

ISSCT ENGINEERING WORKSHOP 2008, BRAZIL

SIMPLE NEW EQUIPMENT & PROCESSES FOR IMPROVING ENERGY EFFICIENCY IN SUGAR FACTORIES

Bruce Moor



SIMPLE ENERGY IMPROVEMENT PLANT & PROCESSES

METHODOLOGY:

USES BOSCH PROJECTS' ENERGY & MASS BALANCE (EMB)

CONSTRUCTS A COMPUTER MODEL OF THE
FACTORY INCLUDING:

- ALL PROCESS MASS FLOWS,
- STEAM & POWER



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**START WITH AN EFFICIENT 1980's
CO-GENERATING FACTORY**



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FACTORY SPECIFICATIONS

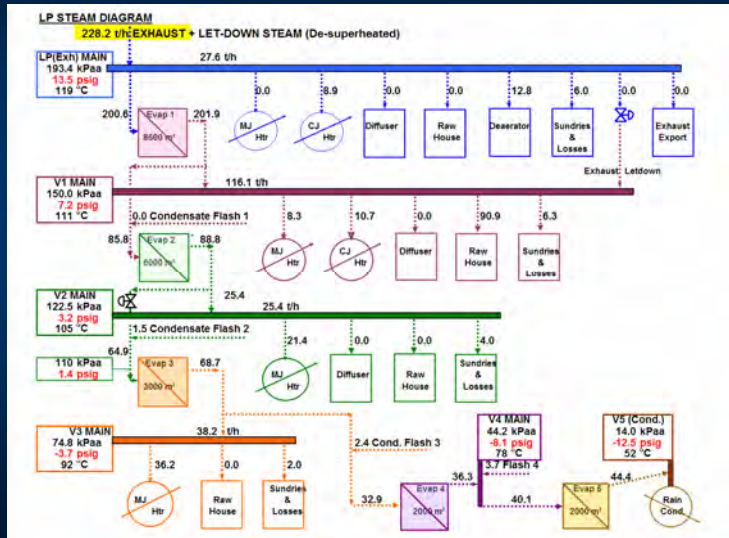
500 TCH Raw sugar factory, No refinery or by-products

Maximum co-generation of electricity from available bagasse

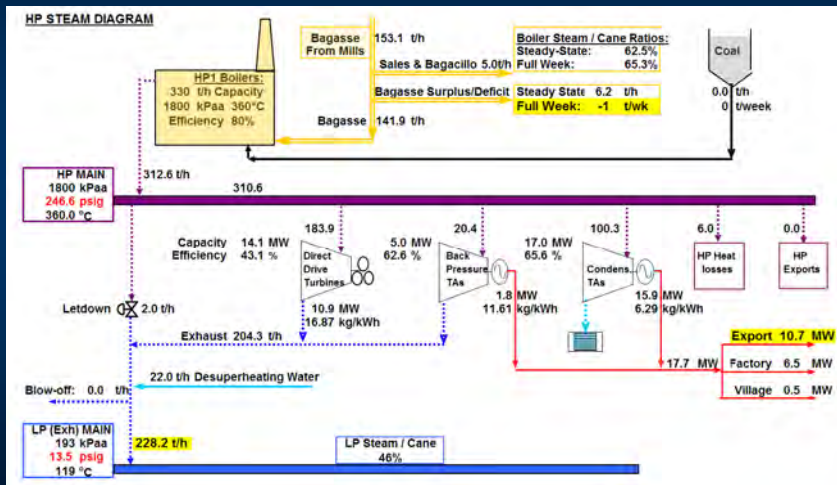
Cane quality	15% Fibre, 14.0% Pol, 84% Purity
Preparation	Heavy duty shredding, PI > 90%
Milling	97.7%, Bagasse moisture 50%
Evaporation	Quintuple effect
Pan boiling	Three boilings, Batch pans on V1
Steam	17 Bar (1800 kPa abs), 360°C
Boiler efficiency	80% on NCV
Turbo-alternators	Back pressure (80% efficiency) & Condensing (65% efficiency)



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EMB STARTS WITH PROCESS STEAM BALANCE



SIMPLE ENERGY IMPROVEMENT PLANT & PROCESSES
- THEN DETERMINES HP TO SUPPLY LP & OPTIMISES POWER GENERATION FROM BAGASSE



**BASE CASE FACTORY CAN EXPORT
10.7 MW**

**WILL NOW ADD PLANT FOR ENERGY
IMPROVEMENTS
AND ASSESS EACH IN TURN**



1. UPGRADE HP STEAM CONDITIONS

Steam pressure / Temperature	Tons steam / ton bagasse	Tons steam / MWh power	MWh power/ 100t bagasse
1800 kPa abs / 360°C	2.42	9.12	24.0
3100 kPa abs / 410°C	2.14	7.22	29.6
4500 kPa abs / 445°C	2.09	6.29	33.3

SELECT 1990's PRESSURE OF 4500 kPa abs

EXPORT POWER INCREASED TO 20.9 MW



2. CONTINUOUS PANS

BATCH PANS REQUIRE EITHER EXHAUST or V1 FOR END OF BOILINGS

CVPs CAN BOIL ON V2 or V3 – BECAUSE OF

- THEIR LOW BOILING HEAD &
- HIGH HEATING SURFACE / VOLUME



2. CONTINUOUS PANS (Contd.)

RETAIN BATCH SEED PANS on V1
INTRODUCE CVPs on V2 for A, B, & C STRIKES

Parameter	Units	Batch pans	Continuous
Total exhaust steam	t/h	226	211
Total use of V1 bleeds	t/h	116	54
Total use of V2 bleeds	t/h	25	87
Power exports	MW	20.9	<u>22.0</u>

(Using V3 would improve further)
Other CVP benefits well established:

- Easy automation
- Good exhaustions
- High time availability

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3. EXTRACTION SYSTEM

MILLING IS POWER INTENSIVE (USES HP STEAM) - THIS COMPETES WITH CO-GENERATION

DIFFUSION IS PROCESS STEAM DEPENDENT - COMPLEMENTS CO-GENERATION



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3. CONVERT MILLING ► DIFFUSION



EVEN WITH IMBIBITION INCREASED FROM 280°F TO 320°F, EXPORT POWER INCREASES TO 30.4 MW (Δ 8.5 MW)

OTHER DIFFUSION BENEFITS: LOW MAINTENANCE, HIGH AVAILABILITY, LOW OPERATING COSTS



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4. CLARIFIER MUD RECYCLING TO DIFFUSER

PRACTISED SUCCESSFULLY SINCE 1998.
ENHANCES ENERGY EFFICIENCY OF DIFFUSION:

- No heat losses from filter station
- Power for the filters and ancillary plant saved
- Evaporation load reduced by no filter wash water
- No vacuum system, bagacillo, mud mixing, cake disposal
- Bagacillo provides additional fuel (2% - 4%)



FILTERS
➤
OUT !



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COMPARING EXTRACTION OPTIONS:

Parameter	Units	Milling	Diffusion	Diff + Mud Recycle
Imbibition on fibre	%	280	320	320
Total boiler steam	t/h	296	297	313
Total process steam	t/h	212	230	229
Power exports	MW	22.0	30.4	33.8

MUD RECYCLING ADDS 3.4 MW



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5. ELECTRIC SHREDDER & MILL DRIVES

Single stage mill and shredder turbines \leq 45% efficient at full load.

Electric shredder & VSD mill drives use 80% efficient multi-stage turbo-alternators

- Impact is larger with milling
- Even better with individual roll VSD drives
- Low maintenance requirements
- But need more power station capacity



5. ELECTRIC DRIVES (Continued)



Shredder & Mill Drives	Power Exports	Milling	Diffusion	Diff + Mud Recycle
Turbines	MW	22.0	30.4	33.8
Electric	MW	29.6	34.4	37.9
Difference	MW	7.6	4.0	4.1



6. BOILERS

**INITIALLY, INCREASED PRESSURE TO 45 BAR.
NOW, 65 BAR IS COMMON IN SUGAR PLANTS**

BOILER EFFICIENCIES HAVE ALSO IMPROVED:

- **MORE HEAT RECOVERY PLANT (AIRHEATERS, ECONOMISERS) FOR FINAL GAS TEMP ± 160°C
Δ 10°C = Δ 1% STEAM PRODUCED**
- **LESS EXCESS AIR (FEEDERS, MEMBRANE WALLS, PIN-HOLE GRATES, FUEL / AIR RATIO CONTROL)
Δ 15% EXCESS AIR = Δ 1% STEAM PRODUCED**



6. BOILERS (Continued)

EFFECTS OF STEAM CONDITIONS & EFFICIENCY:

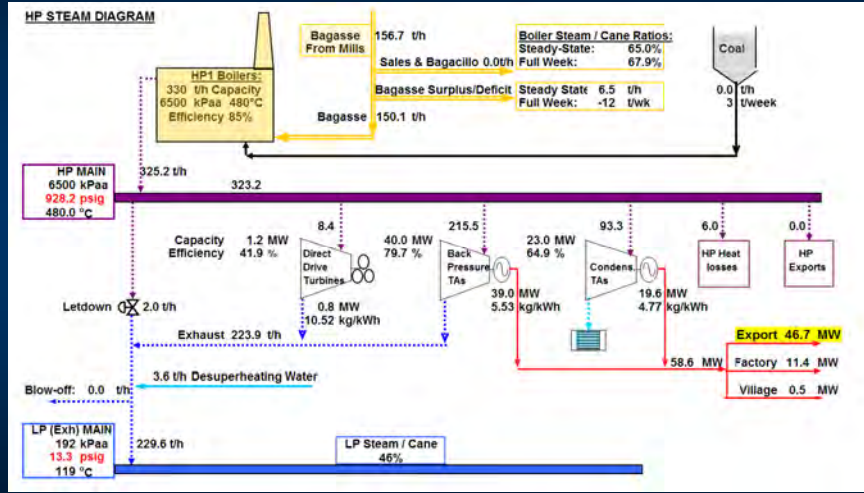
Pressure / Temperature	Boiler LCV effy.	T steam / t bagasse	T steam / MWh	MWh / 100 t bag.
1800 kPaa / 360°C	80%	2.42	9.12	24.0
	85%	2.57	9.12	25.5
4500 kPaa / 445°C	80%	2.09	6.29	33.3
	85%	2.22	6.29	35.4
6500 kPaa / 480°C	80%	2.05	5.52	37.1
	85%	2.18	5.52	39.4

**WITH 65 BAR STEAM & 85% BOILER EFFICIENCY,
EXPORT 46.7 MW**



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EFFICIENT FACTORY HP STEAM



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SUMMARY - From 1980's to MODERN:

FROM	TO	Δ MW EXPORTS
1800 kPa abs Steam	4500 kPa abs Steam	10.2
Batch Pans	Continuous Pans	1.1
Milling	Diffusion	8.4
Diffusion	Diffusion + Mud Recycling	3.4
Turbine Shredder & Mills	Electric Drives	4.1
4500 kPa a, 80% Effy. Boilers	6500 kPa a, 85% Effy. Boilers	8.8

Power Exports increased from 10.7 MW to 46.7 MW



OTHER NEW ENERGY-EFFICIENT PLANT:

- **DIRECT CONTACT HEATERS**
- **LONG TUBE RISING FILM EVAPORATORS**



7. DIRECT CONTACT (DC) HEATERS

Heating steam is condensed into juice and has to be evaporated later.

But very low approach temperatures (ΔT) allow use of lower grade vapour for same juice temperature. This offsets extra evaporation.

Ran the EMB for Milling + CVPs for 2 cases:

- S&T heaters with ΔT of 8°C on V3, V2 & V1
- DC heaters with ΔT of 1.5°C on V4, V3 & V2



7. DC HEATERS (Continued)

Parameter	Units	S & T	D C
Total exhaust steam	t/h	211.9	210.8
Use of V1 for MJ heating	t/h	8.3	-
Use of V2 for MJ heating	t/h	21.3	15.8
Use of V3 for MJ heating	t/h	35.9	18.4
Use of V4 for MJ heating	t/h	-	32.3
Total vapour for MJ heating	t/h	65.5	66.5



7. DC HEATERS (Continued)

BENEFITS OF DC HEATERS:

- Low capital cost
- Eliminate juice heater cleaning
- Reduced mixed juice pumping requirement
- Low maintenance
- Ease of control
- Permit intermediate liming without scaling problems



8. LONG TUBE RISING FILM EVAPORATORS

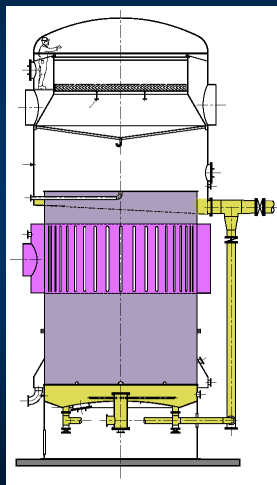
Extensive vapour bleeding requires large 1st and 2nd effect vessels. Our "efficient factory" has 9,000 m² 1st effect. Robert type not ideal for $\geq 4,000$ m² units, so falling film often used.

Falling film evaporators require high recirculation rates – e.g. > 25 litres/cm tube periphery for tubular designs. For 9,000 m², \pm 250 kW of pumping power.

Best solution is long tube rising film evaporators, with integral entrainment separation and un-pumped recirculation.



8. LT RISING FILM EVAPORATORS (Contd.)



BENEFITS of LT EVAPORATORS:

- Low capital cost
- No support structure needed
- Small footprint
- Eliminate pumps
- Low juice retention time - minimises sucrose destruction
- Simple operation



CONCLUSIONS

The integrated Energy & Mass Balance is a powerful tool for optimising factory design.

Examples of modern sugar factory equipment show that energy efficiency can be advanced by simple plant, all with other benefits.

