INTRODUCTION

Projected demands for acrylic acid over the next ten years indicate that a new production facility must be built and on stream in 1987. Acrylic acid (AA) is produced via air oxidation of propylene and is purified via solvent extraction and distillation. The research department has developed some alternative extraction solvents that must be considered and there is a common belief that the purification section distillation system in the new facility can be more efficiently designed. Additional, the new catalyst has been developed, which allows us to consolidate the two-stage reactor system into a single reactor.

The by-product acetic acid can be sold for several uses in the industry. The waste water from the process can be handled in the existing waste treatment plant. The waste gas must be burned to meet environmental regulations. It is necessary, therefore, to develop a basic design of the new plant, determine the capital investment and operating costs, and then determine the manufacturing costs for comparison to the existing plant.

STATEMENT OF THE PROBLEM

Your objectives are:

1. Determine the oxidation reactor operating conditions based on information supplied by research. Determine the size of the reactor and the size of the associated waste heat boilers.
6: Expression

4. Physical properties

2. Spectrometry (wt%)

P = a + bC

3. Reaction 2: Fodded acid

C

4. Physical properties

HCl

5. Technical data

2. Spectrometry (wt%)
## 1. Material and Energy Balances

### 1.1 Reactor

- **Propane (80,000 lb/hr)**
- **Water (10,000 lb/hr)**
- **Air (60,000 ft³/hr)**

### 1.2 Absorber

- **Ammonia (150,000 lb/hr)**
- **Water (50,000 lb/hr)**

### 1.3 Other Data

- **Optimum Temperature:** 650°F
- **Optimum Pressure:** 125 psi

### 1.4 Power Requirement

- **Electricity (600,000 kWh/hr)**

### 1.5 Other Costs

- **Labor,benefits, taxes,etc.: $0.07/hr**
- **Purchased materials:** $0.01/kg

### 1.6 Manufacturing Costs

- **Raw Material Costs:** $2.38/kg
- **Process and 11yr Straight-line depreciation will start in 2005.**
- **Depreciation Rate:** 15%

### 1.7 Cash Flow Information

- **Annual Cash Flow:** $100,000
- **Discount Rate:** 10%
- **Ignite start-up costs:** $30,000

### 2. General Design Information Guidelines

- **Refrigerated water available at 36°C (97°F). Use a 5°C C.**
- **The design of each section may be scaled up or down as required to cover minor discrepancies, or otherwise to maintain a 10°C difference between the inlet and outlet temperatures.**

### 3. General Distillation Absorber Column Design Assumptions

- **Assume liner type, except for the first absorber section at the top of the reactor.**
- **Assume a capacity of 25,000 gal/hr.**

### 4. Oxidation Reactors/Absorber

**DISENTERY AND BASICS**

**Including simplified assumptions**

<table>
<thead>
<tr>
<th>Component</th>
<th>Mole</th>
<th>Weight</th>
<th>Heat of Evaporation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>42.09</td>
<td>44.74</td>
<td>3.02</td>
</tr>
<tr>
<td>B</td>
<td>63.08</td>
<td>17.36</td>
<td>4.59</td>
</tr>
<tr>
<td>C</td>
<td>32.90</td>
<td>18.00</td>
<td>0.00</td>
</tr>
<tr>
<td>D</td>
<td>16.82</td>
<td>1.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Table 2: Heat Capacity Data**

<table>
<thead>
<tr>
<th>Component</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP = A + B * T</td>
<td>10°C</td>
<td>15°C</td>
<td>20°C</td>
</tr>
<tr>
<td>8°C</td>
<td>0.039</td>
<td>0.039</td>
<td>0.039</td>
</tr>
<tr>
<td>10°C</td>
<td>0.050</td>
<td>0.050</td>
<td>0.050</td>
</tr>
<tr>
<td>12°C</td>
<td>0.109</td>
<td>0.109</td>
<td>0.109</td>
</tr>
<tr>
<td>14°C</td>
<td>0.300</td>
<td>0.300</td>
<td>0.300</td>
</tr>
<tr>
<td>16°C</td>
<td>0.600</td>
<td>0.600</td>
<td>0.600</td>
</tr>
</tbody>
</table>

### 5. Other Data

- **Propylene:** 1.00 Lbm/kg
- **Water:** 0.5 Lbm/kg