SYSTEM DESIGN : INTEGRATED SUGAR COMPLEX WITH MINIMUM ENERGY CONSUMPTION & MAXIMUM CO-GEN

Presented by :

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IJT has been awarded a task for setting up of two integrated sugar complex on turnkey basis by Hindustan Petroleum Corporation (HPCL) at Sugauli & Lauriya in Eastern India.

Each complex is designed to crush 3500 Tons of cane / day to produce sugar & ethanol with

- Minimum energy consumption
- Maximum co-generation

The plants were commissioned in Feb 2011

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HPCL Plant, Lauriya



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The presentation deals in selection of system design in respect of :

- Power cycle for maximizing economical cogeneration
- Juice extraction plant for minimum energy consumption with maximum pol extraction.
- Process house bleeding scheme for minimum steam consumption
- Waste heat recovery system
- Drives for minimum transmission losses.
- Flexibility in process technology to cater 30-70% of juice either for sugar processing or for ethanol production (Initially started with 50 % for each).

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Selection of Power cycle for Maximum Cogeneration

IJT has vast experience & expertise in the field of bio-mass based high pressure cogeneration to gain the benefits of combined power and heat cycle since last 10 years.

Theoretical comparison of critical parameters of various pressure and temperature cycles is given in next slide.

Case 1 (off –crop): 100 TPH Traveling Grate boiler with 71% efficiency on mill wet Bagasse having GCV 2270 Kcal/kg and turbine exhaust at 0.1 ata in condensing mode.

Parameter	Unit	45ata/ 440 °C	66ata/ 485 °C	87ata/ 515 °C	110ata/ 540 °C	125ata/ 540 °C
Feed water temp.	°C	105 without HP Heater	150 with one HP Heater	170 with one HP Heater	210 with two HP Heaters	240 with two HP Heaters
Bagasse Quantity	TPH	43.51	41.78	41.2	38.47	36.74
Steam/ Fuel ratio		2.29	2.39	2.42	2.59	2.72
Gross Power output	MW	24.8	26.5	28.5	29.4	29.8
Specific steam	Kg/ KWh	4.03	3.77	3.51	3.44	3.3
Power generation per ton of Bagasse	Kw/ ton	Base	+11.4 %	+21.4%	+33%	+42.3%

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Case 2 (during crop): 100 TPH Traveling Grate boiler with efficiency on GCV 2270 Kcal/kg Basis and turbine back pressure at 2.0 ata

Parameter	Unit	45ata/ 440 °C	66ata/ 485 °C	87ata/ 515 °C	110 ata / 540 °C	125 ata / 540 °C
Feed water temp.	°C	105 without HP Heater	150 with one HP Heater	170 with one HP Heater	210 with two HP Heater	240 with two HP Heater
Bagasse Quantity	TPH	43.51	41.78	41.2	38.6	36.74
Steam/ Fuel ratio		2.29	2.39	2.42	2.59	2.72
Gross Power output	MW	13.8	13.9	15.1	15.5	15.7
Specific steam	Kg/ KWh	7.3	7.18	6.62	6.45	6.36
Power generation per ton of Bagasse	Kw/ ton	Base	+4.7 %	+15.8 %	+29.8%	+34.8%

The table clearly indicates that with increased cycle parameter's

1.Power output increases

2.Steam/Fuel ratio increases

3.Specific fuel consumption reduces

As 125 bar boiler is more expensive in comparison to gain in power and saving in Bagasse ,so IJT selected & installed a traveling grate boiler of 110TPH, 110 Ata 540 ºC for the co-gen plant of the 3500 TCD sugar complex

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110 TPH,110 Ata,540 °C Boiler at HPCL, Lauriya



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Predicted Steam Consumption for HPCL Plant

	T/Hr	% Cane
L.P Steam Requirement	32.56	21.5 @150 TCH
Steam requirement in Distillery	5.0	3.3 @150 TCH
Total Steam Requirement	37.56	24.80 @150 TCH

Selection Of turbo Set

To fulfill steam requirement for sugar & ethanol plant with maximum co-gen ,20MW extraction cum condensing turbo set selected.

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20 MW, 110Ata, Turbo set ,HPCL ,Lauriya



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Selection of Juice Extraction Unit

- Device needs through which higher extraction could be achieved by spending lower power, lower operating and maintenance cost.
- In integrated co-generation sugar plant , the profitability increases as Specific Power export per ton cane increases.
- In order to maximize power export to the grid, energy efficient equipments need to be selected and erected. Diffuser suits for this.
- So IJT proposed to install diffuser in place of milling.

MILLING Vs DIFFUSION

Power Cost : Power consumption in diffuser < 20-30 % in milling

***Capital cost* :** Installation cost in diffuser < 20-30 % in milling

***Maintenance cost* :** Maintenance cost in diffuser < 20-30 % in milling.

Operating cost : Cost of consumables is negligible. Only one operator is required per shift.

Raw Juice Quality : a) Higher Colour in raw juice (Now over come by juice & syrup clarification)
b) Much clearer juice as lower suspended solids
c) Lower starch content

Filtration : Less filtering area required due to lower solids in raw juice

Sugar Extraction : Higher extraction (98%)

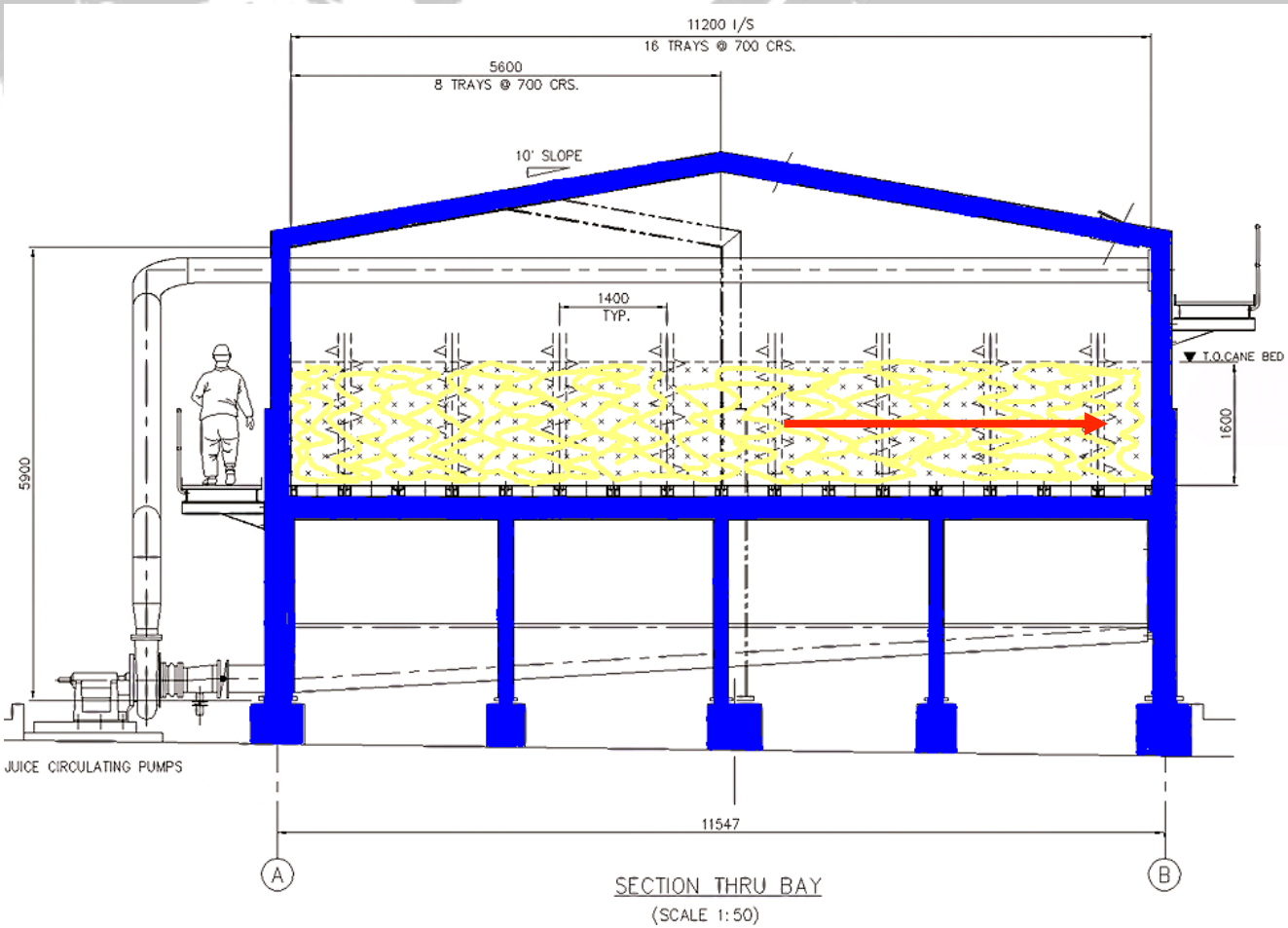
Comparison of Diffuser and Milling

Description	Units	Mills	Chain type Diffuser	Chainless diffuser
Crushing rate	t/day	3500	3500	3500
Fibre % cane	%	16.5	16.5	16.5
Imbibition rate	% fibre	280	320	320
RME (Mittal)	%	96	98.0	98.0
Raw Juice Quality		Base	Lower starch	Lower starch
Bagasse Moisture	%	About 50	About 50	About 50
Pol % Bagasse	%	1.60 - 1.80	1.0- 1.25	1.0-1.25
Power consumption	kWH/T	13-14	9-10	9-10
Capital cost	%	Base	70-80 %	49-56%
Maintenance cost	%	Base	70-80%	35-40%
Expandability		Very limited expandability	Zero expandability	Easy to expand

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Expandability of Chain-Less Diffuser



Additional moving screens can be added for expanding the capacity of Chain-less Diffuser

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Finally ISGEC John Thompson opted for IJT-BOSCH chain less cane diffuser of capacity 3500 TCD .



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IJT-BOSCH chain less cane diffuser of capacity 3500 TCD .



Internal View of Chain-less Diffuser at HPCL- Sugauli



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De-watering Mills

- One no two roller 2035 mm wide mill with under feed roller followed by one no four roller 2035 mm wide mill provided for dewatering of megasse.

- Dewatering mills designed for low speed with high drainage area to obtain final Bagasse of 49% moisture .

- Dewatering mill speed limited to 10 m/min with operating speed between 6-8 m/min.

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Dewatering Mills HPCL- Sugauli



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Compact layout : Adjacent diffuser & process house to reduce piping length for DC heaters



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Compact layout : Juice lines between DC heaters and diffusers



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Processing of Juice

- To fulfill local consumption of sugar and maximum bio-energy recovery, 50 % juice used for ethanol & 50 % for white plantation sugar with D.S. process. Plant has flexibility 30 & 70 % to produce sugar and ethanol respectively and vise versa.

- Plant is completely DCS automated for better efficiency to reduce steam and power consumption.

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Energy Saving Steps Taken at HPCL Sugauli & Lauriya

- Elimination of live/ exhaust steam in process house
- Improved vapour bleeding system using multiple effect evaporators
- Recovery of Waste Heat from condensate of evaporators, juice heater and pans
- Use of Power saving devices
- Use of Extensive Automation

Elimination of Live/ Exhaust Steam in Process House

Live / exhaust steam is normally used for:

- Sulphur melting in factories where Sulphitation process is used
- Super heated wash water system for centrifugals
- Vacuum Pan washing
- Sugar melting
- Molasses conditioning
- Sugar dryer

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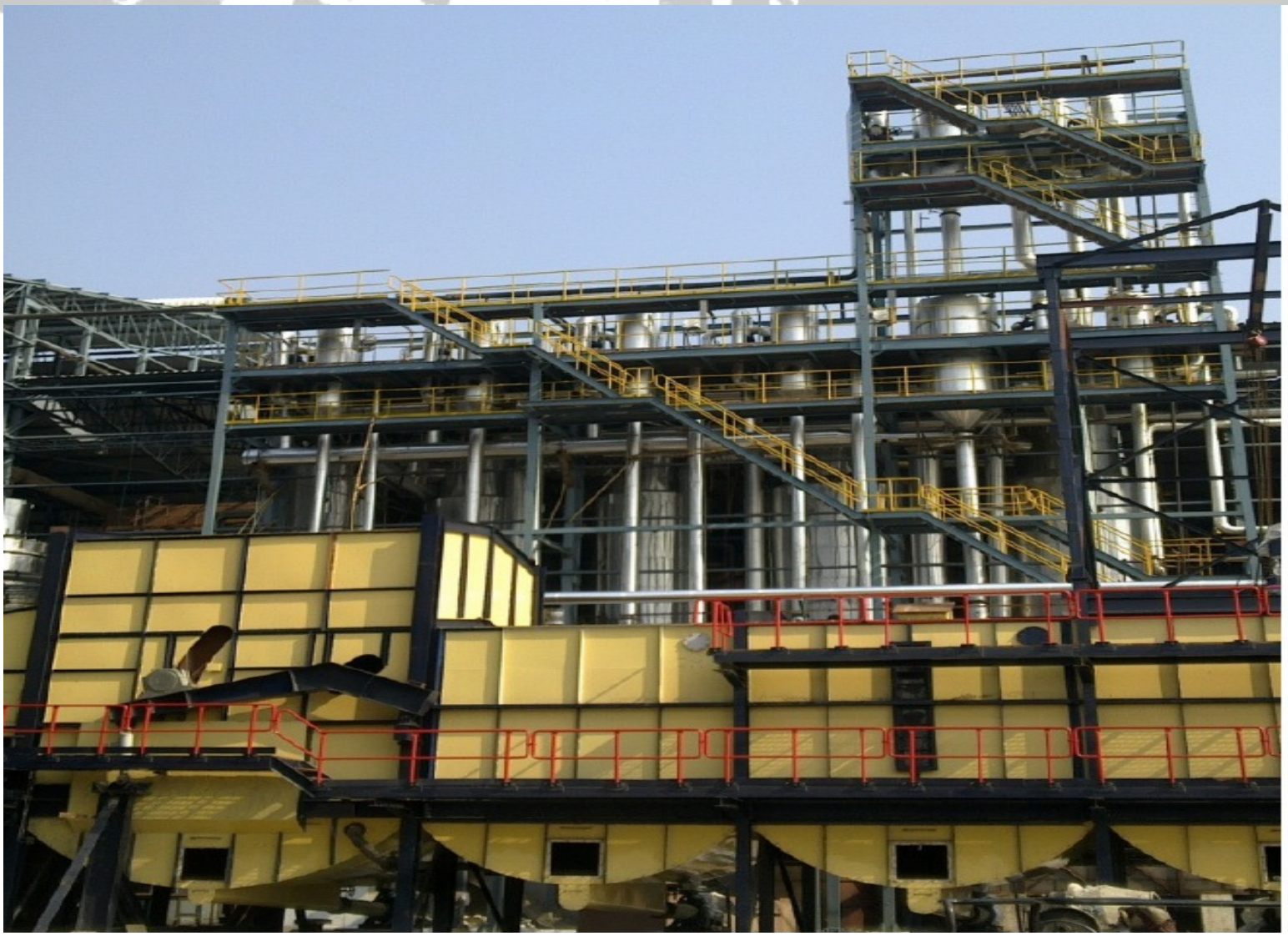
Improved vapour bleeding system by using multiple effect evaporators

- Use of direct contact juice heaters for utilization of later effect vapours at low approach temperatures
- Use of low pressure vapour for Vacuum Pan boiling
- Use of vapour for Vacuum Pan washing in place of exhaust/ live steam

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Direct Contact Heaters with Diffuser at HPCL- Sugauli



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Use of Power Saving Devices

➢ **Use of Variable Frequency drives**

- All cane conveyors for diffuser feeding control
- ID & FD fans of boilers
- All pumps for Juice , Molasses, Massecuite where flow regulation is required

➢ **Use of Planetary Gears**

Wide use of planetary gears from cane carrier to bagging house for power saving.

- Carriers & Conveyors
- Crystallizers
- Pug mill & Magma mixers
- Sugar Melters

➢ **Gravity Flow of Massecuite to Centrifugals**

➢ **Gravity Flow of Condenser cooling Water**

Planetary Gears



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Gravity flow of massecuite to reduce energy consumption due to pumping



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Gravity flow of condenser water to spray pond to minimize energy consumption



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Belt type conveyors for boiler to reduce power consumption



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Use of Extensive Automation

Complete plant is controlled through integrated DCS (Distributed Control System) from centralized control room. For ease of controlling following Subdivisions of the plant are made -

- Boiler control system
- Co-Generation control system
- Diffuser control system
- Juice flow stabilization system & Auto pH Control System
- Evaporator control system
- Automation of Pan, Crystallizer, Centrifugal feed, molasses conditioning ,sugar melting & cooling and condensing control system

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Ethanol Plant

- 60 Klpd ethanol plant (99.8 v/v) with integrated evaporation – 2.0 kg/lit steam.
- Fed batch fermentation process employs a yeast strain or backer's yeast system, which can withstand variations in the molasses quality, temperature and other shock loads.
- Vacuum distillation produces ethanol of international quality standards. There is a lot of demand of ethanol from vacuum distillation. It requires 50 % less steam as compared with the conventional old distillation technologies.

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Cont.

- Falling film type evaporator are used for spent wash evaporation as falling film can be operated at very low temperature difference between heating media and boiling liquid.

- Molecular sieve technology is adopted for dehydration. Molecular sieves are synthetic zeolite typically 3A zeolite.

- Concentrated spent wash from integrated evaporation is fed to the Bio composting areas to windrows by a motorized device which adds the spent wash along with enzyme mixture to the press mud.

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Ethanol Plant HPCL , Lauriya



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Bagasse saving

Moisture of Bagasse	49-50 %
Gross Calorific value of Bagasse	2272 Kcal/kg
Feed water Enthalpy	214.34 Kcal/kg
Boiler Steam Temperature	540 deg C
Boiler Steam Pressure	110 Ata
Boiler efficiency	71 %
Bagasse required for boiler	37.40 TPH
Bagacillo required for vacuum filter	0.72 TPH
Total Bagasse required for plant	38.12 TPH
Estimated Bagasse production	52.50 TPH
Surplus Bagasse	14.38 TPH
Bagasse saved in crop days of 180	62120 Tons

Economics at High Pressure Co generation Plant

Power Generation in season

Power Generation in season	20 MW
Power required for sugar plant @ 19 kwh /ton	2.85 MW
Power required for Distillery and lighting etc	0.3 MW
Power required for TG set & co gen. plant	2.0 MW
Power available for export in season	14.85 MW

Power Generation in off - season

Steam for Off season	86.4 TPH
Power Generation in off- season	17.6 MW
Bagasse required	32.25 TPH
Bagasse required for a day	774 T/day
Nos. of days for co-generation in off season	80 days

Money Realization by export of power

Power export in season 14.85 MWH x 24 hrs x 180 days	64,152,000 units
Power Export in off season 17.6 MWH x 24hrs x 80 days	33,792,000 units
Total power export/ year	97,944,000 units
Realization in USD @ 9.38 US cents / Unit	9,171,120 USD per year

CONCLUSIONS

- In present sugar scenario, sugar mills without co-generation are not viable.

- Use of high pressure cycles to ensure higher steam to Bagasse ratio thus saving Bagasse for off-season. In case of plants using 110 Ata pressure cycle steam to Bagasse ratio is 2.60 as compared to 2.29 for plants with 45 Ata pressure cycle.

- HPCL cash flow shows in table that return of investment is very short .
- As fuel demand is increasing day by day ,the alternative bio-fuels are definitely going to help the economy as our fuel resources sustained no longer.

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THANK YOU

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