Enhancing Energy Efficiency of sugar plant operation

Date: 10th September 2024

HICC, Hyderabad

Overview of Indian Sugar Industry

- Sugar Industry is one of the most energy-intensive industries in the country.
- Average operational days – 150 days/annum
- India has around 534 sugar mill in operation with different capacity ranging from 600 TCD to 20,000 TCD.
- Sugar Industry utilizes both Steam and electricity produced from bagasse fired cogeneration plants for its operation.
- Installed cogeneration capacity is ~8 GW.

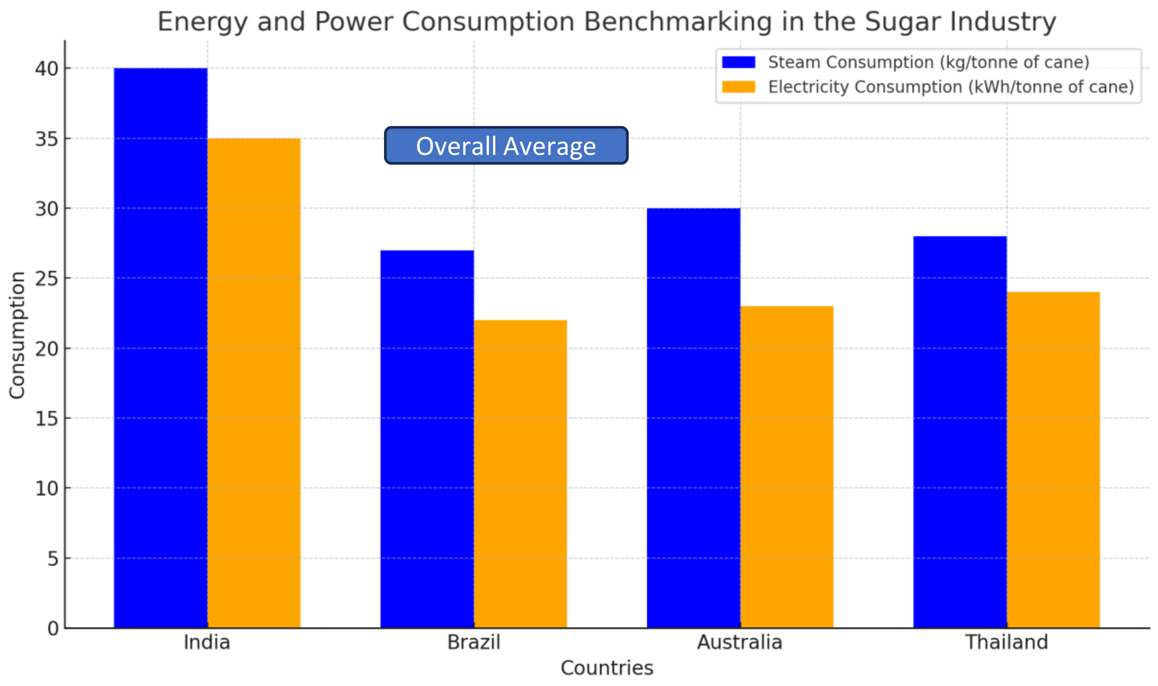
Modern Sugar Industry

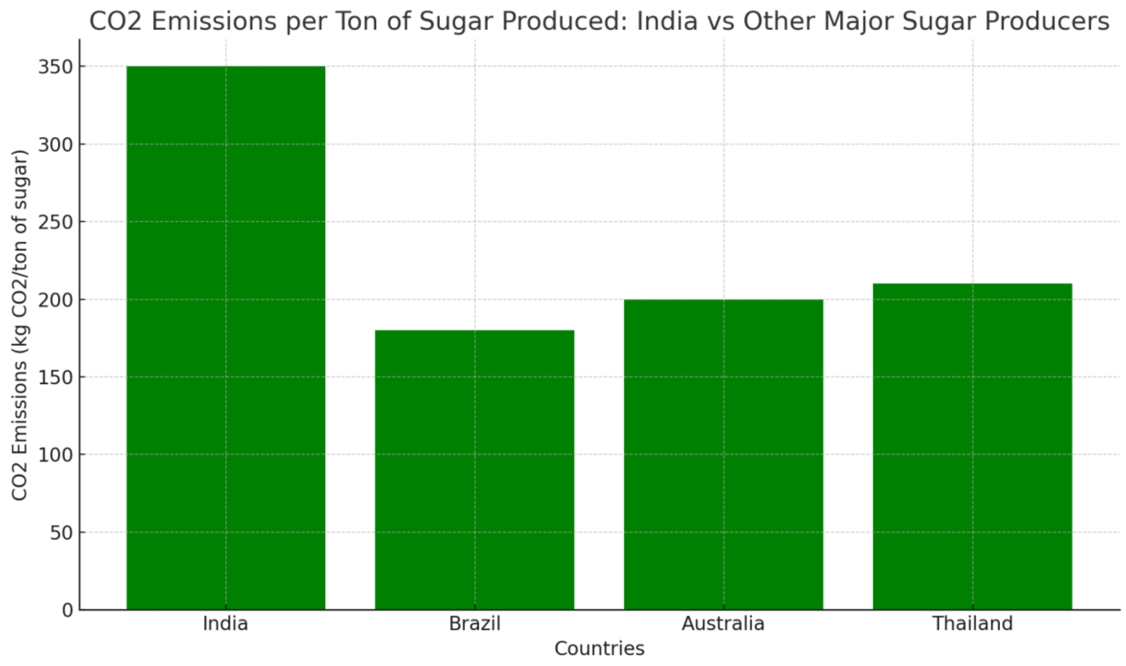
Indian sugar industry, traditionally focused on sugar production, is increasingly diversifying into various value-added products and by-products.

1 Ton of cane crushed produces

- 100 kg of sugar
- 300 kg of bagasse
  - 660 kg of steam
  - 105 kWh of electricity
- 40 kg of Molasses
  - 10 Ltr of Bio-Ethanol
- 30 kg of Press mud
  - CBG
  - Bio-compost
- Excess bagasse
  - 2G Ethanol
  - Bio-Plastics

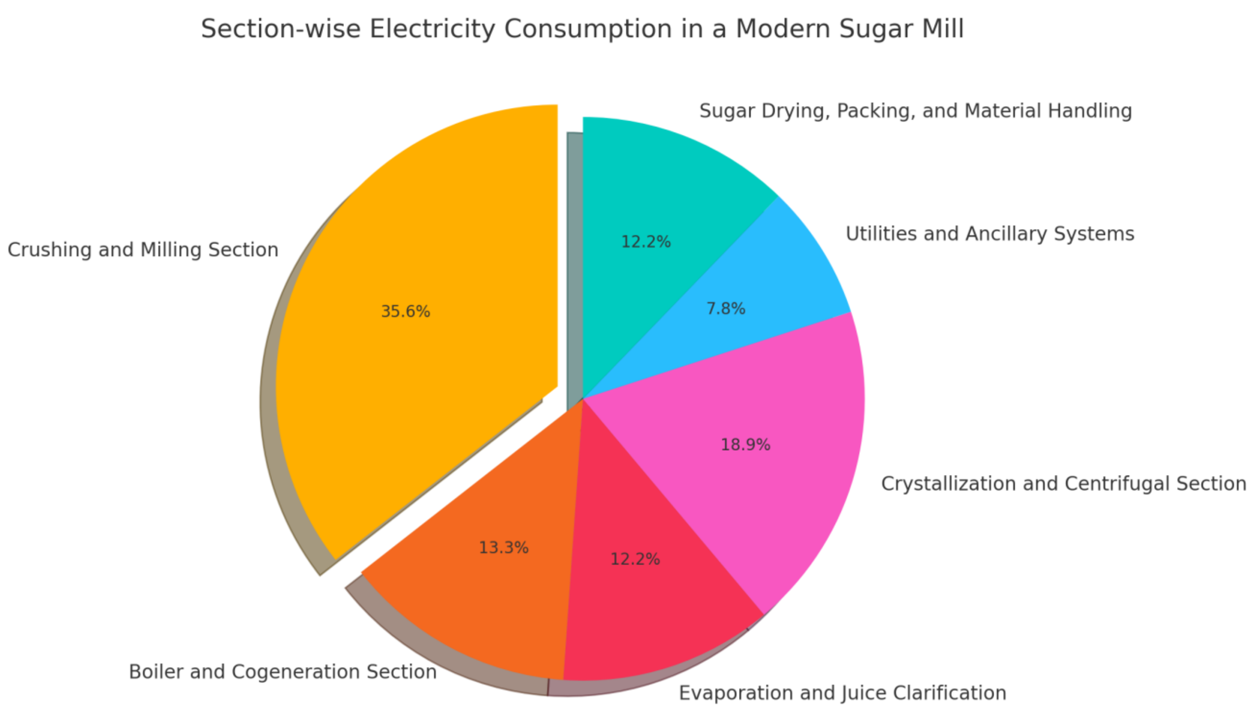
Sugar Industry Benchmarking

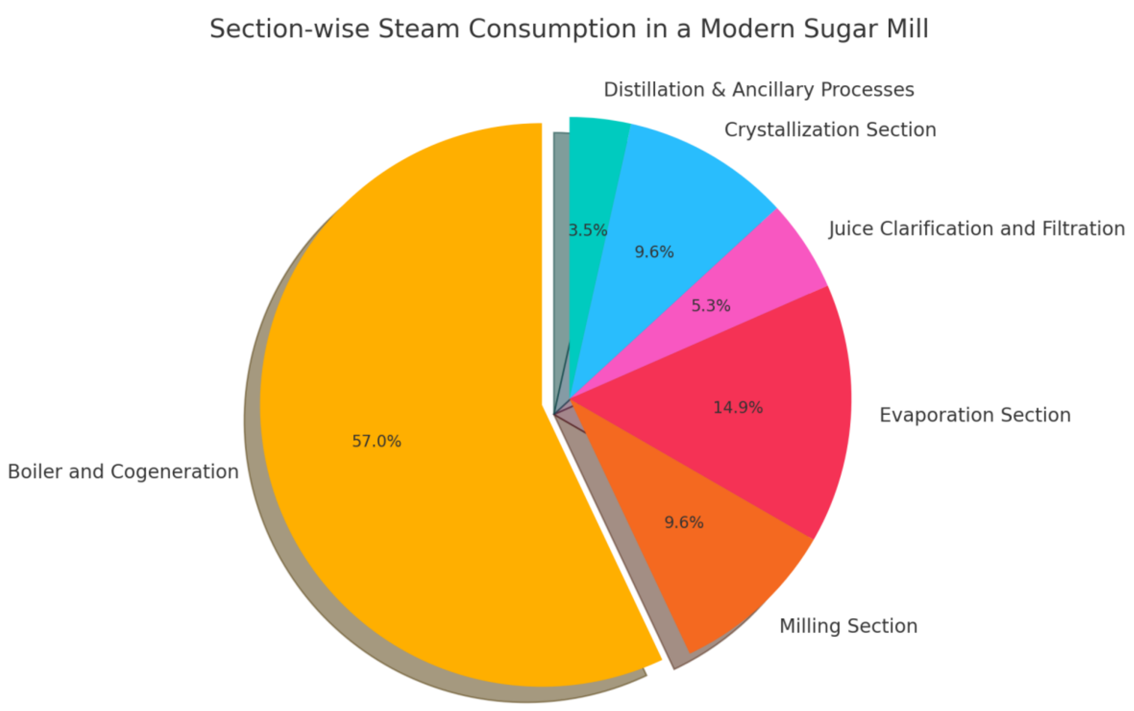




Source: ISMA, UNICA, IEA, FAO, GSA

Section wise Electricity & Steam consumption break-up





Need for Energy Management in Indian Sugar Industry

- Sugar Industry considered as energy intensive sector and soon to be notified under PAT Scheme
  - Baseline study completed in 193 industries from Uttar Pradesh, Maharashtra, Tamil Nadu, Karnataka
  - 10,000 Toe is the threshold level of annual energy consumption for each sugar plant
  - Annual energy consumption of sugar industry is about 20.28 Million MTOE
- Energy efficiency in Indian sugar industry is less than other major sugar producing countries.
- Improving energy efficiency
  - Helps to minimise the sugar production cost
  - Make Indian sugar industry globally competitive
- The carbon emission is much higher in only sugar producing scenarios (622 to 834 kg $CO_{2\text{-}eq}$/MT) than the both sugar and surplus electricity production scenarios (324 and 410 kg $CO_{2\text{-}eq}$/MT)
- Water consumption
  - for electricity production - 209–354 m^3/MWh and
  - sugar production with cogen - 768 – 1040 m^3/MT ,
  - 1458 – 2097 m^3/MT (Only sugar and no Cogen)

The Indian sugar industry offers good potential for energy saving.
The estimated energy saving potential in the Indian sugar industry is about 20%.
*This offers potential of about 650 MW of electrical energy – **NSI**.*

Cogeneration and Steam Optimization

- Cogeneration and Steam Optimization
  - Most of the sugar factories in India, cogeneration units work at very low cycle efficiency.
  - Moisture content of bagasse – important factor for improving pressure and temperature
  - Moisture of bagasse is to be brought down to as low as possible by use of waste heat going out of chimney – using Bagasse Dryer
  - The increased pressure allows for surplus power generation, which can be exported to the grid, contributing to both energy efficiency and renewable energy initiatives.

Boiler Pressure, ata	Cane crushed/hr, MT	Bagasse produced, MT	Steam Produced, MT	Power Potential, MW	Power plant Efficiency, %
67	1	0.3	0.7	0.14	18%
87	1	0.3	0.7	0.17	21%
110	1	0.3	0.7	0.20	24%
125	1	0.3	0.81	0.23	29%
140	1	0.3	0.84	0.28	35%
160	1	0.3	0.87	0.32	40%
225	1	0.3	0.96	0.40	50%

Highest cogeneration (cogen) boiler pressure used in India is typically around **140 ATA (Atmospheres) -** in modern high-efficiency cogeneration plants in the sugar industry.

Source: Bio-Energy from Indian Sugar Industry: A Sustainable Renewable Energy Future (ijert.org)

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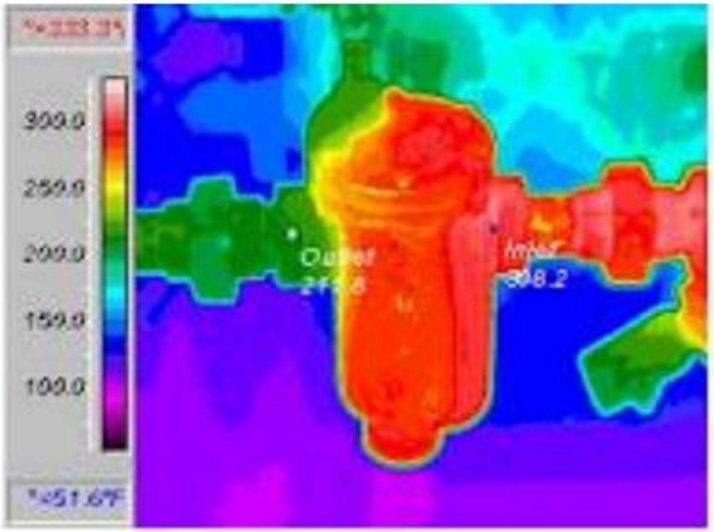
Steam Distribution and leakages

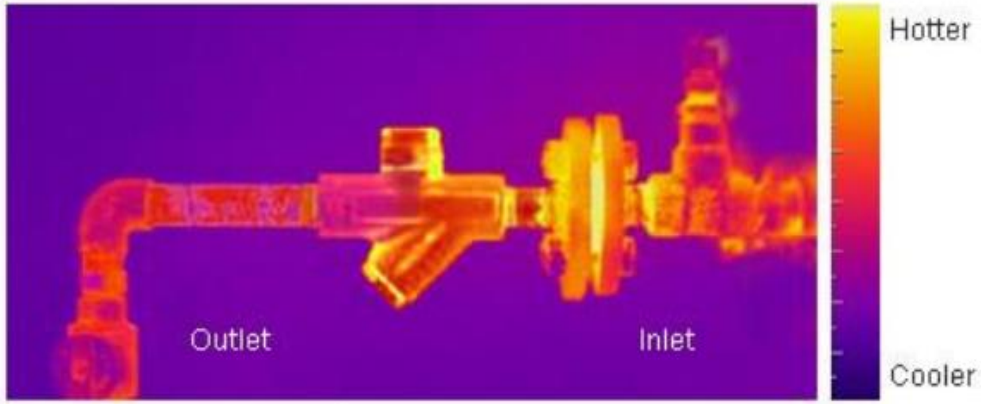
Properly operating Steam Trap



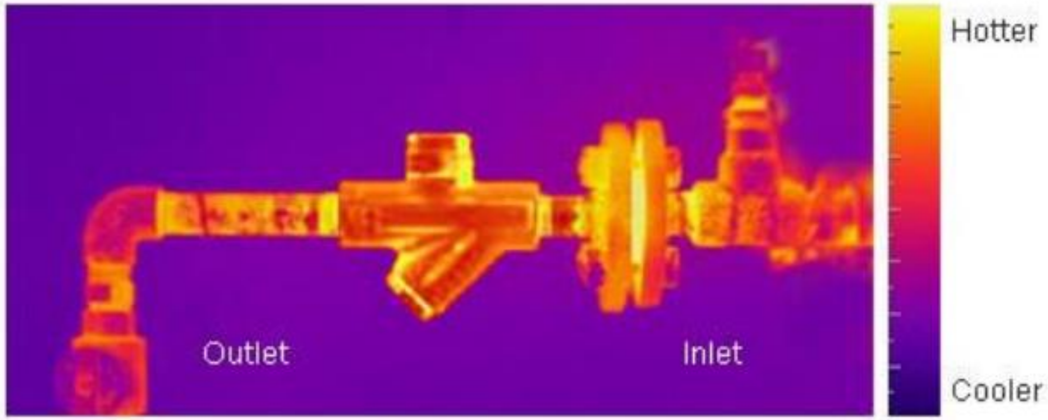
- 100-500 traps per plant (>2000 in refineries)
- Distributed throughout the plant
- Manual testing done on each trap once in few months in the best case

On average 10-20% of traps fail each year

Steam Distribution and leakages



Well functioning trap



Leaking trap

Orifice size (in)	Steam lost (kg/month)	INR Loss per month	Water loss per month (lit)
1/16”	6033	16,892	6,636
1/8”	**23678**	**66,297**	**26,045**
1/4"	94801	265,442	104,281
1/2"	377842	1,057,958	415,626

- **Average of 0.5 – 2 Lakh INR per month lost per leaking trap**
- **75,000 liters lost on average per month per leaking trap**

Steam Distribution and leakages

STIMS – continuous realtime monitoring of steam traps

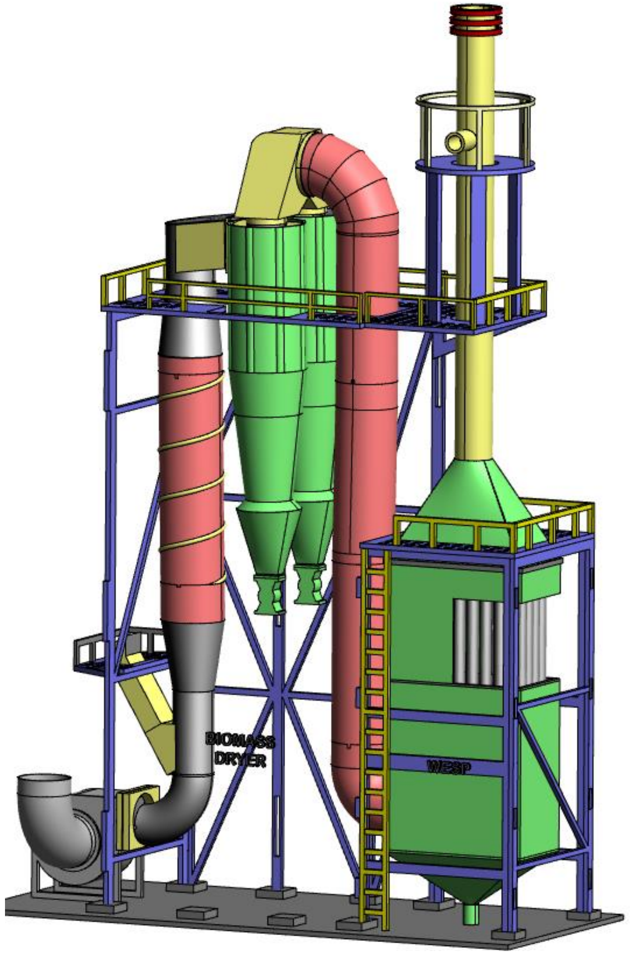
1 Thermocouples on inlet and outlet of each steam-trap (non-invasive)

2 Ultra-low-power , high-range IoT devices continuously monitor the parameters

3 Send data 4 times per hour – wirelessly. Algorithms will determine health of trap

Bagasse Dryer

- Benefits
  - Flue gas cleaning with Bagasse Drying (<40% moisture)
  - Revenue Generation through bagasse saving
  - Smaller footprints & Compact lay-out
  - Capability to reduce emissions 99.5 %
  - Significant GHG Emission reduction [offset)
  - Low Power consumption
  - Substantial Control on aerosols



A typical 20 MW Cogen installed with Bagasse Dryer

Additional energy produced 1.2 – 1.5 MWh

Reduction Particulate emission 10 – 50 mg/Nm3

Overall emissions reduction -1000 – 1350 tCO2/m

Good Replication potential in Indian Sugar Industry - Additional clean green energy – 2200 MW

Source:Enviropol Engineers (P) Ltd

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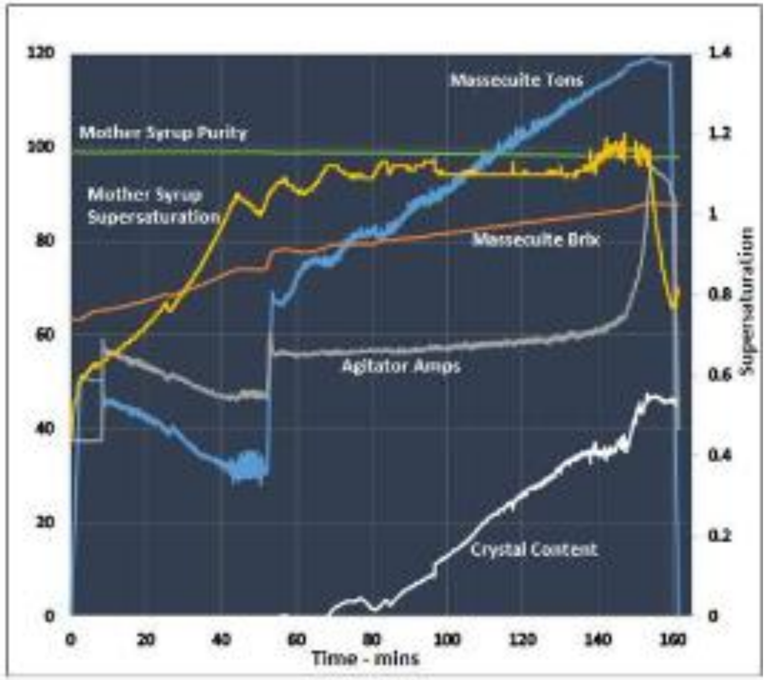
Sugar factory automation and optimization

- Technologies available for process optimization
  - AI/ML
  - Optimal tuning of PID controller
  - Digital twin solutions for optimizing crystallization process
- Automation helps to
  - visualize, control and optimize the process operations
  - Lowering energy consumption
  - Improving quality
  - Reducing inventory cost



Source: IPRO India - Pan Automation

Process Optimization using PID control loops

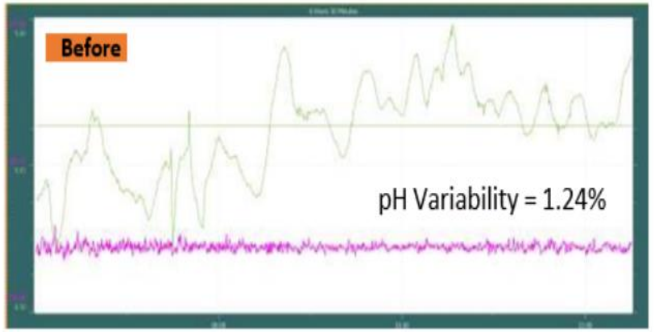
- Shock lime pH optimisation – by using Feed Forward logic
- FD fan and PA fan optimisation
- Gland Steam Temperature optimisation
- Boiler Efficiency Monitoring Tool

- By controlling the variability of process parameters through PID control loop logic several benefits are possible
  - Savings in Additives
  - Process quality improvement
  - Energy savings
  - Steam Savings
  - Fuel savings

Source:AKXA Tech pvt Ltd.

Process Optimization using PID control loops

Shock lime pH optimization, by using Feed Forward logic



Results:

pH Controller variability reduced from 1.24% to 0.45%.

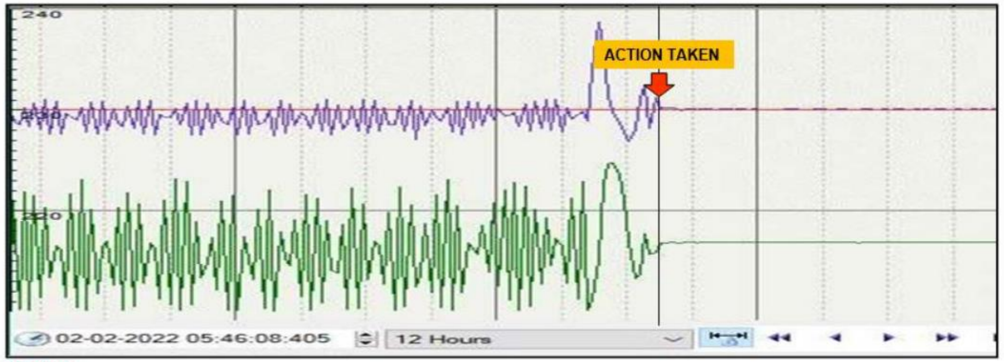
Benefits: Implementation of logic impacts in Purity of juice from 40.0 to 42.50% which affects the brightness of sugar.

Saving in Lime consumption by 0.008 % of cane. Which is equivalent to reduction of 3.9% Lime consumption per day.

Gland Steam Temperature Optimization

PROBLEM : Controlling of Gland Steam Temperature Variation.

ACTION : Optimizing the Controller Loop Settings.



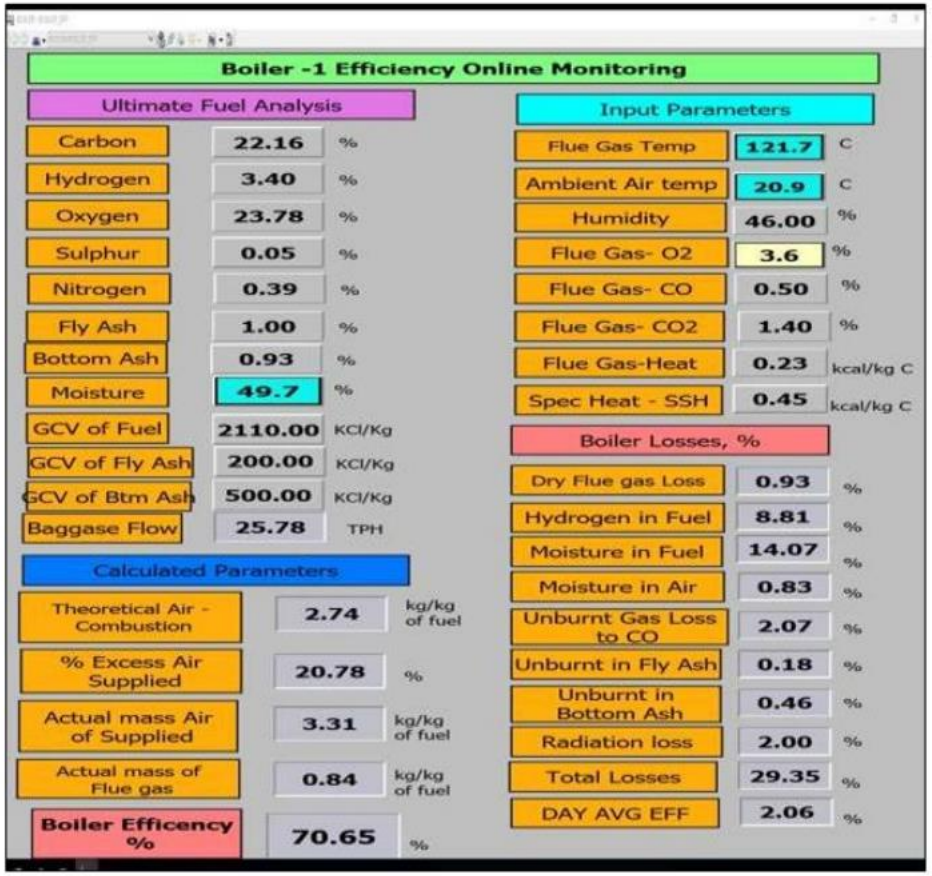
RESULT :

- After Tuning Temperature variations have drastically reduced from +/- 4°C to +/- 1°C.
- Resulted in Zero Alarms in DCS due to reduction in temperature variations.

Source:AKXA Tech pvt Ltd.

Sugar Cogen Plant – Boiler Efficiency Monitoring Tool

Online "Boiler Efficiency Monitoring Tool" at 7500 TCPD sugar plant



- Features :
  - Helps to identify the parameters which are affecting the Boiler efficiency.
  - Helps to minimize or control the energy losses

Source:AKXA Tech pvt Ltd.

Mechanical Vapor Recompression (MVR)

- MVR involves compressing vapor to a high pressure and temperature using a mechanical compressor
  - Can be used to heat the process fluid which generated more vapor
  - It allows continuous energy recovery
  - commonly used in industrial processes such as evaporation and distillation.
  - Very effective in sugar industries
  - Several Indian sugar mills have integrated MVR technology into their operations, particularly focusing on reducing energy costs associated with evaporation

Implementation of MVR led to energy savings of over 30% compared to conventional evaporation systems

Can recover and recycle >97% of water used for process

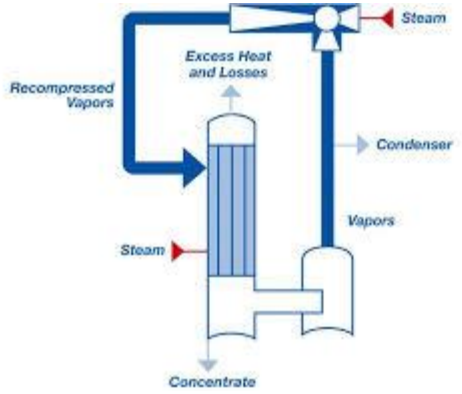
Lowers GHG emissions, contributing to a smaller carbon footprint

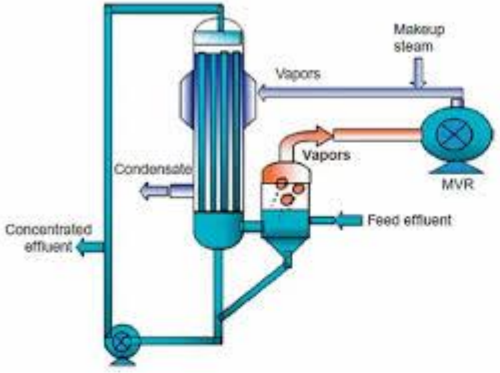
Source:Mechanical Vapor Recompression, MVR, Evaporative Concentration

Mechanical Vapor Recompression (MVR)

- Comparison of Thermal Recompression and Mechanical Vapor recompression

Feature	Thermal Vapor Recompression (TVR)	Mechanical Vapor Recompression (MVR)
Working Principle	Uses motive steam in a steam ejector to compress vapor. No mechanical moving parts.	Uses mechanical energy (compressor/blower) to increase vapor pressure and temperature.
Energy Source	High-pressure steam	Electrical energy
Efficiency	Lower efficiency due to steam consumption.	High efficiency as most vapor is recycled with minimal external energy.
Capital Costs	Lower initial capital costs due to simpler design (no moving parts).	Higher capital costs due to mechanical equipment like compressors.
Operating Costs	Higher operating costs if steam is expensive.	Lower operating costs due to higher energy efficiency, especially if electricity is cheaper than steam.
Maintenance	Minimal maintenance (no moving parts).	Regular maintenance of mechanical components (compressors/blowers).
Application Suitability	Suitable for processes with abundant and cheap steam, small-scale systems.	Ideal for processes requiring energy efficiency, such as large-scale evaporation and desalination.





Source:[Mechanical Vapor Recompression, MVR, Evaporative Concentration]

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Mechanical Vapor Recompression (MVR)

Sugar industry can benefit from MVR technology in a number of ways

Economic Advantages

- Fuel consumption is significantly reduced by this energy-efficient process, which directly benefits the sugar industry

Quality Improvement

- minimizes exposure to high temperatures, which keeps sugar from caramelizing and degrading and guarantees a higher-quality product.

Environmental Sustainability

- Significantly reduces water (Closed loop system) usage and GHG emissions

Production Efficiency

- It improves the stages of concentration and crystallization in the sugar manufacturing process which enhances production capacity and operational flexibility

Applications

- Sugar cane juice and syrup concentration
- Spent wash concentration
- To manufacture refined sugar

Pollution Control in sugar industry – Rotary Particles Collector (RPC) System

- Technology to effectively control air pollution from boilers
  - Efficient and safe alternative to conventional ESPs
  - Minimum Power consumption
  - Comply with stringent air pollution standards set by CPCB
  - Low maintenance cost

India's first RPC implemented for 75TPH Boiler at Udagiri Sugar and Power Ltd.

Source: Sidel Energy and Enviro systems Pvt Ltd

Energy Efficient Motors

IEC Efficiency Terminology

1. IE-Stands for International Energy efficiency class
2. The International Electrotechnical Commission (IEC)
   i. IEC-Ref-Standard **IEC 60034-30-1-2017**
3. Level stands for Different types of Efficiencies
   i. IE1-Standard Efficiency Level
   ii. IE2-High Efficiency Level
   iii. IE3-Premium Efficiency Level
   iv. IE4-Super Premium Efficiency Level
   v. IE 5 – Ultra Premium Efficiency Level

MEPS

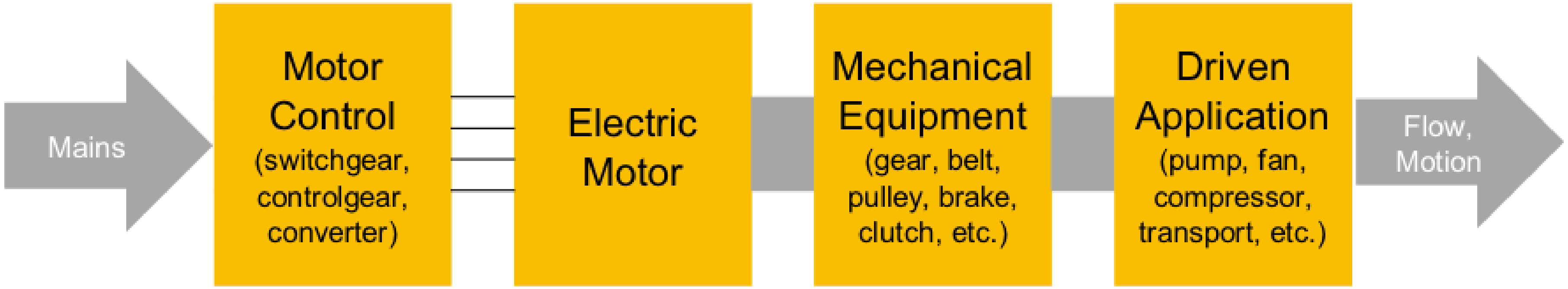
Minimum Efficiency Performance Standards

India has a comparative efficiency label since 2009 and a voluntary standard on IE2 level since 2012.

In 2020, the point was reached where countries consuming 76% of the global electricity consumption by electric motor systems have set MEPS for motors at either IE2 or IE3 level.

https://www.iec.ch/government-regulators/electric-motors#:~:text=Electric%20Motor%20Driven%20Systems%20(EMDS)&text=IEC%20 61800%2D9%2D2%2C%20edition%201%2C%202017%20was,driven%20by%20converters%20was%20published.

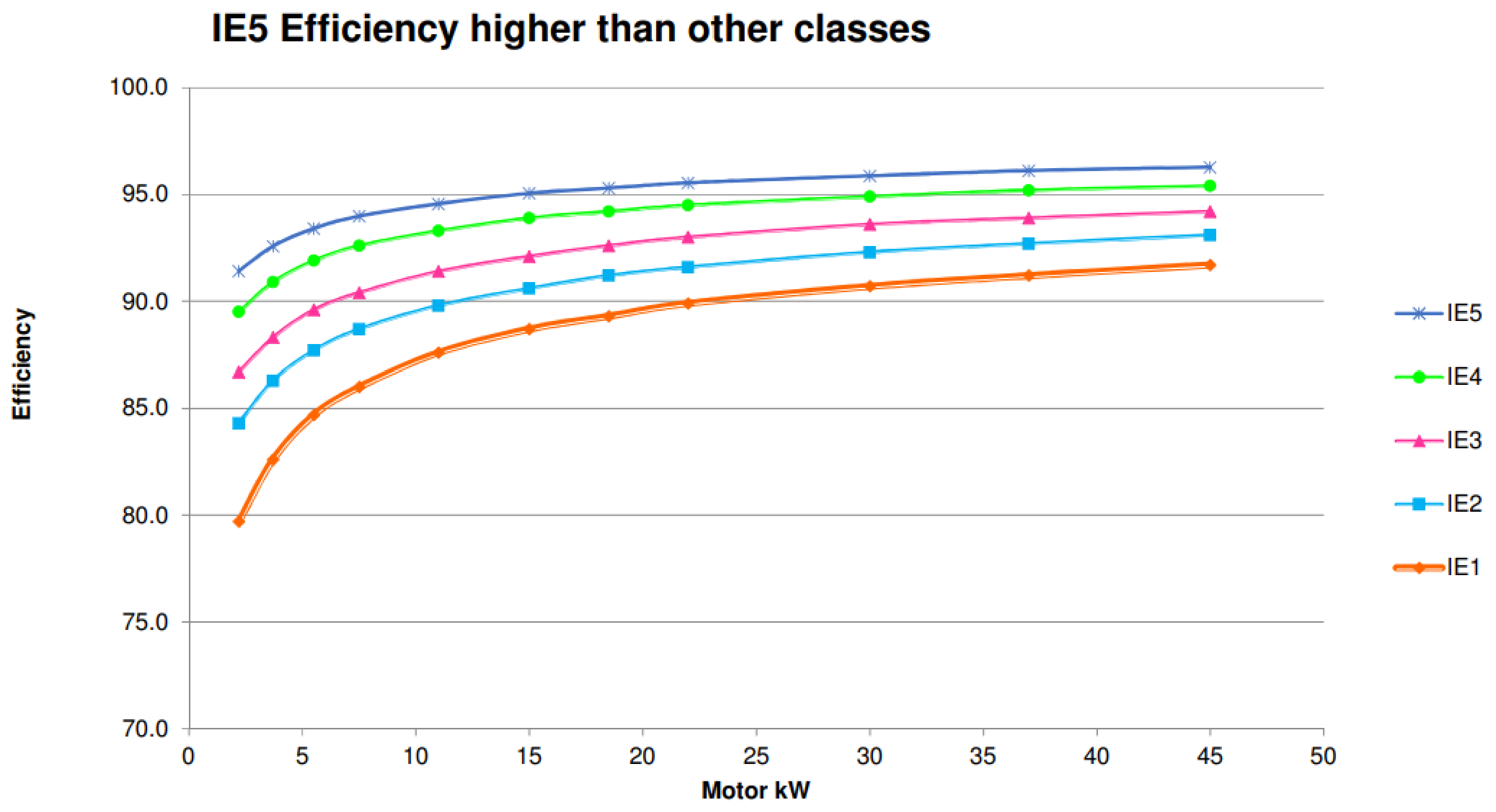
Electric Motor Driven Systems



- IEC 61800-9-2, edition 1, 2017 was published as a test standard and an efficiency classification for converters.
- The Group Efficiency Standard IEC 61800-9-1 defines the interface between the electrical and the mechanical part of the EMDS.
- In IEC 60034-2-3, 2020 a test method was published for motors driven by converters.
- IEC TS 60034-30-2, 2016 an efficiency classification for motors driven by converters was published.

Energy Efficient Motors

Efficiency as per IEC 60034-34-1



Technology comparison - Energy Efficient Motors

	Induction Motor (IM)	Line Start PM(LSPM) - BBL	Synchronous Reluctance(SR) –	Permanent Magnet(PMSM)
Scope	IEC – 60034-30-1	IEC – 60034-30-1	IEC – 60034-30-2	IEC – 60034-30-2
Stator Construction	Proven Technology	Proven Technology	Proven Technology	Proven Technology
Rotor Construction	Proven Technology	New Technology	New Technology	New Technology
Magnets	None	Yes	Yes	Yes
Rotor Losses	Yes	Not Significant	Not Significant	Not Significant
VFD	Not Needed but Possible	Not Needed but Possible to use	Always Needed	Always Needed
VFD Type	Standard	Standard	Not Supported by all VFD Types	Not Supported by all VFD Types
Power Factor	Kwown /Accepted Level	Higher than Ind Motor	Lower than Induction Motor	Higher than Induction Motor
IE 4 Efficiency Level	Difficult to achieve	Can be achieved	Can be achieved	Can be achieved
IE 5 Efficiency Level	Out of scope	Can be achieved	Might be possible	Possible
Comments	Standard in Industry	Potential for High Efficiency	Lower Power Factor	Potential for High Efficiency

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