Un-Common Solutions to Common Problems

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Case Study-1

Energy Conservation by increasing Amine strength.

- MDEA is used extensively in gas plants across the world for H2S absorption and partial CO2 slip.
- Used at strengths from 40 to 45 wt%.
- Many tests and publications compare 50 wt% MDEA as typical strength at usage with other type of amines.
- Many gas plants are units designed for 45 wt% operation.
MDEA strength can be increased by about 5 wt% say from 45 to 50 %.

Results in reduction of water in the amine.

As total MDEA content in amine remains the same, no change to acid gas loading or specifications.
Projected Circulation reduction

- Reduction in amine circulation quantified as follows:

<table>
<thead>
<tr>
<th></th>
<th>t/hr</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>At 45 wt%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>550</td>
<td>55</td>
</tr>
<tr>
<td>Amine</td>
<td>450</td>
<td>45</td>
</tr>
<tr>
<td>Total</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>At 50 wt%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>450</td>
<td>50</td>
</tr>
<tr>
<td>Amine</td>
<td>450</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>900</td>
<td></td>
</tr>
<tr>
<td>Reduction in circulation</td>
<td>100 m3/hr</td>
<td></td>
</tr>
</tbody>
</table>
Heating Requirements*

For gas plants, typical heat requirement for AGRU regenerator is as follows:

• 50-60% to break bond between MDEA and acid gas
• 20-25% for reflux
• 20-25% for heating amine to feed temperature.

* typical data with PHE
Projected savings

- 10% reduction in amine circulation and the energy costs to heat and cool is conserved.
- Further, reduction in pumping costs from atmosphere pressure to about 70 barg.
- Estimated savings on steam is about 5%. Actual savings achieved were more!!
- Power costs
Other Benefits

- CO2 slip in amine absorber column of lean gas increased
- Amine velocity reduction of up to 10%, erosion corrosion reduces proportionately.
- Flow induced vibration issues, if any, reduces.
- Higher H2S content in acid gas to SRU expected to improve performance. 1% rejection of CO2 in sales gas is equivalent to 5% increase in H2S content in SRU feed.
Effects of MDEA concentration

De-Merits:
- Increased MDEA concentration directionally increases hydrocarbon solubility.
- BTEX solubility increases at higher rate as MDEA strength increases.
- Wet CO2 corrosion of sweet gas ??

Merits
- Increase in absorption temperature decreases HC solubility. Hence the HC solubility effects can cancel each other to some extent.
Purpose:

- Maximization of CO2 in sales gas within specifications to meet design intent.
- Reduces energy requirements due to lower CO2 absorption
- Improves SRU feed quality

Probable reasons for increased CO2 absorption

- Generous design margins (number of trays, weir height etc.,)
- Column design for extreme case than actual operating case.
- New column/unit or post TA (clean internals and pristine amine)
Design Intent

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Design</th>
<th>Unit-A</th>
<th>Unit-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amine conc</td>
<td>%</td>
<td>45</td>
<td>44.3</td>
<td>44.3</td>
</tr>
<tr>
<td>CO2 in sweet gas</td>
<td>%</td>
<td>2.5</td>
<td>0.55</td>
<td>1.2</td>
</tr>
<tr>
<td>Amine loading</td>
<td>m/m</td>
<td>0.45</td>
<td>0.48</td>
<td>0.45</td>
</tr>
</tbody>
</table>

- Feed tray at 3 locations, weir height 50 mm.
Observed factors affecting CO2 absorption

- Feed tray location and weir height
- H2S loading
- Temperature inside the column
- Contact time and mixing/agitation
Amine Concentration effects

- Viscosity increases, affecting the mass transfer
- Circulation reduces, affecting the mixing/turbulence

Action taken and results observed
- Concentration was increased by 4%
- Flow decreased twice that amount
- Agitation/turbulence expected to reduce
## Amine Concentration effects

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amine conc</td>
<td>44.4%</td>
<td>48.8%</td>
</tr>
<tr>
<td>Gas feed rate</td>
<td>50% design</td>
<td>50% design</td>
</tr>
<tr>
<td>AG loading</td>
<td>0.54 m/m</td>
<td>0.49 m/m</td>
</tr>
<tr>
<td>CO2 in sweet gas</td>
<td>0.57%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Steam/amine</td>
<td>194 Kg/m³</td>
<td>195 Kg/m³</td>
</tr>
<tr>
<td>AG flow</td>
<td>Base</td>
<td>93%</td>
</tr>
</tbody>
</table>
Benefits

• Steam flow reduced by 5% - reduced regenerator load.

• Acid gas flow reduced by 7% - increased RF residence time and/or additional spare capacity.

• Fuel gas savings in Co-firing, incinerator etc., - Other tangible benefits.
Case Study-3

- Rich Amine control valve location - normally close to regenerator feed inlet nozzle
- To reduce flashing/H2S breakout downstream of CV
- Single phase preferred due to velocity/corrosion and vibration
Project Experience

- Rule of thumb violated.
- Valve placed at ground level and about 35m away from feed nozzle.
- Contractor insists it is better this way
Project Experience

- 30 metres
**Project Experience**

- 30 m elevation equals about 3 bar liquid column

<table>
<thead>
<tr>
<th>Inlet to CV</th>
<th>Vapour wt%</th>
<th>Vapour Vol%</th>
</tr>
</thead>
<tbody>
<tr>
<td>At feed elevation</td>
<td>1%</td>
<td>60%</td>
</tr>
<tr>
<td>At Ground level</td>
<td>0.5%</td>
<td>&lt;30%</td>
</tr>
</tbody>
</table>

- 2 phase flow at inlet to CV – difficult to control
- Weight of 30” control valve require extra strong support (>1000 kg)
- Bracing required anyway due to the elevation.
- Easy maintenance and accessibility
Case study-4

- Acid Gas Enrichment unit not meeting H2S specs

System Description
- MDEA for selective absorption of H2S
- Concentrate from 14% to 40% H2S
- 40-45 wt% MDEA
Trouble shooting-Variables

- Amine Strength
- Amine circulation
- Lean Amine temperature
- H2S in Lean Amine
- Absorber pressure
- Off gas temperature
Approach Temperature

Amine Cooler outlet T

Ambient temperature
Temperature vs H2S slip
Fin fan conundrum

- Design approach 9 deg c
- HTRI indicates reasonable surface area
- Actual approach is 20-30 deg c
- Fin-fan blade angle adjusted - little improvement in performance
- Reverse calculation with HTRI indicated the clue
Fin fan conundrum-Continued

- Air flow required for 20 deg approach is less than half the design flow.
- Fin fan inspection indicated fouling of fins.
- Water wash cleans only top or bottom rows but other 4 rows in between are barely touched by water.
- Moisture and dust storms covered inter-tube area
- Very high resistance to air flow and even blade adjustments does not yield any results.
Proposed solutions

- Foam cleaning- several times until air flow improves.
- Phosphoric acid to improve performance.
Case Study-5

- Problem- Very high SO2 content in Tail gas and severe fluctuation in H2S:SO2 ratio.
- Feed rate and composition fluctuated that started the **synchronous dance** of H2S:SO2
- Feed forward control for flow and composition, trim air control valve wind up check, Air demand control in Auto.
Trend of H2S:SO2 when normal
Synchronous Dance
Probable causes

- After eliminating analyzer issues, control was taken into manual and allowed to settle after several hours.
- Analyzer Time lag was ruled out and so was auto-calibration time (2 minutes every 4 hours)
- Typical case of SNAGU (Situation Normal but All Goofed Up)
**Probable causes-The Eureka moment**

- Paper on Analyzer BP on SRU/TGTU provided an hint.
- SRU catalysts have huge micro pores where reaction occur.
- Each gram of catalyst has several hundred m2 area
- When SO2 is offscale, it soaks up in the micro pores.
- Gets released and/or converted when air is cut until H2S is in excess.
- Two reactor in series confounds the issue.
- Left to the analyzer, it might have taken longer or never to stabilize.
Lessons Learned

- Over range the So2 and H2S to understand what is happening.
- Believe the analyzer (sometimes!!!)
- Mathematical corrections in analyzer for Sv and COS/CS2 are applicable for normal operation and one particular set of operating conditions.
- Expect un-predictable readings when off scale operation.
- Expect SO2 soaking and take ADA controller in manual.
Thank you.

Questions ?