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Falling-Film Evaporator Plant for a Cane Sugar Factory Concept and Operating Results

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Without verbal explanation the information on this document is incomplete

Contents

Falling-Film Evaporator Plant for a Cane Sugar Factory: Concept and Operating Results

Introduction

- ***Cane sugar factory Indian Cane Power Ltd. (ICPL) / India feeds electrical power to local grid with considerable economic benefits***
- ***Objective: to increase of power yield by minimising specific steam consumption***
- ***ICPL is attempting to increase their co-generation proceeds by employing new technologies in sugar production and gaining surplus electricity from bagasse.***

New FFE evaporation plant (Season 2012/13)

- ***ICPL's original proven concept:***
  - evaporation plant with Robert and falling film evaporators
  - continuously operating vacuum pans for B- and C-product

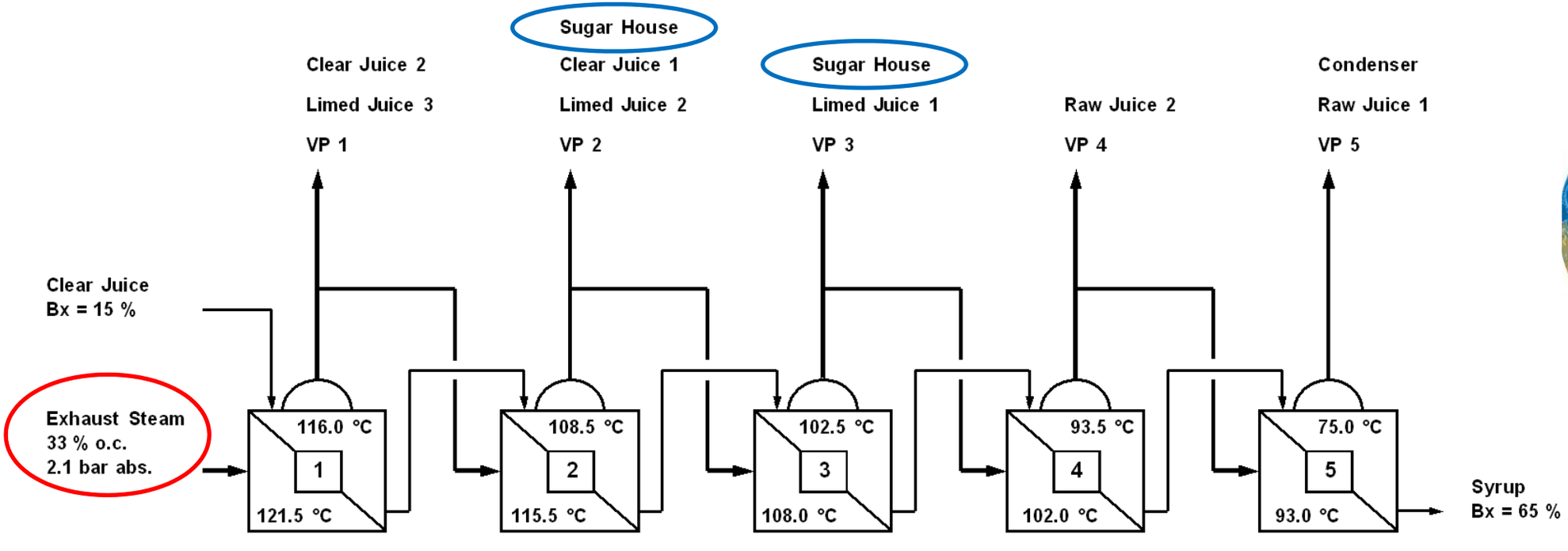
- ***New 5-effect falling film evaporation plant: Capacity improvement***
  - designed for 7,000 TCD
  - FFE1 – 4000 m²
  - FFE2 – 4000 m²
  - FFE3 – 4000 m²
  - FFE4 – 1000 m²
  - FFE5 – 1000 m²
  - additional equipments like pumps, tanks, heat exchangers

- ***3rd (and 2nd) vapour used for crystallisation***

OPERATING FIGURES OF ICPL (SEASON 2012/13)

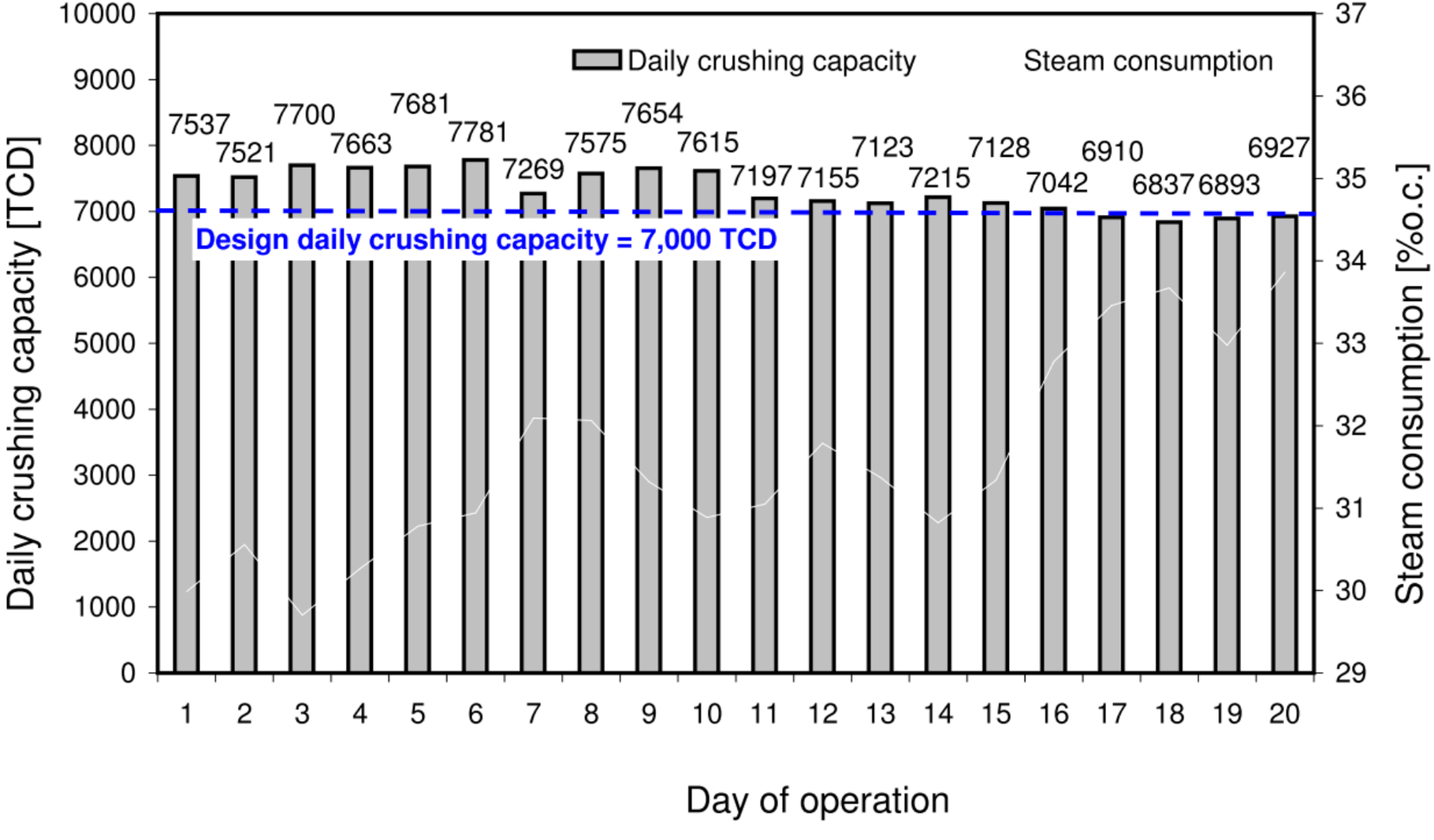
Operating figures (Season 2012/13)

- ***Typical operating conditions:***
  - Crushing rate 7,000 tcd
  - Juice Brix from 15 % to 65 %
  - Temperature vapour 1: 116 °C
  - Temperature vapour 5: 75 °C
  - Steam requirement: 33 % o. c. at 2.1 bar abs.



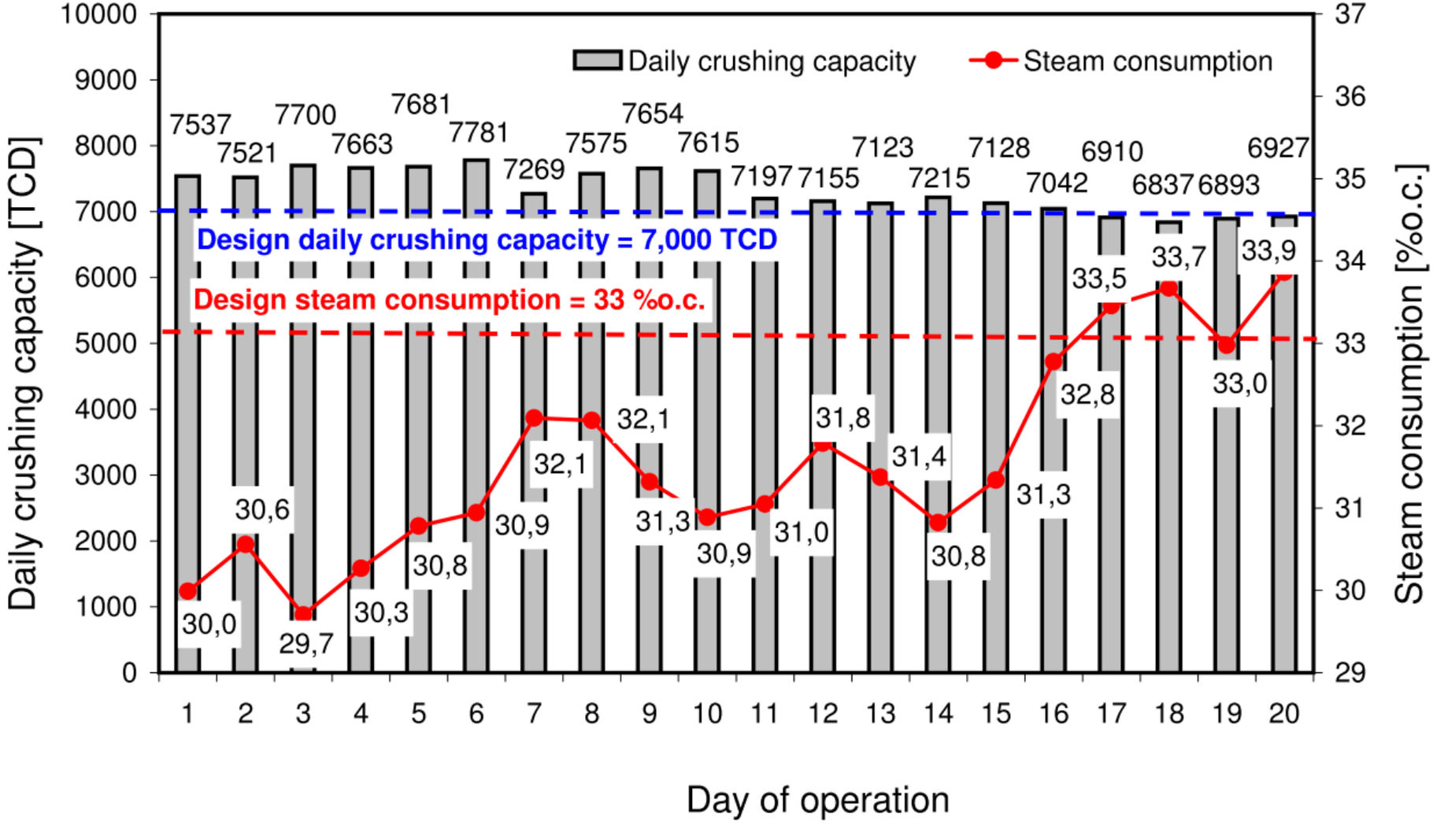
Operating figures (Season 2012/13)

- ***Daily crushing capacity from start of campaign***



Operating figures (Season 2012/13)

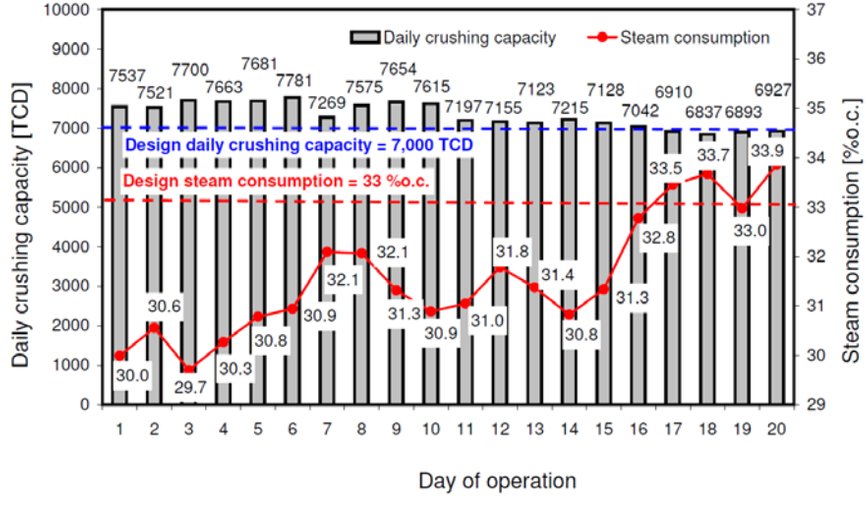
- ***Daily crushing capacity from start of campaign***
  and specific steam consumption



Operating figures (Season 2012/13)

- ***Begin of operation***
  - crushing capacity 10% over design capacity
  - specific steam consumption 10% less than design figure
  - heating surfaces are clean

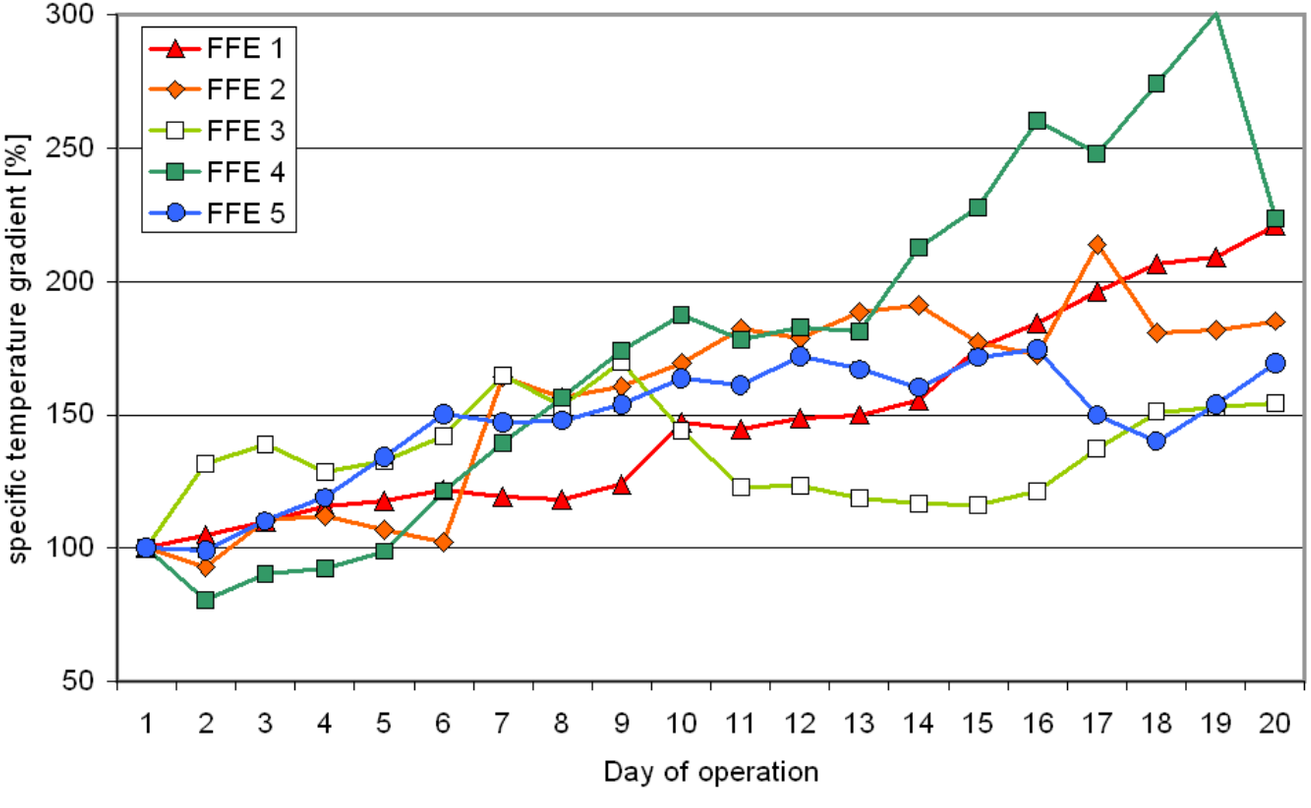
- ***After 18 days of operation***
  - crushing capacity remains slightly below design capacity
  - specific steam consumption raises above design figure
  - heating surface became scaled



- ***Cleaning of evaporator plant after 21 days***

Scaling

- ***Scaling takes place during operation of the evaporation plant***
- ***Scale hampers heat flow by solid layer with low heat conductivity***
- ***At constant evaporation rate the temperature gradient rises due to scale formation on heating surfaces.***
- ***Specific temperature gradient is a good measure for scale development***



- ***After 21 days the specific temperature gradient becomes twice than beginning of operation***

Scaling

- ***Analysis of scales from heating tubes (Feb 2012)***

Effect	FFE 1	FFE 2	FFE 3	FFE 4	FFE 5
Calcium carbonate	2.8 %	3.1 %	< 0.1 %	1.5 %	2.9 %
Calcium phosphate	42.8 %	6.6 %	3.5 %	3.0 %	1.4 %
Calcium sulphate	11.2 %	19.7 %	32.3 %	31.8 %	27.5 %
Calcium sulphite	0.1 %	14.4 %	< 0.1 %	1.8 %	< 0.1 %
Silicate	0.4 %	9.3 %	21.1 %	34.9 %	31.8 %
Scale samples					
Scale structure	Soft, thin layer. Can easily be scraped off.	Soft, thin layer. Can easily be scraped off.	Hard, thick layer. Difficult to remove mechanically.	Very hard, thin layer. Very difficult to remove mechanically.	Very hard and compact, thick layer. Very difficult to remove mechanically.

Scaling

- ***Composition is typical of evaporators in the cane sugar industry***

Effect	FFE 1	FFE 2	FFE 3	FFE 4	FFE 5
Calcium carbonate	2.8 %	3.1 %	< 0.1 %	1.5 %	2.9 %
Calcium phosphate	42.8 %	6.6 %	3.5 %	3.0 %	1.4 %
Calcium sulphate	11.2 %	19.7 %	32.3 %	31.8 %	27.5 %
Calcium sulphite	0.1 %	14.4 %	< 0.1 %	1.8 %	< 0.1 %
Silicate	0.4 %	9.3 %	21.1 %	34.9 %	31.8 %

- ***Juice purification: phospho-defecation with clear juice sulfitation***
  - High calcium phosphate content in first effects : soft scale
  - High calcium sulfite content in the second effect
  - High calcium sulfate content in last effects : hard scale
  - High content of silicate in last effects : very hard scale

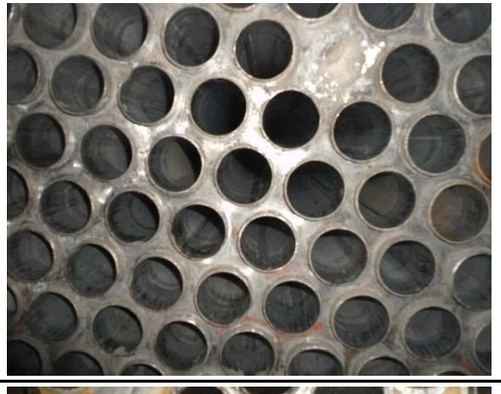
Cleaning

- ***Standard chemical cleaning at ICPL after 21 days of operation***
  - Alkaline cleaning (10 % caustic soda + sodium carbonate) at 100 °C for 8 h
  - Acid cleaning (6 % formic acid) at 95 °C for 8 h

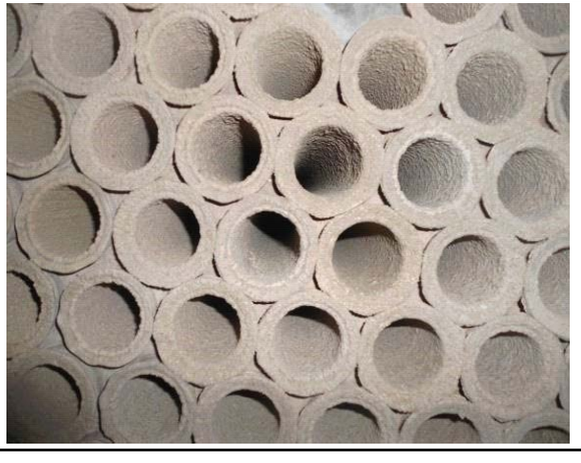
- ***Result***
  - FFE1: very good cleaning, clean heating surfaces
  - FFE2. very good cleaning, clean heating surfaces
  - FFE3: good cleaning, heating surfaces largely clean
  - FFE4: poor cleaning, heating tubes still covered
  - FFE5: poor cleaning, heating tubes still covered

- ***Measures***
  - FFE1, FFE2, FFE3: chemical cleaning after 30 days
  - FFE4, FFE5: alternating chemical cleaning and high pressure water cleaning with shorter operating time

Cleaning

Effect	Before cleaning	After cleaning	Cleaning effect
FFE 1			Very good. Heating tubes are clean.
FFE 2			Very good. Heating tubes are clean.
FFE 3			Good. Heating tubes are largely clean.

Cleaning

Effect	Before cleaning	After cleaning	Cleaning effect
FFE 4			Poor. Heating tubes still covered with considerable encrustations.
FFE 5			Poor. Heating tubes still covered with considerable encrustations.

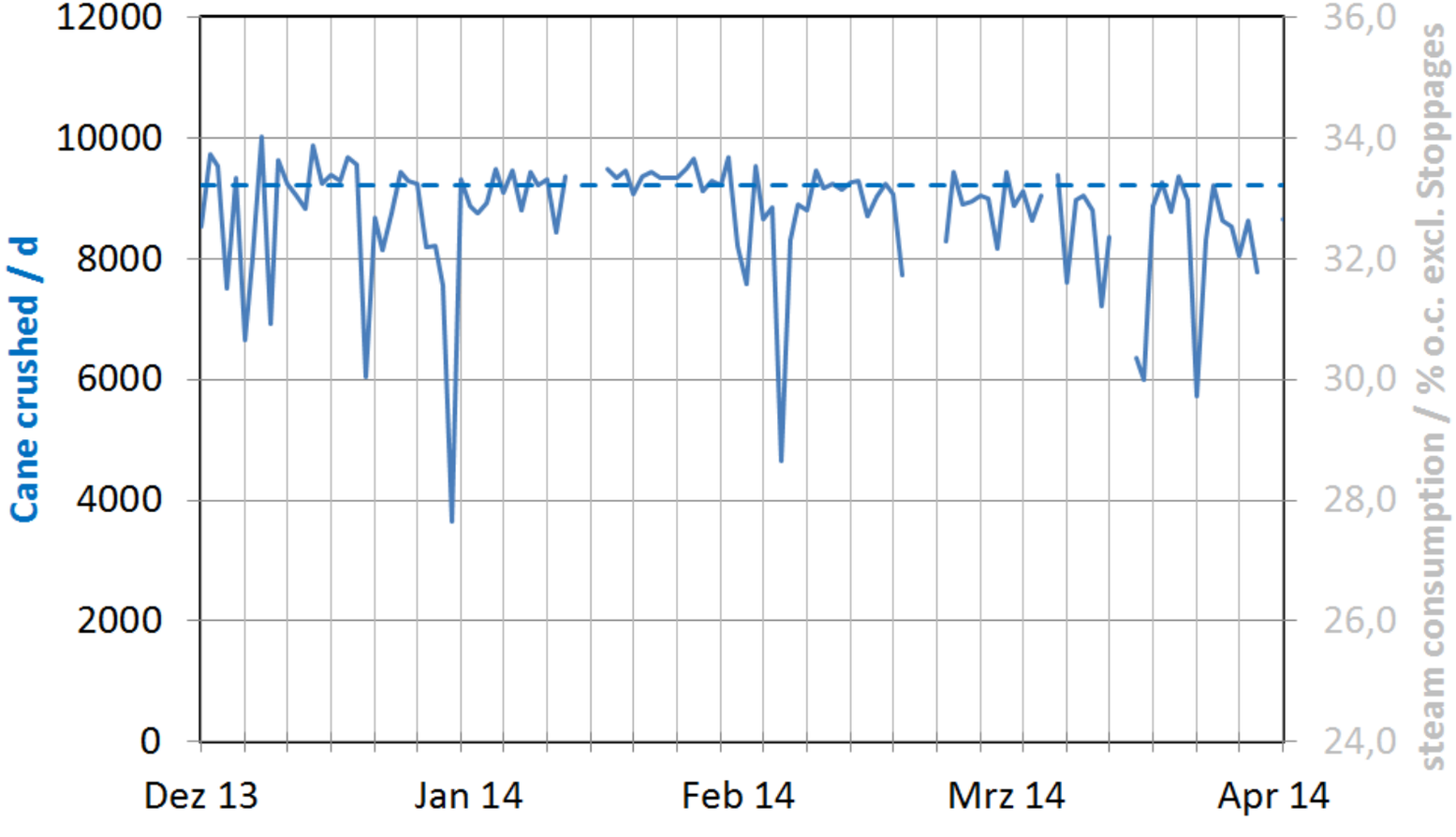
OPERATING FIGURES OF ICPL (SEASON 2012/13)

New Configuration Season 2013/14

- ***Two new BMA falling film evaporators were added before season 2013/14***
  - **2 x 4000 m²**
- ***Updated 5-effect falling film evaporation plant***
  - FFE1 – 4000 m²
  - FFE2 – 4000 m²
  - FFE3 – 4000 m²
  - **FFE4 – 4000 m²**
  - FFE5 – 1000 m²
  - Spare bodies for cleaning
    1x 4000 m²: FFE3 and FFE4
    1x 1000 m²: FFE5 (former FFE4)

Operating figures (Season 2013/14)

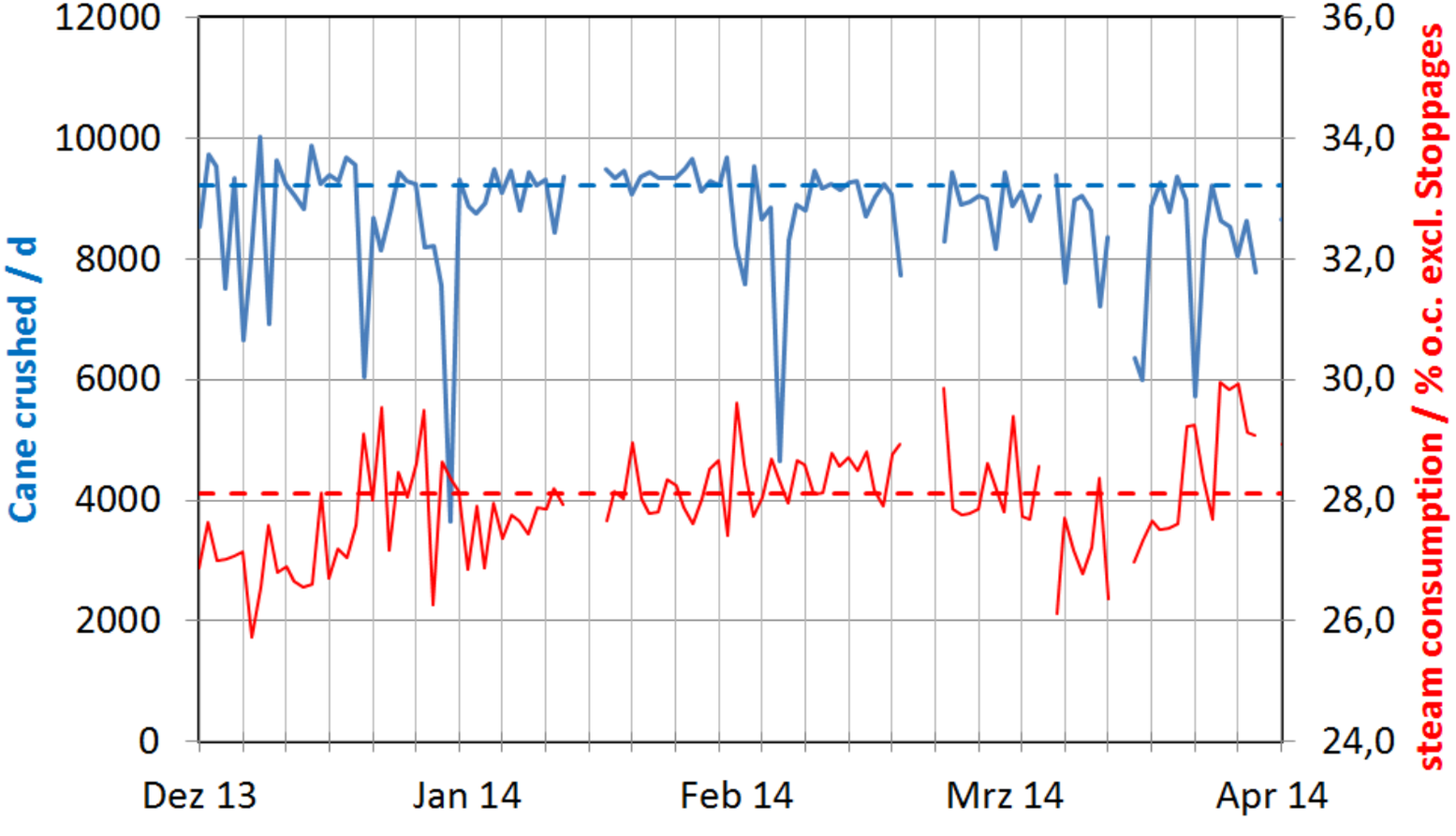
- ***Season 2013/14***
  - Cane crushing (average without stoppages) **9200 tcd**



Operating figures (Season 2013/14)

Season 2013/14

- Cane crushing (average without stoppages) **9200 tcd**
- Steam consumption (average without stoppages) **28.1 % o.c.**
  (with clean heating surfaces of evaporators down to 27 % o.c.)



Operating figures (Season 2013/14)

- ***Season 2013/14***
  - Cane crushing (average without stoppages) **9200 tcd**
  - Steam consumption (average without stoppages) **28.1 % o.c.**

- ***Cleaning of evaporators in season 2013/14***
  - 1st and 2nd effect: up to 40 days of operation
  - 3rd and 4th effect: up to 20 days of operation
  - 5th effect: each 10 days of operation

- ***Comparison to the season 2012/13***
  - Steam production remaining at average 104 t/h (maximum 110 t/h)
  - Increased steam efficiency from 30 to 33 % o.c. to 28.1 % o.c.
  - Increased crushing capacity by approx. 30 %
  - Surplus bagasse is used for power production during off-season

Is it only due to the installation of 2 new evaporators?

Why this low steam % o.c.?

- ***Not only the installation of two new falling film evaporators, additional measures for boiling sugar were realised***

- ***A-pans with powerful agitators***
  - Excellent circulation
  - High heat transfer
  - Working with 3rd vapour and even with 4th vapour possible

- ***Separate syrup concentrator on 4th vapour***

- ***Non-condensables from pans are directed to condenser***
  - Full steam/vapour system is operating under vacuum
  - Heating of continuous pans became more stable
  - Less water addition to boiling

Summary

- ***5-effect falling film evaporator plant with vapour 3 for A-product crystallization shows reliable operation with 30to33%o.c.steam demand and helps maximising electric power generation***

- ***Scale forms during several weeks of operating period between cleaning and limits crushing capacity***

- ***Compositionofscale varies from first effect (mostly calcium phosphate) to last effect (calcium sulphate and silicate)***

- ***Cleaningeffort is low in first, second and third effect: only by chemical cleaning; in both last effects chemical cleaning is supported by high pressure water cleaning***

Summary

Passion for Progress

Summary

- ***Installing 2 standby evaporators (one for 3rd/4th effect + one for 5th effect) and sugar boiling with 4th, 3rd and 2nd vapour shows reliable operation with 28%o.c.steamdemand (seasons average without stoppages) and helps maximising electric power generation***

- ***Highheatingsurfacein4theffect is a mandatory to bleed a respectable quantity of vapour for sugar boiling***

- ***Equipmentofsugarboilingmustbeabletoworkatlowheating temperatures***
  - Powerful agitator reduce necessary temperature difference
  - Tight steam and vapour system to work at vacuum (low quantity of non-condensable gases, NCGs conducted to condenser)
  - Increased syrup brix for feed to A-boiling (syrup concentrator)

- ***Low1stvapourtemperature reduces heating requirement for clear juice***

NEW FFE PROJECT IN PAKISTAN
JDW UNIT III (GSM)

Current situation: 11,800 TCD

- ***Steam consumption for process = 48,9 %c. (240 t/h)***
- ***Total steam production = 49,4 %c. (243 t/h)***
- ***Electrical power production = 13,4 MW (7,9 MW for own consumption + 5,5 MW for WAPDA Export)***
- ***Bagasse surplus = 4,6 %c. = 22,8 t/h***
- ***Condenser losses = 0,5 %c. = 2,3 t/h***

Future situation: 13,000 TCD

- ***Change in evaporation station***
  - Installing 2 new FFE's (5,000 m² each) as new 1st effect
  - The current 1st effect will act as 2nd effect
  - The current 2nd effect will act as 3rd effect
  - The current 3rd effect will act as 4th effect

- ***Heating A-CVP with VP 3 instead of VP 2***
- ***Installation of new heaters to improve vapour bleeding***

Future situation: 13,000 TCD

- ***New heating surface distribution in the evaporation station (Red heating surfaces are standby)***
  - 1st effect: 5,000 m² + 5,000 m² + 3,500 m²
  - 2nd effect: 3,500 m² + 3,000 m² + 2,500 m²
  - 3rd effect: 2,500 m² + 2,100 m² + 1,800 m²
  - 4th effect: 1,800 m² + 1,500 m²
  - 5th effect: 900 m² + 900 m²

Future situation: 13,000 TCD

- ***Expected new results***

  - Total steam consumption = 41,9 %c. (227 t/h)
  - Reduction of steam consumption of 7 %c.
  - Electrical power production = 22,6 MW (8,7 MW fro own consumption + 13,9 MW for WAPDA Export)
    (The electrical power production is calculated based on a specific steam consumption of the new turbines in the Cogeneration Plant of 5,5 kW.h/kg steam)
  - Bagasse surplus = 8,7 %c. = 47 t/h
  - Condenser losses = 0,12 %c. = 0,6 t/h

Passion

for

Progress

With special thanks to:

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