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Retention Time Correction Tank at Juice Sulphiter: A Case Study

Manish Srivastava[1]* and Ashish Tripathi[2]
[1]General Manager
[2]Manager – Production
Triveni Engineering and Industries Ltd., Sugar Unit - Raninangal, Moradabad-244401

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ABSTRACT

The retention time plays a very important role at each and every step of sugar cane processing especially in juice sulphiter. In the present scenario of B heavy diversion, most of the sugar plants are running on 15-20 % higher capacity with same infrastructure resulting in shortage of designed retention time in their juice sulphiter. This article is about the importance of the retention time in the juice sulphiter for proper completion of reaction and maximum removal of non-sugars.

Keywords : Juice sulphiter, retention time, color removal, retention correction tank, physico chemical reaction.

INTRODUCTION

In the double sulphitation process, juice sulphiter is the main equipment in which the mixed juice is clarified by means of application of MOL and SO_2 gas. The following reactions take place inside the juice sulphiter-

Precipitation of calcium sulphite ($CaSO_3$)

The solution of $Ca(OH)_2$ will dissociate completely as

$$Ca(OH)_2 \leftrightarrow Ca^{++} + 2OH^-$$

Formation of Sulphurous Acid (H_2SO_3)

$$SO_2 + H_2O \leftrightarrow H2SO_3$$

Dissociation of H_2SO_3

$$H_2SO_3 \leftrightarrow 2H+ + (SO_3)^{--}$$

Precipitation of Calcium Sulphite-

$$Ca^{++} + (SO_3)^{--} \leftrightarrow CaSO_3$$

Minimum 7 to 8 minutes are required for effective physico chemical reaction and maximum precipitation of $CaSO_3$. Some part of remaining Ca^{++} ion reacts with P_2O_5 present in cane juice to form precipitates of calcium phosphate, which plays an important role of sweeping effect inside the clarifier to sweep out other impurities of the juice inside the clarifier.

$$H_3PO_4 \leftrightarrow 3H^{+\,+} (PO_4)^{-\,-\,-}$$

$$3Ca^{++} + 2(PO_4)^{-\,-\,-} \leftrightarrow Ca_3(PO_4)_2$$

Need of Retention Correction Tank

Until the Season 2018-19, we were producing C Heavy and with the available boiling house machinery, we were able to crush 5100-5200 TCD. With this rate of crush, our retention time in juice sulphitor was 7-8 minutes. The color removal between mixed juice to clear Juice was around 40-42 % (Table 1)

*Corresponding Author email: manishsrivastava@rng.trivenigroup.com

Table 1 : Month wise average percentage of color removal between mixed juice and clear juice during season 2018-19

Month	Crush Rate (TCD)	Color Mixed Juice (IU)	Color Clear Juice (IU)	% Color Removal
November	5239	28258	16931	40.08
December	5185	30053	18031	40.00
January	5125	28169	16416	41.72
February	5112	28137	16364	41.84
March	4947	30323	18002	40.63
April	4917	30664	18113	40.93
May	4845	28952	17151	40.76

From the Season 2019-20 onwards, we switched to B Heavy diversion process and our crush rate increased from 5100 TCD to 5800 TCD. The retention time in Juice sulphitor decreased considerably and the percentage of color removal also decreased. (Table 2)

Table 2 : Season wise percentage of color removal between mixed juice and clear juice

Month	SN 2019-20	SN 2020-21	SN 2021-22	SN 2022-23
	% of color removal between Mixed juice and Clear juice			
November	25.15*	30.64	31.67	30.01
December	23.77*	31.26	31.89	31.05
January	31.64	30.62	30.09	30.77
February	32.60	24.74*	31.09	31.55
March	30.07	29.83*	30.93	30.49
April	32.40	30.07	30.45	31.81
May	31.55	31.41	31.16	30.30

*During this period defecation process was being followed to produce Raw Sugar.

During the off-season 2023, we had a small expansion of the plant and we were ready to crush 6500 TCD on B Heavy diversion and 6000 TCD on C Heavy diversion. Due to decrease in color removal % during past four season sowing to lower retention time in juice sulphiter, there was a need of a retention correction tank to compensate the retention time inside the juice sulphitor for completion of reaction and maximum precipitation of $CaSO_3$ and $Ca_3(PO_4)$. Accordingly, a correction tank was added with existing juice sulphiter so as to have optimum retention time, which enabled efficient physico chemical reaction.

Integration of retention time correction tank with existing juice sulphiter

Instead of making a new juice sulphiter with a bigger diameter, due to chances of improper mixing of MOL and SO_2 gas, we made a separate fabricated M.S. tank of 10 M^3 volume having a top mounted stirring arrangement (Output RPM 24) in series with the existing juice sulphiter. The juice out let line fromjuice sulphiter is connected to the bottom of this correction tank. The juice outlet line from a working height of 1150 mm from this correction tank goes to the sulphited juice receiving tank for further processing.

The total retention time in both the equipment is kept more than 7 minutes at a crush rate of 6500 TCD (Table 3).

The juice from juice sulphitor outlet and correction tank outlet along with the clear juice from clarifier outlet was drawn taking the residence time in to account and

Table 3 : Percentage of color removal after installation of retention correction tank at juice sulphitor during the season 2023-24

Month	Crush Rate (TCD)	Process	Total Retention Time in Minutes (J.S.+ Ret. Corr. Tank)	M.J. Color (IU)	C.J. Color (IU)	% of Color removal
November	6140	BH Diversion	7.80	31106	18592	40.23
December	6483	BH Diversion	7.40	29771	17758	40.35
January	6291	BH/CH Diversion	7.62	25330	14864	41.32
February	5818	CH Diversion	8.24	24400	14557	40.34
March	5824	CH Diversion	8.23	24905	14599	41.38

analyzed for CaO, P_2O_5, color and turbidity. Although, there was no set correlation found between the results but there was a definite trend of improvement between the figures of juice sulphitor outlet and correction tank outlet. It implies that the incomplete precipitation of $CaSO_3$ and $Ca_3(PO_4)_2$ is being completed during the residence time in the retention correction tank resulting in better clear juice quality in terms of color and turbidity (Table 4, Figure 1).

Table 4 : Analytical comparison of outlet juice from juice sulphitor, Retention correction tank and clarifier

Date	Juice Sulphitor Outlet				Retention Correction Tank Outlet				Clear Juice from Clarifier Outlet			
	CaO	P_2O_5	Color	Turb.	CaO	P_2O_5	Color	Turb.	CaO	P_2O_5	Color	Turb.
25.12.23	1290	65	17673	11.7	1250	61	16997	9.8	1220	59	16576	2.0
28.12.23	1430	60	16890	13.3	1390	55	16226	10.3	1370	52	15854	1.8
30.12.23	1430	57	16750	9.3	1380	54	16231	7.9	1370	53	15906	1.8
07.01.24	1240	73	17615	12.4	1210	68	16997	9.2	1190	60	16644	2.1
10.01.24	1260	81	16010	15.4	1230	74	15466	11.5	1210	68	15187	1.5
18.01.24	1240	76	15395	12.2	1210	72	14816	9.4	1200	65	14486	1.6
07.02.24	1390	84	15607	13.5	1350	78	15030	10.5	1320	70	14701	1.5
13.02.24	1320	67	15828	12.8	1290	62	15255	9.4	1250	58	14872	1.7
21.02.24	1330	71	15487	15.6	1300	67	14949	11.1	1280	56	14624	2.2

RESULTS

With the installation of retention correction tank in series with the existing juice sulphiter, we successfully completed the season 2023-24. The results were encouraging and highlights are as under-

- Color removal between M.J. and C.J. increased up to 8-10%
- CaO rise between M.J. and C.J. was reduced by 5-6%
- Turbidity of clear juice recorded up to 1.5

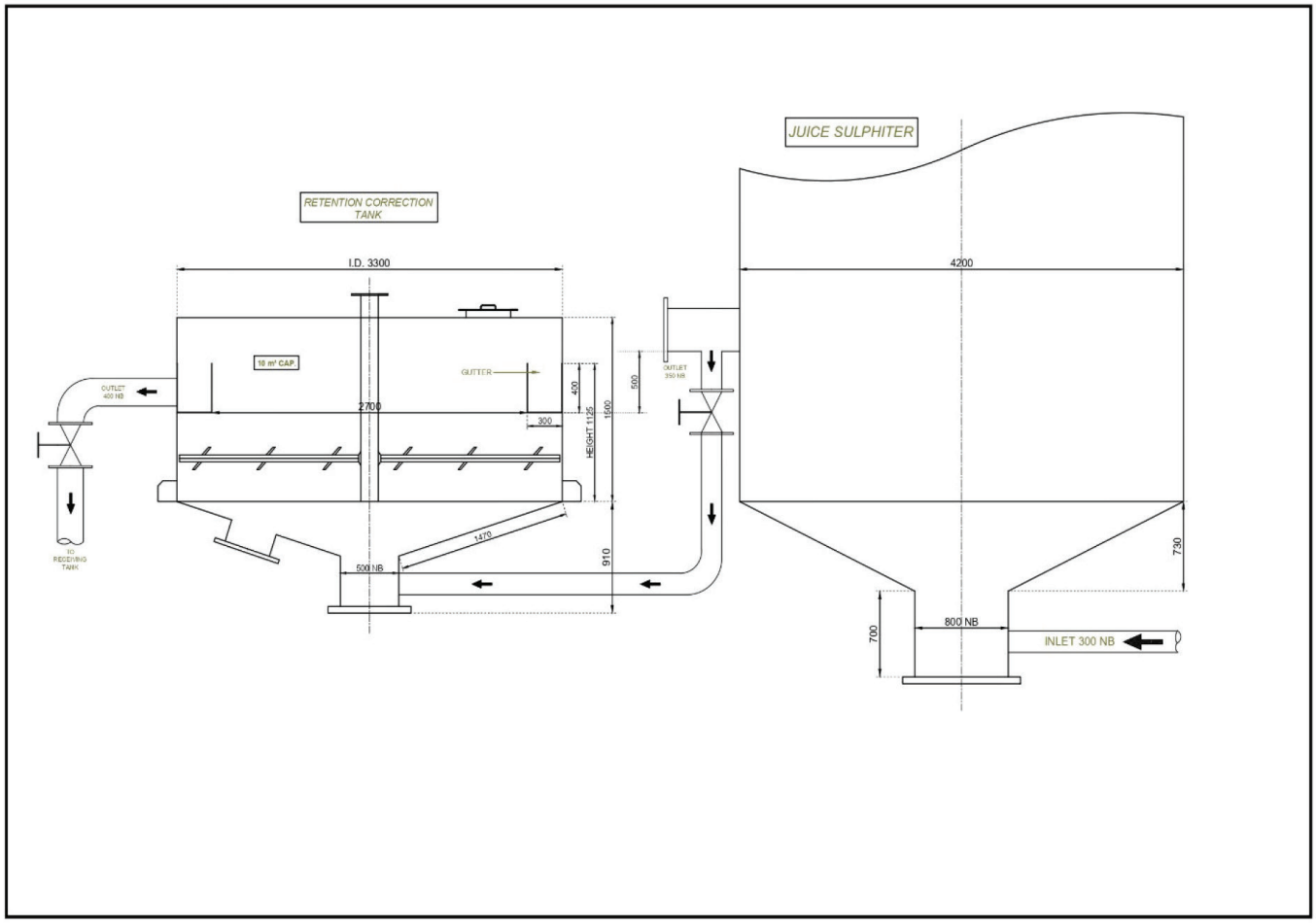

Figure 1 : Drawing of the system of integrated retention correction tank with existing juice sulphiter

- Degree of scaling in evaporator bodies reduced substantially
- Improvement in Mud settling rate
- Improvement and consistency in sugar quality

CONCLUSION

Above data and results showed that this system is very effective in terms of clarification process and quality of end product. Total cost incurred in making this system was only Rs 650000. This system can be implemented where we are handling higher crush rate with existing juice sulphiter and the retention time in the sulphiter is on lower side due to higher juice flow rate.

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