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Utilization of Excess Vapour and Idle Equipments to Produce Single Stage Refined Sugar During Diversion of Boiling House Intermediates to Ethanol Production

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ABSTRACT

India is producing plantation white sugar on low production costs and ease of operation and only a few factories manufacturing refined sugar. Karnataka is the third-largest state in terms of sugar production. During the 2023–2024 season, 76 factories in the state crushed over 585 lakh MT of cane and produced 53.18 lakh MT of sugar. Out of this only eight factories produced refined sugar, while 36 sugar factories are sending various boiling house intermediates like cane juice/syrup/B-heavy molasses to their distilleries for ethanol production. Sugar industries is diverting intermediate compounds of the sugar process, such as juice/syrup/B-heavy molasses, for ethanol generation over the past five years, demonstrating a new path to self sustainability in the Indian sugar sector. However, diversion of B-heavy molasses and sugarcane juice/syrup to ethanol has caused a few issues in sugar processing, such as lower syrup brix % and reduced vapour consumption at the pan station. During the diversion of intermediate compounds, there is an excess of vapor and equipments such as centrifugal machines and vacuum pans of C massecuite boiling have become idle. Thus, it is possible to overcome operational challenges and manufacture high-quality refined sugar with less investment by making use of this extra vapour and the idle equipments. This paper addresses how to manage the excess vapour, left over after syrup and B heavy molasses are diverted in plantation white sugar plants. It also explains how to use this vapour and idle equipments to produce single-stage, refined/sulphur-free sugar production with minimal investment using the best technology now available.

Keywords : Syrup, B heavy molasses, ethanol, plantation white sugar, defeco remelt clarification, multi bed filter, excess vapor.

INTRODUCTION

The implementation of the syrup and B-heavy molasses diversion policy for ethanol production has helped the Indian sugar sector to regain its glory. Ethanol policy benefited farmers and sugar mills while also assisting the nation in reducing oil imports.

Nowadays, sugar factories have an average crushing capacity of 6000 TCD. Additionally, new distillery plants producing 100 to 200 KLPD of ethanol on syrup and B heavy molasses based are being established. So, during the diversion period, several equipments become idle, and the following issues arise in sugar processing (Londhe and Khandagave, 2022):

a. Reduction in pan vapour consumption by 10-15% based on reduction of massecuite % cane.

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b. Reduction in syrup brix% upto 15 units depends on quantity of syrup diverted.

c. Lower syrup brix causes increase in specific vapour consumption of A m/c.

d. Low sugar recovery and low massecuite %.

To resolve these issues, excess vapour needs to be vented at the pan station in order to increase syrup brix, it is a waste of vital energy, and it also significantly increases steam usage. In addition to these issues, certain distilleries that receive their syrup from sulphitation process plants also deals with less yield, increased volatile acidity, disruptions to yeast metabolism, and finding of SO_2 traces in ethanol that exceeds specific norms stipulated by OMC's (Panda et al. 2022). In order to solve this specific problem, some factories have arranged a separate stream that only supplies the defecated syrup to distilleries.

Through observation of these issues and procedures, SNSI conducted a case study on the estimation of the required steam % and equipment for the conventional process, as well as excess vapor and idle equipment during the diversion of intermediate and quantity/coast of chemicals, for a 6000 TCD sugar plant, recommended methods for making use of surplus vapor and idle machinery to produce sugar that is single-stage refined / sulphur-free with minimal expenditure.

General considerations

Crushing capacity: 6000 TCD, distillery capacity: 120 KLPD (syrup + molasses based)

Mixed juice % cane: 100, SJ % cane: 115% and CJ % cane: 105 % cane: 100.

The quantity of steam required for juice heating and miscellaneous remains same in all cases. (i.e., no diversion with PWS, syrup + B Heavy diversion with PWS, syrup + B heavy with refined sugar production)

For juice heating 40.16 MT of steam i.e., 13.44% on cane is required. Detailed vapour requirement for juice heating is given below:

Table 1 : Various juice heating duties and their vapour requirement for 6000 TCD (from one of factory performance)

Juice heating	Juice Quantity (MT)	Juice inlet Temp ^{0}C	Juice outlet Temp ^{0}C	Vapour used	Vapour Quantity Required
RJ 1st heating	272.73	35	50	15	6.68
RJ Final heating	272.73	50	75	25	11.55
SJ 1st heating	313.64	72	88	16	8.60
SJ 2nd heating	313.64	88	103	15	8.15
CJ 1st heating	272.73	94	99	5	2.34
CJ 2nd heating	272.73	99	105	6	2.84
				Total Vapour required	40.16
				Steam % cane for Juice heating	14.72%

Part A : steam/vapour and equipments (pans and centrifugal machines) required for – 6000 TCD plantation white sugar plant without any intermediate diversion.

Table 2 : Steam utilization for various heating duties

Exhaust steam	**1st Vapour**	**2nd Vapour**	**3rd Vapour**	**4th**	**5th Vapour**
• Super heating wash water • Hot air blower • M/c and seed pipelines, Pump suctions	• Pan washing • Sugar melting • CJ 2nd heating • SJ 2nd heating	• A, B and C m/c boiling • CJ 1st heating • SJ 1st heating	• RJ final heating • Molasses conditioner		VJJH-RJ 1st

Table 3 : Steam required for various heating duties

	Quantity of steam required MT/Hr	**Steam % cane**
Juice Heating	40.16	14.72
Evaporation	0.66	0.24
A m/c (28%)	30.55	8.60
B m/c (13%)	11.2	3.1
C m/c (8%)	6.93	2.50
Miscellaneous	8.18	3.00
Total	95.08	34.81

Table 4 : Equipments required: pan and centrifugal

A massecuite:			
M/c % cane	28%	Quantity/Hr	70 MT
Quantity/Day	1680	Machine capacity	1250Kg/ Charge
Boiling time	4 Hrs	No. of cycles	18
No. of strike/day	6	M/c cured/Hr by c/f machine	22.5 Ton
M/c Qty/ strike	280	No. c/f of machine required	3.11= 3+1
80Ton Pans required	3		
60Ton Pan required	1		
B massecuite:			
M/c % cane	13%		
Quantity/Hr	32.5 MT	c/f Machine capacity	15MT/ Hr
Continuous pan capacity required	35MT/Hr	No. of c/f machine required	2.16=2+1
C massecuite:			
M/c % cane	8%		
Quantity/Hr	20 MT	c/f Machine capacity	12MT/ Hr
Continuous pan capacity required	25MT/Hr	No. of c/f machine required CFW	1.66=2
		No. of c/f machine required CAW	1

Part B : Steam and equipments (pan and centrifugation) required for 6000 TCD plantation white sugar plant with diversion of 22% of total syrup (or 6.6% on cane i.e., 330 MT/day) and complete B heavy molasses:

Table 5 : Steam utilization (vapour bleeding)

Exhaust	1st	2nd	3rd	4th	5th
• Super heating wash water	• Pan washing • Sugar melting	• A and B m/c boiling	• RJ final heating		VJJH-RJ 1st
• Hot air blower	• CJ 2nd heating	• CJ 1st	• Molasses conditioner		
• M/c and seed pipelines, Pump suctions	• SJ 2nd heating	• SJ 1st			

Table 6 : Steam required for two massecuite boiling schemes in plantation white sugar production

	Quantity of steam required MT/Hr	Steam % cane
Juice Heating	40.16	14.72
Evaporation	8.72	3.2
A m/c (19%)	20.12	7.30
B m/c (9%)	5.80	2.20
Miscellaneous	8.18	3.00
Total	82.97	30.42

Table 7 : Equipments required : pan and centrifugal

A massecuite:			
M/c % cane	19.0 %	Quantity/Hr	47.5 MT
Quantity/Day	1140	Machine capacity	1250Kg/ Charge
Boiling time	4 Hrs	No. of cycles	18
No. of strike/day	6	M/c cured/Hr by machine	22.5 Ton
M/c Qty/ strike	190	No. of C/F machine required	03
80 Ton Pans	02		
60 Ton Pans	01		
B m/c			
M/c % cane	9 %		
Quantity/Hr	22.5 MT	C/F Machine capacity	14MT/ Hr
Continuous pan capacity required	25 MT/Hr	No. of C/F machine required	1.25=2

Part C : Steam and equipments (pan and centrifugation) required for – 6000 TCD single stage refined sugar plant with diversion of syrup and B heavy molasses:

Most of the sugar factories in India follow double sulphitation process, it has its own limitations (Patil and Jaiswal, 2010). They are as given below:

1. High chemical cost
2. Corrosion due to sulphur gas
3. Less removal of non sugars resulting in higher molasses production

4. Higher losses due to retention of juice, syrup and molasses at lower process pH
5. High maintenance cost due to acidic boiling
6. Environmental unfriendly process
7. Low shelf life of final product
8. Inconsistent quality of final product

In view of the above drawbacks factories are converting their double sulphitation process to defeco remelt phospoflotation method of clarification with multi bed filters as single stage refinery. So it improves product quality and reduces chemical cost. This Part C contains utilization of excess vapour and idle equipments for refined sugar manufacturing.

Table 8 : Steam utilization of refinery sugar production boiling house

Exhaust	1st	2nd	3rd	4th	5th
• Super heating wash water	• Pan washing	• R1, R2, A and B m/c boiling	• Molasses conditioner	RJ Final heating	VJJH-RJ 1st
• Hot air blower	• Sugar melting	• CJ 1st	• Melt		
• M/c and seed pipelines, Pump suctions	• CJ 2nd heating • SJ 2nd heating	• SJ 1st	concentration		

Table 9 : Steam required in refinery sugar production boiling house

	Quantity of steam required MT/Hr	Steam % cane
Juice Heating	40.16	14.72
Evaporation	4.59	1.68
R1 m/c (11)	8.60	3.80
R2 m/c (4.5)	3.50	1.50
A m/c (19%)	20.73	3.30
B m/c (9%)	5.95	1.20
Melt concentration	3.24	
Miscellaneous	5.54	2.00
Total	95.99	35.20

Table 10 : Equipments required : pan and centrifugal - A and B massecuite pan and centrifugal machines are same as said in Part-B

R1 + R2 massecuite			
M/c % cane	11+4.5 =15.5%	Quantity/Hr	38.7 MT
Quantity/Day	930	C/F Machine capacity	1250Kg/ Charge
Boiling time	2.5 Hrs	No. of cycles	18
No. of strike/day	9.6	M/c cured/Hr by machine	22.5 Ton
M/c Qty/ strike	96.8	No. of C/F machine required	2+1
80Ton Pans	01		
60Ton Pans	01		

Table 11 : Equipments required for all three cases

	Conventional process (No diversion)	During Syrup and BH diversion	Idle equipments
Pans			
A m/c	4	2	2
B m/c	35MT/Hr	35 MT/Hr 60MT Grain Pan	–
C m/c	25 MT/Hr 60MT Grain Pan	-	25 MT/Hr
Centrifugal			
A m/c	4	3	1
B m/c	3	2	1
C m/c - CFW CAW	2 1	- -	3

Ways to handle idle equipments to produce refined sugar:

- All type of juice heaters, lime station, vaccum filter and clarifier same should be used in producing raw sugar.
- Juice sulphiter is modified and used for defecation.
- Evaporator: same set of evaporators are used, with modification for higher syrup brix, by withdrawing vapour from later bodies.
- If syrup clarification system is present, the same is used for melt clarification with small modification.
- Additional deep bed filters needs to be installed.
- 25 MT/Hr C m/c conti pan is now idle, it can be used for B m/c boiling.
- 35 MT/Hr B m/c continuous pan become idle so it is used for raw A m/c boiling with this 80 MT batch pan is used for footing.
- Now two batch pans of 80 MT are idle, those are utilized to boil R1 and R2 m/c boiling and 60 MT batch pan is used for refinery footing.
- For raw A m/c is curing in 3 batch centrifugal machines are required and 1 machine become idle.
- With idle machine addition 2 machines have to install to cure R1 and R2 m/c.
- Excess equipments of C m/c curing like pug mill, mingler and melter are used for Raw sugar melting.

Table 12 : Additional machineries required for Defeco melt phospotation process (Singhal, 2022)

S. No.	Equipments	Capacity	Quantity
1	Raw sugar melter	30MT/Hr	1
2	Melt receiver	30 m^3	1
3	Raw melt pump	35 m^3/hr	2
4	Raw melt vibro screen	15 m^3/hr	2
5	P_2O_5 preparation tank	4 m^3	1
6	P_2O_5 Dosing pump	1.0m^3/hr	2
7	Flocculent preparation tank	4 m^3	1

8	Flocculent dosing pump	1.0m^3/hr	2
9	Color ppt preparation tank	4 m^3	1
10	Color ppt dosing pump	1.0 m^3/hr	2
11	Lime sucrate preparation tank	4 m^3	1
12	Lime sucrate dosing pump	1.0m^3/hr	2
13	Raw melt heater		
14	Melt reaction tank	5.0 m^3	1
15	Melt clarifier	15 m^3	1
16	Clear melt tank	15 m^3	1
17	Clear melt pumps	30 m^3/hr	2
18	Multi bed filters	15 m^3 /Hr	2
19	Air blowers		2
20	Back wash tank	2 m^3	1
21	Filtered melt tank	20 m^3	
22	Filtered melt pumps	30 m^3/hr	2
23	Melt concentrator columns		2

Chemical consumption (Technical performance report of Karnataka sugar mills 2023):

Table 13 : Per day chemicals requirements and it's cost for 6000 TCD factory producing plantation white sugar.

S. No	Particulars	% on cane	Quantity/day (MT)	Cost in Rs/Day
01	Lime	0.15	9.0	90,000/-
02	Sulphur	0.050	3.0	60,000/-
03	Flocullent	0.0002	0.012	6.300/-
			Total cost:	1,56,300/-

Table 14 : Per day chemicals requirements and it's cost 6000 TCD factory producing raw and refined sugar during syrup + B heavy molasses diversion

S. No	Parciculars	% on Cane	Quantity/day (Mt)	Cost in Rs/Day
01	Lime	0.090	5.4	54,000/-
02	Sulphur	0.000	0	0
03	Ortho Phosphoric Acid	0.0095	0.57	55,000/-
04	Flocculent	0.0015	0.09	47,250/-
05	Melt colour precipitant	0.0015	0.09	11,250/-
			Total Cost	1,67,500/-

CONCLUSION

Plantation white sugar production is an oldest method it has its own disadvantages in manufacturing and in global market. This process conversion method helps in minimizing the process difficulties while diverting of syrup and B Heavy molasses in conventional sugar manufacturing plant. It also earns premium on sugar price which provides additional

revenue to the industry in minimum investment of 18 to 20 crores.

The cost of chemical required is almost the same. It doesn't require additional manpower, if proper utilization of existing manpower is made. If firm wants to stop intermediate diversion and switch back to 3 massecuite boiling for producing PWS. It is easy to shift the process because all the equipments are in the working condition in refinery. Some industries are making separate defecation process stream just to supply syrup for ethanol production so that the problem is solved by this conversion process. As refined sugar is getting high market value in domestic consumption also, it is right time for India to switch over from plantation white sugar to refinery/sulphurless sugar.

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