

Material balances for Example 3.19: Ethylene Oxide Flowsheet

The example demonstrates the formulation and solution of material balances for a simple process flowsheet with recycle. The solution is computed using CVX, a convex optimization package distributed by cvxr.com. The following example solves Example 3.19 of the Murphy textbook.

JCK 9/28/2012

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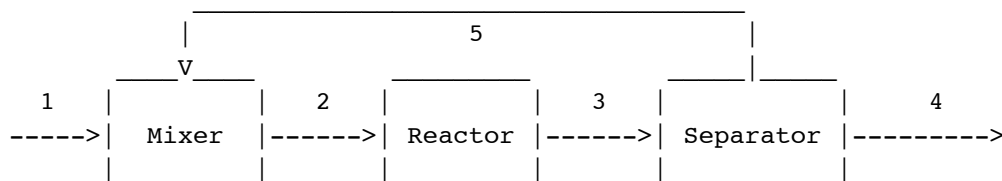
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Functions Used

- CVX
- `displaytable.m`

Process Flowsheet

The process flowsheet consists of three units, five streams, and three components: ethylene (E), oxygen (O), and ethylene oxide (EO). The feedstream consists of 196 kgmol/hr E and 84.5 kgmol/hr. The reaction stoichiometry is given by



Component Numbering

To minimize the potential for coding errors, we use component indices chosen as mnemonics of the species contained in the process flowsheet.

```

O = 1;    % oxygen
E = 2;    % ethylene
EO = 3;   % ethylene oxide
  
```

Stoichiometric Coefficients

Stoichiometric coefficients are stored in a vector. The index corresponds to the species involved in the reactions.

```
v(O) = -1;
v(E) = -2;
v(EO) = 2;
```

Reactor Conversion

The reactor performance is stated in terms of the fraction of the feed E converted to EO. This fraction is fce3.

```
fce3 = 0.06;
```

Separator Efficiencies

The separator efficiency is specified in terms of the fraction of each incoming component that goes to the preferred outlet stream.

```
fo5 = 0.995;
fe5 = 0.98;
feo4 = 0.97;
```

Solution of the Steady State Equations

The stream variables are represented by a matrix $n(3,5)$ of variables, and the extent of reaction is a single variable x . Once these are declared, we simply write out all of the material balance equations and process specifications.

```
cvx_begin quiet

% Declare the problem variables
variables n(3,5);    % A table of molar flowrates
variables x;        % Extent of reaction

% Mixer Balance
0 == n(O,1) + n(O,5) - n(O,2);
0 == n(E,1) + n(E,5) - n(E,2);
0 == n(EO,1) + n(EO,5) - n(EO,2);

% Reactor Balance
0 == n(O,2) - n(O,3) + v(O)*x;
0 == n(E,2) - n(E,3) + v(E)*x;
0 == n(EO,2) - n(EO,3) + v(EO)*x;

% Separator Balance
0 == n(O,3) - n(O,4) - n(O,5);
0 == n(E,3) - n(E,4) - n(E,5);
0 == n(EO,3) - n(EO,4) - n(EO,5);

% Feed Stream Specifications
n(O,1) == 84.5;
n(E,1) == 196;
n(EO,1) == 0;

% Reactor Conversion
```

```

2*x == fce3*n(E,2);

% Seperator Effciencies
n(O,5) == fo5*n(O,3);
n(E,5) == fe5*n(E,3);
n(EO,4) == feo4*n(EO,3);

```

```
cvx_end
```

Display Results

```

disp('Stream Table [kgmol/hr]');
displaytable([n;sum(n)],{'O','E','EO','TOTAL'},'Stream','%5.1f');
fprintf('\nEO purity      = %5.3f  mol%%\n',100*n(3,4)/sum(n(:,4)));

```

```

Stream Table [kgmol/hr]
      Stream(1)  Stream(2)  Stream(3)  Stream(4)  Stream(5)
O           84.5    2050.8    1976.1     9.9    1966.3
E           196.0    2487.3    2338.1    46.8    2291.3
EO            0.0     4.6    153.9    149.2     4.6
TOTAL        280.5    4542.7    4468.1    205.9    4262.2

```

```
EO purity      = 72.488  mol%
```

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