Proceedings STAI, Factory Processing
Vol. 82 (2024) : 277-284
doi: 10.69794/82SAC/978-81-969264-0-3/277-284

Steam Saving at Various Process Combinations at DBSIL, Ramgarh

A.A. Beig[1], Neeraj Kumar Chaudhary[2]* and Arun Kumar[3]
[1]DGM – Production
[2]GM – Production
[3]Sr. Executive
Dalmia Bharat Sugar and Industries Ltd., Sugar Unit Ramgarh, Misrikh, Sitapur - 261403

Received : May 21, 2024; Accepted : June 22, 2024

ABSTRACT

Saving of the steam and balancing of intermittent vapor is an important aspect in the scenario of various process combinations adopted due to 25-30% diversion of thick or thin juice for ethanol production. Considering the present need, application of Reileaux principle in case of shifting vapor bleeding from earlier effects to later effects of multiple effect evaporators for same application is a well-known practice of the steam economy. Vapor demand varies at different applications depending upon the process combination adopted, along with it vapor load of multiple effect evaporator effects varies. In the present study, we attempted to install a steam efficient evaporator and vapor bleeding system at our plant with integration of existing evaporation system at different process combinations.

Keywords : B-Hy (B-Heavy), C-Hy (C-Heavy), RJ (Raw juice), SJ (Sulphited juice), CJ (Clear juice), VLJH (Vapor line juice heater), DCH (Direct contact heater), PTHE (Plate type heat exchanger), FFE (Falling film evaporator), Ex. Steam (Exhaust), Condensate

INTRODUCTION

In the relentless pursuit of efficiency and sustainability, the sugar industry continually seeks innovative solutions to optimize its production processes. In the past few years keeping in mind the government's policy for enhancing ethanol production. The process started diversion of partial syrup to meet out the objective of ethanol production enhancement. We also started production of B- Hy molasses in place of C-Hy molasses. Conventional evaporator systems are based on Reileaux principle using extensive vapor to get lower steam consumption in boiling house. After starting of syrup diversion process to distillery massecuite quantities at pan get reduced accordingly, there is a major reduction in steam demand at pans thus effect-wise vapor generation vs consumption of quintuple effect evaporator get unbalanced. Our steam consumption % cane was 42-43% on cane with process combination of C-Hy production with three and half massecuite boiling in conventional quintuple evaporator bodies. Therefore, it becomes essential to modify our system to use 3rd or 4th effect vapor bleeding for boiling operation at pans to get maximum steam saving. In old conventional quintuple effect evaporator last body vacuum was maintained at 625-650 mm Hg, which corresponds to 54-55°C temperature, so a modification was suggested in previous system to raise the last body temperature 68-70°C so that vapor bleeding from later effects could be done to get steam economy.

Consumption of exhaust steam depends on the inter pressure, vapor bleeding arrangement, number of effects and waste heat recovery (Lal and Mittal 2013). In our new upgraded system falling film evaporators has been installed to reduce the steam demand having high evaporation rates and force circulation in place of conventional robert bodies up to 3rd effect of evaporators and at the 4th and 5th effect modified evaporator bodies are used. The heat of excess condensate is recovered in raw juice heating (28-38 °C) through liquid-liquid heaters. A huge capacity vapor line juice

*Corresponding Author email: c.neerajkumar@dalmiasugar.com

heaters (38-68°C) has also been installed at raw juice heating to recover heat from waste vapor going to condensers. At sulphited juice heating 1st stage (70-80°C) liquid-liquid heaters are used for recovering heat of common condensate received from cigar. However at CJ heating, a plate type heat exchangers have been installed by replacing direct contact juice heaters to prevent water addition in CJ before entering to evaporation system. The pan boiling has been shifted from 2nd vapor to 3rd vapor. The steam demand up to 9-10% on cane has been reduced by following these modifications. After installation of this system the lowest steam consumption % cane recorded less than 31% on cane on return condensate basis with process combination B-heavy production with partial syrup diversion (25-30%) of total syrup with two and half massecuite boiling scheme.

MATERIALS AND METHOD

On the basis of above facts, we have conducted a study of steam consumption at various process combinations with new modified evaporator system to evaluating overall impact on steam consumption. The various process combinations that we had adopted for this study are discussed herein.

1. B-Hy production with 25-30% syrup (64-65° Brix) diversion to distillery
2. Only B-Hy production
3. C-Hy production with thick juice diversion (38-42° brix) equivalent to 25-30% syrup.
4. Only C-Hy production

We had calculated steam consumption of our plant before steam saving project installation vs after steam saving project installation to evaluate an overall generation and consumption of steam at different heating stages and processes. We have summarized evaporator heating surfaces, vapor bleeding arrangement and vapor pressures and temperatures in both cases as follows:

Case-I: Only C-Hy production with old evaporator configuration

Case-II: Various process combinations (as given above) with new evaporator configuration system.

Major changes and modification were done in evaporator configuration from case-I to case-II shown in (Table 1). In old evaporator configuration (Case-I) three evaporator sets were installed, two evaporator sets were in operation at a time having 1st effect semi kestner of 1500 and 2000 M2 heating surface area and rest effects were conventional robbert type bodies of 1500,800,600 and 400 M2. In new evaporator configuration (Case-II) falling film evaporators installed up to 3rd effect, 1st and 2nd effect of 5000 M2 and 3rd effect of 6000 M2 heating surface area. At 4th effect modified robbert type evaporator bodies of 1666,1000 and 533 M2 were used, clubbed robbert bodies of 800 and 600 M2 used as 5th effect in series as shown in Table 1.

Table 1 : Heating surfaces of old and new evaporator configurations

Particulars	Old evaporator configuration (Case-I)				New evaporator configuration (Case-II)		
Effect	Working		Standby	Type	Working	Standby	Type
1st effect	1500	1500	2000	SK	5000	5000	FFE
2nd effect	1500+800	1500	2500	Robbert	5000	5000	FFE
3rd effect	800	800	800	Robbert	6000	6000	FFE
4th effect	600	400	600	Robbert	1000+533	1666	Robbert
5th effect	400	400	400	Robbert	800+600	800+600	Robbert

Table 2 : Pressure distribution of old quintuple effect evaporator system (Case-I)

We compared pressure distribution, temperature and juice brixes in both cases, which played key role in reduction of steam demand at various stages.

Exhaust pressure			1.00 Kg/cm^2(g)					
Atm. Pressure			1.033 Kg/cm^2(g)					
Vacuum in last body			630 mmhg					
Abs. pressure in last body			0.18 Kg/cm^2 (abs)					
Particular	**Abs. press. (kg/cm^2)**	**Temp (°C) actual**	**Latent heat (Kcal/kg)**	**Total heat**	**Specific volume**	**Juice inlet / outlet brix**		
Exhaust steam	2.03	121	526	648	0.87		Inlet brix	Outlet brix
1st vapor	1.59	113	532	645	1.10	1st effect	12	18
2nd vapor	1.16	104	538	642	1.47	2nd effect	18	31
3rd vapor	0.76	92	545	638	2.19	3rd effect	31	42
4th vapor	0.41	77	555	631	3.94	4th effect	42	52
5th vapor	0.18	58	566	623	8.60	5th effect	52	61

Table 3 : Pressure distribution of new quintuple effect evaporator system (Case-II)

Exhaust pressure			1.00 Kg/cm^2(g)					
Atm. Pressure			1.033 Kg/cm^2(g)					
Vacuum in last body			530 mmhg					
Abs. pressure in last body			0.31 Kg/cm^2 (abs)					
Particular	**Abs. press. (kg/cm^2)**	**Temp (°C) actual**	**Latent heat (Kcal/kg)**	**Total heat**	**Specific volume**	**Juice inlet / outlet brix**		
Exhaust steam	2.03	121	526	648	0.87		Inlet brix	Outlet brix
1st vapor	1.72	116	530	646	1.02	1st effect	12	16
2nd vapor	1.35	109	535	643	1.28	2nd effect	16	24
3rd vapor	1.09	102	539	641	1.56	3rd effect	24	41
4th vapor	0.71	91	546	637	2.33	4th effect	41	53
5th vapor	0.31	70	558	629	5.04	5th effect	53	66

Vapor bleeding arrangement

Measure changes in vapor bleeding done from case-I to case-II as shown in Figure 1, 2 and Table 4.

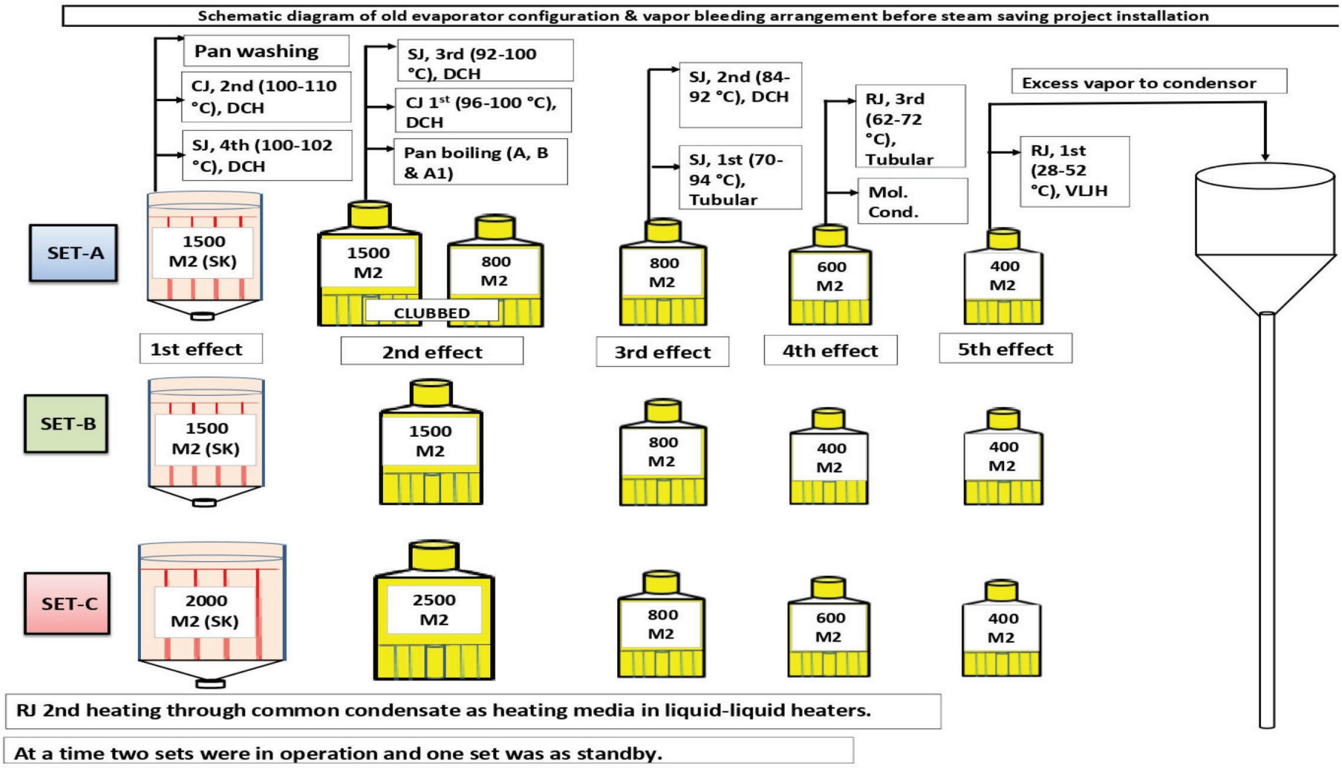

Figure 1 : Schematic diagrams of old evaporator configurations with vapor bleeding

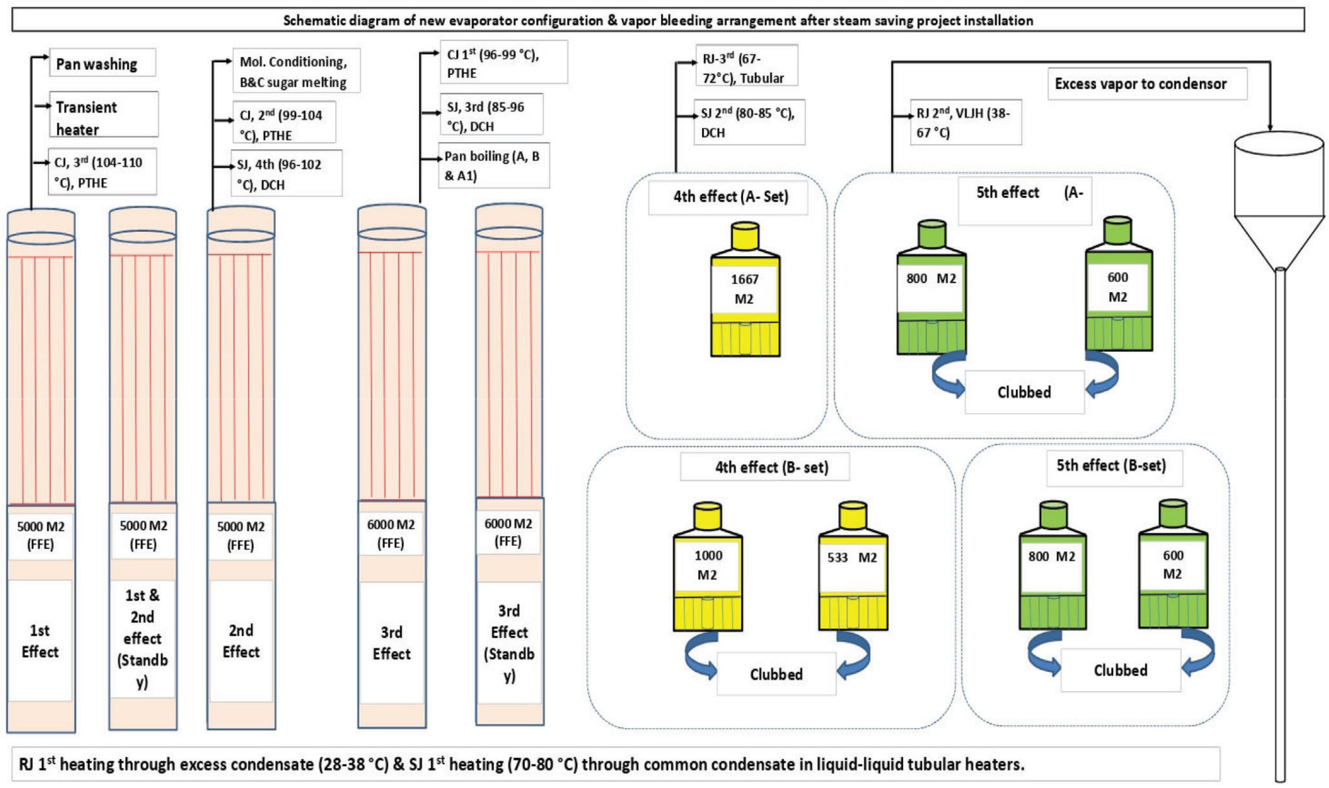

Figure 2 : Schematic diagrams of new evaporator configurations with vapor bleeding

Table 4 : Vapor bleeding scheme of old vs new evaporator configuration

Particulars	Before steam saving project (Case-I)			After steam saving project (Case-II)		
	Range temp	Heating media	Type of equipment	Range temp	Heating media	Type of equipment
RJ 1st heating	28-52	5th vapor	Tubular	28-38	Excess condensate	Tubular (Liq-Liq)
RJ 2nd heating	52-62	Common condensate	Tubular (Liq-Liq)	38-68	5th vapor	Tubular
RJ 3rd heating	62-72	4th vapor	Tubular	68-72	4th vapor	Tubular
SJ 1st heating	70-84	3rd vapor	Tubular	70-80	Common condensate	Tubular (Liq-Liq)
SJ 2nd heating	84-92	3rd vapor	DCH	80-85	4th vapor	DCH
SJ 3rd heating	92-100	2nd vapor	DCH	85-96	3rd vapor	DCH
SJ 4th heating	100-102	1st vapor	DCH	96-102	2nd vapor	DCH
CJ 1st heating	96-100	2nd vapor	DCH	96-99	3rd vapor	PTHE
CJ 2nd heating	100-110	1st vapor	DCH	99-104	2nd vapor	PTHE
CJ 3rd heating	NA	NA	NA	104-110	1st vapor	PTHE
A m/c graining		2nd vapor	Batch pan		3rd vapor	Batch pan
A m/c Boiling		2nd vapor	Batch pan		3rd vapor	Batch pan
B m/c graining		2nd vapor	Batch pan		3rd vapor	Batch pan
B m/c boiling		2nd vapor	Batch pan		3rd vapor	Batch pan
C m/c graining		2nd vapor	Batch pan		3rd vapor	Batch pan
C m/c boiling		2nd vapor	Batch pan		3rd vapor	Batch pan
A1 m/c graining		2nd vapor	Batch pan		3rd vapor	Batch pan
A1 m/c boiling		2nd vapor	Batch pan		3rd vapor	Batch pan
Condensate flash pot (Cigar)	03 nos compartment	1st vapor cond. flash to 3rd body calandria		04 nos. compartment	Excess SHWW recirculation flash to 2nd body calandria	
		2nd vapor cond. flash to 4th body calandria			1st vapor cond. flash to 3rd body calandria	
		3rd vapor cond. flash to 5th body calandria			2nd vapor cond. flash to 4th body calandria	
		NA			3rd vapor cond. flash to 5th body calandria	
Molasses conditioning		4th vapor	DCH type		2nd vapor	DCH type
Pan washing & cutover line washing		1st vapor/ Exhaust steam			1st vapor/ Exhaust steam	
SHWW		Exhaust condensate	PTHE		Exhaust condensate	PTHE
Sugar drying		NA			NA	
Melt heating		NA			2nd vapor	

Filtrate heating		NA			NA	
Transient heater/ Centrifugals washing		Live steam	7.0 kg/cm^2 (g)		1st vapor	0.70-0.75 kg/cm^2 (g)
Sulphur melting		Live steam	7.0 kg/cm^2 (g)		Live steam	7.0 kg/cm^2 (g)
Evaporator soda boiling		Exhaust steam	1.0 kg/cm^2 (g)		Exhaust steam	1.0 kg/cm^2 (g)

Vapor bleeding adoption in old configuration was only studied for C-Hy production process, because we have operated plant at only C-Hy diversion with old configuration and after installation of steam saving project new configuration of evaporator has been adopted for all process combinations.

On the basis of above given vapor bleeding data, we compared steam demand in both cases and evaluated reduction of steam demand at various stations.For steam consumption calculation, the data was taken from our plant actual running process parameters for a fixed period so data may vary from combination to combination as shown in Table 5:

Table 5 : Actual periodical data at various process combinations and comparison of steam consumption in boiling house Case-I vs Case-II

Particulars	**UOM**	**Old configuration (Case-I)**	**New configuration (Case-II)**			
		Only C-Hy	**B-Hy+ Syrup Diversion**	**Only B-Hy**	**C-Hy + Thick juice diversion**	**Only C-Hy**
Plant crushing capacity	**TCD**	**6000**	**6380**	**6326**	**6645**	**6392**
Crushing rate	TPH	250.00	265.83	260.04	276.88	266.33
Mix juice	% cane	119.00	117.90	120.10	116.00	121.00
Sulphited juice	% cane	145.16	143.90	146.52	143.96	147.50
Sulphited juice after DCH dilution	% cane	149.90	148.70	151.42	148.15	152.42
RVF wash water	% cane	7.00	7.00	7.00	7.25	8.00
Clear juice% cane		128.80	127.16	130.34	128.55	131.10
CJafter DCH/ PTHE dilution	**% cane**	**132.04**	**127.16**	**130.34**	**128.55**	**131.10**
CJ dilution from DCH/ PTHE	% cane	3.24	0	0	0	0
CJ Brix	°	12	12	12	12	12
Syrup Brix	°	61	66	66	65	66
Diverted syrup/Thick juice Qty.	TPD	---	**Thick syrup @ 65 Bx-424 TPD**	---	**Thick juice @ 41.68 Bx-714.43 TPD**	---
Diverted syrup	% total syrup	---	26.71	---	30.49	---
Ex. Pressure	Kg/cm^2 (g)	1.00	1.00	1.00	1.00	1
Atm. Pressure	Kg/cm^2	1.03	1.03	1.03	1.03	1.03
Ex. Pressure	Kg/cm^2 (abs)	2.03	2.03	2.03	2.03	2.03
Last body vacuum	mmHg	630	530	540	540	550
Pressure in Last body	Kg/cm^2 (abs)	0.18	0.31	0.30	0.30	0.28

Total Pr. Drop	Kg/cm^2 (abs)	1.85	1.72	1.73	1.73	1.75
Pr. Drop in one body	Kg/cm^2 (abs)	0.37	0.34	0.35	0.35	0.28
A massecuite	% cane	30.90	23.30	25.81	21	26.58
B massecuite	% cane	13.80	10.79	13.53	10.71	13.14
C massecuite	% cane	7.63	---	---	6.53	7.52
A1 massecuite	% cane	4.12	5.90	5.07	2.74	3.12
A-Heavy molasses	% cane	16.31	12.10	13.75	11.54	13.5
A-Light molasses	% cane	1.58	2.29	2.02	1.92	2.15
B-Heavy molasses	% cane	8.80	---	---	5.7	6.75
C-Light molasses	% cane	2.11	---	---	1.03	1.72
A1-Heavy molasses	% cane	2.47	2.50	1.95	1.59	1.44
Steam for juice heating	% cane	18.15	15.25	15.96	15.61	16.00
Steam for Pan boiling, molasses cond.	% cane	23.36	16.82	18.20	16.55	19.66
Steam % cane, Miscellaneous	% cane	3.71	3.53	3.39	4.35	3.47
Steam saved from Cigar	% cane	2.52	2.96	3.11	3.03	3.20
Resultant steam consumption	% cane	42.70	32.63	34.43	33.49	35.92

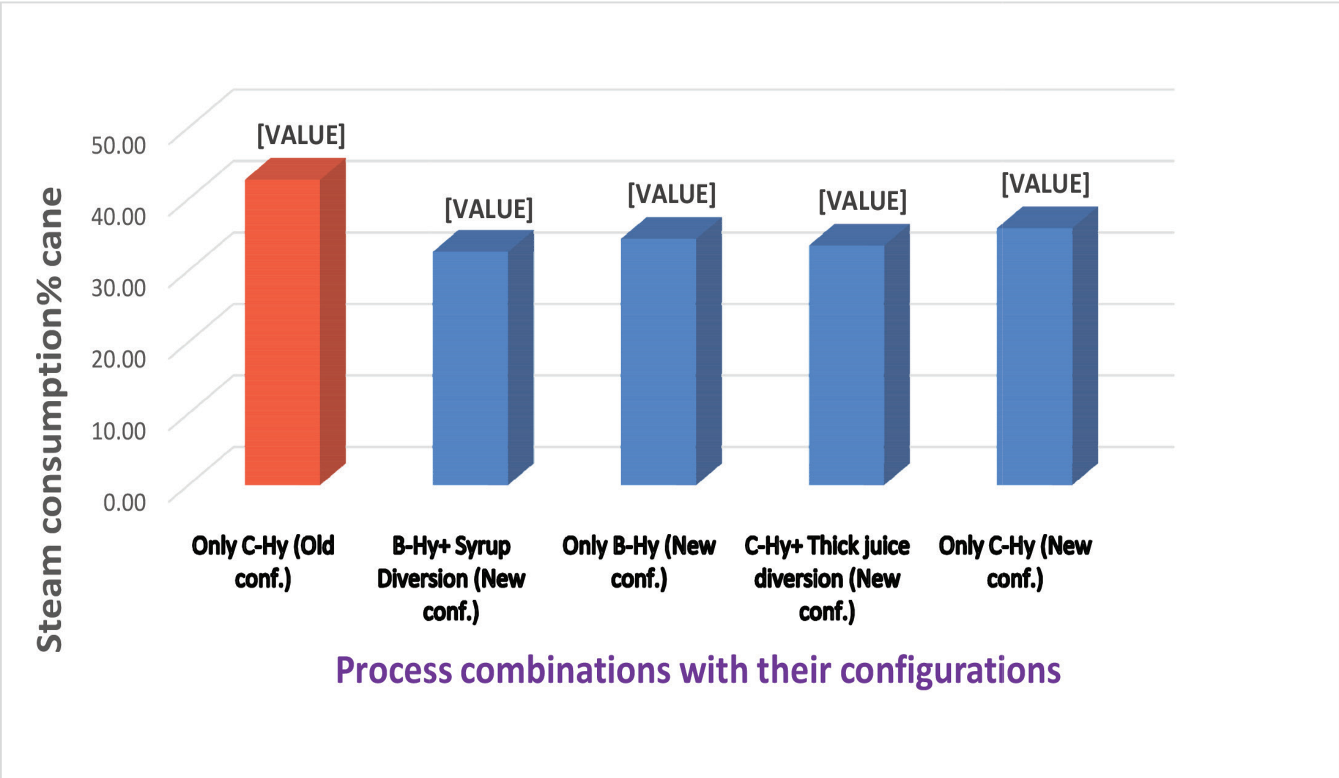

Figure 3 : Graph showing steam consumption comparison in old configuration vs new configuration with all combinations

Major changes and their impact on steam consumption

In RJ heating, use of excess condensate (condensate which was excess after plant requirement) started in place of common condensate approx. 10°C temperature rise of RJ we get from excess condensate.

Huge heating surface VLJH (650 m^2) was installed to recover maximum heat from vapor going to condenser. Use of 4th vapor minimized for RJ final heating from this we get a steam saving of 0.3% on cane.

New liquid-liquid heaters installed to recover heat from common condensate (evaporators generated condensate) for SJ 1st heating in place of 3rd vapor. It gave a steam saving of 2.25-2.35% on cane.

In CJ heating all stages DCH replaced with PTHE to prevent addition of water in CJ heating through DCH. From this we got a steam saving of 0.15-0.25% on cane.

We replaced our condensate flash recovery system from three compartment to four compartment and get an additional steam saving from flash vapor of about 0.50% on cane.

We installed falling film evaporators at 1st, 2nd & 3rd effect of evaporator system. Due to syrup diversion massecuite quantities were less and in falling film evaporators temperature and pressure drop was also less which allows us to shift pan boiling operation from 2nd vapor to 3rd vapor and mechanical circulators also installed in 5 nos. A-side pans for hassle-free operation, from which we got a resultant steam reduction of about 3.50-6.75% on cane at different process combinations.

We also started use of 1st vapor in place of 9 ATA steam for centrifugal washing and transient heater application.

RESULTS AND CONCLUSION

The case study show that overall steam% cane reduction in case-I vs case-II (B-Hy+ syrup diversion) was ranged between 9.50-10.00%. On the other hand if we compare case-II with its various process combinations reduction in steam % cane ranged between 1.00-3.50% with effective use of falling film evaporators and replacement with high pressure vapor to low pressure vapor in pan boiling, pan washing and juice heating application. Modified use of condensate flash recovery system and installation of liquid-liquid heaters to recover heat of common condensate and excess condensate etc., brought down the steam consumption of plant considerably.

ACKNOWLEDGEMENT

Authors express their sincere thanks to top management of M/s Dalmia Bharat sugar and Industries Ltd. for the valuable support and encouragement to write the article.

REFERENCES

Bhojraj S.K. (2013). Modified evaporator configuration for achieving efficient steam consumption and measures taken to sustain it, to suit integral sugar complex. *Proceedings of STAI Annual Convention* 77:409-422.

Lal Chhoteand Mittal I.D. (2013), A case study on economical use of quadruple effect over quintuple effect evaporator in sugar industry. *Proceedings of STAI Annual Convention* 77:441-458.