STATE-OF-THE-ART TECHNOLOGIES IN A STANDALONE SUGAR REFINERY

DURRAH ADVANCED DEVELOPMENT COMPANY, KINGDOM OF SAUDI ARABIA

ISGEC HEAVY ENGINEERING LIMITED, INDIA

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CONCEPT ADOPTED FOR THE REFINERY

Use of injection and sweet water in place of process water for melting of raw sugar.

Adoption of patented IER and BRS technology to minimize chemical / water consumption and effluent generation.

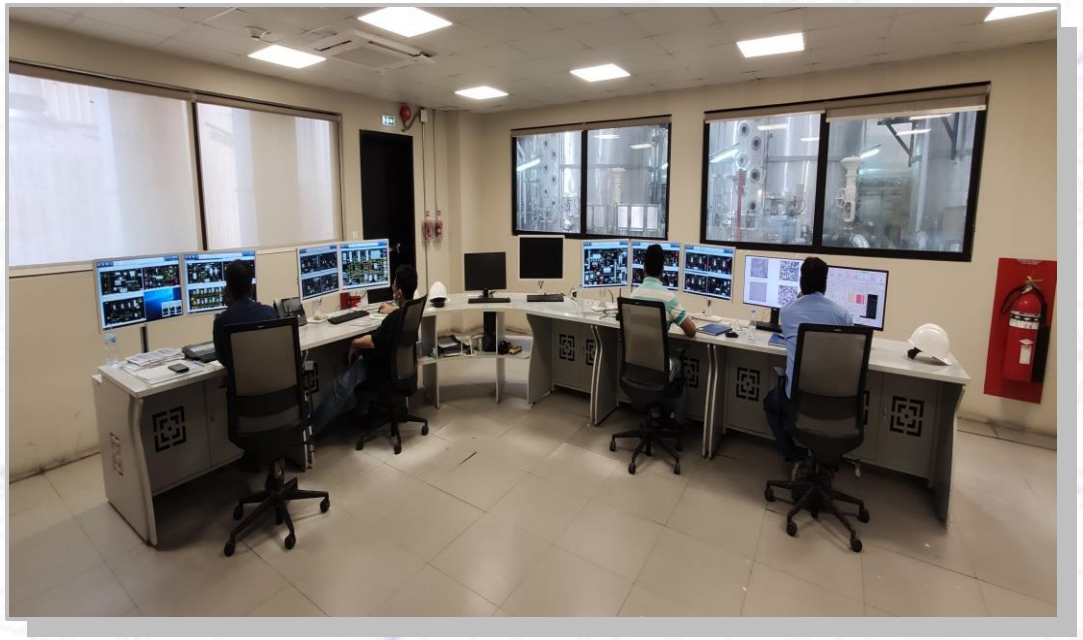
Steam economy through Triple Effect melt concentration along with a liquor-flash system, a condensate-flash system and extensive vapour bleeding arrangement.

Use of Sea water PHE for cooling of injection and utility water to avoid evaporation losses.

Energy saving by using Fuzzy logic Sequence control in batch centrifugal machines and VFD’s.

HIGHLIGHTS OF PLANT

- Port based Standalone Sugar Refinery.
- Refined Sugar output: 2500 TPD of EEC2 grade sugar (<45 IU)
- Yield : > 97.5 % from VHP grade Raw Sugar.
- Clarification Process Adopted : Carbonatation + IER + BRS.
- Colour reduction : > 55% in Carbonatation & > 75% in IER
- Brine recovery : >98 % through NF, RO & Electro Dialysis
- Automated vacuum pan boiling with pan microscope.
- Online Sugar crystal colour & moisture monitoring



STATE OF ART ATTRIBUTES OF PLANT

Fully automated sugar refinery.

Automatic bagging of sugar.

Minimal effluent disposal.

Minimal chemical consumption

Energy efficient plant.

Reduced solid waste disposal.

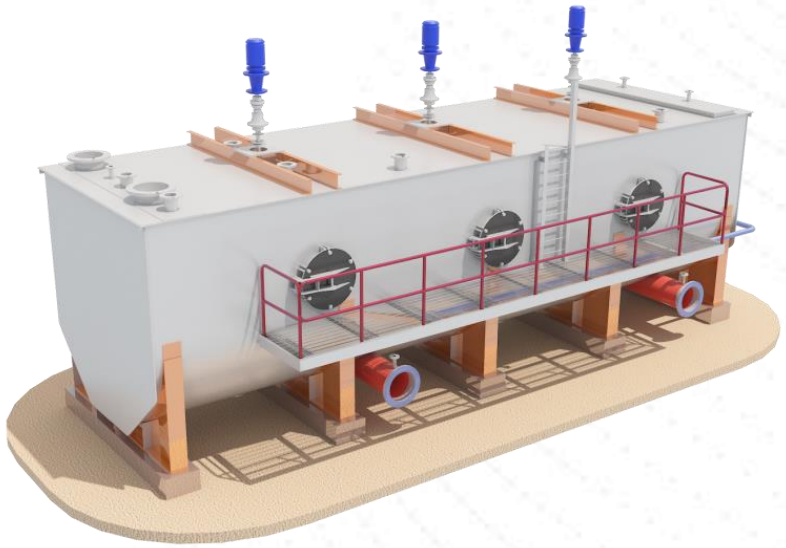
Optimum sea water requirement.

Optimum process water requirement.

RAW SUGAR MINGLING, MELTING, SCREENING & HEATING

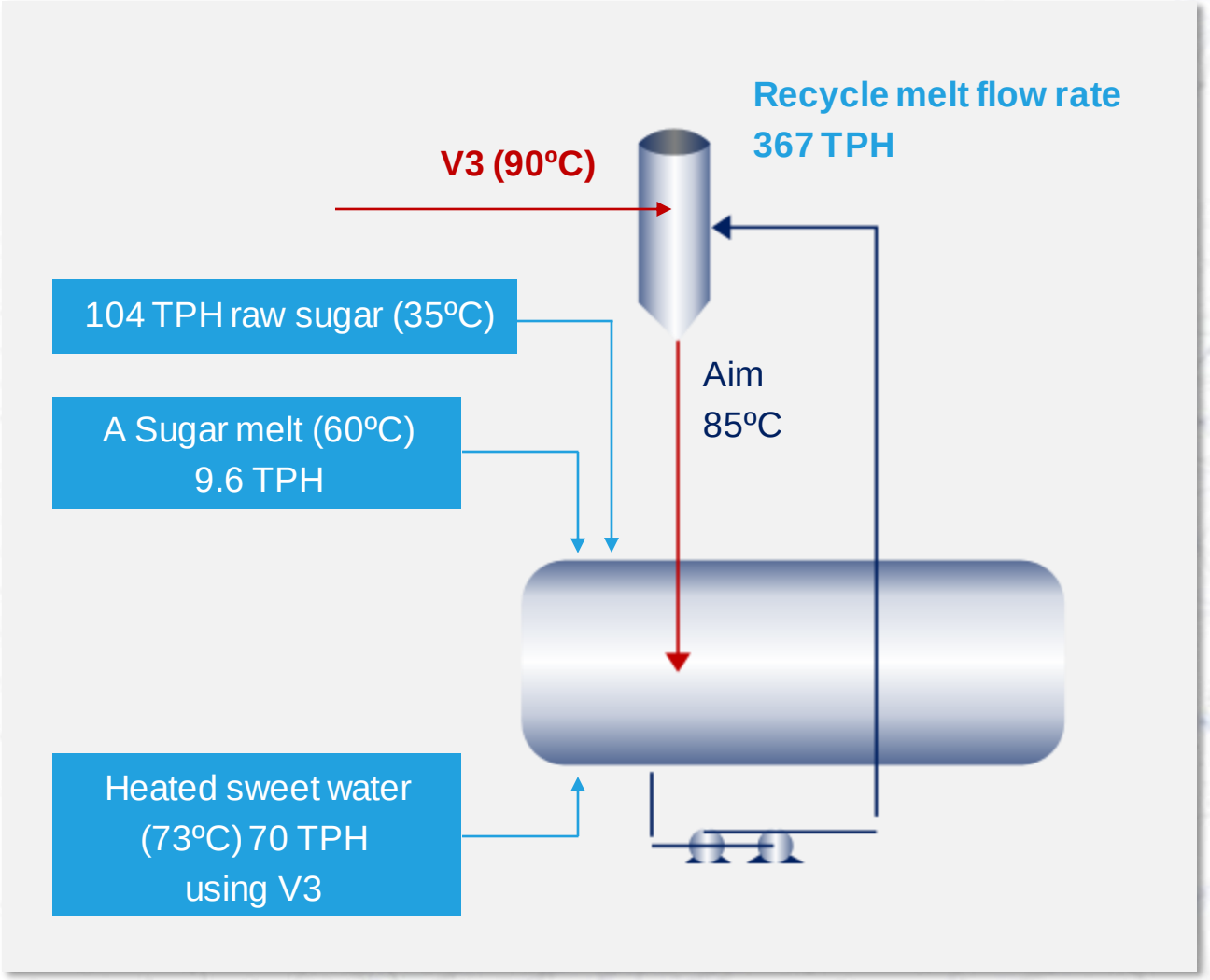
Raw sugar melter

Consists of 3 compartments, each provided with agitators and raw melt recirculation system from 2nd & 3rd compartment through direct contact heaters.



CONT...

- No direct contact of high temperature steam
- Color development only in range of 2-3% which is 5-8% in case of direct use of LP steam
- Efficient screening by rotary screen & low maintenance.
- Use of low pressure vapor for steam economy.



CARBONATATION

Double stage carbonation with Ritcher tubes.

CO_2 from Flue gas by natural gas fired boiler.

Avg. 55 % colour reduction across carbonation @ average 0.854 CaO dose rate % DS on melt

Carbonation efficiency achieved 38%

Colour reduction through carbonatation

Date	Raw melt colour IU	CaO dose rate % DS melt	Filtered liquor colour IU	Colour reduction %
25-05-2021	1654	0.85	850	49
26-05-2021	1591	0.86	701	56
27-05-2021	1547	0.87	729	53
28-05-2021	1566	0.85	668	57
29-05-2021	1579	0.87	658	58
30-05-2021	1614	0.83	705	56
31-05-2021	1533	0.84	595	61
01-06-2021	1523	0.87	728	52
Average	1576	0.854	704	55

CANDLE FILTER WITH RAMP AND CLOTH

- **No. of Filters : 8, Ramp /filter :** 31
- **Filter Area :** 311 m2 each
- Poly propylene filter, cloth used as supporting media

Filtration flux : 0.105 m3/m2/h

PRESS FILTER TO RECOVER SUGAR FROM FILTERED MUD

Filtration area: 199 m2

MELT DE-COLOURIZATION BY ION EXCHANGE COLUMN AND BRS

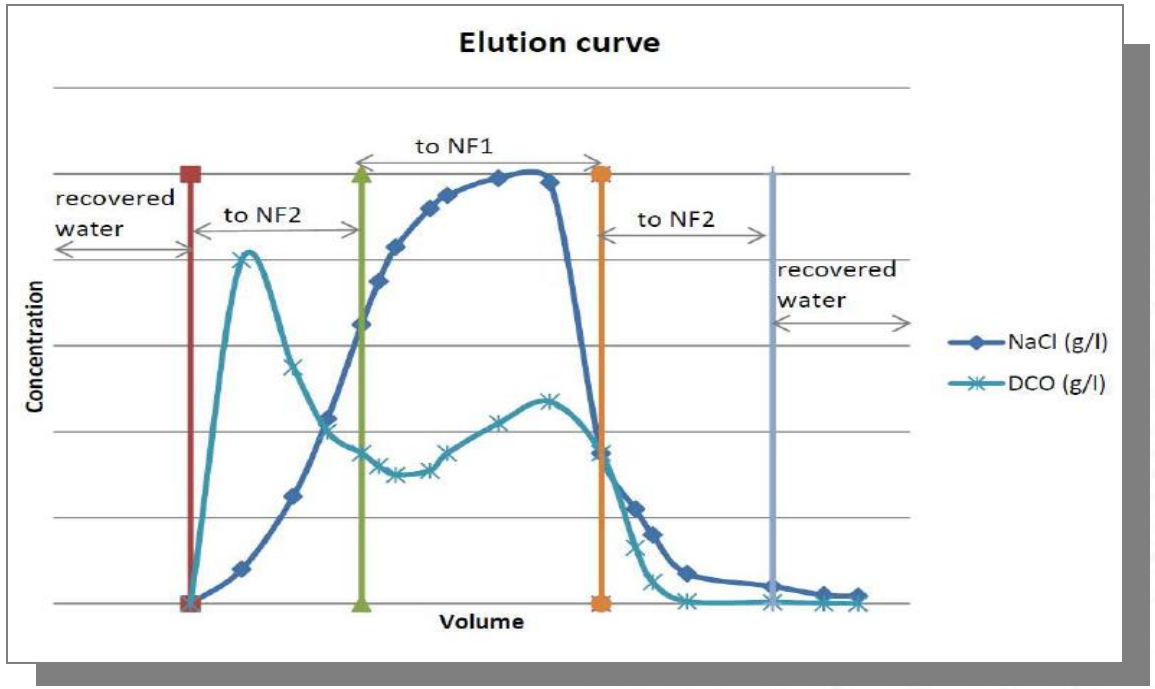
Upward flow, twin bed ER for 75 % colour reduction.

Two-stage nano-filtration: to recover salt in permeate and retain colour in the concentrated stream.

Reverse osmosis: to recover water and separate salt from water.

ED (electro dialysis) : concentration of diluted recovered brine.

Evaporator: to concentrate the nf2 reject and mix with final molasses.



Regeneration elution curve.

IER – Spent acid colour profile

BRS PROCESS FLOW

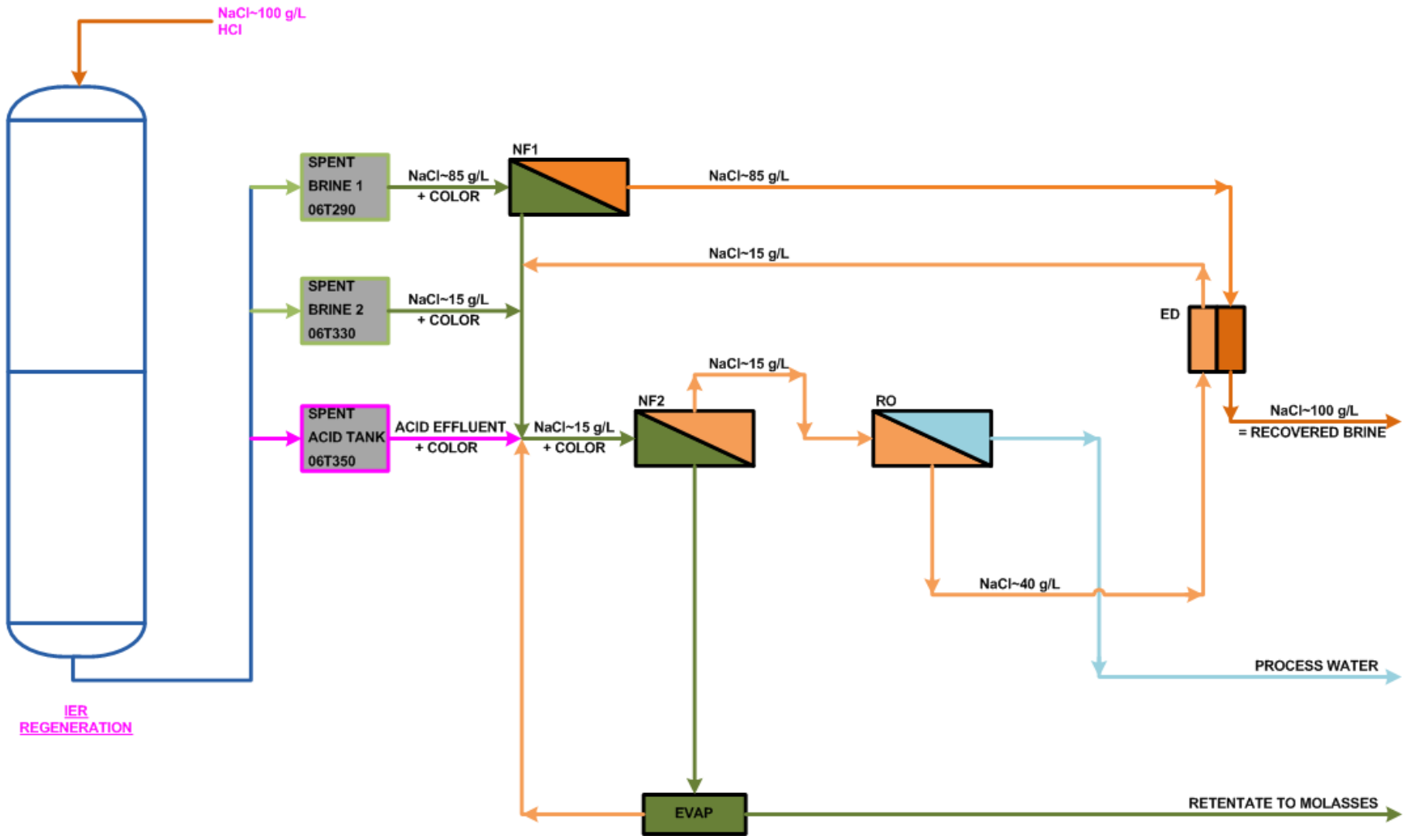
In brine recovery, 80-85 g/L of NaCl is recovered by NF1 from the third fraction of the IER outlet, which again is sent to electrodialysis to increase its concentration to 100 g/L.

NF1 retentate from the third and fourth fraction of the ion exchange column regeneration is further concentrated to 40 g/L of NaCl in the NF2 and RO units.

The final reject from the NF2 unit is sent to the evaporators for concentration and then finally to mix with the final molasses.

The products from NF2 (Permeate) and RO (Retentate) are fed to the ED on the other end to transfer salt from low concentration to higher concentration. The remaining 15 g/L from the counter stream of the ED is sent back to the NF2 feed for further recovery

BRS : PROCESS FLOW



BRINE RECOVERY SYSTEM: NF,RO & ED

BRS SALT RECOVERY COMPARISON

Description	Unit	Others	Durrah
Volume of brine required /column	m3	58	58
Salt concentration in brine	g/L	107	107
Initial fresh salt used in one regeneration	kg	6206	6206
Number of regeneration/day	-	2.5	2.5
Average fresh salt used /day	kg	2320	500
Salt recovery	%	85.05	96.78

TRIPLE EFFECT MELT CONCENTRATOR

- **Avg. Steam Consumption :** 654 kg/kg RSO
- **Avg. Power consumption : 65** kW/T RSO

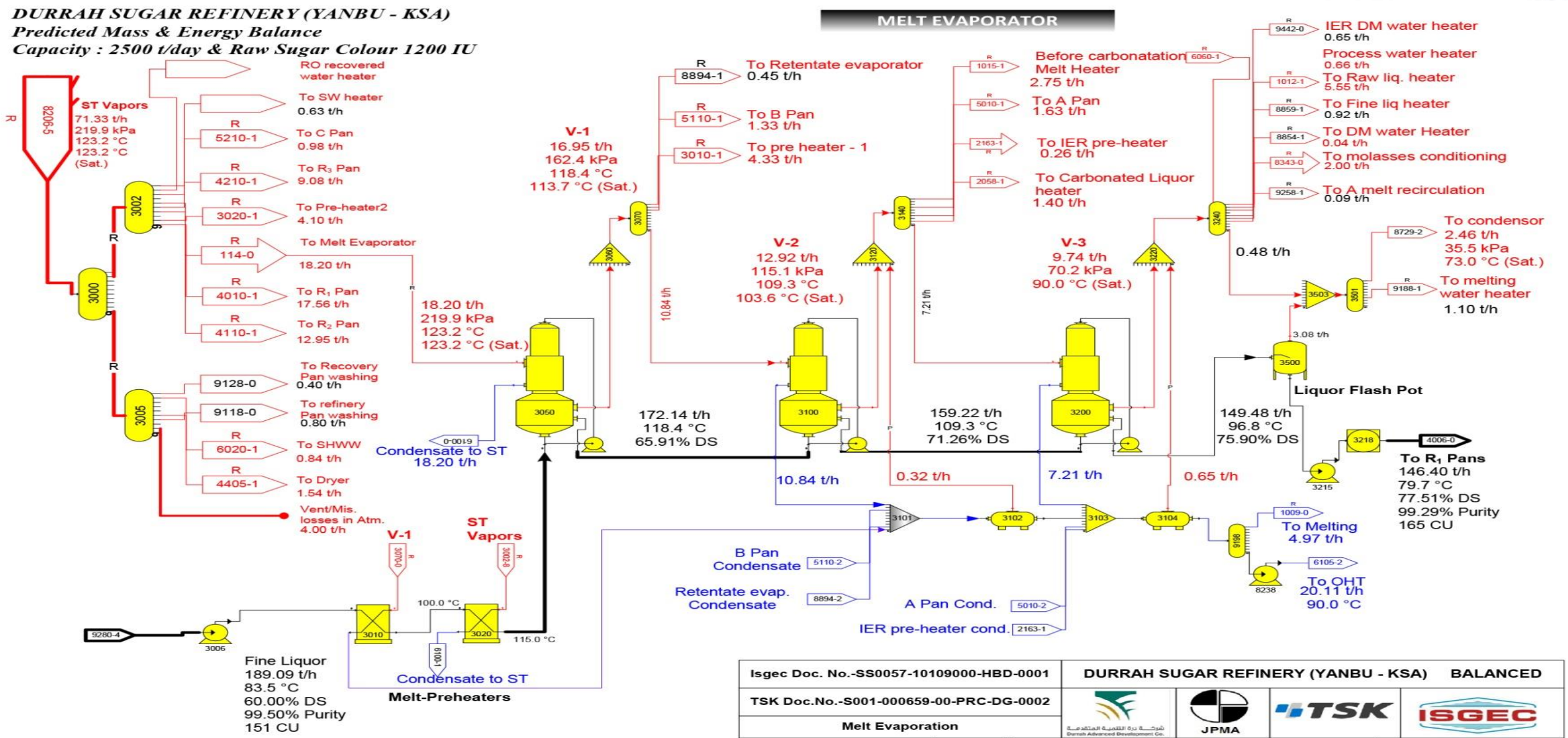
VAPOUR BLEEDING SCHEME

Vapor	Pressure in Kpa/Temp. in ºC	Vapor
ST vapor	219.9 kPa 123.2 oC	• RO recovered water heater • Sweet water heater • R1, R2, R3 & C pans • Melt evaporator-FFE • SHWW heater • Dryer air heater • Melt preheater-2 • Pan washing
V1	161.2 kPa 113.5 ºC	B Pan Retentate evaporators Melt Pre heater-1
V2	114.5 kPa 103.4 ºC	A Pan Screened Raw melt heater Before and After Carbonated melt heaters IER Pre heater
V3	70.2 kPa 90.0 ºC	• IER water heater • Process water heater • Fine liquor heater (FFE) • Raw Liquor heate • A melt recirculation heater • R1,R2,R3, A and B molasses conditioners • Melting water heater

STEAM AND POWER CONSUMPTION DURING OPERATION

Date	Raw sugar t/d	Refined sugar t/d	Steam t/d	Power kW/t RSO	Steam kg/kg RSO
01-11-2021	2478	2357	1551	68	0.658
02-11-2021	2232	2186	1576	73	0.721
03-11-2021	2616	2514	1595	68	0.634
04-11-2021	2361	2293	1435	73	0.626
05-11-2021	2408	2372	1471	67	0.620
06-11-2021	2681	2626	1567	68	0.597
07-11-2021	2480	2298	1515	73	0.659
08-11-2021	2326	2193	1504	74	0.686
09-11-2021	2161	2419	1490	67	0.616
10-11-2021	2299	2189	1576	73	0.720
Average	2404	2345	1528	70	0.654

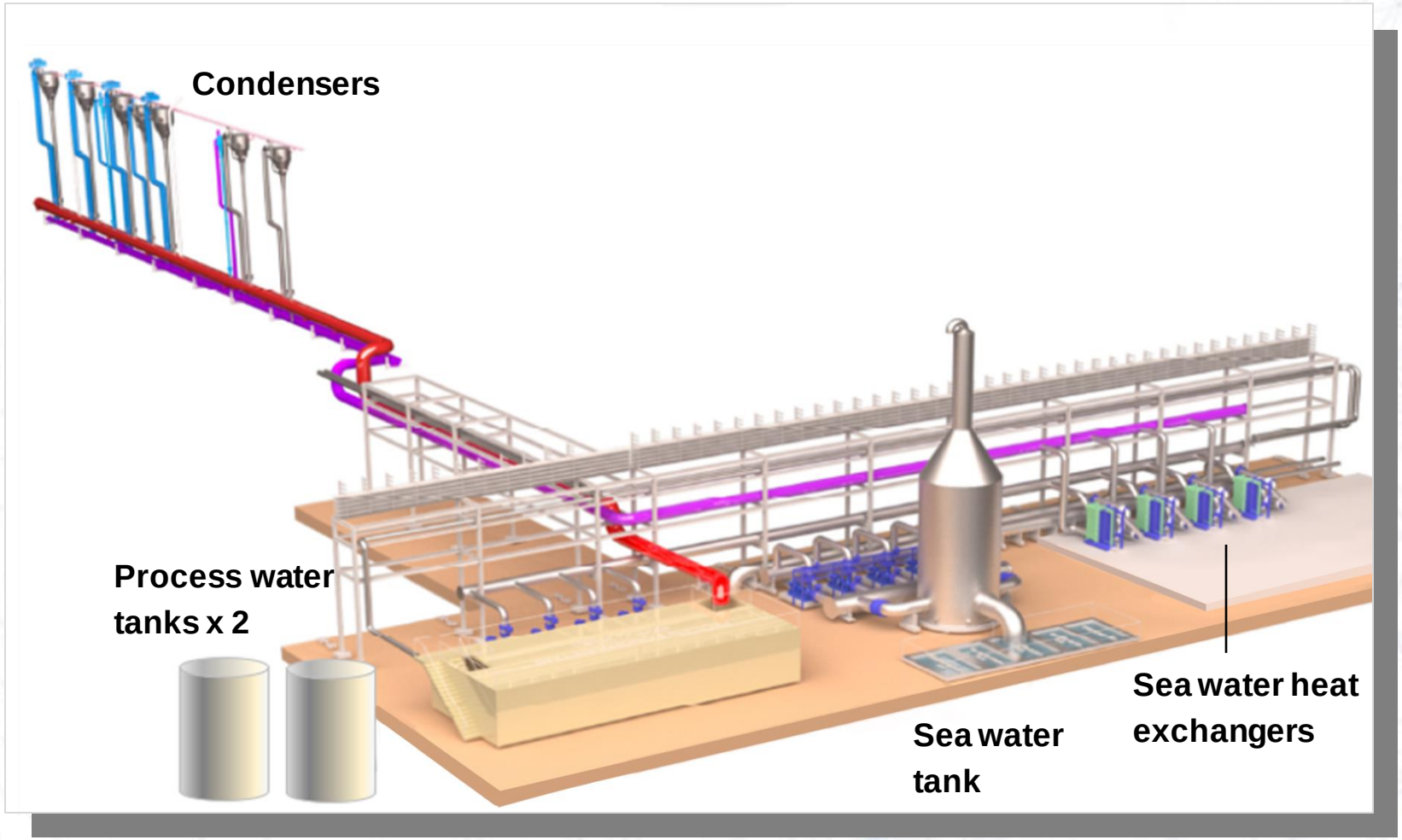
VAPOR BLEEDING SCHEME



COOLING WATER CIRCUIT

Sea water : To cool the injection water & utility water in closed loop via PHE.

Using hot injection water for melting of raw sugar and sugar dust.

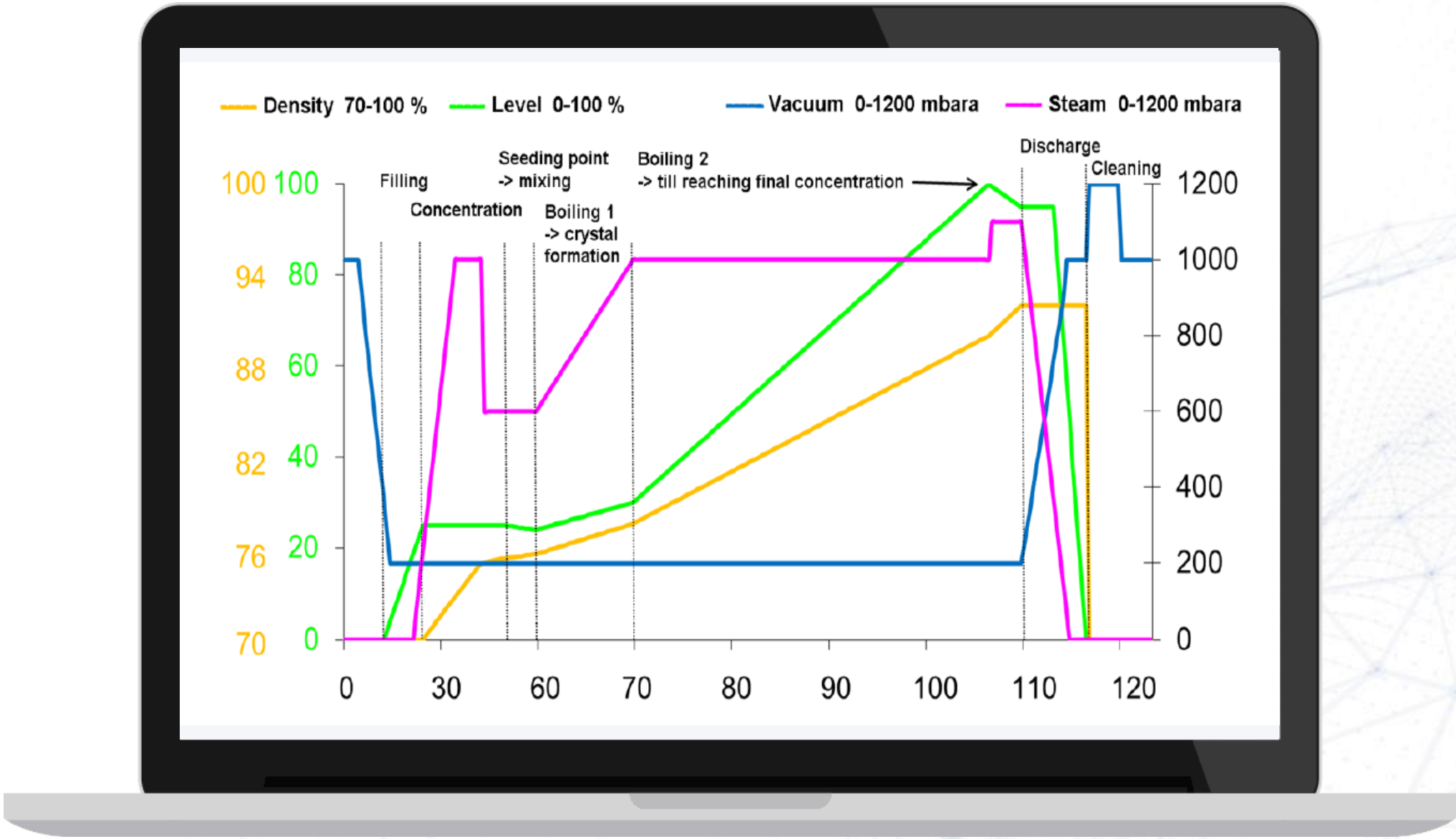


AUTOMATIC VACUUM PAN BOILING

- High crystal yield with minimum variation in CV
- Less fluctuation of vapour load
- Other loops used include vacuum control, pressure control, level control, mechanical circulator variable speed control (see Figure 11 for typical operation parameters).
- Apart from the automation, liquor preheating on direct contact heaters was implemented using V3 vapour which is kept free from the remaining sugar crystal fines from the centrifugals.
- At the sugar-boiling stage, online crystal growth measurement is performed using a pan microscope coupled to a high-resolution digital camera mounted in front of a sight glass on the pan wall
- A controlled and adaptive powerful LED light source illuminates the crystals moving inside the pan behind the sight glass in front of the microscope and its rugged camera.

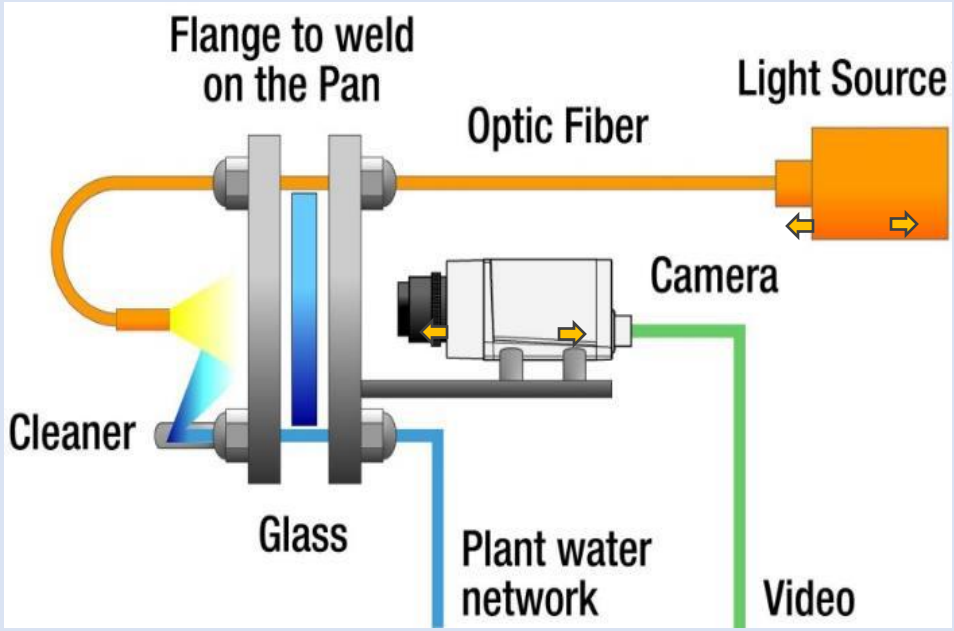
- Very sharp images of the crystals are continuously sent to a computer in control room where the dedicated software applies specific algorithms to each image and calculates, among other parameters, the coefficient of variation (CV) and the mean aperture (MA) of the crystals in real time.

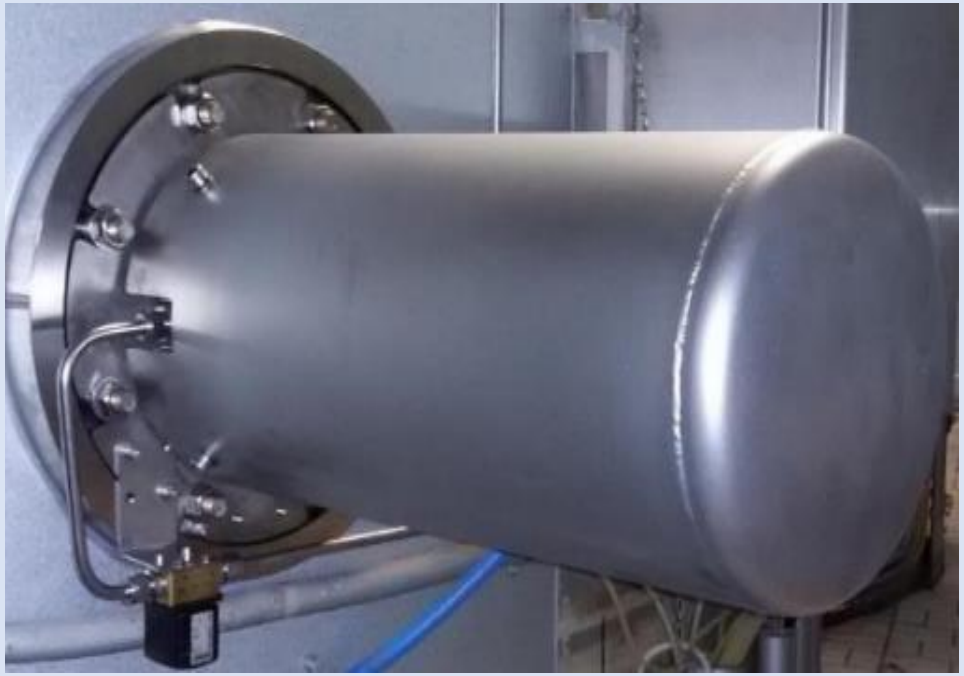
PAN BOILING CURVE



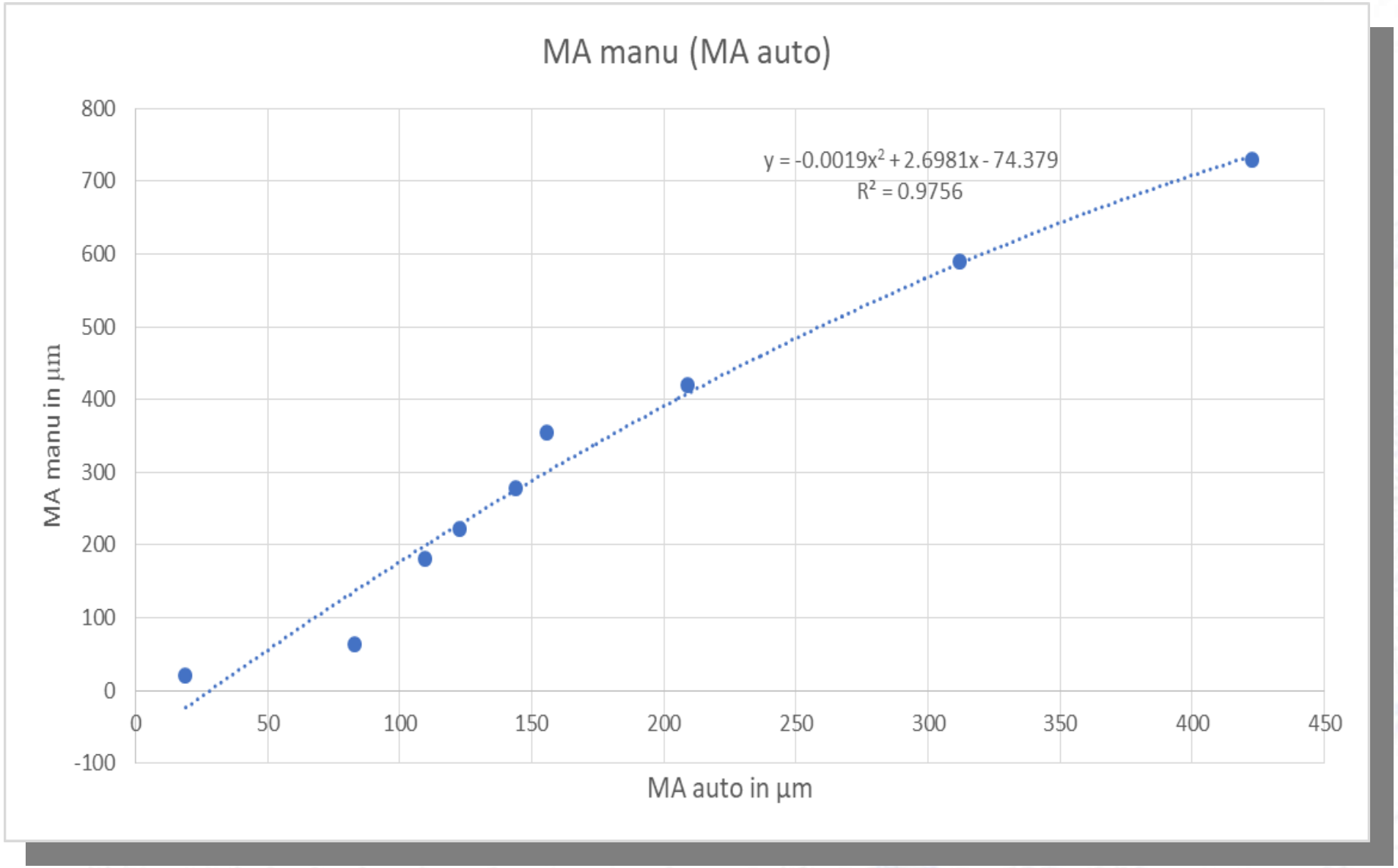
CRYSTALLOSCOPE: CRYSTOBSERVER

- Crystal growth monitoring by using a pan microscope
- Provide real time statistical information (CV, MA, fines, etc.)
- Record Video sequence of all strikes.
- Possible to compare different strike video & key parameters.





MA MEASUREMENT BY PAN MICROSCOPE



CENTRIFUGATION STATION

Intelligent feed control (DynFAS-FS): based on a strike receiver level for optimum filling of massecuite in the basket.

Fully automated batch machines: 1810kg/charge.

Improved syrup separation system.

Mono-axial discharger: Discharge time only 18-20 sec.

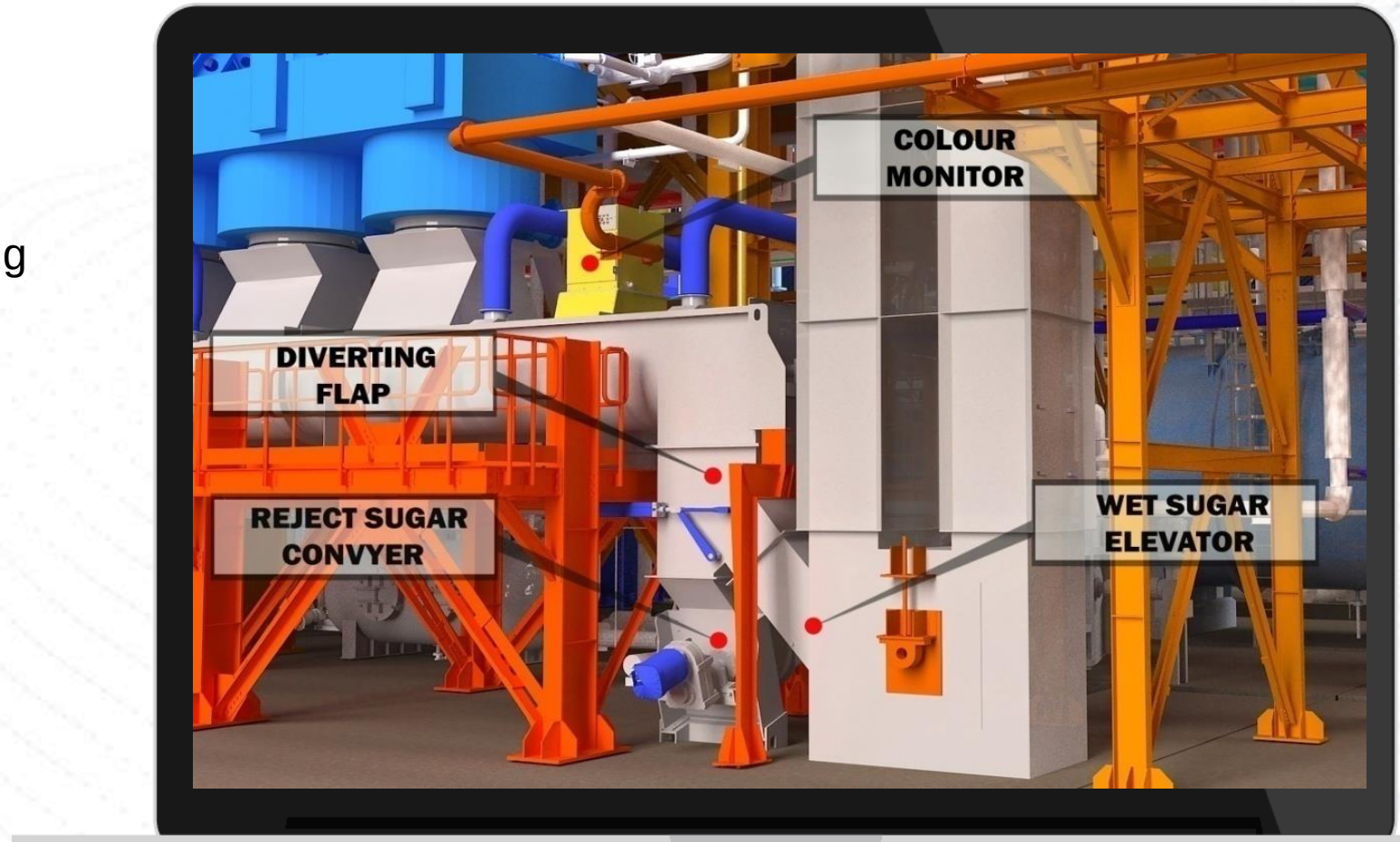
Cycles/hour:>24

SEQUENCE CONTROL FOR BATCH SUGAR CENTRIFUGAL MACHINE

ISGEC

COLOUR MONITOR : COLOBSERVER

- Online colour monitoring system for refined sugar.
- Continuous colour monitoring and automatic rejection of “off-spec” sugar.
- Wash water timer adjustment based on input.



SUGAR DRYING AND COOLING STATION

Cascade Rotary Sugar Dryer: **105 TPH**

Drying air Blower : **60000 kg/h**.

Static Fluidized Bed dryer :**105 TPH**.

Cooling air blower : **40000 kg/h**.

Chillers : **5 x 391 kW**

Description	Sugar temperature °C	Air temperature °C	Air temperature °C
Chillers inlet	-	-	10
Chillers out	-	-	5
Dryer	33-35	75-98	-
FBC inlet	50-55	22-23	20
FBC Outlet	33-35	40-45	25

SUGAR CONDITIONING SILO

Sugar conditioning silo : **40,000 tons**.

Diameter : **55 meter** and height **40 meter**.

Designed air flow : **12,000 m3/h.**

Process:

The conditioning process consists of three phases: (a) The preheating, (b) filling and (c) post-conditioning phase, which are described as follows:

Preheating Phase: Before filling sugar in the silo it is heated up to approx. 30°C for 2 to 3 days with conditioned air.

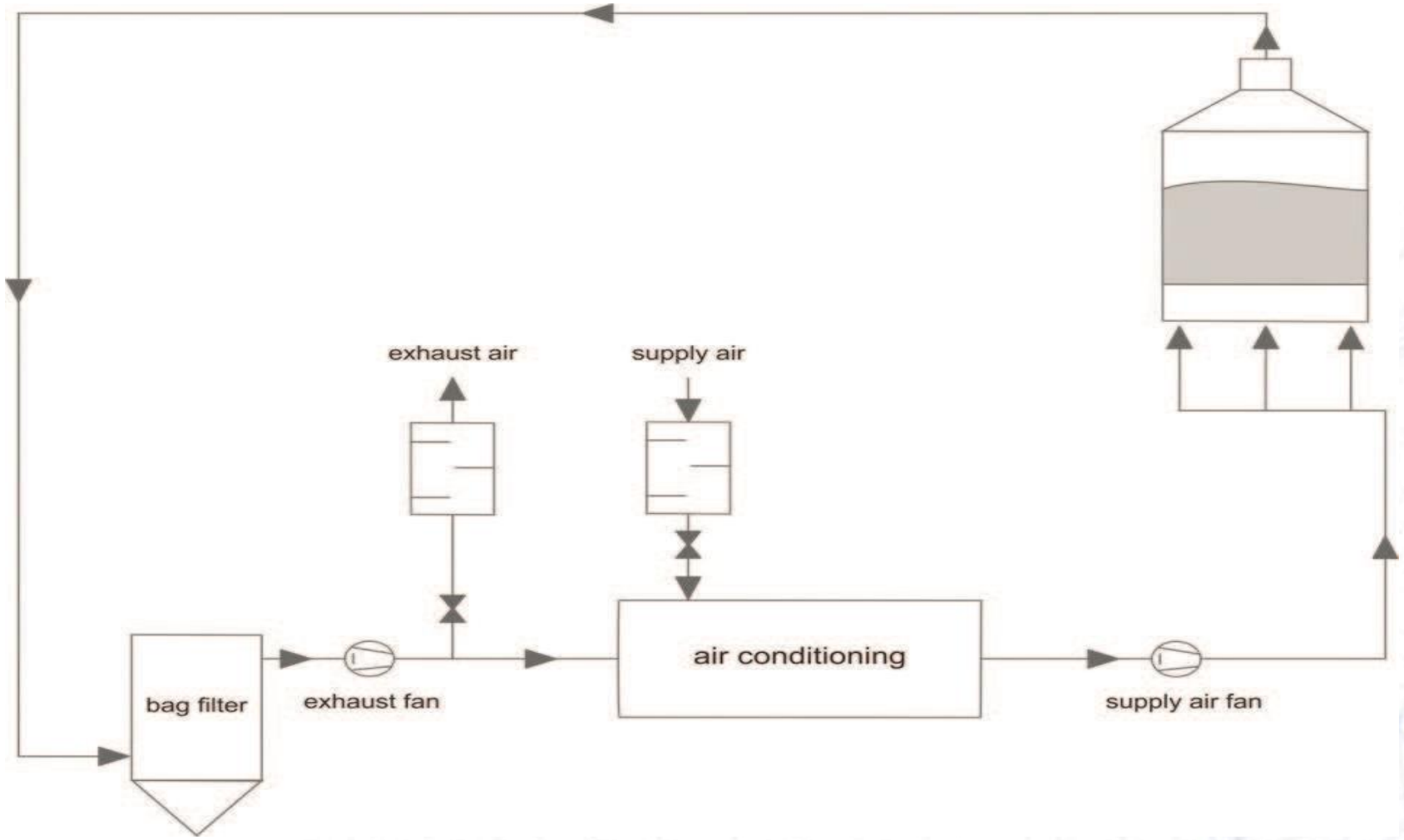
b. Filling phase: During the filling phase the silo air should have a temperature of approx. 25–30°C and a relative humidity of approx. 30%. In this phase the circulating air volume should be regulated by adjusting the fan speed.

c. Post-conditioning phase:

- The silo should be regularly ventilated.
- Attention should be paid to the relative humidity in the silo.
- To minimize risk of static discharges, the relative humidity should not be too low.
- To maintain the flavour of sugar at least 10% of circulated air

(Figure 16) is replaced by fresh air independent of any weather condition.

SKETCH DIAGRAM OF SUGAR CONDITIONING SILO PROCESS



SUGAR CONDITIONING SILO

RESULTS ACHIEVED

Particulars	Detail	UOM	Average
Refined Sugar ouput (RSO)	Excluding stoppage	RSO	2559.04
Final Sugar	Pol	%	99.95
	Moisture	%	0.03
	Ash	%	0.009
	Crystal size	mm	0.60
	Color	IU	<35
Yield	@ 99.0 % raw sugar pol	%	> 97.3
Chemical consumption	CaO @ 91.2 Purity	% DS Melt	0.84
	HCL 33 % purity	L/day	677
	NaOH 49 % purity	L/day	496
	NaCl 99.3 % purity	Kgs/day	846
Steam	Generation	TPD kg/T RSO	1432 655
Sea Water	Inlet temperature	0C	29.4
	Outlet temperature	0C	37.1
Effluent generation from process plant	Flow rate	m3/T RSO	0.15
Power	Consumption	kw/T RSO	65-70

CONCLUSION

- Plant has performed PG test with max Refined Sugar out put 2643 TPD
- With the adoption of the latest technologies in sugar refineries, bottom line can be improved with.
- Optimal use of consumables like fuel, process water, sea water & chemicals.
- Minimum impact the environment by reducing the effluent generation.

Thank You!