



Journey of Energy Conservation at Narmada Sugar Pvt. Ltd., M.P.

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ABSTRACT

Sugar industry is progressing a lot for reducing steam consumption for sugar production. In last two decades various innovative concepts are indigenously developed in Indian sugar industry for reducing steam consumption. M/s Narmada Sugar pvt. Ltd, Salichoka MP (NSPL) had implemented these innovative developments in steam conservation and successfully reduced steam consumption from 46-48 % on cane to 36.0 % on cane and further aiming to 32.0 % on cane for sulphurless/refined sugar production. The major concepts implemented for reducing steam consumption at NSPL are use of modern FFE, hexaple effect, Increasing last effect vapour temp – 75.0°C+, increasing syrup brix % to 76.0+, massecuite boiling in modern vertical continuous pan with 5th vapours, massecuite boiling in batch pans by providing mechanical circulators with 4th vapours, extensive use of process condensate for raw juice heating, recirculation of cooled process condensate for waste heat recovery and its reuse for juice heating and finally development of skilled man power for adopting modern technologies. The journey of NSPL on this endeavor of steam reduction in last 6 crushing seasons, is discussed in this article.

Keywords: Steam reduction, hexaple evaporator, practicing syrup brix % - 76.0+, reducing pan vapour consumption, pan boiling on 4th and 5th vapours, effective use of FFE / VKT and mechanical circulators, recirculation and reheating cooled condensate for waste heat recovery, refinery, High pressure boiler and Prime mover.

INTRODUCTION

Energy remains one of the critical challenges of the future in sugar sectors. Businesses need to strike the balance between operational efficiency and sustainable development. With soaring energy prices and increased scarcity of natural resources, pin pointing energy efficiency from planning to manufacturing to operations, make good business sense. One of the ways of reducing energy costs is to become more energy efficient to optimize existing resources and plan the right investments in new technology.

Sugar industry plays very important role in global energy consumption, and it is one of the most energy consuming industries. This industry consumes considerable amount of energy for production viz a viz generate the energy as cogeneration. The energy

conservation in such plant is paid less attention as compared to those developed countries. Also, there is a need for prorate recycle economy, energy generation facilitating technological progress, reduce consumption, and protect the environment. Hence, energy efficiency and conservation should be viewed as new source of energy. Energy efficiency improvement measures in sugar mill is done in bleeding arrangement and incorporation of energy efficient product and technology in sugar processing units during heating, evaporation and concentration and waste heat recovery system.

During crushing season 2016-17, Narmada Sugar Pvt. Ltd (NSPL) hasd converted 3500 TCD sulphitation plant in to 5000 TCD sulphurless sugar plant. Initial sulphurless sugar production unit needs very high steam consumption of the order of 46.0-47.0 % on

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cane. To achieve sustainability in sugar business and also to increase power export, NSPL had adopted phase wise reduction on steam consumption. NSPL had implemented various development in steam saving

continuously and had achieved remarkable results within last 6 crushing seasons. Figure 1 indicates NSPL journey in steam reduction area for last six crushing seasons,

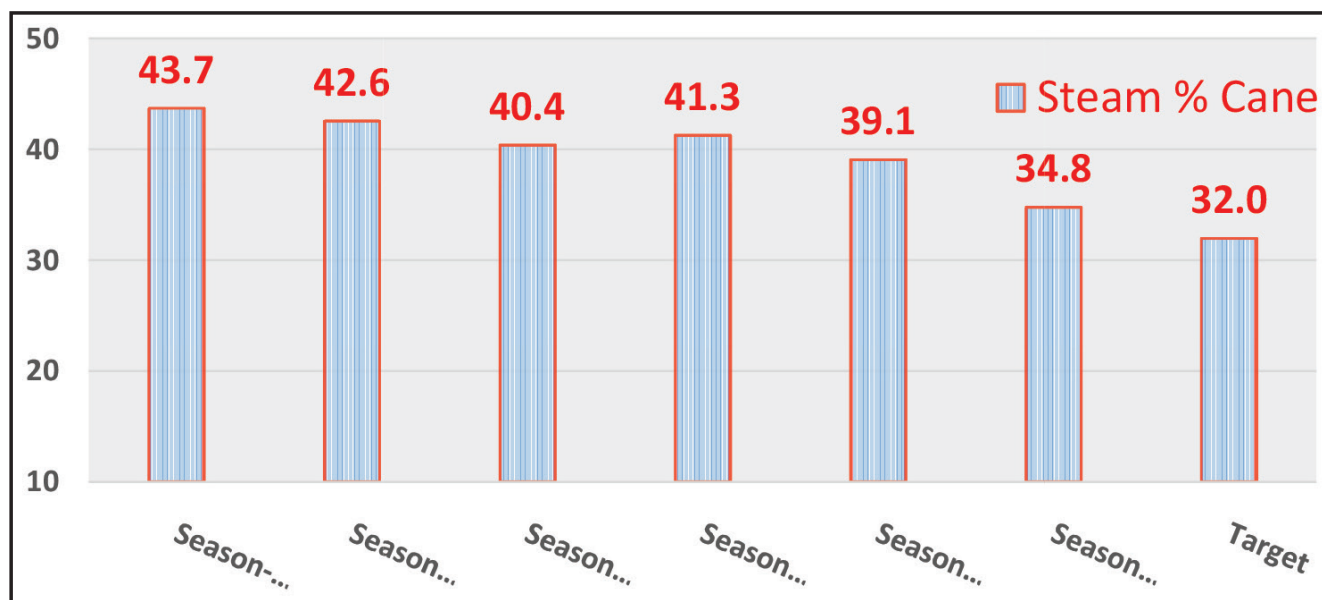


Figure 1 : NSPL - Steam % cane comparative - sulphurless sugar production

The various efforts made by NSPL in achieving 35.0 % steam consumption on cane for sulphurless sugar production is penned down in this paper.

NSPL phase wise efforts for reducing steam consumption

- *Season 2016-17: Conversion of sulphitation process by sulphurless sugar production*

Considering the advantages of avoiding sulphur in sugar production, M/s Narmada Sugar had converted double sulphitation process to defeco melt clarification in 2016 off season. Crush rate was 227 TCH (5000 TCD). During 2016-17 crushing season, evaporator station vapour bleeding scheme was as follows:

During 2016-17 crushing season factory had achieved steam consumption of the order of 44 % on cane with full crush rate. At lower crush rate steam consumption was above 46.0 % on cane. During 2016-17 factory had adopted many new concepts and equipment as follows:

- Replacement of old boilers by single high pressure boiler Pr.-125Kg/cm² and Cap-150TPH
- Replacement of conventional milling tandem by latest two roller mills without trash plate
- Sulphitation process replaced with defecation followed by melt clarification by phosfloatation
- Adopted modern FFE – 3 nos for improving steam economy
- Vapour bleeding arrangement - Figure 2 indicate evaporator configuration of NSPL during 2016-17 crushing season.
- DCH for defecated juice heating
- PHE for clear juice heating
- Wide gap plate type heat exchanger for Raw Juice heating by condensate
- Condensate heat recovery system (Cigar)
- Vapour line juice heater on continuous pan vapours

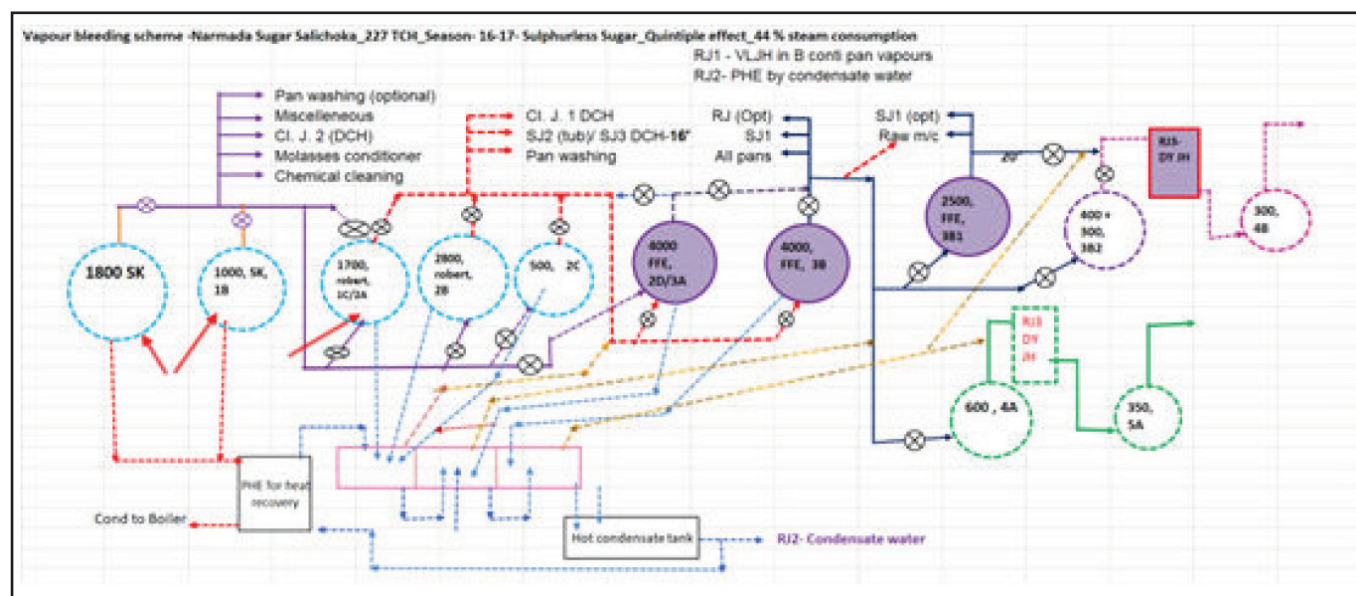


Figure 2 : 2016-17 – NSPL evaporator configuration

- Mechanical circulators to batch pans
- DCH for molasses conditioning
- Automation of all condensers
- Vertical continuous pan for Raw M/c Cap-60TPH
- Single stage melt concentrator
- Melt clarification system suitable to 50.0 m³/hr melt flow

Vapour bleeding was designed for 42.0 % steam consumption on cane but through out crushing season the targeted performance was not achieved. During this crushing season factory had faced many problems such as syrup jamming, Heavy scaling at evaporator, non-effective tube cleaning system, unavailability of skilled man power, jamming of refinery equipment, discharge lines of raw m/c etc. Hence, crushing was not exceeded 4000-4200 TCD and steam % Cane-47.0 to 48.0.

Season 2017-18

During 2017 off season factory had installed following units in view of rectifications of various difficulties faced by sugar mill in 2016-17 crushing season:

- Falling film evaporator H.S.-5000 m²

- One vertical continuous pan for raw cap-60 TPH and existing continuous pan was used for BM/c boiling.
- Extension of spray pond and use of highly efficient pumps at spray and injection station
- Increasing capacity of milk of lime tank

In 2017 -18 crushing season crush rate was achieved in the range of 4800 TCD with ease and steam consumption during full crush rate was achieved in the range of 45.0-46.0 % on cane. Various problems such as syrup jamming, heavy scaling, jamming of equipment's are normalized and sugar quality is improved considerably.

Season 2018-19

- During 2018-19 crushing season, following equipment's are added for achieving 250 TCH crush rate
 - 5000 m² H.S. – 1 no
 - Addition of air-cooled crystalliser of 100 MT capacity for raw VKT as massecuite receiver
 - Vapour line juice heaters at raw VKT – 2 nos – Figure 3 indicates schematic sketch of two VLJH in VKT vapour line

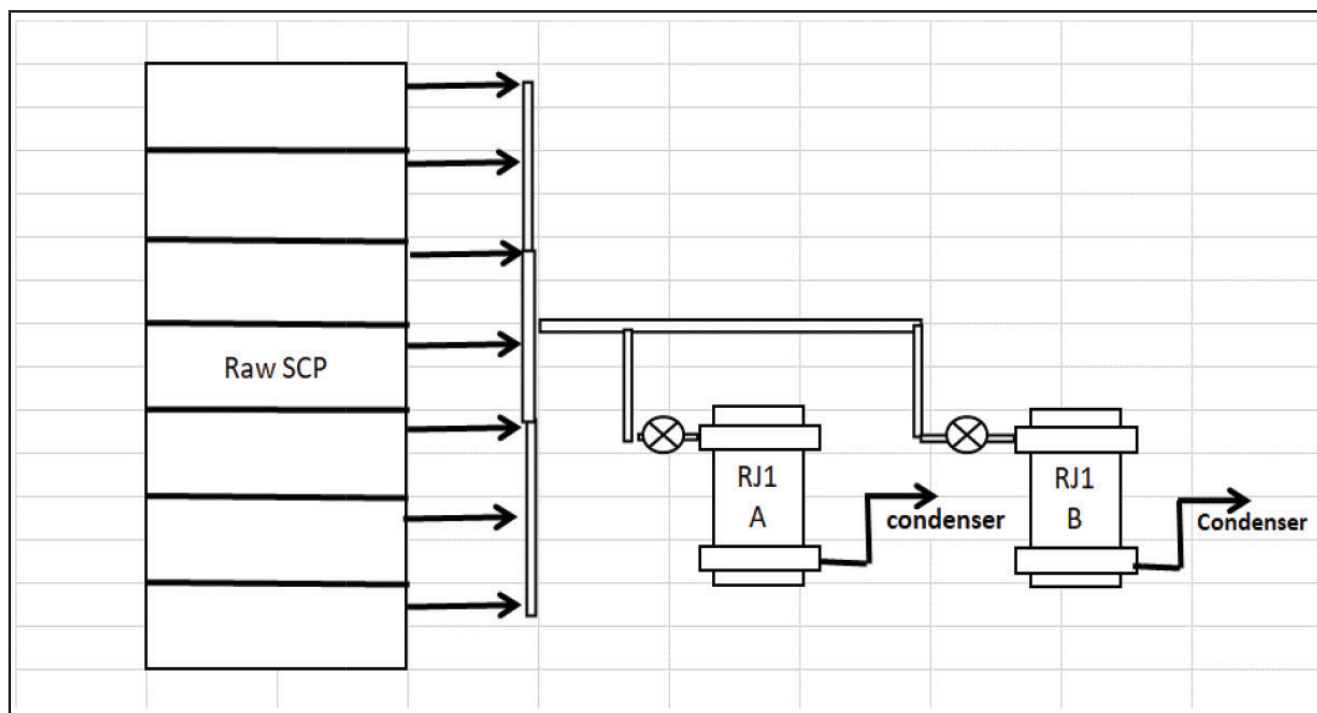


Figure 3 : Narmada sugar - season 2018-19 - arrangement of two VLJH in raw SCP vapour

- Major modifications in 18-19 season
- Adopted three stage grit removal system- 1st 12 mesh screens, second is vibro-screen of 60 mesh and third is hydro clones
- Increased working height of defecator for increasing retention time to 7.0 minute.
- Addition of Auto pH control system with flow meter at M.O.L.
- Clarifier operation by overflow level except any stoppage for reducing turbidity in clear juice.
- At 250 TCH crush rate both raw juice PHE are used without cleaning option.
- Added CIP pump of 250 m³/hr for all PHE and Juice Heater
- Juice entry in two bodies of first effect in series by addition of juice transfer pump from IA to IB.
- Installed air-cooled crystalliser of 100 MT capacity for raw VKT as massecuite receiver. Help in liquidation of any compartment within 10 minutes as well as consistent massecuite flow to raw pug mill.
- Grain for raw VKT is prepared in batch pan in place of VKT chamber and fed to VKT through massecuite pump. This practice helped in reducing false grain and improve exhaustion in VKT.
- Increased the slope of refinery m/c gutter to reduce gutter jamming problems
- Vapour bleeding arrangement is improved and given in Table 1
- Factory had successfully achieved 230 TCH crush rate with 42.0 % steam consumption on cane during consistent crush rate. Imbibition quantity is also increased and raw juice % was continuously in the range of 112- 114 % on cane, sugar colour of the range of 40-45 IU is produced consistently

Season 2019-20

- During 2019-20 crushing season, following equipment's are added for achieving 250 TCH crush rate

Table 1 : Season 2018-19 – NSPL vapour bleeding details

Effect nos	Vapour bleeding details
1st effect	DJ3 DCH –88-101°C, Cl. J 2 – PHE –102-108 °C, Raw melt – 54-840c, Molasses conditioning. Pan washing, Soda boiling, Raw sugar melting, B & C sugar melting, hot air at hoppers,
2nd effect	Cl. J 1 – PHE – 96-102; Horizontal continuous pan, Refine boiling,
3rd effect	DJ2 DCH – 78-88°C, Raw m/c grain, C m/c boiling, Refine grain
4th effect	RJ3- 60-72°C, DJ1 DCH -70-78°C, Raw m/c - VKT, B m/c VKT,
5th effect	Nil
Common condensate	RJ2 Wide gap PHE – 45.0 -60.0°C
Raw VKT Vapours	RJ1- VLJH – 32.0 to 45.0°C
Exhaust	Cut line, superheated wash water, Magma lines,

- No major change in vapour bleeding system
- Major modifications in 2019-20
- Replacement of M.S. pipe of raw juice by S.S. from mill house to defecators.
- Addition of 04 nos duplex heater of 107 m H.S. each for 30 % raw juice heating by 1st vapour (E2) condensate
- Use of cooled E2 condensate to distillery for fermentation.
- Heating of makeup water for boiler (D.M. Water) by E2 condensate.
- Tubular JH cleaning by caustic soda solution - To reduce cleaning time and cost as well as to avoid opening and closing of JH covers during season.
- Steam connection was done in calendria in all FFE and Robert body in place of connection in body for chemical boiling.
- Use of flow meter for clear juice – To assess evaporator system working and performance.
- Pneumatic cut over valve in low grade m/c boiling pan.
- Installation of mass flow meter and check weighing scale for Bh molasses during Bh diversion to distillery.
- Cooling of Bh molasses - plate type heat exchanger.
- Factory had successfully achieved 240 TCH crush rate with 42.0 % steam consumption during

consistent crush rate. Imbibition quantity is also increased and raw juice % was continuously in the range of 112- 114 % on cane. Syrup brix % achieved 71.0+. Sugar colour of the range of 40-45 IU is produced consistently.

Season 2020-21

- During 2020-21 crushing season crush rate of 250 TCH with Bh diversion to distillery is followed throughout the crushing season.
- Major modifications in boiling house
 - ◆ To avoid fluctuation in vacuum, mechanical seals are provided to various pumps which are working under vacuum
 - ◆ Facing problem of higher drain condensate quantity in exhaust line mainly due to low exhaust temp from TG set – below 130 °C. Exhaust line drains collection in a pit and transfer to boiler feed water. This increases return condensate by about 2.0 % on cane.
 - ◆ Installation of Condensate Polishing Unit (C.P.U.) for treatment of 1st vapour (E2) condensate. Capacity of CPU-80M³/hr. Reduction in COD is -60-70%. Treated E2 condensate is used for distillery operation
 - ◆ To reduce COD in E2 condensate, provided external catchall in 1st/2nd effect FFE.
 - ◆ Installation of spray water treatment system cap-20 m³/hr.

- Major modifications in vapour bleeding scheme
 - ◆ Use of 2nd vapour for chemical boiling in place of 1st vapour
 - ◆ Use of exhaust steam at cut over line and super-heated wash water was replaced by 1st vapour.
 - ◆ For sugar drying, 1st vapour is replaced by 2nd vapour
 - ◆ For B and C sugar melting, use of clear juice started and melt brix % increased to 76-78.
 - ◆ No C m/c production. No use of vapours for C boiling
- Factory had successfully achieved 250 TCH crush rate with 40.4 % steam consumption on cane during consistent crush rate. Imbibition quantity is also maintained and raw juice % was continuously in the range of 112- 114 % on cane. Syrup brix % achieved 69.0+. Sugar colour of the range of 40-45 IU is produced consistently.

Season 2021-22

- During 2021-22 crushing season crush rate of 260 TCH with BH diversion to distillery is followed throughout the crushing season.
- No major changes in vapour bleeding scheme
- No major modifications in boiling house
- Factory had successfully achieved 260 TCH crush rate with 41.30 % steam consumption on cane during consistent crush rate.
- Imbibition quantity is also maintained and raw juice % was continuously in the range of 112- 114 % on cane.
- Increased syrup brix % - 70.5+.
- Sugar colour of the range of 40-45 IU is produced consistently.
- Higher steam consumption due to increased solid load.

Season 2022-23

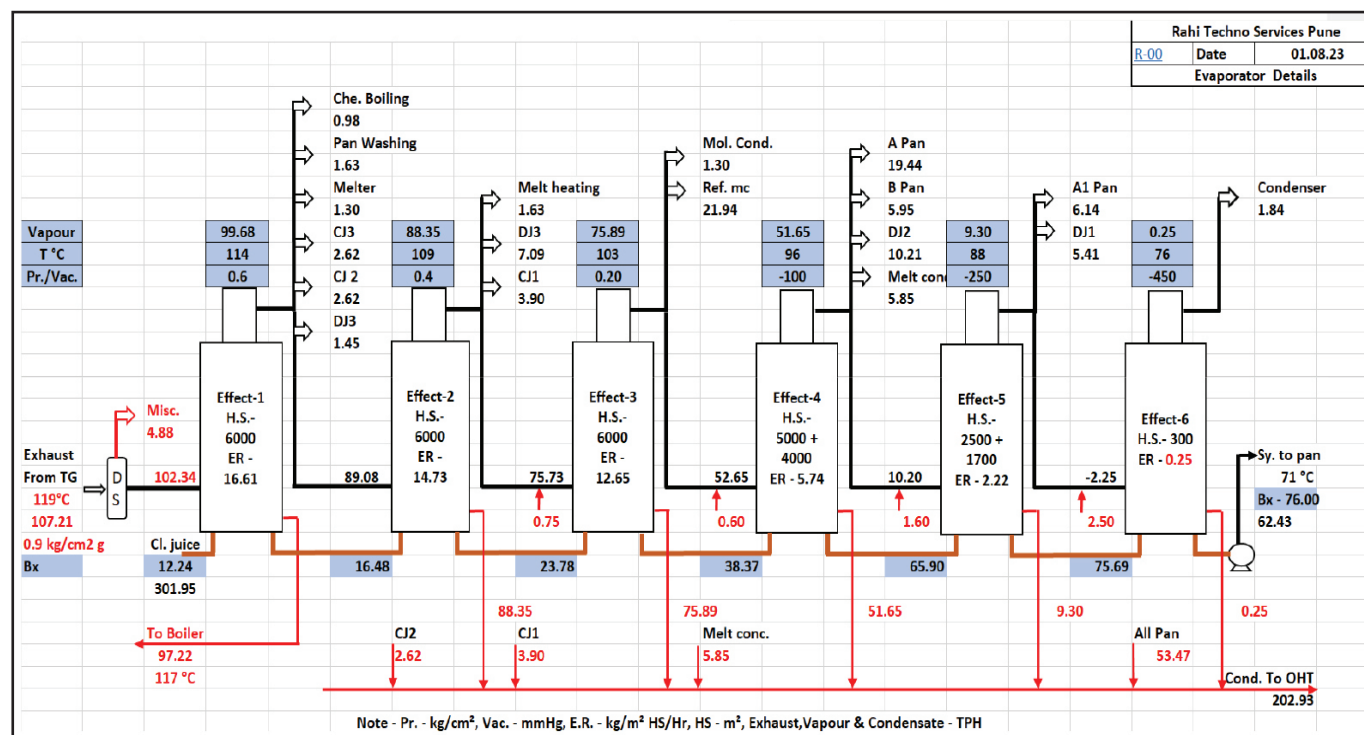
- During 2022-23 crushing season crush rate of 270 TCH with Bh and syrup diversion to distillery is followed throughout the crushing season.

- Major modifications in boiling house
 - ◆ Installation of one nos FFE of 6000 m² H.S.
 - ◆ Addition of one nos. SEDL make batch type pan cap-80 Ton for refined m/c Boiling. Use of 3rd vapour.
 - ◆ One batch type C/F machine cap-1750kg/charge for raw M/c curing
 - ◆ One nos spray pump of cap-2500 m³/hr head-18m.
 - ◆ Replacement of all existing cluster by nozzle dia-25mm and suitable for pump head 18m and discharge 60 m³/hr/cluster.
 - ◆ Spray pond modifications for 7000 TCD crush rate - main header and branch pipe line modifications.
 - ◆ Modification in vapour, condensate and juice line of evaporator system.
 - ◆ Existing DYJH is converted as VLJH of evaporator with separate condensate withdrawal
 - ◆ Rori melter is shifted at height for gravity melt flow to raw mingler.
- Major changes in vapour bleeding scheme
 - ◆ RJ3 switched from 4th vapour to 5th vapour
 - ◆ 1/3rd refinery massecuite shifted from 2nd vapour to 3rd vapour
- Factory had successfully achieved 270 TCH crush rate with 39.10 % steam consumption during consistent crush rate.
- Imbibition quantity is also maintained and raw juice % was continuously in the range of 112- 114 % on cane.
- Increased syrup brix % - 75.0+.
- Sugar colour of the range of 40-45 IU is produced consistently.

Season 2023-24

- During 2023-24 crushing season crush rate of 333 TCH with total Bh and partial syrup diversion to distillery is followed.

- Major modifications in boiling house
 - ◆ Addition of new two nos FFE of 6000 m² H.S. of tube length-12 m as 1st and 1st / 2nd effect
 - ◆ Discarding 2800 m² robert body
 - ◆ Use of 1700 m² robert body as 5th effect
 - ◆ Complete raw juice heating done by condensate. First part 30% raw juice heated by first vapour (E2) condensate in existing duplex heater and remaining 70% raw juice heated by common recirculated condensate.
 - ◆ Recirculation of cold condensate is followed - heating in two stages: 1st stage heating in VLJH by VKT vapour and 2nd stage heating in DCH by 5th vapour up to temp. 84-86 °C.
 - ◆ Correction heating of raw juice done in PHE by remaining common condensate.
 - ◆ Existing VLJH of evaporator is used for DJ1 heating by 5th vapour
 - ◆ New DCH of dia-1500mm is used for DJ2 heating by 4th Vapour.
 - ◆ DJ3 heating is done in existing two nos. DCH - parallel working - by 3rd / 2nd vapour.
 - ◆ 1st juice heating is done in PHE by 2nd vapour and 2nd clear juice heating in PHE by 1st vapour
 - ◆ 3rd clear juice heating is done in DCH by 1st vapour.
 - ◆ 4th vapour connection is provided in batch pans - 30% Refined M/c boiling, Raw and Refined M/c seeding pans and B-M/c boiling
 - ◆ Addition of one compartment in clarifier dia-24 ft and make clarifier 555.
 - ◆ Raw and A1-M/c boiling in VKT is done by 5th vapour
 - ◆ Raw melt is concentrated in melt concentrator by using 4th vapour.



**Figure 4 : Narmada Sugar Pvt. Ltd., Salichoka, MP - season 2023-24 - evaporator
HMBD and vapour bleeding details**

- ◆ HSA at 4th effect is increased – 4000 x 2 and 5000 X 1 – operation HSAs - 8000 m² / 9000 m²
- ◆ HSA at 5th effect is increased – 4000FFE X 1, 2500 FFE X 1 and 1750 R X 1 – operation HSA - 6500 m² / 5300 m²
- ◆ 350 m²/ 300 m² robot body as sixth effect.
- ◆ Necessary modifications in vapour pipe, condensate, juice pipe and vapour for pans, juice heaters.
- Major changes in vapour bleeding
 - ◆ Conversion of quintuple effect to hexaple effect. The detail HMBD of hexaple effect implemented in season 2023-24 is given in Figure 4.
 - ◆ Raw juice heating totally by condensate
- ◆ Used condensate reheating and its reuse for raw juice heating is followed. The condensate recycle, reheating and reuse scheme is given in Figure 5.
- ◆ Shifting DJ heating 5th followed by 4th followed by 3rd vapour
- ◆ Adopting 3rd stage clear juice heating by addition of DCH
- ◆ Eliminating use of 2nd vapours for pan boiling operation
- ◆ Use of 5th vapours to raw VKT / B VKT
- Factory had successfully achieved 320 TCH crush rate with 34.80 % steam consumption on cane during consistent crush rate.
- Imbibition quantity is also maintained and raw juice % was continuously in the range of 112-114 % on cane.

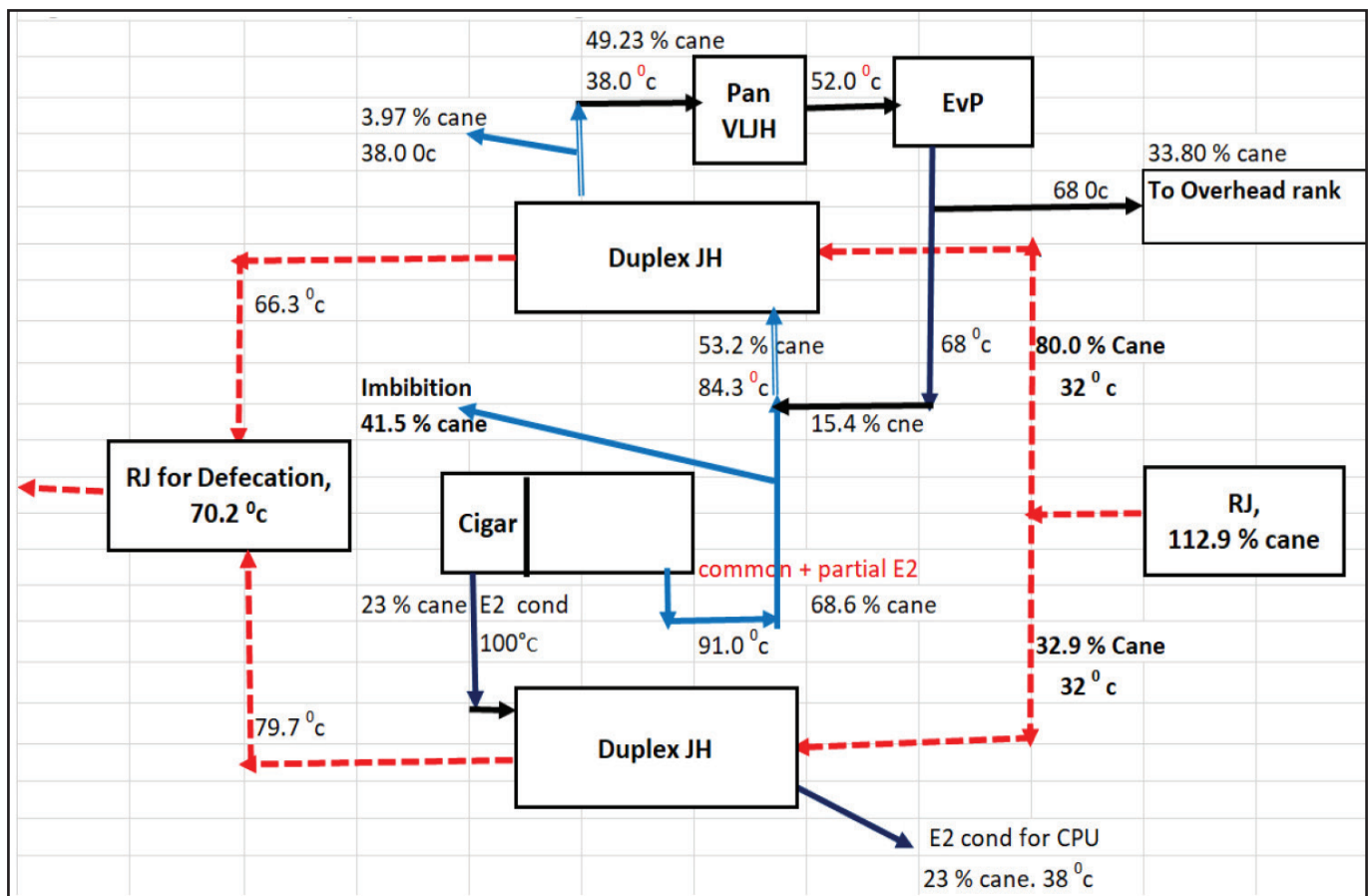


Figure 5 : Hot condensate cycle for Narmada Sugar Salichoka - season 23-24

- NSPL had continuously tried to handle higher syrup brix. The progress of higher syrup brix at NSPL is clearly explained in Figure 6. During 2023-24 crushing season NSPL had succeeded to handle syrup brix % - 76.0+.
- Sugar colour of the range of 40-45 IU is produced consistently.
- Table 2 indicates the various technical data comparison of NSPL working in last 6 crushing seasons.

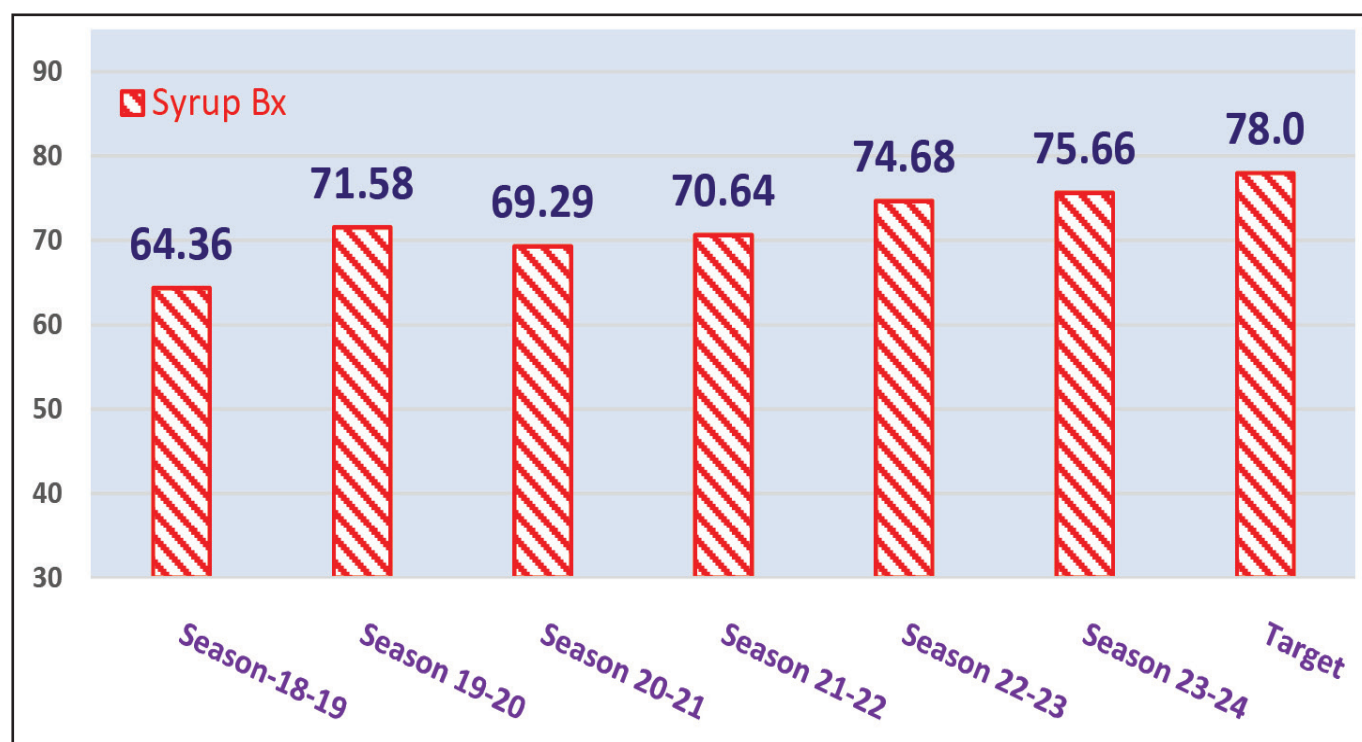


Figure 6 : NSPL - Syrup brix progress - sulphurless sugar production

Table 2 : - Factory performance data for last 6 crushing season

Particulars	Season 18-19	Season 19-20	Season 20-21	Season 21-22	Season 22-23	Season 23-24
Normal Crush rate TCH	250	250	250	260	272	335
Steam % Cane	43.7	42.6	40.4	41.3	39.1	34.8
M.J. % Cane	112.35	112.95	113.08	112.87	112.75	112.14
Added Water % Cane	43.45	45.51	44.73	43.88	43.46	42.70
Ref. M/c % Cane	26.30	27.60	23.01	28.40	25.04	25.05
Raw M/c % Cane	28.30	29.50	24.73	30.61	27.28	26.69
A1-M/c % Cane	11.80	10.79	8.99	10.44	12.25	5.14
B-M/c % Cane	0.00	0.00	0.00	7.50	8.78	8.46
C-M/c % Cane	8.50	5.89	6.69	0.00	0.00	0.00
Raw Melt % Cane	23.54	24.41	21.49	21.79	19.39	21.69

Analysis Details						
Primary Juice Bx	19.78	19.92	18.58	19.41	19.36	19.63
Primary Juice Pty.	85.88	86.07	84.6	86.02	84.95	86.61
Raw Juice Bx	13.30	13.93	12.93	13.71	13.92	14.05
Raw Juice Pty.	84.27	84.39	83.20	84.43	83.37	84.57
Clear Juice Bx	12.45	13.33	11.83	12.90	12.97	13.71
Clear Juice Pty.	84.55	84.65	83.40	85.46	83.82	85.15
Syrup Bx	64.36	71.58	69.29	70.64	74.68	75.66
Syrup Pty.	84.34	84.75	83.70	85.74	83.95	85.30

CONCLUSION

NSPL Salichoka MP had successfully achieved 35.0 % steam consumption for sulphur less sugar production @ 112-114 % mixed juice. Factory had implemented hexaple effect evaporator with 76.0+ syrup brix successfully. While achieving 35 % steam consumption factory had successfully implemented various concepts such as use of modern FFE, hexaple effect, increasing last effect vapour temp – 75.0°C, increasing syrup brix % to 76.0+, massecuite boiling in modern vertical continuous pan with 5th vapours, massecuite boiling in batch pans by providing mechanical circulators with 4th vapours, extensive use of process condensate for raw juice heating, recirculation of cooled process condensate for waste heat recovery and its reuse for juice heating and finally development of skilled man power for adopting modern technologies.

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