Making Inroads in Energy Conservation

The Dairy Industry - Kerala
The Market

• Competitiveness made adverse by –
  
  – **Raw material intensive** – for dairy it is as high as 78% of total cost (raw milk)
    • Not entirely in your control
  
  – **Rising Energy Costs**
    • In the last 3 yrs with the drastic increase in fuel costs your fuel bill will have soared for the same consumption.
      • In the last year alone fuel prices have almost doubled
  
  – **Quality an important element**
    • An audit can help sort out issues like steam starvation, improper temperature / pressure for your process
  
  – **Capacity utilization & Productivity**
    • An audit can help you optimize your system to improve both
  
  – **Environmental norms**
    • Better efficiency, reduced consumption, reduced emissions

*Energy Conservation | Environment | Process Efficiency*
Specific Fuel Consumption

- SFC for 7 Non-powder plant dairies
- The worst plant requires almost three times more energy to process one litre of milk

<table>
<thead>
<tr>
<th>Plant</th>
<th>Kcal/lit of milk (SFC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>98</td>
</tr>
<tr>
<td>B</td>
<td>97</td>
</tr>
<tr>
<td>C</td>
<td>72</td>
</tr>
<tr>
<td>D</td>
<td>61</td>
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<tr>
<td>E</td>
<td>50</td>
</tr>
<tr>
<td>F</td>
<td>38</td>
</tr>
<tr>
<td>G</td>
<td>32</td>
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</table>
Specific Fuel Consumption

- SFC for 7 Powder plant dairies

- Again, the worst plant requires almost three times more energy to process one litre of milk
## Values for SFC

<table>
<thead>
<tr>
<th>Plant</th>
<th>Fuel</th>
<th>Classification</th>
<th>Plant Capacity in Lacs / day</th>
<th>Milk /unit of fuel</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>FO</td>
<td>Milk + Products</td>
<td>2.3</td>
<td>167</td>
</tr>
<tr>
<td>B</td>
<td>FO</td>
<td>Milk + Products</td>
<td>2.7</td>
<td>162.3</td>
</tr>
<tr>
<td>C</td>
<td>FO</td>
<td>Milk + Product</td>
<td>1.5</td>
<td>162.3</td>
</tr>
<tr>
<td>D</td>
<td>FO</td>
<td>Milk + Product</td>
<td>1.4</td>
<td>160.7</td>
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<tr>
<td>E</td>
<td>FO + Natural gas</td>
<td>Powder</td>
<td>12</td>
<td>Combined Fuel</td>
</tr>
<tr>
<td>F</td>
<td>FO</td>
<td>Powder</td>
<td>1.65</td>
<td>71</td>
</tr>
<tr>
<td>G</td>
<td>FO</td>
<td>Powder</td>
<td>3.5</td>
<td>67</td>
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What impacts SFC

- S:F, Milk to Steam and SFC for Above 7 Non Powder plant dairies
What impacts SFC

• Differences in SFC due to differences in the Steam and Condensate loop i.e.
  
  – Steam to Fuel Ratio i.e Efficient steam generation
    
    • Boiler Efficiency
    • Optimum Feed water temperature
    • Reduced blow down losses
  
  – Milk to Steam Ratio
    
    • Optimized steam distribution
    • Optimized steam utilization
## What is Steam?

<table>
<thead>
<tr>
<th>Gauge pressure bar</th>
<th>Temp. °C</th>
<th>Water (h₁)</th>
<th>Specific Enthalpy of evap'tion (h fg)</th>
<th>Steam (h g)</th>
<th>Volume Dry Sat. m³/kg</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
<td>419</td>
<td>2257</td>
<td>2676</td>
<td>1.673</td>
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<tr>
<td>1</td>
<td>120</td>
<td>506</td>
<td>2201</td>
<td>2707</td>
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<td>2</td>
<td>134</td>
<td>562</td>
<td>2163</td>
<td>2725</td>
<td>0.603</td>
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<td>3</td>
<td>144</td>
<td>605</td>
<td>2133</td>
<td>2738</td>
<td>0.461</td>
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<tr>
<td>4</td>
<td>152</td>
<td>671</td>
<td>2108</td>
<td>2749</td>
<td>0.374</td>
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<tr>
<td>5</td>
<td>159</td>
<td>641</td>
<td>2086</td>
<td>2757</td>
<td>0.315</td>
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<tr>
<td>6</td>
<td>165</td>
<td>697</td>
<td>2066</td>
<td>2763</td>
<td>0.272</td>
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<tr>
<td>7</td>
<td>170</td>
<td>721</td>
<td>2048</td>
<td>2769</td>
<td>0.24</td>
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</table>
Graphical Representation of Steam Tables
An efficient Steam & Condensate Loop

- In an ideal S& C Loop of the total energy supplied to boiler
  - About 80% is utilized for conversion to steam
  - 3% of this energy is lost due to distribution losses
  - Only 57% of the energy supplied to the boiler is utilized by the process
  - The balance 20% exists as condensate and flash steam.

Energy Conservation | Environment | Process Efficiency
S&C Loop in a dairy - SFC

- S:F – Efficient Generation
  - Boiler efficiency
    - Highly oversized boilers operating at part loads
    - Frequent variations in load prevalent
    - Low loading & variations in load pattern results in frequent start-stops and thus poor efficiency
    - Steam is not generated at rated pressure affecting steam quality
    - No Diagnostics

8-10% saving is there on account of improving Boiler Efficiency

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Boiler Load & Steam to Fuel Ratio

S:F VARIATION AGAINST LOAD

% LOAD

S:F RATIO
Boiler Load & Steam to Fuel Ratio

S:F VARIATION AGAINST LOAD

S:F RATIO

% LOAD

Energy Conservation | Environment | Process Efficiency
S&C Loop in a dairy - SFC

• S:F – Efficient Generation
  – Optimizing Feed water temperature – Six degree rise in FWT results in a 1% improvement in efficiency

• Feed water tank management
  – Oversized feed water tanks observed across dairies
  – No feed water management or control
  – A detailed mass balance calculation required to put in place feed water management strategy
S&C Loop in a dairy - SFC

• S:F – Efficient Generation
  – Optimizing Feed water temperature – Six degree rise in FWT results in a 1% improvement in efficiency
  
  • Maximizing Condensate & Flash recovery
    – CRF very poor across dairies
    – Where condensate is being recovered it is done by electrical pumps with multiple handling of condensate and hence heat loss
    – Across most plants flash steam is not recovered

  – Optimizing Blow down
    • Blow down is manual across dairies
    • No heat recovery

Overall 6-8% saving potential there in Dairies on account of CR
S&C Loop in a dairy - SFC

- Milk to Steam Ratio
  - Causes of distribution losses
    - Pressure drop issues observed across plants
    - Lines over/undersized, redundant lines, routing issues
    - Improper insulation/ bare lines leading to higher radiation losses
S&C Loop in a dairy - SFC

- Milk to Steam Ratio – Steam Utilization
  
  - Higher Steam Consumption in the process due to
    
    - Temperature overshoot in processes prevalent during milk pasteurization, ghee preparation, etc
    
    - Incorrect traps on the process which impact condensate evacuation and lead to higher steam consumption and also poor productivity
    
    - Number of CIP cycles – Heat recovery from the CIP section
    
    - In dairies with milk powder – 70% of the steam is consumed in the powder plant
      
      - Poor steam economy observed on the evaporator with huge potential for savings

% reduction in steam utilization has been found to be 10-15%

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Average Saving Potential

On an Average there is potential to save 24 – 33 % on fuel in Dairy Plants !!!
## SFC Variation

<table>
<thead>
<tr>
<th>Dairy</th>
<th>Thrissur</th>
<th>Kottayam</th>
<th>Alapuzha</th>
<th>Trivandrum</th>
<th>Cochin</th>
<th>Kollam</th>
<th>Kannur</th>
<th>Calicut</th>
<th>Palakkad</th>
<th>Wayanad</th>
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</thead>
<tbody>
<tr>
<td>Steam/Fuel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.06</td>
<td>7.27</td>
<td>11.74</td>
<td>13.11</td>
<td>11.7</td>
<td>10.91</td>
<td>11.42</td>
<td>11.9</td>
<td>3.97</td>
<td>2.01</td>
<td></td>
</tr>
<tr>
<td>Milk/Steam</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>8.5</td>
<td>17.87</td>
<td>11.34</td>
<td>12.73</td>
<td>14.38</td>
<td>15.75</td>
<td>22.16</td>
<td>31.25</td>
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<td></td>
</tr>
<tr>
<td>Milk/Fuel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>111.82</td>
<td>130</td>
<td>133.26</td>
<td>166.97</td>
<td>168.38</td>
<td>172</td>
<td>253.2</td>
<td>372</td>
<td>44.74</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
- For FO fired Boilers ideal S:F is 14
- Palakkad & Wayanad have wood and coconut shell as fuel.
Variation in Boiler efficiency

- Palakkad & Wayanad have wood and coconut shell as fuel
- All others have FO as fuel
Condensate & Flash recovery

• Poor Condensate recovery across the plants. Condensate contains almost 20% the energy in steam.

• Only 2 plants – Thrissur & Kochi Recover condensate.

• No plant recovers flash steam – Flash steam contains 50% of the energy in condensate.
Objectives

Bridge the variation across units and make the best plant better.

- In-depth study of process & system
- Establishing the facts with actual measurements
- Comparison of existing performance with accepted norms
- Identify potential for savings and improvement
The Audit Advantage

- Quantify Energy Consumption & Utilization
- Comparing present operating conditions with norms
- Norms are continuously getting better due to improvements
- Energy saving measures identified in 3 stages- short, medium and long term
- Working out detailed payback period for Investment Decisions
- Conclude whether energy being spent is spent efficiently or not.
Why FM?

✓ Prioritizing
Analysis of Pay back calculations and preparing the hierarchy chart.

✓ Commitment of Savings
Bridge the gap between the existing & industry best.

✓ Quantification*
Quantification of achieved savings with respect to committed savings.

✓ Sustaining the Savings
• Identifying key parameters to be monitored & practical solutions for same with required accuracy & to identify gaps in sustaining savings over a period of time.
• Help establish operating practices to bridge the gaps
• Enhance overall awareness through trainings

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Why FM?

– Rich experience & know-how of both Steam & Processes to arrive at the right solution for each industry and each plant

• Energy Conservation Partner since 1946
• Over 1000+ process audits including sectors like Tyre-Tube, Textiles, Food & Beverages, Rubber, Pharmaceuticals, Chemicals, SEP, Oil & Petrochemicals, Fertilisers, Breweries, Distilleries and many more!

– Team of qualified, professional industry specific auditors

– Each audit is discussed with a panel of experts in-house

– Part of Forbes Marshall Group of companies, leaders in Steam Engineering & Process Instrumentation
Benchmarks Of Success

- Reduced SFC
- Increased process output
- Improved product quality
- Reduced down time
- Improved monitoring & control process
- Direct monetary savings
Steam Utilization in Dairy

Hot Water usage In Dairy

- Pasturiser - Milk, Cream, Butter Milk, Curd, Ice-cream Mix, UHT,
- CIP System for Silos / tanks
- Can / Crate / Bottle washer
Hot Water generation System

- 1. Conventional system – Steam Mixing (Storage type TANK HEATING)
- 2. New Generation – Packaged Plant Room system (Instantaneous)
Steam Mixing heating System-

Uncondensed Steam Bubbles Rise to Top of Tank and Escape to Atmosphere

Steam Control Valve Delivers Partial Pressure Steam, Reducing Steam Velocity at Sparger Thus Reducing Efficiency of Steam Condensation

Steam

Hot Zone

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Problem Face by Dairy In steam Mixing

- Rough Operation – Steam hammer and vibration
- Poor Temperature Control
- Energy Loss – Uncondensed steam bubbles represent a direct loss of energy
- Limited turn down capability.
- No condensate recovery
- Steam -> Fuel -> Money gets wasted to maintain the temperature under no load conditions
What is PPRS

Simplest and the best way to generate hot water using Low Pressure steam for

- Pasteurizer units
- CIP System
- Crate / Can / Bottle Washer
Hot water for pasteurizer & UHT

- Steam
- Condensate
- Heating water circulation
- Unpasteurised milk
- Pasteurised milk
- Chilled water in
- Chilled water out

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Why PPRS System- for Dairy

- Instantaneous in nature as low hold up volume
- Effective temperature control
- No pressure drop in the boiler during peak loads
- No implosions, water hammer & noise problems
- Best for Continuous operations
- Energy efficient, low carbon footprint, saves up to 10% fuel
PACKAGED PLANT ROOM SYSTEM.
Components of a Typical PPRS

Pressure reducing station
Plate heat exchanger
Primary temperature control loop
Over heat protection loop
Stall protection
Condensate recovery equipment
PRESSURE REDUCING STATION

• To reduce excess pressure of steam as per the design to ensure constant pressure steam is provided to plate heat exchanger

• To provide dry saturated steam to have better heat transfer

• To safeguard PHE from damage by providing a safety valve
TEMPERATURE CONTROL LOOP

• Temperature transmitter – senses the water temperature at the outlet of the PHE & gives 4 – 20 ma signal
• PID controller - accepts signal from the transmitter & gives output to the E/P converter
• E/P converter - based on the signal from controller, actuates the control valve
• Control valve - this accepts signal from E/P converter and controls the flow of steam to PHE
OVER HEAT PROTECTION LOOP

• Temperature sensor - this senses the temperature of hot water at the outlet of PHE

• On/Off controller - this accepts signal from temp. sensor, and gives the output based on the set temp.

• Solenoid valve – this accepts signal from on/off controller and stops the steam supply

NOTE :- This loop comes in to action only when primary loop fails
CONDENSATE RECOVERY EQUIPMENT

• Pumping trap combination - This is used to remove condensate from the PHE under all conditions, even under stall condition

• Condensate removal is essential, to keep the PHE heating area free from condensate.
FEATURES MAKING PPRS THE CLEAR WINNER

• Instantaneous nature allows Hot water at any time
• Easy to maintain and Install
• Less Steam Consumption and High thermal Efficiency
• Compact in volume, weight and liquid holdup & Provision for capacity expansion
• Accurate & constant temperature under various heat loads.
• Low water content reduces the risk of legionella breeding.
Direct UHT Controls

- Pre-heated milk
- UHT ring nozzle injector
- Milk to homogeniser
- Separator
- Pressure reducing valve set
- Clean steam filter
- Steam trap set
- Condensate
- Condensate
- Spirax Sarco hygienic steam trap
Stall and condensate removal

What is stall?

- No movement of condensate
Stall and condensate removal

What is stall?
No movement of condensate = back-up in heater

Fig. 13.1.1 An air heater battery suffering the effects of stall
Condensate flows out when heater pressure is higher than backpressure.
Stall occurs when the backpressure is higher than the pressure in the heat exchanger.

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Plate Heat Exchanger Temperature Control and Condensate Drainage

- Steam flow
- Steam supply to pump
- Condensate
- Condensate
- Steam trap
- Pressure powered pump
- Plate heat exchanger
- Pneumatic valve and actuator with positioner
- Controller
- Secondary flow out
- Secondary flow in
Hot Liquor Tank Controls

- Pressure reducing valve station
- Self acting temperature control
- Steam trap set
- Level control system
- Condensate
- Steam trap set
- Water
Condensate and Flash Recovery

- Flash Vessel for flash steam recovery
- Steam Operated Pump
COMPARISON: COMPACT / CONVENTIONAL

CONVENTIONAL STEAM TRAP STATION

- Upstream Isolation valve
- Thermodynamic Trap
- Bypass Valve

500mm

COMPACT STEAM TRAPPING STATION

- Steam
- Condensate

160 mm

245 mm

Estimated weight:

- CONVENTIONAL: 8 kg
- COMPACT: 3.5 kg

MODEL: PC01N + UTD3

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PC01 N with UTD3 for MAIN DRAINS

Pipeline Connector (PC01N) ---- having Inlet & outlet isolation piston valve ((integrated in single stem-piston))

Universal Thermodynamic Trap (UTD3)

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Air Heater Control System With Flash Steam Pre-Heater

- Pneumatic actuated valve with positioner
- Steam flow
- Flash steam to pre-heater
- Air vent
- Sensor
- Pre-heater
- Flash steam recovery vessel
- Steam trap set
- Condensate
- Steam trap set
- Heated air to spray dryer

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Case Study

- A dairy plant in Surat had 5 TPH Gas Fired Boiler was consuming
  - 4500 scfm gas per day to produce 9 lac lit milk
  - They were having zero condensate recovery
  - FWT was maintained at 50 Deg C by direct steam injection
  - Un insulated FWT and no level management
  - There was no Pressure reduction and all equipment were consuming steam @ 7 barg Pr
  - Steam trap selection on Pasteurizer, Ghee Vat and other equipment was mostly Thermodynamic and most location there were no traps
  - CIP PHE was facing stalling problem
  - All Pasteurizer were using Hot water tank with direct steam injection for Hot water generation
• We studied the plant and recommended to
  – Install Pressure Reducing station and Operate all Equipment @ 3 barg
  – Improving condensate recovery from all pasteurizers and CIP
  – Insulating FWT and installing proper level management
  – Automatic pumping trap on PHE
  – PPRS system instead direct injection Tank based steam system.
  – Rightly sized Ball Float steam traps for all Equipment
  – After implementation of entire system
Result

• Feed water temperature improved from 50 Deg C to 75 Deg C (w/o steam injection)
• No stalling Observed on CIP PHE
• Hot water System yielded (PPRS)
  – PRECISE TEMPERATURE CONTROL
  – NO WASTAGE OF STEAM THRU OVERHEATING / SURFACE EVAPORATION/ BUBBLING / HOT STANDBY.
  – HOT WATER ALWAYS AVAILABLE – SO NO REWORK ON BATCH
  – NEAT AND CLEAN WORKPLACE
• Fuel Consumption dropped from 4500 to 3500 scfm
• Total 22% saving on Fuel Bill

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Case Study – Dairy in Calcutta

- To study the impact of S&C on SPFC
  - Capacity of the dairy: 4 lakh lts/day
  - Fuel bill (FO): 93 Lakhs

- Observations in Steam Generation
  - 2 boilers of 5 tph each, operating at 500 kg/hr
    - Frequent on-off operations
    - Fouling of the punker plate
    - Poor Combustion efficiency ie as low as 70%
  - Common Feed water tank: Temp 51°C

- Observations in Steam Distribution
  - Lines oversized leading to higher condensation losses
  - Inadequate main line trapping
Case Study - Metro Dairy

• Observations in Steam Utilisation
  – Temperature overshoot On hot water tank (ice cream plant) and crate washer
  – Pasteurization Indirect heating DT is 6°
    High regeneration efficiency
    Adequate process automation
  – Reduce flow rate of water circulation on CIP

• Observations on Steam Traps
  – Check feasibility of stall conditions across Temp controlled PHEs

• Observations on Condensate Recovery
  – Condensate Recovery improvement from 38 to 78%

Result of SPFC from 163 to 210 ie savings of Rs 23 Lakhs

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Thank You