ABC Corporation's resins production unit wants to carry out a study estimate of a plant to produce phenol as a raw material at a cheaper cost than the current market price of $0.64/lb. The production rate of concern is 100,000 metric tons per year.

**Organizational Problem**

The phenol production process is based on the oxidation and cleavage of cumene.

**Oxidation of Cumene (Hock process)**:

\[
\begin{align*}
C_6H_{12}CH(CH_3)_2 + O_2 & \rightarrow C_6H_5C(CH_3)_2OOH \\
C_6H_5CH(CH_3)_2 + \frac{1}{2}O_2 & \rightarrow (CH_3)_2C_6H_4CH_2OH
\end{align*}
\]

**Cleavage reactions to produce phenol and acetone/AMS by-products**:  

\[
\begin{align*}
(CH_3)_2C_6H_4CH_2OH & \rightarrow C_6H_5(CH_3)CH_3 + H_2O \\
C_6H_5C(CH_3)_2OOH & \rightarrow C_6H_5OH + CH_3COOH
\end{align*}
\]

AMS and acetone are by-products of the reactions that are sold for credit. In addition to the credit received from by-products, there is also fuel credit obtained from the vent in the process. Finally, water is the only waste in the process and will be sent to a wastewater treatment facility.

**Key Economic Results**

- **Total cost per pound of product**: $0.857/lb
- **Total Capital Investment (TCI)**: $183 MM
- **Total annual operating costs**: $299 MM/yr

**Process Economics**

**Capital Investment Summary**

**Equipment Installed Cost**

**Utilities Cost Summary**

**Economic Conclusions**

The production cost for the design process exceeds the current market price of $0.64/lb of phenol and makes the implementation of the design impractical. Unless new alternative methods or adjustments to optimize the process are determined, executing the process design is not economically viable. Therefore, it is not recommended that this design be implemented.

**Safety Considerations**

<table>
<thead>
<tr>
<th>Component</th>
<th>Hazards</th>
<th>Toxicity/Dangers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone</td>
<td>Flammable, harmful if swallowed or contacted with skin, irritant</td>
<td></td>
</tr>
<tr>
<td>Cumene</td>
<td>Flammable, toxic, harmful if swallowed or contacted with skin, irritant, carcinogenic, hazardous to environment</td>
<td></td>
</tr>
<tr>
<td>AMS</td>
<td>Flammable, toxic, harmful if swallowed or contacted with skin, irritant, hazardous to environment</td>
<td></td>
</tr>
<tr>
<td>CHP</td>
<td>Oxidizing, toxic, corrosive, harmful if swallowed or contacted with skin, irritant, hazardous to environment</td>
<td></td>
</tr>
<tr>
<td>Phenol</td>
<td>Combustible, corrosive, harmful if swallowed or contacted with skin, irritant</td>
<td></td>
</tr>
</tbody>
</table>

**Major Hazards**

- Oxygen concentration in oxidation reactor
- CHP distillation column reboiler
- Cleavage reactor

**General Safety**

- Training
- Proper PPE
- Protective systems and alarms
- Routine inspection and monitoring of process

**Environmental Considerations**

Environmental pollution is a major concern for all industrial plants, such as the phenol production plant. Proper disposal is imperative for maintaining the wellbeing of the surrounding environment.

For the phenol production process the streams of concern are:

- Vent from 2nd stage separator
- Vent from partial condenser
- Wastewater from acetone-water separation train

**References**