray evaporation losses. The water in spray pond is circulated for cooling of prime movers, compressors and other equipments.

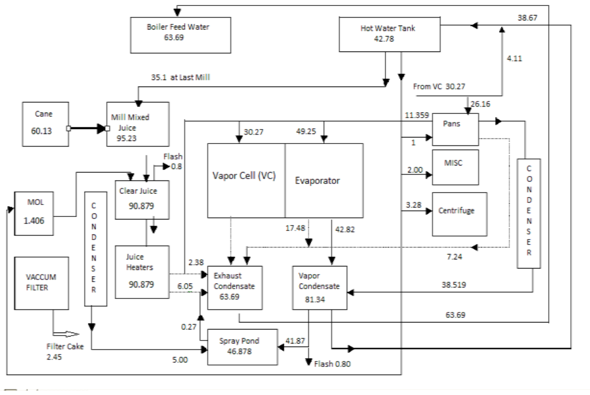

Fig. 4.1 Hot Water Balance

4.2 The cold-water requirement is 78.61 tons/hr. This can be reduced to 31.73 tons/hr by using excess condensate of 46.878 tons/hr as cold water by reducing its temperature to atmospheric temperature, i.e. fresh cold water requirement can be reduced by 59.63% by adopting recycling of the condensate in the mill.

4.3 Using live steam for cleaning purposes means loss of pure boiler feed water, which is difficult to replace. As such process condensate water should be used for cleaning purposes. It shall reduce TDS (Total dissolved solids) and corresponding blow offs from boiler.

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