System Description

Design

- Induced draft counter flow
- Flow rate - 2000 m³/hr
- Heat load - 16 Gcal/h
- Wet bulb - 29°C
- Supply Temp - 33°C
- Return Temp - 41°C
- Fill “Munters CF12060”

Operating

- Plant Load - 65%
- CT Thermal Load - 55%
- Supply Temp - 34.7°C
- Return Temp - 38.2°C
- VFD inline for CT fans
- No flow meter
Problem Statement

- For Cooling tower less than 2 years old, Supply temperature remains high at around 35 °C. Approach of ~ 8 °C.
- Limits Production ramp up plan.
- Plant tried to improve the performance of cooling tower with the CT supplier.
- Actions like increasing Blade angle did not yield results.
- To augment increase in production, unit decided to invest in additional cell and pumps.
- Additional Cell requires Capex of around 1 Cr and increase in load ~ 150 KW

Can we fix it?
Elements affecting CT Performance

CT Performance

- L/G
- Water Quality
- Fills
- CW Network
Graphical analysis of L/G Ratio

Operating Line
L/G is slope. Hot and cold water temp ($T_2$ and $T_1$) is the terminal points.
Difference Between Counter and Cross Flow

Figure 27. Counterflow Cooling Diagram

Figure 30. Counterflow Cooling Diagram for Constant Conditions, Variable $L/G$ Ratios
### Difference in NTU for Cross and Counterflow

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet bulb temp of air</td>
<td>29°C</td>
</tr>
<tr>
<td>L/G ratio</td>
<td>1.2</td>
</tr>
<tr>
<td>Water in temp</td>
<td>41°C</td>
</tr>
</tbody>
</table>

![Graph showing NTU comparison between Cross and Counterflow](image-url)
<table>
<thead>
<tr>
<th>Parameters</th>
<th>UOM</th>
<th>Design</th>
<th>Operating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling water Flow</td>
<td>m³/hr</td>
<td>2000</td>
<td>2600</td>
</tr>
<tr>
<td>Inlet Temperature</td>
<td>°C</td>
<td>41</td>
<td>38.2</td>
</tr>
<tr>
<td>Outlet Temperature</td>
<td>°C</td>
<td>33</td>
<td>34.7</td>
</tr>
<tr>
<td>Range</td>
<td>°C</td>
<td>8</td>
<td>3.5</td>
</tr>
<tr>
<td>Approach</td>
<td>°C</td>
<td>4</td>
<td>8.7</td>
</tr>
<tr>
<td>L/G</td>
<td></td>
<td>1.6</td>
<td>3</td>
</tr>
<tr>
<td>Wet Bulb Temperature</td>
<td>°C</td>
<td>29</td>
<td>26</td>
</tr>
</tbody>
</table>

**Design NTU (KaV/L)** - 1.54

**Water Evaporated** – kg/hr*(ft³/ft²)
Cooling Break Up

- **Spray Zone**: 6%
- **Fill Zone**: 86%
- **Rain Zone**: 8%

NTU Required: -1.54

NTU Available: -1.56

Munters 12060

Source: CTI TP88-07
Water quality must be checked before selecting fills
- TSS, Biological content, Oil & Grease

<table>
<thead>
<tr>
<th></th>
<th>Cross-flute</th>
<th>Offset flute</th>
<th>Vertical flute microstructure</th>
<th>Vertical flute no microstructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS (ppm) w/high Bio</td>
<td>&lt;100</td>
<td>&lt;200</td>
<td>&lt;500</td>
<td>&lt;2000</td>
</tr>
<tr>
<td></td>
<td>&lt;25</td>
<td>&lt;50</td>
<td>&lt;200</td>
<td>&lt;1000</td>
</tr>
<tr>
<td>Bio and Scale Control</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>Oil and Grease</td>
<td>None</td>
<td>&lt;1</td>
<td>&lt;5</td>
<td>&lt;25</td>
</tr>
<tr>
<td>Fibers</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Source: CTI TP06-19
Corrective Actions & Improvements

- Circulation rate reduced from 2600 to 1900 m³/h
- Fan VFD is bypassed.
- The range is increased from 3.5 to 5° Deg C.
- Supply temp improved from 35 to 33.5 deg C.
- Cooling tower treatment program to be reviewed.
Cooling Tower Network

Design:
Heat Load: 16 Gcal/hr
Flow: 2000 m3/hr
CWS: 33 °C
CWR: 41 °C

Design:
Flow: 2430 m3/hr
CWS: 33 °C
CWS: 39.5 °C
Cooling Tower Network

Parallel Arrangement

Series/Parallel Arrangement
### Defining The Target

#### Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Existing</th>
<th>Proposed</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Heat Load</td>
<td>16</td>
<td>16</td>
<td>Gcal/h</td>
</tr>
<tr>
<td>Cooling Water Supply Temperature</td>
<td>33.0</td>
<td>33.0</td>
<td>°C</td>
</tr>
<tr>
<td>Cooling Water Return Temperature</td>
<td>39.5</td>
<td>41.0</td>
<td>°C</td>
</tr>
<tr>
<td>Cooling Water Flow rate</td>
<td>2430</td>
<td>1960</td>
<td>m³/hr</td>
</tr>
<tr>
<td>Potential Reduction in CW Flow Rate</td>
<td></td>
<td>470</td>
<td>m³/hr</td>
</tr>
</tbody>
</table>

#### Composite Curve & CW Supply Line

- **Composite Curve**
- **CW Supply Line**
- **Linear (CW Supply Line)**

- Revised CW Return Temp.
Cooling Tower Network Evolution

Cooling Tower

P-1

Flow = 2430 m³/hr
CWS = 33 ºC

P-2

891 m³/hr
35 m³/hr
153 m³/hr
471 m³/hr
417 m³/hr
461 m³/hr

HCL Furnace
Process Building
CCU HE
CL2 Liquefaction

Rectifier
Intercoolers
(Air Compressor)

CWR = 38.2 ºC

33°C

Capex saved – 100 lakhs

Opex saved – Rs. 88 Lacs/yr.

Cooling Tower

P-1

Flow = 1960 m³/hr
CWS = 33 ºC

P-2

891 m³/hr
35 m³/hr
153 m³/hr
471 m³/hr
417 m³/hr
461 m³/hr

HCL Furnace
Process Building
CCU HE
CL2 Liquefaction

Rectifier
Intercoolers
(Air Compressor)

CWR = 40 ºC

CWR 41 deg C

34.5 ºC
Tip for Low cost capacity Enhancement

- Add fills in Rain Zone
Thank You.