Contaminated dirt from a fuel transfer site is to be cleaned. It has been proposed to use a steam stripper to remove the fuel and you need to assess the viability of this proposal. The operation includes a steam stripper fed by 900 lb steam with 600 lb steam leaving the stripper. The 600 lb steam is condensed to saturated water with a small fraction of organics and fed into a separatory tank and then into a boiler. Both the condenser and the separatory tank are isothermal.

The organic contaminant can be modeled as n-octane with the following Antoine constants from the NIST webbook (note T is in °K, P in bar):

**Antoine Equation Parameters**

\[
\log_{10}(P) = A - \frac{(B \cdot T)}{(T + C)}
\]

- \(P\) = vapor pressure (bar)
- \(T\) = temperature (K)

View plot Requires a JavaScript / HTML 5 canvas capable browser.

<table>
<thead>
<tr>
<th>Temperature (K)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Reference</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>326.08 - 399.72</td>
<td>4.04867</td>
<td>1355.126</td>
<td>-63.633</td>
<td>Williamham, Taylor, et al., 1945</td>
<td></td>
</tr>
</tbody>
</table>

n-Octane critical point \(T_c = 569^\circ\text{K}, P_c = 24.9\text{ bar}\)  
(Unit conversion 1 atmosphere is 14.7 psi, 1.01 bar, 0.101 MPa, 760 mmHg, 29.9 inHg)

In the chemical industry 900 lb steam refers to 900 psig saturated steam. (psig is gauge pressure such as you would read from a pressure gauge on a process line.)
To answer the following questions most effectively make a table listing $P$ (MPa), $T$ (°C), $U$ (kJ/kg), State (SL, SV, SHS, SCL) (SL is saturated liquid, SHS is super heated steam, etc.) for each of the streams A, B, C, D. (You don’t need to completely fill this table.)

You can also make a similar table of $UL$, $UV$, $T$, $P$ for the necessary extrapolations from the steam tables. (You don’t need to completely fill this table.)

a) What is the temperature for streams A and B. What is $\Delta U$ for the steam stream in the stripper?
b) Can this operation remove n-octane from the dirt? (Use the Antoine equation under the assumption that you can extend the temperature range.)
c) What is $\Delta U$ for the condenser?
d) Will octane condense into a liquid in the condenser? (Use the Antoine equation under the assumption that you can extend the temperature range. Assume that liquid water and n-octane are completely immiscible.)
e) What is $\Delta U$ for the boiler?
Answers

Quiz 1  1/12/2017

CH 12 Thermo

<table>
<thead>
<tr>
<th>P (MPa)</th>
<th>T (°C)</th>
<th>h (kJ/kg)</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 6.28</td>
<td>279</td>
<td>2540</td>
<td>LV</td>
</tr>
<tr>
<td>B 4.22</td>
<td>254</td>
<td>2600</td>
<td>LV</td>
</tr>
<tr>
<td>C 259</td>
<td>1090</td>
<td></td>
<td>SL</td>
</tr>
<tr>
<td>D 4922</td>
<td>219</td>
<td>1090</td>
<td>SL</td>
</tr>
</tbody>
</table>

\[(900 \text{ ps} + 14.7 \text{ ps}) \times 0.10 (\text{MPa}) = 6.28 \text{ MPa}\]
\[(600 \text{ ps} + 14.7 \text{ ps}) \times 0.10 (\text{MPa}) = 4.22 \text{ MPa}\]

\[u = \frac{1}{2} c^2 (p + 14.7 \text{ ps})\]

\[\begin{align*}
2590 & \quad 275 & \quad 5.95 & \quad \Delta T = \frac{5}{0.41 - 5.91} = 4 \text{ °C} \\
2580 & \quad 285 & \quad 6.42 & \\
1080 & \quad 2600 & \quad 3.98 & \quad \Delta T = \frac{4.32 - 3.96}{0.32 - 3.96} = 4 \text{ °C} \\
1100 & \quad 2600 & \quad 9.32 & \quad 0.71
\end{align*}\]

a) \[T_a = 279 \text{ °C} \quad T_b = 254 \text{ °C}\]
\[\Delta T = 10 \text{ K/°F}\]

b) Assume 400 °C can be extended to 552 °C
\[P = 10 \times (400 - (1360 + (552 + (-63.6))) = 18.4 \text{ bar}\]
\[\text{or } 1.84 \text{ MPa}\]
1.84 \text{ MPa} < 5 \text{ MPa} \text{ so the moisture will not be effectively removed.}

c) Condenser is B to C

\frac{(2600 - 1090) \text{ K}}{\text{K}} = 1510 \text{ K/K}

d) The condenser temperature is 254 °C (527 °F)

p_i = 5 \text{ MPa}

\text{From part b)} \quad P_{\text{sat}} = 10

4.65 - \left(\frac{1360}{527 - 0.65}\right)

= 13.0 \text{ bar}

1.30 \text{ MPa}

5 \text{ MPa} \gg 1.30 \text{ MPa}

so moisture would condense

e) Boiler is steam D to A

\Delta q = 1090 \frac{\text{K}}{\text{K}} - 2590 \frac{\text{K}}{\text{K}} = -1500 \frac{\text{K}}{\text{K}}