UNIVERSITY HONORS PROGRAM

SENIOR PROJECT - APPROVAL

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PROJECT TITLE: Interactive Learning Applications in Chemical Engineering

I have reviewed this completed senior honors thesis with this student and certify that it is a project commensurate with honors level undergraduate research in this field.

Signed: Paul Frymier, Faculty Mentor

Date: 5/7/01

Comments (Optional):

IT'S AMAZING. I WISH MR NOE HAD CLONED HIMSELF.

Interactive Learning Applications in Chemical Engineering

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Abstract:

As we move into the 21st century, educators seek to modernize their methods by complementing the traditional curriculum with interactive tools to accelerate the learning process. In undergraduate engineering education, this step has special significance. Currently, the great majority of time spent by students on the undergraduate level is occupied by learning the numerical methods needed to sufficiently analyze the type of problems presented to them as engineers. While it is accepted that this knowledge is desired in an engineer, the reality is that the practicing engineer will seldom use these manual methods with the presence of the advanced design tools available today. It is desired, therefore, to place more focus on developing true problem-solving ability and less on mathematical skill. Interactive tools have been developed by educational institutions and businesses worldwide that remove the tedium of rote calculation while retaining the core concepts of the problems they help solve. Many of these applications are available on the Internet, but the sheer extent of the Web makes finding those applications that fit the criteria time-consuming and difficult. As an aid to Chemical Engineering students at UT, a web page has been developed that contains links to the most useful of these programs, in addition to references that can expedite the completion of Chemical Engineering exercises. A need has been expressed for a comprehensive calculator for graphical analysis of separations equipment, and such a tool was not found to exist. Programs were therefore developed that allow for the automated graphical analysis of absorbers, strippers, and distillation columns.

Introduction and Purpose

Modern educators are increasingly attempting to leverage technology as a means to accelerate the learning curve at all levels of education. At the undergraduate level, there is a strong movement towards computerizing the educational experience, evident in the growing abundance of distance learning programs and web-based curricula. In the push towards new methods of teaching, however, the focus on creating a greater level of understanding within students must not be lost.

In engineering education, this conflict is at its peak. Already, professors must balance the need of an engineer to be able to understand the mathematical framework behind physical phenomena with the practical reality that most engineers with an undergraduate degree will not encounter these problems in their daily work. The information must be taught, however, as the ability to solve the unexpected and unusual problem is the ability that distinguishes an engineer. It can be seen that the skill of utmost value to an engineer, then, is the ability to apply an analytical method of thought to solve new problems.

If interactive learning is to be applied to engineering education, it must fulfill the dual goals of accelerating the acquisition of the mathematical and physical concepts that define engineering, and of building a mental framework of cause and effect to enhance the student's problem-solving ability. A calculator that disconnects the user from the process severely hampers its teaching potential. A useful learning tool must allow the user to see the physical change in the process, or in an accurate representation thereof, which results from changing parameters associated with the process. Similarly, a useful learning tool must not be so complex that the important information is buried within a sea of peripheral information. A tool that operates in this way allows the user to quickly develop an intuition associated with the process, so that the behavior of a corresponding real-world process can be predicted based on some initial observations. Some students can develop this intuition solely from working with the mathematics of the process. Some students cannot, however, and this does not necessarily have bearing on their potential as engineers, as engineers work with real systems and not abstract ones.

This project represents an effort to construct one of these interactive educational tools. This tool allows the construction of graphical solutions to

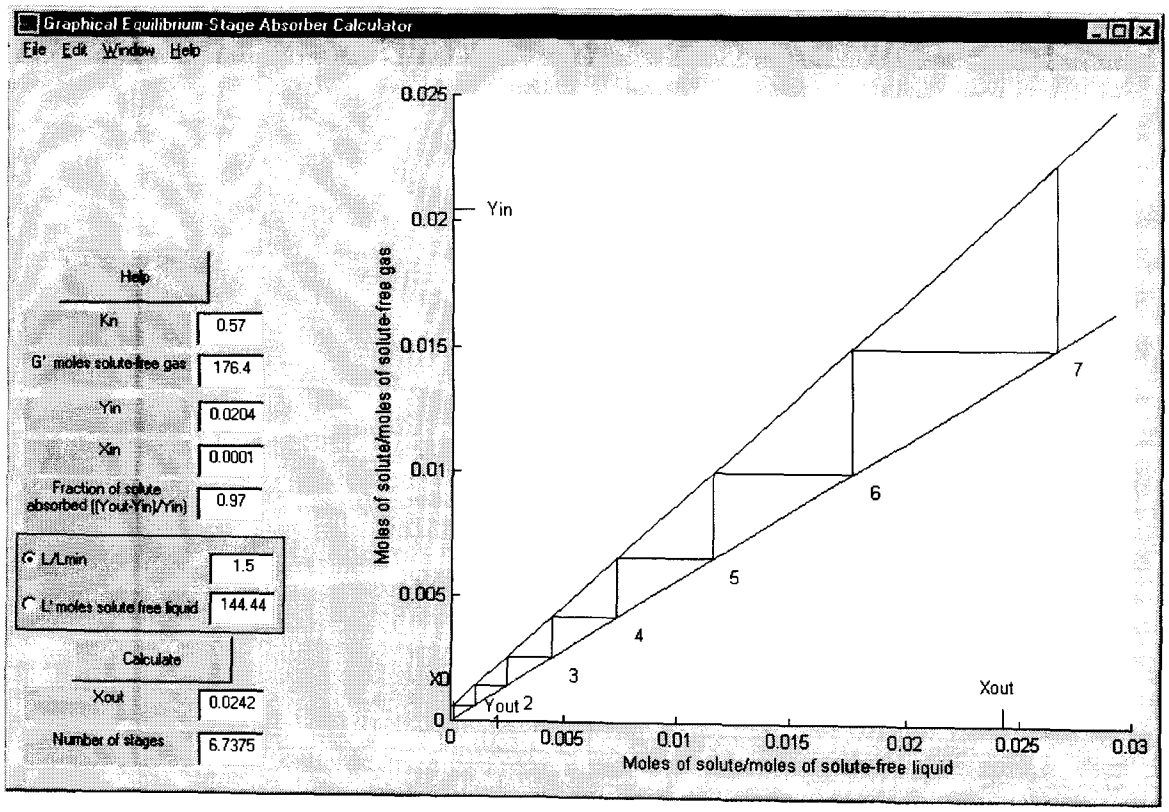
several types of separations equipment. These methods have long been used as educational tools, as their graphic nature fosters better understanding than purely algebraic methods. The tools that have been constructed remove the tedium associated with plotting line after line to reach a trial-and-error solution, without eliminating their inherent educational value.

The Applications

Application 1: Graphical Solution of an Absorber

This application uses the method for solving an absorber graphically detailed in Sieder and Henley, page 282. This solution is for countercurrent, steady-state flow. It assumes isobaric, isothermal conditions. It also assumes that equilibrium will be achieved on each stage.

Figure 1: Absorber User Interface



This program allows the user to input:

- K_n, the ratio of the mole fraction of solute in the gas phase to the mole fraction of solute in the liquid phase.
- G', The moles of solute-free gas fed into the absorber per arbitrary time period.
- Y_{in}, the ratio of moles of solute to moles of solute-free gas fed into the absorber.
- X_{in}, the ratio of moles of solute to moles of solute-free liquid fed into the absorber.
- The fraction of solute removed from the gas fed to the absorber.
- Either
    - L/L_{min}, the ratio of the liquid flow rate to the minimum liquid flow rate (i.e. the flow rate required with infinite stages).
    - L', the moles of solute-free liquid fed into the absorber per arbitrary time period

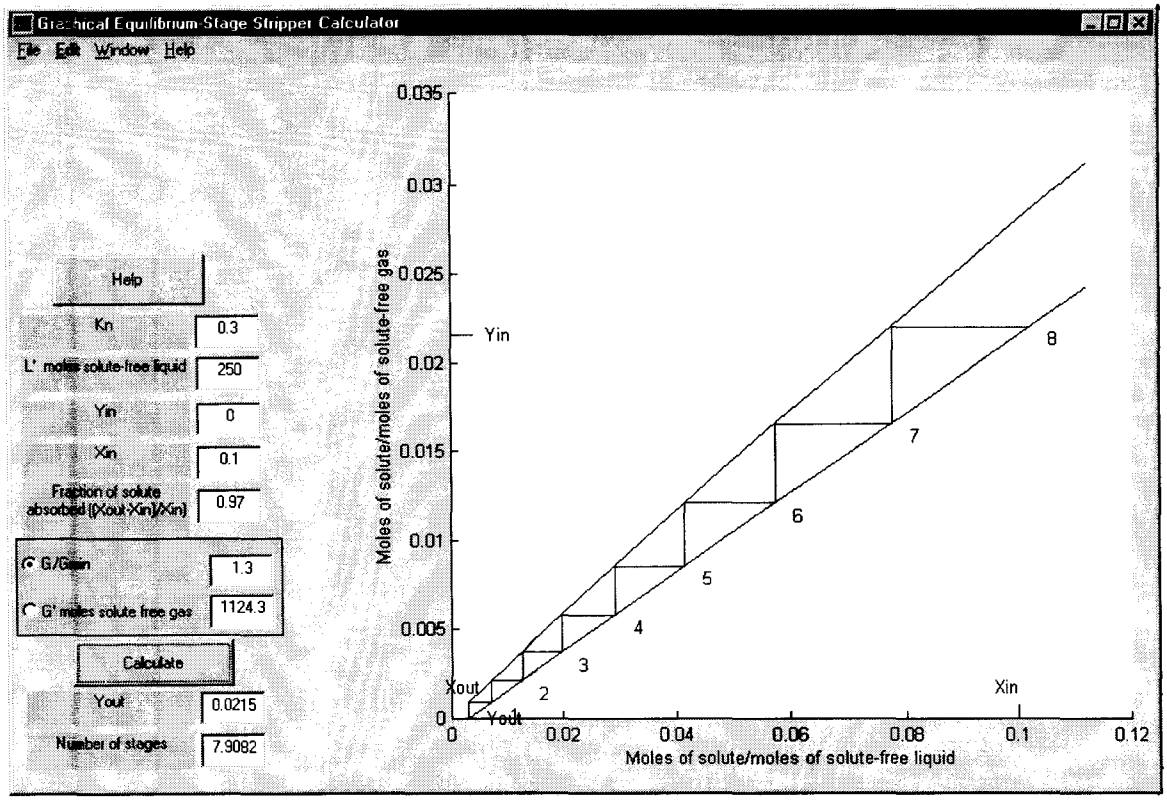
The program creates for the user:

- X_{out}, the ratio of moles of solute to moles of solute-free liquid leaving the absorber.
- The number of stages required to achieve the specified separation.
- A diagram showing the compositions of the gas and liquid at each stage.

Application 2: Graphical Solution to a Stripper

This application uses the method for solving a stripper graphically detailed in Sieder and Henley, page 282. This solution is for countercurrent, steady-state flow. It assumes isobaric, isothermal conditions. It also assumes that equilibrium will be achieved on each stage.

Figure 2: Stripper User Interface



This program allows the user to input:

- K_n, the ratio of the mole fraction of solute in the gas phase to the mole fraction of solute in the liquid phase.
- L', the moles of solute-free liquid fed into the absorber per arbitrary time period
- Y_{in}, the ratio of moles of solute to moles of solute-free gas fed into the absorber.
- X_{in}, the ratio of moles of solute to moles of solute-free liquid fed into the absorber.
- The fraction of solute removed from the liquid fed to the absorber.
- Either
    - G/G_{min}, the ratio of the gas flow rate to the minimum gas flow rate (i.e. the flow rate required with infinite stages).
    - G', the moles of solute-free gas fed into the absorber per arbitrary time period

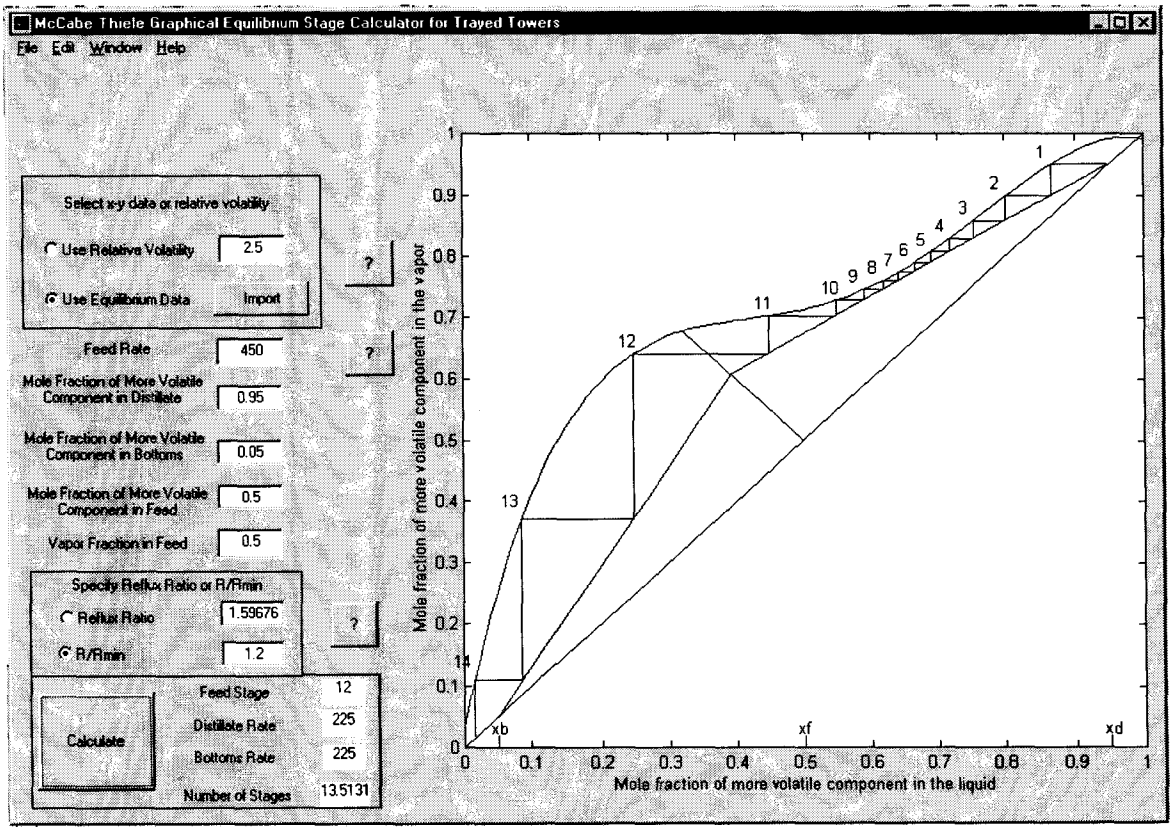
The program creates for the user:

- Y_{out}, the ratio of moles of solute to moles of solute-free gas leaving the absorber.
- The number of stages required to achieve the specified separation.
- A diagram showing the compositions of the gas and liquid at each stage.

Application 3: McCabe-Thiele Graphical Equilibrium-Stage Method for Trayed Towers

This application uses the McCabe-Thiele method for obtaining a solution for the distillation of a binary mixture. It is detailed in Seader and Henley, page 355. It assumes isobaric and isothermal conditions. The McCabe-Thiele method also introduces an assumption of constant molal overflow. This means that the vapor and liquid total flow rates do not change significantly across each stage, only the composition changes.

Figure 3: McCabe-Thiele User Interface



This program allows the user to input:

- Either:
  - Relative Volatility, the ratio of the lighter component's K value to the heavier component's K value. This is valid only for ideal mixtures.
  - Equilibrium Data, a tab-delimited text file containing the x-y data for the lighter component.
- Feed Rate, the molar feed rate of the mixture to be separated.
- Mole fraction of the more volatile component in the distillate.
- Mole fraction of the more volatile component in the bottoms product.
- Mole fraction of the more volatile component in the feed.
- Vapor fraction of feed.
- Either:
  - R/R_{min}, the ratio of the reflux ratio to the reflux ratio when there are an infinite number of stages.
  - Reflux Ratio, the ratio of distillate recycled to distillate taken as product.

This program creates for the user:

- The best stage for the feed to be fed into.
- The molar flow rate of distillate.
- The molar flow rate of bottoms product.
- The number of stages required for this separation.
- A diagram showing the vapor and liquid composition at each stage, as well as other information about the system.

References

Seader, J.D., and Ernest J. Henley, Separation Process Principles, Wiley & Sons, New York, 1998.

Matlab version 5.1, ©1984-1997 The Mathworks, Inc.

The Matlab code for the absorber simulation

```
clear
cla

HH = findobj(gcf,'Tag','Gprimetag');
Gprime = str2num(get(HH,'String'));

HH = findobj(gcf,'Tag','Yintag');
Ynplus1 = str2num(get(HH,'String'));

HH = findobj(gcf,'Tag','Xintag');
X0 = str2num(get(HH,'String'));

HH = findobj(gcf,'Tag','Fractag');
Fracabsorbed = str2num(get(HH,'String'));

HH = findobj(gcf,'Tag','LoverLmintag');
LoverLmin = str2num(get(HH,'String'));

HH = findobj(gcf,'Tag','Lprimetag');
Lprime = str2num(get(HH,'String'));

HH = findobj(gcf,'Tag','Ktag');
K = str2num(get(HH,'String'));

HH = findobj(gcf,'Tag','Radiobutton1');
buttonstatus = (get(HH,'Value'));

Y1=Ynplus1*(1-Fracabsorbed);

Lprimemin=Gprime*(Ynplus1-Y1)/((Ynplus1/(Ynplus1*(K-1)+K))-X0);

if buttonstatus==1
   Lprime=Lprimemin*LoverLmin;
end

Xn=(Ynplus1-Y1)*(Gprime/Lprime)+X0;

xdisp=Xn/25;
ydisp=Ynplus1/25;

eqcurve=inline('K.*X./(1+(1-K).*X)-zeroterm','X','K','zeroterm');

Operatingline=inline('Xfun.*(Lprime/Gprime)+Y1 -
X0*(Lprime/Gprime)','Xfun','Lprime','Gprime','Y1','X0');

if LoverLmin<=1
   warndlg('L/Lmin must be greater than 1')
elseif eqcurve(X0,K,0)>Operatingline(X0,Lprime,Gprime,Y1,X0)
   warndlg('Xin is too high to achieve the specified fraction removed')
elseif Lprime<Lprimemin
   warndlg('Lprime is less than Lmin')
elseif K<0
   warndlg('K must be positive')
elseif Gprime<0
   warndlg('Gprime must be positive')
elseif Ynplus1<0
   warndlg('Yin must be positive')
elseif X0<0
   warndlg('Xin must be positive')
elseif Fracabsorbed<=0
   warndlg('Fraction absorbed must be between zero and one')
elseif Fracabsorbed>=1
   warndlg('Fraction absorbed must be between zero and one')

else

stage=0;
xcoord1=X0;
```

```
ycoordl=Y1;
while xcoordl<Xn
   xcoordr=fzero(eqcurve,0.5,0.00001,[],K,ycoordl);
   ycoordr=ycoordl;
   line([xcoordl xcoordr],[ycoordl ycoordr]);
   lastxl=xcoordl;

   ycoordl=Operatingline(xcoordr,Lprime,Gprime,Y1,X0);
   xcoordl=xcoordr;
   line([xcoordr xcoordl],[ycoordr ycoordl]);

   stage=stage+1;
   s=num2str(stage);
   text(xcoordr+(Xn/30),ycoordr-(Ynplus1/30),s);
end
hold on
Xmin=X0;
Xmax=xcoordl + 0.1*(xcoordl-X0);
X=Xmin:0.00001:Xmax;
Y=eqcurve(X,K,0);
plot(X,Y);
Y=Operatingline(X,Lprime,Gprime,Y1,X0);
plot(X,Y);
xlabel('Moles of solute/moles of solute-free liquid');
ylabel('Moles of solute/moles of solute-free gas');
text(Xn-xdisp,2*ydisp,'Xout');
line([Xn Xn],[0 ydisp]);
text(X0-xdisp,2*ydisp,'X0');
line([X0 X0],[0 ydisp]);
text(1.5*xdisp,Ynplus1,'Yin');
line([0 xdisp],[Ynplus1 Ynplus1]);
text(1.5*xdisp,Y1,'Yout');
line([0 xdisp],[Y1 Y1]);

hold off


HH = findobj(gcf,'Tag','Xouttag');
set(HH,'String',Xn);

NumStages=stage -((xcoordr-Xn)/(xcoordr-lastxl));

HH = findobj(gcf,'Tag','Ntag');
set(HH,'String',NumStages);

HH = findobj(gcf,'Tag','Lprimetag');
set(HH,'String',Lprime)
end
```

```
function absorber()
% This is the machine-generated representation of a Handle Graphics object
% and its children.  Note that handle values may change when these objects
% are re-created. This may cause problems with any callbacks written to
% depend on the value of the handle at the time the object was saved.
%
% To reopen this object, just type the name of the M-file at the MATLAB
% prompt. The M-file and its associated MAT-file must be on your path.

load absorber

a = figure('Color',[0.8 0.8 0.8], ...
    'Colormap',mat0, ...
    'Name','Graphical Equilibrium-Stage Absorber Calculator', ...
    'NumberTitle','off', ...
    'PointerShapeCData',mat1, ...
    'Position',[202 180 836 532], ...
    'Tag','Fig1');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'Position',[1.86207 84.4138 148.345 54], ...
    'Style','frame', ...
    'Tag','Frame1');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[1 1 1], ...
    'Position',[102.724 219.724 36.6207 19.2414], ...
    'String','176.4', ...
    'Style','edit', ...
    'Tag','Gprimetag');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[0.752941 0.752941 0.752941], ...
    'Position',[5.58621 219.724 93.7241 19.2414], ...
    'String','G''  moles solute-free gas', ...
    'Style','text', ...
    'Tag','StaticText1');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[0.752941 0.752941 0.752941], ...
    'Position',[5.58621 194.897 93.7241 19.2414], ...
    'String','Yin', ...
    'Style','text', ...
    'Tag','StaticText1');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[1 1 1], ...
    'Position',[102.724 194.276 36.6207 19.2414], ...
    'String','0.0204', ...
    'Style','edit', ...
    'Tag','Yintag');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[0.752941 0.752941 0.752941], ...
    'Position',[5.58621 171.31 93.7241 19.2414], ...
    'String','Xin', ...
    'Style','text', ...
    'Tag','StaticText1');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[1 1 1], ...
    'Position',[102.414 170.069 36.6207 19.2414], ...
    'String','0.0001', ...
    'Style','edit', ...
    'Tag','Xintag');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[0.752941 0.752941 0.752941], ...
```

```
    'Position',[5.58621 139.034 93.1034 29.7931], ...
    'String','Fraction of solute absorbed ((Yout-Yin)/Yin)', ...
    'Style','text', ...
    'Tag','StaticText1');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[1 1 1], ...
    'Position',[102.724 145.862 36.6207 19.2414], ...
    'String','0.97', ...
    'Style','edit', ...
    'Tag','Fractag');
b = axes('Parent',a, ...
    'CameraUpVector',[0 1 0], ...
    'CameraUpVectorMode','manual', ...
    'Color',[1 1 1], ...
    'ColorOrder',mat2, ...
    'Position',[0.383971 0.093985 0.59689 0.864662], ...
    'Tag','Axes1', ...
    'XColor',[0 0 0], ...
    'YColor',[0 0 0], ...
    'ZColor',[0 0 0]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'HandleVisibility','callback', ...
    'HorizontalAlignment','center', ...
    'Position',[0.0149398 -0.00152505 0], ...
    'String','Moles of solute/moles of solute-free liquid', ...
    'Tag','Axes1Text9', ...
    'VerticalAlignment','cap');
set(get(c,'Parent'),'XLabel',c);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'HandleVisibility','callback', ...
    'HorizontalAlignment','center', ...
    'Position',[-0.00319277 0.0124183 0], ...
    'Rotation',90, ...
    'String','Moles of solute/moles of solute-free gas', ...
    'Tag','Axes1Text8', ...
    'VerticalAlignment','baseline');
set(get(c,'Parent'),'YLabel',c);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'HandleVisibility','callback', ...
    'HorizontalAlignment','right', ...
    'Position',[-0.0193373 0.0260893 0], ...
    'Tag','Axes1Text7', ...
    'Visible','off');
set(get(c,'Parent'),'ZLabel',c);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'HandleVisibility','callback', ...
    'HorizontalAlignment','center', ...
    'Position',[0.0149398 0.0254357 0], ...
    'Tag','Axes1Text6', ...
    'VerticalAlignment','bottom');
set(get(c,'Parent'),'Title',c);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line20', ...
    'XData',[0.0001 0.00106892], ...
    'YData',[0.000612 0.000612]);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line19', ...
    'XData',[0.00106892 0.00106892], ...
    'YData',[0.000612 0.00140539]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
```

```
    'Position',[0.00187778 -6.8e-005 0], ...
    'String','1', ...
    'Tag','Axes1Text15');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line18', ...
    'XData',[0.00106892 0.00246278], ...
    'YData',[0.00140539 0.00140539]);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line17', ...
    'XData',[0.00246278 0.00246278], ...
    'YData',[0.00140539 0.00254673]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.00327164 0.000725391 0], ...
    'String','2', ...
    'Tag','Axes1Text14');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line16', ...
    'XData',[0.00246278 0.00447085], ...
    'YData',[0.00254673 0.00254673]);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line15', ...
    'XData',[0.00447085 0.00447085], ...
    'YData',[0.00254673 0.00419103]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.00527972 0.00186673 0], ...
    'String','3', ...
    'Tag','Axes1Text13');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line14', ...
    'XData',[0.00447085 0.0073699], ...
    'YData',[0.00419103 0.00419103]);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line13', ...
    'XData',[0.0073699 0.0073699], ...
    'YData',[0.00419103 0.00656488]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.00817877 0.00351103 0], ...
    'String','4', ...
    'Tag','Axes1Text12');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line12', ...
    'XData',[0.0073699 0.011568], ...
    'YData',[0.00656488 0.00656488]);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line11', ...
    'XData',[0.011568 0.011568], ...
    'YData',[0.00656488 0.0100024]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.0123768 0.00588488 0], ...
    'String','5', ...
    'Tag','Axes1Text11');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line10', ...
    'XData',[0.011568 0.0176739], ...
    'YData',[0.0100024 0.0100024]);
```

```
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line9', ...
    'XData',[0.0176739 0.0176739], ...
    'YData',[0.0100024 0.0150022]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.0184827 0.00932242 0], ...
    'String','6', ...
    'Tag','Axes1Text10');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line8', ...
    'XData',[0.0176739 0.0266117], ...
    'YData',[0.0150022 0.0150022]);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line7', ...
    'XData',[0.0266117 0.0266117], ...
    'YData',[0.0150022 0.0223208]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.0274206 0.0143222 0], ...
    'String','7', ...
    'Tag','Axes1Text5');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line6', ...
    'XData',mat3, ...
    'YData',mat4);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line5', ...
    'XData',mat5, ...
    'YData',mat6);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.0232953 0.001632 0], ...
    'String','Xout', ...
    'Tag','Axes1Text4');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line4', ...
    'XData',[0.0242659 0.0242659], ...
    'YData',[0 0.000816]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[-0.000870636 0.001632 0], ...
    'String','X0', ...
    'Tag','Axes1Text3');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line3', ...
    'XData',[0.0001 0.0001], ...
    'YData',[0 0.000816]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.00145595 0.0204 0], ...
    'String','Yin', ...
    'Tag','Axes1Text2');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line2', ...
    'XData',[0 0.000970636], ...
    'YData',[0.0204 0.0204]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.00145595 0.000612 0], ...
```

```
   'String','Yout', ...
   'Tag','Axes1Text1');
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line1', ...
   'XData',[0 0.000970636], ...
   'YData',[0.000612 0.000612]);
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[1 1 1], ...
   'Position',[109.241 88.1379 36.6207 19.2414], ...
   'String','144.443', ...
   'Style','edit', ...
   'Tag','Lprimetag');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Callback','HH = findobj(gcf,''Tag'',''Radiobutton2'');set(HH,''Value'',0);', ...
   'Position',[4.34483 114.207 94.9655 19.2414], ...
   'String','L/Lmin', ...
   'Style','radiobutton', ...
   'Tag','Radiobutton1', ...
   'Value',1);
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Callback','HH = findobj(gcf,''Tag'',''Radiobutton1'');set(HH,''Value'',0);', ...
   'Position',[4.34483 88.1379 104.276 19.8621], ...
   'String','L'' moles solute free liquid', ...
   'Style','radiobutton', ...
   'Tag','Radiobutton2');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[1 1 1], ...
   'Position',[109.241 110.483 36 18.6207], ...
   'String','1.5', ...
   'Style','edit', ...
   'Tag','LoverLmintag');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'Callback',mat7, ...
   'Position',[24.2069 266.897 84.4138 27.931], ...
   'String','Help', ...
   'Tag','Pushbutton1');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'Callback','abscalc', ...
   'Position',[33.5172 56.4828 89.3793 25.4483], ...
   'String','Calculate', ...
   'Tag','Pushbutton2');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Position',[4.96552 242.69 93.7241 19.2414], ...
   'String','Kn', ...
   'Style','text', ...
   'Tag','StaticText1');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[1 1 1], ...
   'Position',[101.793 242.69 36.6207 19.2414], ...
   'String','0.57', ...
   'Style','edit', ...
   'Tag','Ktag');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[1 1 1], ...
   'Position',[103.655 34.7586 36.6207 19.2414], ...
```

```
    'String','0.0242659', ...
    'Style','edit', ...
    'Tag','Xouttag');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[0.752941 0.752941 0.752941], ...
    'Position',[6.82759 34.7586 93.7241 19.2414], ...
    'String','Xout', ...
    'Style','text', ...
    'Tag','blah');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[1 1 1], ...
    'Position',[103.655 11.1724 36.6207 19.2414], ...
    'String','6.73754', ...
    'Style','edit', ...
    'Tag','Ntag');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[0.752941 0.752941 0.752941], ...
    'Position',[6.82759 11.1724 93.7241 19.2414], ...
    'String','Number of stages', ...
    'Style','text', ...
    'Tag','StaticText1');
```

The Matlab code for the stripper simulation

```
clear
cla

HH = findobj(gcf,'Tag','Gprimetag');
Lprime = str2num(get(HH,'String'));

HH = findobj(gcf,'Tag','Yintag');
Y0 = str2num(get(HH,'String'));

HH = findobj(gcf,'Tag','Xintag');
Xnplus1 = str2num(get(HH,'String'));

HH = findobj(gcf,'Tag','Fractag');
Fracabsorbed = str2num(get(HH,'String'));

HH = findobj(gcf,'Tag','LoverLmintag');
GoverGmin = str2num(get(HH,'String'));

HH = findobj(gcf,'Tag','Lprimetag');
Gprime = str2num(get(HH,'String'));

HH = findobj(gcf,'Tag','Ktag');
K = str2num(get(HH,'String'));

HH = findobj(gcf,'Tag','Radiobutton1');
buttonstatus = (get(HH,'Value'));

X1=Xnplus1*(1-Fracabsorbed);

Ynmin=K*Xnplus1/(1+Xnplus1)/(1-(K*Xnplus1/(1+Xnplus1)));
Gprimemin=Lprime*(X1-Xnplus1)/(Y0-Ynmin);
Gminalt=Fracabsorbed*Lprime/K;

if buttonstatus==1
   Gprime=Gprimemin*GoverGmin;
end

Yn=Xnplus1*(Lprime/Gprime)+Y0-X1*(Lprime/Gprime);

xdisp=Xnplus1/25;
ydisp=Yn/25;

eqcurve=inline('K.*X./(1+(1-K).*X)','X','K');

Operatingline=inline('Xfun.*(Lprime./Gprime)+Y0-X1.*(Lprime./Gprime)-
zeroterm','Xfun','Lprime','Gprime','X1','Y0','zeroterm');

if GoverGmin<=1
   warndlg('G/Gmin must be greater than 1')
elseif eqcurve(X1,K)<Operatingline(X1,Lprime,Gprime,X1,Y0,0)
   warndlg('Yin is too high to achieve the specified fraction removed')
elseif Gprime<Gprimemin
   warndlg('Gprime is less than Gmin')
elseif K<0
   warndlg('K must be positive')
elseif Lprime<0
   warndlg('Lprime must be positive')
elseif Y0<0
   warndlg('Yin must be positive')
elseif Xnplus1<0
   warndlg('Xin must be positive')
elseif Fracabsorbed<=0
   warndlg('Fraction stripped must be between zero and one')
elseif Fracabsorbed>=1
   warndlg('Fraction stripped must be between zero and one')

else
```

```
stage=0;
xcoordr=X1;
ycoordr=Y0;
while xcoordr<Xnplus1
   ycoordl=eqcurve(xcoordr,K);
   xcoordl=xcoordr;
   line([xcoordr xcoordl],[ycoordr ycoordl]);
   lastxl=xcoordl;

   xcoordr=fzero(Operatingline,0.5,0.00001,[],Lprime,Gprime,X1,Y0,ycoordl);
   ycoordr=ycoordl;
   line([xcoordl xcoordr],[ycoordl ycoordr]);


   stage=stage+1;
   s=num2str(stage);
   text(xcoordr+(Xnplus1/30),ycoordr-(Yn/30),s);
end
hold on
Xmin=X1;
Xmax=xcoordr + 0.1*(xcoordr-X1);
X=Xmin:0.00001:Xmax;
Y=eqcurve(X,K);
plot(X,Y);
Y=Operatingline(X,Lprime,Gprime,X1,Y0,0);
plot(X,Y);
xlabel('Moles of solute/moles of solute-free liquid');
ylabel('Moles of solute/moles of solute-free gas');
text(Xnplus1-xdisp,2*ydisp,'Xin');
line([Xnplus1 Xnplus1],[0 ydisp]);
text(X1-xdisp,2*ydisp,'Xout');
line([X1 X1],[0 ydisp]);
text(1.5*xdisp,Yn,'Yin');
line([0 xdisp],[Yn Yn]);
text(1.5*xdisp,Y0,'Yout');
line([0 xdisp],[Y0 Y0]);

hold off


HH = findobj(gcf,'Tag','Xouttag');
set(HH,'String',Yn);

NumStages=stage -((xcoordr-Xnplus1)/(xcoordr-lastxl));

HH = findobj(gcf,'Tag','Ntag');
set(HH,'String',NumStages);

HH = findobj(gcf,'Tag','Lprimetag');
set(HH,'String',Gprime)
end
```

```
function stripper()
% This is the machine-generated representation of a Handle Graphics object
% and its children.  Note that handle values may change when these objects
% are re-created. This may cause problems with any callbacks written to
% depend on the value of the handle at the time the object was saved.
%
% To reopen this object, just type the name of the M-file at the MATLAB
% prompt. The M-file and its associated MAT-file must be on your path.

load stripper

a = figure('Color',[0.8 0.8 0.8], ...
   'Colormap',mat0, ...
   'Name','Graphical Equilibrium-Stage Stripper Calculator', ...
   'NumberTitle','off', ...
   'PointerShapeCData',mat1, ...
   'Position',[202 180 836 532], ...
   'Tag','Fig1');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'Position',[1.86207 84.4138 148.345 54], ...
   'Style','frame', ...
   'Tag','Frame1');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[1 1 1], ...
   'Position',[102.724 219.724 36.6207 19.2414], ...
   'String','176.4', ...
   'Style','edit', ...
   'Tag','Gprimetag');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Position',[5.58621 219.724 93.7241 19.2414], ...
   'String','L''  moles solute-free liquid', ...
   'Style','text', ...
   'Tag','StaticText1');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Position',[5.58621 194.897 93.7241 19.2414], ...
   'String','Yin', ...
   'Style','text', ...
   'Tag','StaticText1');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[1 1 1], ...
   'Position',[102.724 194.276 36.6207 19.2414], ...
   'String','0', ...
   'Style','edit', ...
   'Tag','Yintag');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Position',[5.58621 171.31 93.7241 19.2414], ...
   'String','Xin', ...
   'Style','text', ...
   'Tag','StaticText1');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[1 1 1], ...
   'Position',[102.414 170.069 36.6207 19.2414], ...
   'String','0.1', ...
   'Style','edit', ...
   'Tag','Xintag');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
```

```
   'Position',[5.58621 139.034 93.1034 29.7931], ...
   'String','Fraction of solute absorbed ((Xout-Xin)/Xin)', ...
   'Style','text', ...
   'Tag','StaticText1');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[1 1 1], ...
   'Position',[102.724 145.862 36.6207 19.2414], ...
   'String','0.97', ...
   'Style','edit', ...
   'Tag','Fractag');
b = axes('Parent',a, ...
   'CameraUpVector',[0 1 0], ...
   'CameraUpVectorMode','manual', ...
   'Color',[1 1 1], ...
   'ColorOrder',mat2, ...
   'Position',[0.383971 0.093985 0.59689 0.864662], ...
   'Tag','Axes1', ...
   'XColor',[0 0 0], ...
   'YColor',[0 0 0], ...
   'ZColor',[0 0 0]);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'HandleVisibility','callback', ...
   'HorizontalAlignment','center', ...
   'Position',[0.0796787 -0.0054902 0], ...
   'String','Moles of solute/moles of solute-free liquid', ...
   'Tag','Axes1Text9', ...
   'VerticalAlignment','cap');
set(get(c,'Parent'),'XLabel',c);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'HandleVisibility','callback', ...
   'HorizontalAlignment','center', ...
   'Position',[-0.0141365 0.044902 0], ...
   'Rotation',90, ...
   'String','Moles of solute/moles of solute-free gas', ...
   'Tag','Axes1Text8', ...
   'VerticalAlignment','baseline');
set(get(c,'Parent'),'YLabel',c);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'HandleVisibility','callback', ...
   'HorizontalAlignment','right', ...
   'Position',[-0.103133 0.0939216 0], ...
   'Tag','Axes1Text7', ...
   'Visible','off');
set(get(c,'Parent'),'ZLabel',c);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'HandleVisibility','callback', ...
   'HorizontalAlignment','center', ...
   'Position',[0.0796787 0.0915686 0], ...
   'Tag','Axes1Text6', ...
   'VerticalAlignment','bottom');
set(get(c,'Parent'),'Title',c);
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line20', ...
   'XData',[0.003 0.003], ...
   'YData',[0 0.0017078]);
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line19', ...
   'XData',[0.003 0.00754683], ...
   'YData',[0.0017078 0.0017078]);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
```

```
    'Position',[0.0108802 0.000493351 0], ...
    'String','1', ...
    'Tag','Axes1Text15');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line18', ...
    'XData',[0.00754683 0.00754683], ...
    'YData',[0.0017078 0.00428778]);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line17', ...
    'XData',[0.00754683 0.0144158], ...
    'YData',[0.00428778 0.00428778]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.0177491 0.00307333 0], ...
    'String','2', ...
    'Tag','Axes1Text14');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line16', ...
    'XData',[0.0144158 0.0144158], ...
    'YData',[0.00428778 0.00816636]);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line15', ...
    'XData',[0.0144158 0.0247421], ...
    'YData',[0.00816636 0.00816636]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.0280754 0.00695192 0], ...
    'String','3', ...
    'Tag','Axes1Text13');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line14', ...
    'XData',[0.0247421 0.0247421], ...
    'YData',[0.00816636 0.0139545]);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line13', ...
    'XData',[0.0247421 0.0401524], ...
    'YData',[0.0139545 0.0139545]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.0434858 0.0127401 0], ...
    'String','4', ...
    'Tag','Axes1Text12');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line12', ...
    'XData',[0.0401524 0.0401524], ...
    'YData',[0.0139545 0.0224984]);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line11', ...
    'XData',[0.0401524 0.0628997], ...
    'YData',[0.0224984 0.0224984]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.0662331 0.021284 0], ...
    'String','5', ...
    'Tag','Axes1Text11');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line10', ...
    'XData',[0.0628997 0.0628997], ...
    'YData',[0.0224984 0.0349087]);
```

```
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line9', ...
   'XData',[0.0628997 0.0959407], ...
   'YData',[0.0349087 0.0349087]);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'Position',[0.099274 0.0336942 0], ...
   'String','6', ...
   'Tag','Axes1Text10');
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line8', ...
   'XData',[0.0959407 0.0959407], ...
   'YData',[0.0349087 0.0525195]);
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line7', ...
   'XData',[0.0959407 0.142828], ...
   'YData',[0.0525195 0.0525195]);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'Position',[0.146161 0.0513051 0], ...
   'String','7', ...
   'Tag','Axes1Text5');
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line6', ...
   'XData',mat3, ...
   'YData',mat4);
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line5', ...
   'XData',mat5, ...
   'YData',mat6);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'Position',[0.096 0.00291467 0], ...
   'String','Xin', ...
   'Tag','Axes1Text4');
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line4', ...
   'XData',[0.1 0.1], ...
   'YData',[0 0.00145733]);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'Position',[-0.001 0.00291467 0], ...
   'String','Xout', ...
   'Tag','Axes1Text3');
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line3', ...
   'XData',[0.003 0.003], ...
   'YData',[0 0.00145733]);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'Position',[0.006 0.0364334 0], ...
   'String','Yin', ...
   'Tag','Axes1Text2');
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line2', ...
   'XData',[0 0.004], ...
   'YData',[0.0364334 0.0364334]);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'Position',[0.006 0 0], ...
```

```
    'String','Yout', ...
    'Tag','Axes1Text1');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line1', ...
    'XData',[0 0.004], ...
    'YData',[0 0]);
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[1 1 1], ...
    'Position',[109.241 88.1379 36.6207 19.2414], ...
    'String','469.646', ...
    'Style','edit', ...
    'Tag','Lprimetag');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[0.752941 0.752941 0.752941], ...
    'Callback','HH = findobj(gcf,''Tag'',''Radiobutton2'');set(HH,''Value'',0);', ...
    'Position',[4.34483 114.207 94.9655 19.2414], ...
    'String','G/Gmin', ...
    'Style','radiobutton', ...
    'Tag','Radiobutton1', ...
    'Value',1);
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[0.752941 0.752941 0.752941], ...
    'Callback','HH = findobj(gcf,''Tag'',''Radiobutton1'');set(HH,''Value'',0);', ...
    'Position',[4.34483 88.1379 104.276 19.8621], ...
    'String','G'' moles solute free gas', ...
    'Style','radiobutton', ...
    'Tag','Radiobutton2');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[1 1 1], ...
    'Position',[109.241 110.483 36 18.6207], ...
    'String','1.5', ...
    'Style','edit', ...
    'Tag','LoverLmintag');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'Callback',mat7, ...
    'Position',[22.9655 267.517 84.4138 27.931], ...
    'String','Help', ...
    'Tag','Pushbutton1');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'Callback','stripcalc', ...
    'Position',[33.5172 56.4828 89.3793 25.4483], ...
    'String','Calculate', ...
    'Tag','Pushbutton2');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[0.752941 0.752941 0.752941], ...
    'Position',[4.96552 242.69 93.7241 19.2414], ...
    'String','Kn', ...
    'Style','text', ...
    'Tag','StaticText1');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[1 1 1], ...
    'Position',[101.793 242.69 36.6207 19.2414], ...
    'String','0.57', ...
    'Style','edit', ...
    'Tag','Ktag');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[1 1 1], ...
    'Position',[103.655 34.7586 36.6207 19.2414], ...
```

```
    'String','0.0364334', ...
    'Style','edit', ...
    'Tag','Xouttag');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[0.752941 0.752941 0.752941], ...
    'Position',[6.82759 34.7586 93.7241 19.2414], ...
    'String','Yout', ...
    'Style','text', ...
    'Tag','blah');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[1 1 1], ...
    'Position',[103.655 11.1724 36.6207 19.2414], ...
    'String','6.08658', ...
    'Style','edit', ...
    'Tag','Ntag');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[0.752941 0.752941 0.752941], ...
    'Position',[6.82759 11.1724 93.7241 19.2414], ...
    'String','Number of stages', ...
    'Style','text', ...
    'Tag','StaticText1');
```

The Matlab code for the McCabe-Thiele simulation

```
point=get(gca,'CurrentPoint');
xclick=point(1,1);
yclick=point(1,2);
HH = findobj(gcf,'Tag','EditText7');
xd = str2num(get(HH,'String'));
Rvalue=((xd/yclick)-1)/(1-(xclick/yclick));

%  Make sure R is a valid reflux ratio

if Rvalue > 0
   HH = findobj(gcf,'Tag','EditText1');
   set(HH,'String',Rvalue);
   mainprog;
else
   msgbox('Clicks below the 45 line are invalid');
end
```

```
function ya=eqcurve(x,generic,type,zeroterm)
if type == 1
   ya=(generic.*x)./(1+x.*(generic-1))-zeroterm;
else
   ya=polyval(generic,x)-zeroterm;
end
```

```
function exclude(number,mainfighandle)
if number == 1
   HH = findobj(mainfighandle,'Tag','Radiobutton1');
   set(HH,'Value',0);
elseif number == 2
   HH = findobj(mainfighandle,'Tag','Checkbox1');
   set(HH,'Value',0);
elseif number == 4
   HH = findobj(mainfighandle,'Tag','Radiobutton2');
   set(HH,'Value',0);
elseif number == 3
   HH = findobj(mainfighandle,'Tag','Radiobutton3');
   set(HH,'Value',0);
end
```

```
[filename,pathname] = uigetfile('*.txt','Get Equilibrium Data');
if filename == 0
   %msgbox('No data was loaded');
   else
   cd(pathname)
   dataset=dlmread(filename,'\t');
   P=polyfit(dataset(:,1),dataset(:,2),4);
   end
%else
%  msgbox('This data is not formatted correctly')
%end
```

```
function ya=line45(x)
ya=x;
```

```
%  get values from the gui

HH = findobj(gcf,'Tag','Checkbox1');
type(1) = (get(HH,'Value'));
HH = findobj(gcf,'Tag','Radiobutton2');
type(2) = (get(HH,'Value'));
FigAHandle=gcf;

HH = findobj(FigAHandle,'Tag','EditText1');
R = str2num(get(HH,'String'));

HH = findobj(FigAHandle,'Tag','EditText5');
relvol = str2num(get(HH,'String'));

HH = findobj(FigAHandle,'Tag','EditText8');
F = str2num(get(HH,'String'));

HH = findobj(FigAHandle,'Tag','EditText7');
xd = str2num(get(HH,'String'));

HH = findobj(FigAHandle,'Tag','EditText6');
xb = str2num(get(HH,'String'));

HH = findobj(FigAHandle,'Tag','EditText4');
xf = str2num(get(HH,'String'));

HH = findobj(FigAHandle,'Tag','EditText2');
VapFrac = str2num(get(HH,'String'));

HH = findobj(FigAHandle,'Tag','EditText12');
RoverRmin = str2num(get(HH,'String'));

%Check for validity of input
if relvol < 0
   msgbox('Relative volatility must be positive')
elseif R < 0
   msgbox('Reflux ratio must be positive')
elseif F < 0
   msgbox('Feed rate must be positive')
elseif xd < xf
   msgbox('xdistillate must be greater than xfeed')
elseif xb > xf
   msgbox('xbottoms must be less than xfeed')
elseif xb < 0
   msgbox('xbottoms must be greater than zero')
elseif xd >= 1
   msgbox('xdistillate must be less than 1')
elseif xb <= 0
   msgbox('xbottoms must be greater than 0')
elseif RoverRmin<1
   msgbox('R/Rmin must be greater than 1')
else

%  if everything is ok, run the program
mccabeeval;
end
```

```
clear
global P type
P=[0 0 0 0];
mccabegui;
```

```
breakflag=0;
if P(1)==0 & type(1)==0
   msgbox('You must import data if you do not want to use relative volatility');
else
%HH = findobj(FigAHandle,'Tag','EditText1');
%R = str2num(get(HH,'String'));

%HH = findobj(FigAHandle,'Tag','EditText5');
%relvol = str2num(get(HH,'String'));

%HH = findobj(FigAHandle,'Tag','EditText8');
%F = str2num(get(HH,'String'));

%HH = findobj(FigAHandle,'Tag','EditText7');
%xd = str2num(get(HH,'String'));

if xd > 0.999
   msgbox('Warning, xd is set very high. Results may be inaccurate.')
   figure('FigAHandle')
end

%HH = findobj(FigAHandle,'Tag','EditText6');
%xb = str2num(get(HH,'String'));

if xb < 0.001
   msgbox('Warning, xb is set very low. Results may be inaccurate.')
   figure('FigAHandle')
end

%HH = findobj(FigAHandle,'Tag','EditText4');
%xf = str2num(get(HH,'String'));

%HH = findobj(FigAHandle,'Tag','EditText2');
%VapFrac = str2num(get(HH,'String'));



if VapFrac == 0
   VapFrac = 0.00001;
end

%HH = findobj(FigAHandle,'Tag','EditText12');
%RoverRmin = str2num(get(HH,'String'));

if type(1) == 1
   generic=relvol;
else
   generic=P;
end


B=F*(xf-xd)/(xb-xd);
D=F-B;
q=1-VapFrac;

p1=fzero('point1',0.5,[],[],q,xf);

p3=fzero('point3',0.5,[],[],q,xf,generic,type(1));

%  If the user selects R/Rmin instead of specifying R, type(2) is zero. In this case,
%  Rmin must be calculated. If relative volatility is used (type(1)=1), you know the
behavior is
%  ideal, and you can calcluate Rmin directly. If it is not, you must test to see if there
is a
%  pinch point present.
if type(2) == 0
   if type(1) == 1
      yclick=qline(p3,q,xf);
```

```
      xclick=p3;
      Rmin=((xd/yclick)-1)/(1-(xclick/yclick));
      R=RoverRmin*Rmin;
      HH = findobj(FigAHandle,'Tag','EditText1');
      set(HH,'String',R);
   elseif type(1) == 0
      xpinch=xf;
      y1=eqcurve(xpinch,generic,type(1),0);
      y2=eqcurve(xpinch+0.001,generic,type(1),0);
      y_at_xd=y1+((y2-y1)/0.001*(xd-xpinch));
      if xd<y_at_xd
         yclick=qline(p3,q,xf);
         xclick=p3;
         Rmin=((xd/yclick)-1)/(1-(xclick/yclick));
         R=RoverRmin*Rmin;
         HH = findobj(FigAHandle,'Tag','EditText1');
         set(HH,'String',R);
      else
         while xd>y_at_xd
            xpinch=xpinch+0.001;
            y1=eqcurve(xpinch,generic,type(1),0);
            y2=eqcurve(xpinch+0.001,generic,type(1),0);
            y_at_xd=y1+((y2-y1)/0.001*(xd-xpinch));
         end
         Rmin=((xd/y1)-1)/(1-(xpinch/y1));
         R=RoverRmin*Rmin;
         HH = findobj(FigAHandle,'Tag','EditText1');
         set(HH,'String',R);
         p2=fzero('point2',0.5,[],[],R,xd,q,xf);
         if p2<p3
            yclick=qline(p3,q,xf);
            xclick=p3;
            Rmin=((xd/yclick)-1)/(1-(xclick/yclick));
            R=RoverRmin*Rmin;
            HH = findobj(FigAHandle,'Tag','EditText1');
            set(HH,'String',R);
         end
      end
   end

end

p2=fzero('point2',0.5,[],[],R,xd,q,xf);

if p2<p3
   msgbox('Reflux ratio is set below minimum reflux')
   break
end

%  Draw equilibrium curve

xeqcurve=0:0.01:1;

yeqcurve=eqcurve(xeqcurve,generic,type(1),0);

slopestrip=((rect(p2,R,xd)-xb))/(p2-xb);
interceptstrip=rect(p2,R,xd)-(slopestrip*p2);

plot(xeqcurve,yeqcurve);
axis([0 1 0 1]);
hold on

%  Draw Rectifying Line
line([p2 xd],[rect(p2,R,xd) xd]);

%  Draw 45-line
line([0 1],[0 1]);
```

```
%  Draw Stripping Line
line([xb p2],[xb qline(p2,q,xf)]);

%  Draw q-line and make it clickable
qlinehandle=line([p3 p1],[qline(p3,q,xf) qline(p1,q,xf)]);
set(qlinehandle,'ButtonDownFcn','clickfun');

%  Step off the rectifying section until the feed stage is reached
stage = 0;
xcoordr=xd;
ycoordr=xd;
while xcoordr>p2
   if breakflag==0
   xcoordl=fzero('eqcurve',xcoordr,[],[],generic,type(1),ycoordr);
   ycoordl=eqcurve(xcoordl,generic,type(1),0);
   line([xcoordl xcoordr],[ycoordl ycoordr]);

   %  If the specified values are physically impossible,
   %  the program exits with an error. Impossibility is detected by
   %  testing to see if the step size between stages is becoming
   %  infinitely small.
   infinitecriteria=abs(xcoordr-xcoordl);
   if infinitecriteria<0.0001
      breakflag=1;
   end


   ycoordr=rect(xcoordl,R,xd);
   xcoordr=xcoordl;
   line([xcoordl xcoordr],[ycoordl ycoordr]);
   stage=stage+1;
   s=num2str(stage);
   text(xcoordl-0.02,ycoordl+0.02,s);
   else
   xcoordr=0;
   end
end

%  Step off stripping section
if breakflag == 0
FeedStage=stage;
ycoordr=strip(xcoordr,slopestrip,interceptstrip);
line([xcoordr xcoordr],[ycoordl ycoordr]);
while xcoordr>xb
   xcoordl=fzero('eqcurve',xcoordr,[],[],generic,type(1),ycoordr);
   ycoordl=eqcurve(xcoordl,generic,type(1),0);
   line([xcoordl xcoordr],[ycoordl ycoordr]);
   lastxl=xcoordl;
   lastxr=xcoordr;

   ycoordr=strip(xcoordl,slopestrip,interceptstrip);
   xcoordr=xcoordl;

   if ycoordr>xcoordl
      line([xcoordl xcoordr],[ycoordl ycoordr]);
   else
      line([xcoordl xcoordr],[ycoordl xcoordr]);
   end

   stage=stage+1;
   s=num2str(stage);
   text(xcoordl-0.03,ycoordl+0.03,s);
end

%  Label the plot
hold off
xlabel('Mole fraction of more volatile component in the liquid');
ylabel('Mole fraction of more volatile component in the vapor');
```

```
text(xb-0.01,0.03,'xb');
line([xb xb],[0 0.02]);
text(xd-0.01,0.03,'xd');
line([xd xd],[0 0.02]);
text(xf-0.01,0.03,'xf');
line([xf xf],[0 0.02]);


%  Return string values to the output boxes
NumStages=stage-((xb-lastxl)/(lastxr-lastxl));
HH = findobj(FigAHandle,'Tag','EditText11');
set(HH,'String',num2str(NumStages));

HH = findobj(FigAHandle,'Tag','EditText3');
set(HH,'String',num2str(FeedStage));

HH = findobj(FigAHandle,'Tag','EditText9');
set(HH,'String',num2str(D));

HH = findobj(FigAHandle,'Tag','EditText10');
set(HH,'String',num2str(B));

%  Keep axes clickable to get reflux ratio
set(gca,'ButtonDownFcn','clickfun');

else
   hold off
   plot([0 1],[0 1]);
   msgbox('Error: Infinite Stages');

end

%  Warn the user if the specified xb or xd requires less than one stage
%  i.e., it is achieved with a simple flash

if xb>p3
   msgbox('The specified xbottoms may be thermodynamically impossible assuming equilibrium
stages. If the figure appears corrupted, decrease xb and try again.')
elseif xd<p3
   msgbox('The specified xdistillate may be thermodynamically impossible assuming
equilibrium stages. If the figure appears corrupted, increase xd and try again.')
end
end
```

```
function mccabegui()
% This is the machine-generated representation of a Handle Graphics object
% and its children.  Note that handle values may change when these objects
% are re-created. This may cause problems with any callbacks written to
% depend on the value of the handle at the time the object was saved.
%
% To reopen this object, just type the name of the M-file at the MATLAB
% prompt. The M-file and its associated MAT-file must be on your path.

load mccabegui

a = figure('Color',[0.752941 0.752941 0.752941], ...
   'Colormap',mat0, ...
   'Name','McCabe Thiele Graphical Equilibrium Stage Calculator for Trayed Towers', ...
   'NumberTitle','off', ...
   'PointerShapeCData',mat1, ...
   'Position',[5 5 900 600], ...
   'Tag','Fig1');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'Position',[10.5 6.75 206.25 78.75], ...
   'Style','frame', ...
   'Tag','Frame3');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Position',[10.5 84 160.5 62.25], ...
   'Style','frame', ...
   'Tag','Frame2');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[1 1 1], ...
   'Position',[121.655 112.966 39.1034 15.5172], ...
   'String','1.79842', ...
   'Style','edit', ...
   'Tag','EditText1');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'Callback','mainprog', ...
   'Position',[14.8966 16.7586 67.6552 57.7241], ...
   'String','Calculate', ...
   'Tag','Pushbutton1');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Position',[22.9655 131.586 137.172 11.1724], ...
   'String','Specify Reflux Ratio or R/Rmin', ...
   'Style','text', ...
   'Tag','StaticText1');
b = axes('Parent',a, ...
   'Box','on', ...
   'ButtonDownFcn','clickfun', ...
   'CameraUpVector',[0 1 0], ...
   'Color',[1 1 1], ...
   'ColorOrder',mat2, ...
   'Position',[0.39481 0.0932568 0.593142 0.809182], ...
   'Tag','Axes1', ...
   'XColor',[0 0 0], ...
   'XLimMode','manual', ...
   'YColor',[0 0 0], ...
   'YLimMode','manual', ...
   'ZColor',[0 0 0]);
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line37', ...
   'XData',mat3, ...
   'YData',mat4);
c = line('Parent',b, ...
```

```
    'Color',[0 0 1], ...
    'Tag','Axes1Line36', ...
    'XData',[0.402107 0.95], ...
    'YData',[0.597893 0.95]);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line35');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line34', ...
    'XData',[0.05 0.402107], ...
    'YData',[0.05 0.597893]);
c = line('Parent',b, ...
    'ButtonDownFcn','clickfun', ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line33', ...
    'XData',[0.387426 0.5], ...
    'YData',[0.612574 0.5]);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line32', ...
    'XData',[0.883721 0.95], ...
    'YData',[0.95 0.95]);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line31', ...
    'XData',[0.883721 0.883721], ...
    'YData',[0.95 0.907405]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.863721 0.97 0], ...
    'String','1', ...
    'Tag','Axes1Text21');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line30', ...
    'XData',[0.796744 0.883721], ...
    'YData',[0.907405 0.907405]);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line29', ...
    'XData',[0.796744 0.796744], ...
    'YData',[0.907405 0.851509]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.776744 0.927405 0], ...
    'String','2', ...
    'Tag','Axes1Text20');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line28', ...
    'XData',[0.696397 0.796744], ...
    'YData',[0.851509 0.851509]);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line27', ...
    'XData',[0.696397 0.696397], ...
    'YData',[0.851509 0.78702]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.676397 0.871509 0], ...
    'String','3', ...
    'Tag','Axes1Text19');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line26', ...
    'XData',[0.596467 0.696397], ...
    'YData',[0.78702 0.78702]);
```

```
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line25', ...
   'XData',[0.596467 0.596467], ...
   'YData',[0.78702 0.7228]);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'Position',[0.576467 0.80702 0], ...
   'String','4', ...
   'Tag','Axes1Text18');
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line24', ...
   'XData',[0.510524 0.596467], ...
   'YData',[0.7228 0.7228]);
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line23', ...
   'XData',[0.510524 0.510524], ...
   'YData',[0.7228 0.667569]);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'Position',[0.490524 0.7428 0], ...
   'String','5', ...
   'Tag','Axes1Text17');
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line22', ...
   'XData',[0.445447 0.510524], ...
   'YData',[0.667569 0.667569]);
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line21', ...
   'XData',[0.445447 0.445447], ...
   'YData',[0.667569 0.625747]);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'Position',[0.425447 0.687569 0], ...
   'String','6', ...
   'Tag','Axes1Text16');
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line20', ...
   'XData',[0.400765 0.445447], ...
   'YData',[0.625747 0.625747]);
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line19', ...
   'XData',[0.400765 0.400765], ...
   'YData',[0.625747 0.597031]);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'Position',[0.380765 0.645747 0], ...
   'String','7', ...
   'Tag','Axes1Text15');
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line18', ...
   'XData',[0.400765 0.400765], ...
   'YData',[0.625747 0.595806]);
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line17', ...
   'XData',[0.37092 0.400765], ...
   'YData',[0.595806 0.595806]);
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line16', ...
```

```
   'XData',[0.37092 0.37092], ...
   'YData',[0.595806 0.549366]);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'Position',[0.34092 0.625806 0], ...
   'String','8', ...
   'Tag','Axes1Text14');
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line15', ...
   'XData',[0.327793 0.37092], ...
   'YData',[0.549366 0.549366]);
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line14', ...
   'XData',[0.327793 0.327793], ...
   'YData',[0.549366 0.482258]);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'Position',[0.297793 0.579366 0], ...
   'String','9', ...
   'Tag','Axes1Text13');
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line13', ...
   'XData',[0.271448 0.327793], ...
   'YData',[0.482258 0.482258]);
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line12', ...
   'XData',[0.271448 0.271448], ...
   'YData',[0.482258 0.394583]);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'Position',[0.241448 0.512258 0], ...
   'String','10', ...
   'Tag','Axes1Text12');
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line11', ...
   'XData',[0.206791 0.271448], ...
   'YData',[0.394583 0.394583]);
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line10', ...
   'XData',[0.206791 0.206791], ...
   'YData',[0.394583 0.293974]);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'Position',[0.176791 0.424583 0], ...
   'String','11', ...
   'Tag','Axes1Text11');
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line9', ...
   'XData',[0.142772 0.206791], ...
   'YData',[0.293974 0.293974]);
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line8', ...
   'XData',[0.142772 0.142772], ...
   'YData',[0.293974 0.194358]);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'Position',[0.112772 0.323974 0], ...
   'String','12', ...
   'Tag','Axes1Text10');
c = line('Parent',b, ...
```

```
    'Color',[0 0 1], ...
    'Tag','Axes1Line7', ...
    'XData',[0.0880058 0.142772], ...
    'YData',[0.194358 0.194358]);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line6', ...
    'XData',[0.0880058 0.0880058], ...
    'YData',[0.194358 0.109139]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.0580058 0.224358 0], ...
    'String','13', ...
    'Tag','Axes1Text9');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line5', ...
    'XData',[0.0467145 0.0880058], ...
    'YData',[0.109139 0.109139]);
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line4', ...
    'XData',[0.0467145 0.0467145], ...
    'YData',[0.109139 0.0467145]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.0167145 0.139139 0], ...
    'String','14', ...
    'Tag','Axes1Text8');
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'HandleVisibility','callback', ...
    'HorizontalAlignment','center', ...
    'Position',[0.498438 -0.0497336 0], ...
    'String','Mole fraction of more volatile component in the liquid', ...
    'Tag','Axes1Text7', ...
    'VerticalAlignment','cap');
set(get(c,'Parent'),'XLabel',c);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'HandleVisibility','callback', ...
    'HorizontalAlignment','center', ...
    'Position',[-0.0546875 0.497336 0], ...
    'Rotation',90, ...
    'String','Mole fraction of more volatile component in the vapor', ...
    'Tag','Axes1Text6', ...
    'VerticalAlignment','baseline');
set(get(c,'Parent'),'YLabel',c);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.04 0.03 0], ...
    'String','xb', ...
    'Tag','Axes1Text5');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line3', ...
    'XData',[0.05 0.05], ...
    'YData',[0 0.02]);
c = text('Parent',b, ...
    'Color',[0 0 0], ...
    'Position',[0.94 0.03 0], ...
    'String','xd', ...
    'Tag','Axes1Text4');
c = line('Parent',b, ...
    'Color',[0 0 1], ...
    'Tag','Axes1Line2', ...
    'XData',[0.95 0.95], ...
    'YData',[0 0.02]);
```

```
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'Position',[0.49 0.03 0], ...
   'String','xf', ...
   'Tag','Axes1Text3');
c = line('Parent',b, ...
   'Color',[0 0 1], ...
   'Tag','Axes1Line1', ...
   'XData',[0.5 0.5], ...
   'YData',[0 0.02]);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'HandleVisibility','callback', ...
   'HorizontalAlignment','right', ...
   'Position',[-0.665625 1.11901 0], ...
   'Tag','Axes1Text2', ...
   'Visible','off');
set(get(c,'Parent'),'ZLabel',c);
c = text('Parent',b, ...
   'Color',[0 0 0], ...
   'HandleVisibility','callback', ...
   'HorizontalAlignment','center', ...
   'Position',[0.498438 1.01421 0], ...
   'Tag','Axes1Text1', ...
   'VerticalAlignment','bottom');
set(get(c,'Parent'),'Title',c);
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Position',[8.68966 156.414 108 11.1724], ...
   'String','Vapor Fraction in Feed', ...
   'Style','text', ...
   'Tag','StaticText2');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[1 1 1], ...
   'Position',[120.414 153.31 39.7241 18], ...
   'String','0.5', ...
   'Style','edit', ...
   'Tag','EditText2');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Position',[94.9655 65.7931 70.1379 14.2759], ...
   'String','Feed Stage', ...
   'Style','text', ...
   'Tag','StaticText3');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.9 0.9 0.9], ...
   'Position',[182.483 67.0345 26.069 15.5172], ...
   'String','7', ...
   'Style','text', ...
   'Tag','EditText3');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'Callback','fileload', ...
   'Position',[118.552 297.931 57.7241 20.4828], ...
   'String','Import', ...
   'Tag','Pushbutton2');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Position',[8.06897 175.034 108.621 22.3448], ...
   'String','Mole Fraction of More Volatile Component in Feed', ...
   'Style','text', ...
   'Tag','StaticText4');
b = uicontrol('Parent',a, ...
```

```
   'Units','points', ...
   'BackgroundColor',[1 1 1], ...
   'Position',[120.414 182.483 39.7241 14.8966], ...
   'String','0.5', ...
   'Style','edit', ...
   'Tag','EditText4');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[1 1 1], ...
   'Position',[121.655 328.966 40.9655 17.3793], ...
   'String','2.5', ...
   'Style','edit', ...
   'Tag','EditText5');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Position',[7.44828 201.103 106.759 29.1724], ...
   'String','Mole Fraction of More Volatile Component in Bottoms', ...
   'Style','text', ...
   'Tag','StaticText6');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Position',[5.58621 234.621 108 29.7931], ...
   'String','Mole Fraction of More Volatile Component in Distillate', ...
   'Style','text', ...
   'Tag','StaticText7');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[1 1 1], ...
   'Position',[120.414 209.793 39.7241 14.8966], ...
   'String','0.05', ...
   'Style','edit', ...
   'Tag','EditText6');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[1 1 1], ...
   'Position',[120.414 240.828 39.7241 16.1379], ...
   'String','0.95', ...
   'Style','edit', ...
   'Tag','EditText7');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Position',[9.93103 271.862 105.517 11.7931], ...
   'String','Feed Rate', ...
   'Style','text', ...
   'Tag','StaticText8');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[1 1 1], ...
   'Position',[120.414 268.138 40.9655 17.3793], ...
   'String','450', ...
   'Style','edit', ...
   'Tag','EditText8');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Position',[94.9655 40.3448 70.1379 19.8621], ...
   'String','Distillate Rate', ...
   'Style','text', ...
   'Tag','StaticText9');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Position',[93.1034 22.3448 72.6207 19.2414], ...
   'String','Bottoms Rate', ...
   'Style','text', ...
```

```
   'Tag','StaticText10');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.9 0.9 0.9], ...
   'Position',[182.483 48.4138 25.4483 15.5172], ...
   'String','225', ...
   'Style','text', ...
   'Tag','EditText9');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.9 0.9 0.9], ...
   'Position',[182.483 29.1724 25.4483 14.8966], ...
   'String','225', ...
   'Style','text', ...
   'Tag','EditText10');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Callback','exclude(1,gcf)', ...
   'Position',[19.8621 330.207 93.7241 13.6552], ...
   'String','Use Relative Volatility', ...
   'Style','radiobutton', ...
   'Tag','Checkbox1', ...
   'Value',1);
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.9 0.9 0.9], ...
   'Position',[180.75 8.25 30 14.25], ...
   'String','13.9204', ...
   'Style','text', ...
   'Tag','EditText11');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Position',[93.1034 8.06897 76.3448 11.1724], ...
   'String','Number of Stages', ...
   'Style','text', ...
   'Tag','StaticText12');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Position',[7.44828 290.483 176.897 90.6207], ...
   'Style','frame', ...
   'Tag','Frame1');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Callback','exclude(2,gcf)', ...
   'Position',[19.8621 301.655 88.7586 11.1724], ...
   'String','Use Equilibrium Data', ...
   'Style','radiobutton', ...
   'Tag','Radiobutton1');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[1 1 1], ...
   'Position',[122.276 89.3793 38.4828 15.5172], ...
   'String','1.2', ...
   'Style','edit', ...
   'Tag','EditText12');
b = uicontrol('Parent',a, ...
   'Units','points', ...
   'BackgroundColor',[0.752941 0.752941 0.752941], ...
   'Callback','exclude(3,gcf)', ...
   'Position',[27.931 111.103 87.5172 13.0345], ...
   'String','Reflux Ratio', ...
   'Style','radiobutton', ...
   'Tag','Radiobutton2');
b = uicontrol('Parent',a, ...
```

```
    'Units','points', ...
    'BackgroundColor',[0.752941 0.752941 0.752941], ...
    'Callback','exclude(4,gcf)', ...
    'Position',[26.6897 88.1379 90 16.7586], ...
    'String','R/Rmin', ...
    'Style','radiobutton', ...
    'Tag','Radiobutton3', ...
    'Value',1);
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'BackgroundColor',[0.752941 0.752941 0.752941], ...
    'Position',[19.8621 358.138 144.621 11.7931], ...
    'String','Select x-y data or relative volatility', ...
    'Style','text', ...
    'Tag','StaticText5');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'Callback','mccabehelp(1)', ...
    'Position',[198 315.75 27.75 27], ...
    'String','?', ...
    'Tag','Pushbutton3');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'Callback','mccabehelp(2)', ...
    'Position',[198 262.5 27.75 27], ...
    'String','?', ...
    'Tag','Pushbutton3');
b = uicontrol('Parent',a, ...
    'Units','points', ...
    'Callback','mccabehelp(3)', ...
    'Position',[188.25 101.25 27.75 27], ...
    'String','?', ...
    'Tag','Pushbutton3');
```

```
function mccabehelp(switchvar)

switch switchvar
case 1

   helpdlg('The equlibrium curve can be generated either from a relative volatility or an
imported set of equilibrium data. To choose equilibrium data or relative volatility, click
the appropriate button. Equilibrium data must be in the form of a tab-delimited text file,
with the first column being mole fraction in the liquid phase (x) and the second column
being mole fraction in the gas phase (y).','McCabe Thiele Help Window');

case 2

   helpdlg('The feed rate must be on a molar basis. The bottoms and distillate rates are
in the same units as the feed rate.','McCabe Thiele Help Window')

case 3

   helpdlg('You must either select to specify the reflux ratio or the fraction of minimum
reflux. If the reflux ratio is the chosen specification, reflux ratios may be chosen by
clicking on the q-line (the line joining the equilibrium curve and the 45 line).','McCabe
Thiele Help Window')

end
```

```
function zero=point1(x,q,xf)
zero=qline(x,q,xf)-line45(x);
```

```
function zero=point2(x,R,xd,q,xf)
zero=rect(x,R,xd)-qline(x,q,xf);
```

```
function zero=point3(x,q,xf,generic,type)
zero=eqcurve(x,generic,type,0)-qline(x,q,xf);
```

```
function y=qline(x,q,xf)
y=q/(q-1).*x-xf/(q-1);
```

```
function y=rect(x,R,xd)
y=(R/(R+1)).*x+(1/(R+1))*xd;
```

```
function y=strip(x,slopestrip,interceptstrip)
y=slopestrip*x+interceptstrip;
```

The presentation

Interactive Learning Applications in Chemical Engineering

By Jacob Noe

Faculty Mentor: Dr. Paul Frymier

Interactive Learning Applications in Chemical Engineering

- The Roadblocks of Engineering Education
- Web Resources for Chemical Engineers
- Graphical Equilibium-Based Mass Transfer Simulations

Roadblocks of Engineering Education

- What is Engineering about?
- Webster's: the application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people.
- Engineering educators attempt to impress upon their students the idea that the goal of an engineering student is to obtain the ability to solve problems, and not solely the ability to solve equations or perform experiments.

Roadblocks of Engineering Education

- Most of the time in engineering courses is devoted instead to developing the mental tools required for engineering instead of focusing on the engineering process itself.
- Engineering educators constantly seek ways to expedite the acquisition of these tools, and to change the focus to the engineering process.
- There has been a strong movement to modernize engineering classroom education by introducing interactive tools that eliminate the tedium of working through pages of complex equations to solve conceptually simple problems.

Goals of Interactive Tools

- The program must be easy to use.
  - If the program is difficult to use, it defeats its own purpose.
- The program should make the underlying concepts as visible as possible.
  - Where the mathematics permits, the program should make the physical nature of the calculations visible.
- The program should allow a large degree of interaction
  - The nature of engineers is to experiment. Any parameter that can be changed in the physical system that has an effect should be alterable by the user.

Web Resources for Chemical Engineers

- At educational institutions and businesses around the world, these tools have been developed.
- The vast size of the internet makes these programs difficult to find.
- There is a need for students to have access to these tools in an efficient manner.

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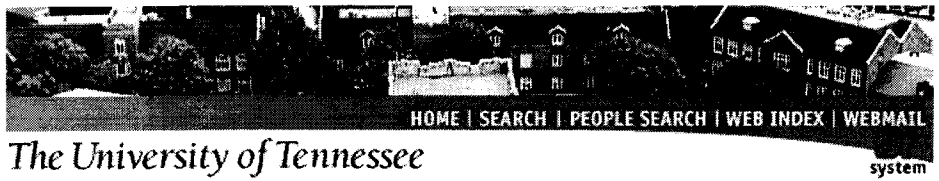
Address http://web.utk.edu/~jnoe1/project/Calculators.htm Go



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Web Resources for Chemical Engineers

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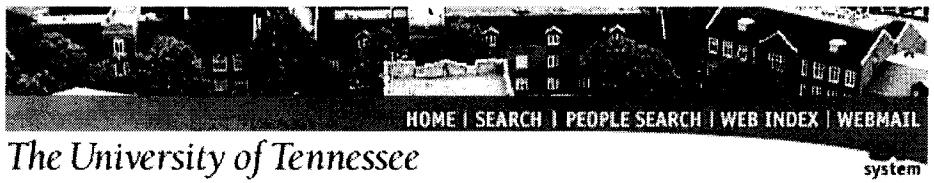

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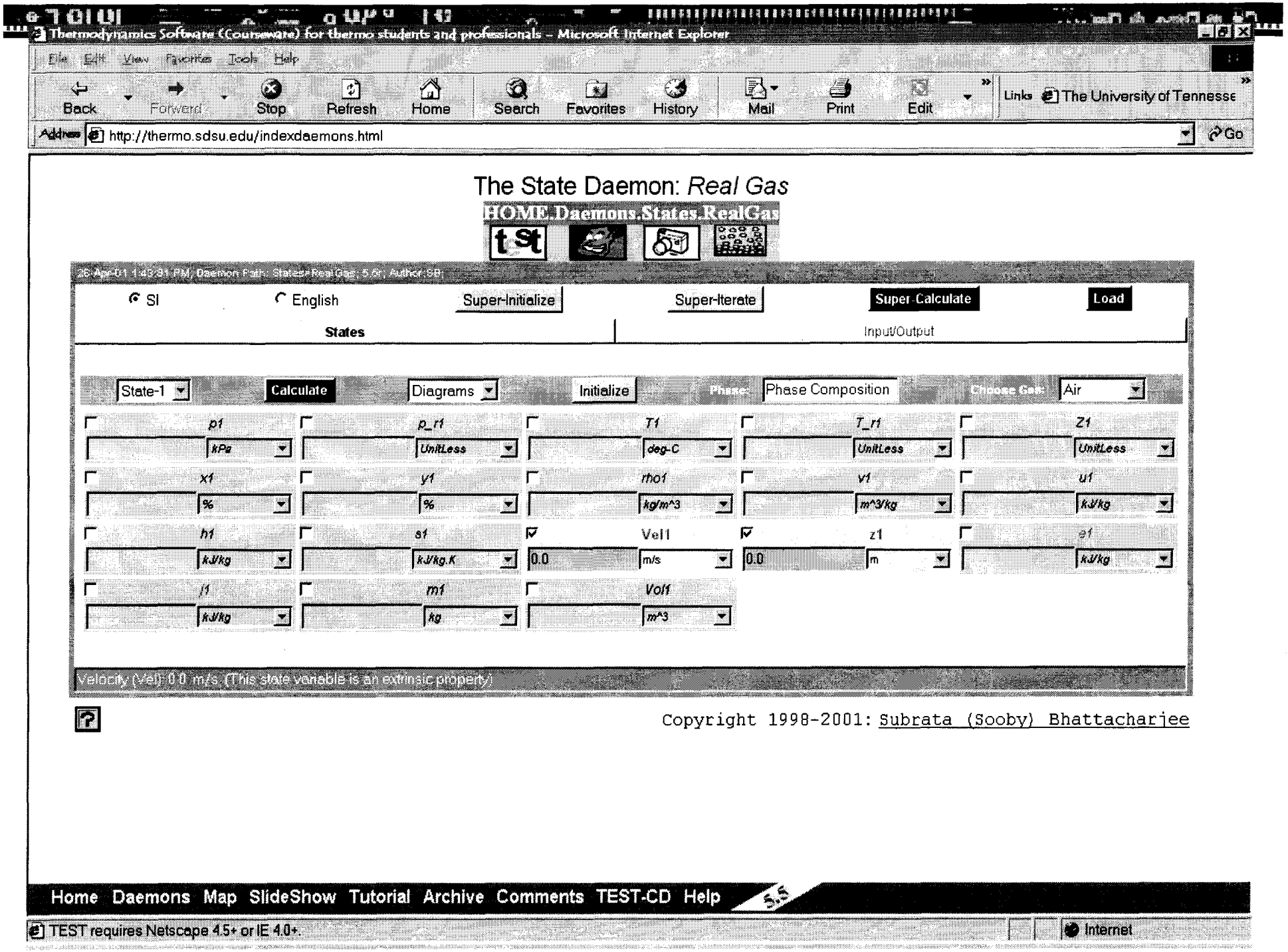
Web Resources for Chemical Engineers

Home

General Science Information

- **Treasure Troves of Science**

  This site has excellent guides to Chemistry and Physics, arranged like a gigantic list of Frequently Asked Questions.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p1 kPa
p_r1 UnitLess
T1 deg-C
T_r1 UnitLess
Z1 UnitLess
x1 %
y1 %
rho1 kg/m^3
v1 m^3/kg
u1 kJ/kg
h1 kJ/kg
s1 kJ/kg.K
Vel1 0.0 m/s
z1 0.0 m
e1 kJ/kg
f1 kJ/kg
m1 kg
Vol1 m^3
Velocity (Vel) 0.0 m/s (This state variable is an extrinsic property)
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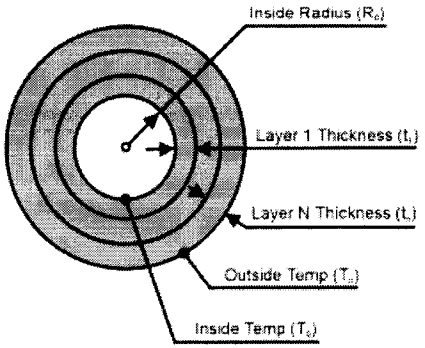
TEST requires Netscape 4.5+ or IE 4.0+.
Internet

Conduction Across Multilayered Isothermal Cylinder

Description

This page calculates the temperature at the outer wall surface (T_n) for an isothermal (constant temperature) multilayer cylinder with heat (Q) flow from the inner cylinder face to the outer face.



Define the cylinder's inside radius, length, inner wall temperature (T_0), and the heat conducted through the layers. This page will calculate the outer wall temperature. T_n will be colder for positive values of Q and hotter for negative values of Q. Layers up to the first zero value for thickness or conductivity will be included in the calculation.

About this Calculator

Verification Test Case

Properties

Multilayer Cylinder and Flow Conditions

Description	Symbol	Value	Units
Inner Radius	R_0	0.025	Meters
Length	L	0.5	Meters
Temperature at Inner Surface	T_0	50	°C
Heat Flow from Inner to Outer Surface	Q	10	W

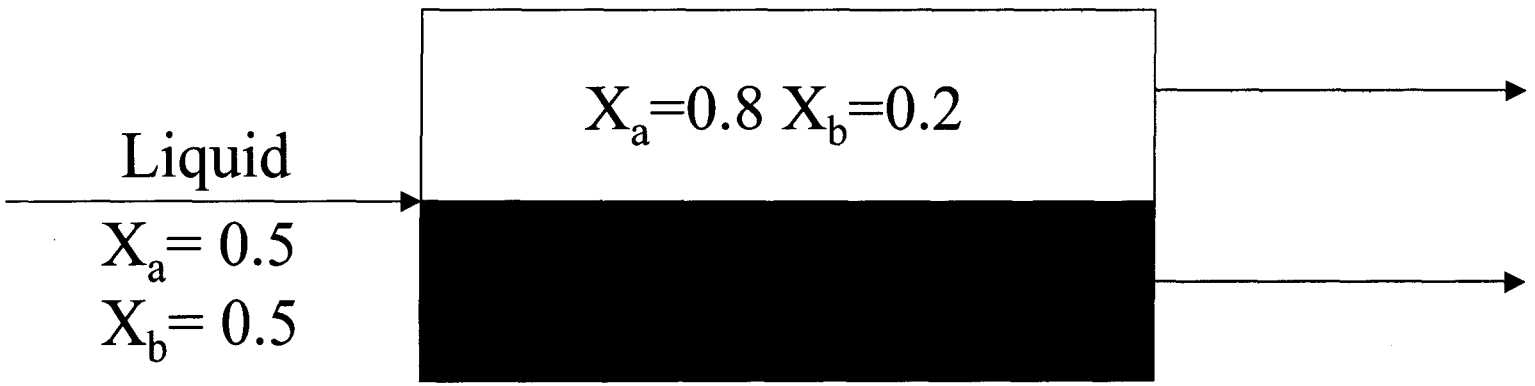
Layer Thickness and Conductivity (First zero value ends the list)	Sym	Thickness (m)	Sym	Conductivity (W/m-°C)

Graphical Equilibrium-Based Mass Transfer

- A need was seen for a better tool for teaching the physical basis for separation equipment.
- These concepts have been traditionally taught using graphical methods of calculation.
- A program was created to replicate the experience of solving these problems graphically without the time investment required.

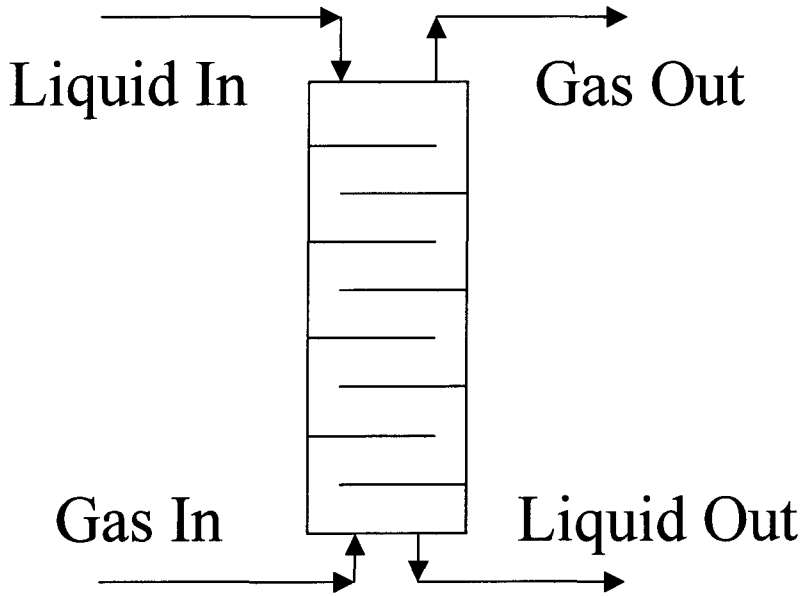
An Overview of Separators

- For a given concentration of a chemical in the liquid phase, there exists a fixed, corresponding concentration in the gas phase at equilibrium.
- If a solution of two liquids is allowed to evaporate in a closed system, the gas phase will have a higher concentration of the lower-boiling liquid
- Now suppose you get rid of the gas and allow the liquid to evaporate again. The liquid becomes even richer in b.



An Overview of Separators

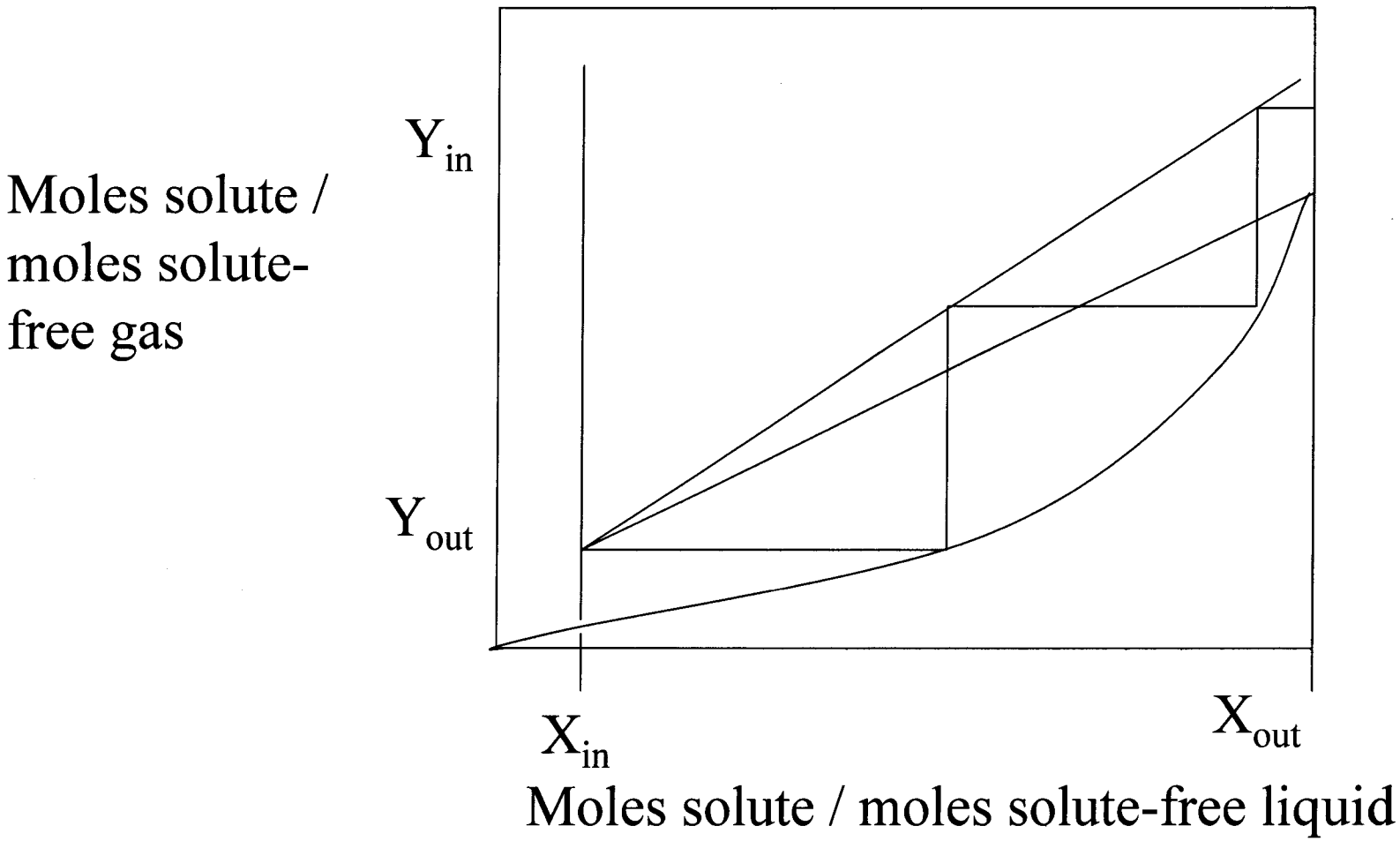
- A separator is basically a sequence of these chambers. Each "chamber" is called a plate or stage.



An Overview of Separators

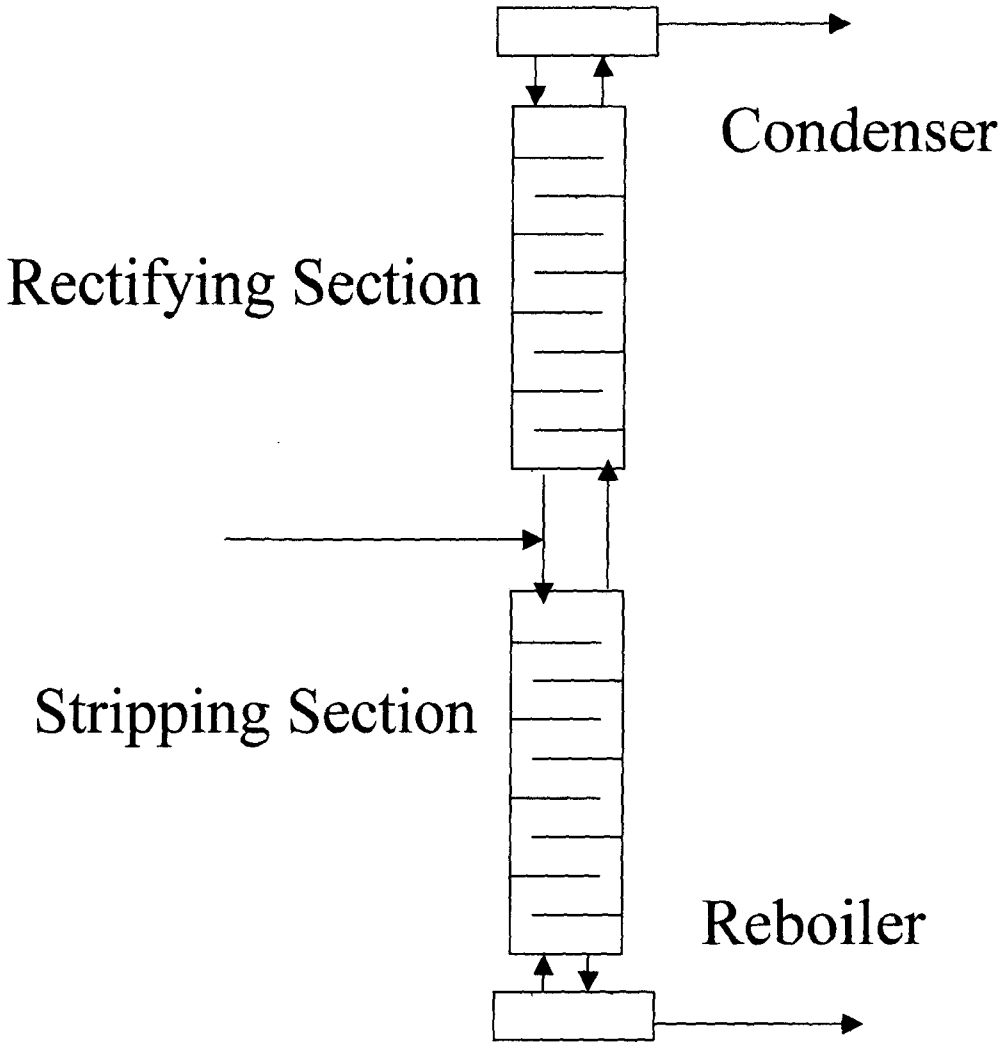
- Say that we are designing something to remove gasoline from water, and air is going to be used to strip the gasoline from the water.
- The more air you use, the more gasoline is removed.
- The more stages you use, the more gasoline is removed.
- Both supplying air and building stages costs money, what balance is the most efficient?

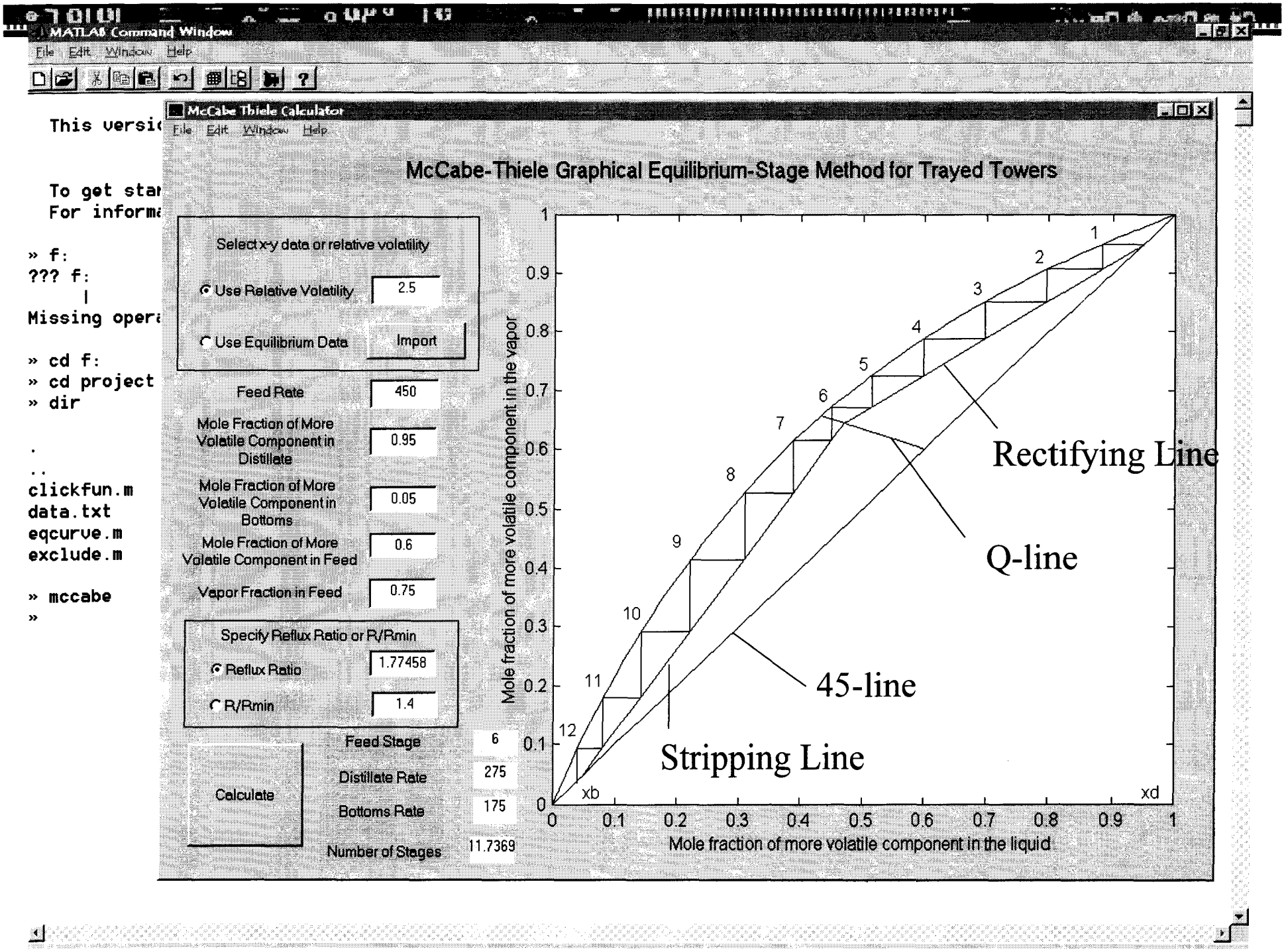
Graphical Solution to an Absorber



Distillation

- A distillation column is, in concept, an absorber combined with a stripper.
- At each end, some of the gas or liquid is recycled back into the column.
- This introduces even more variables.

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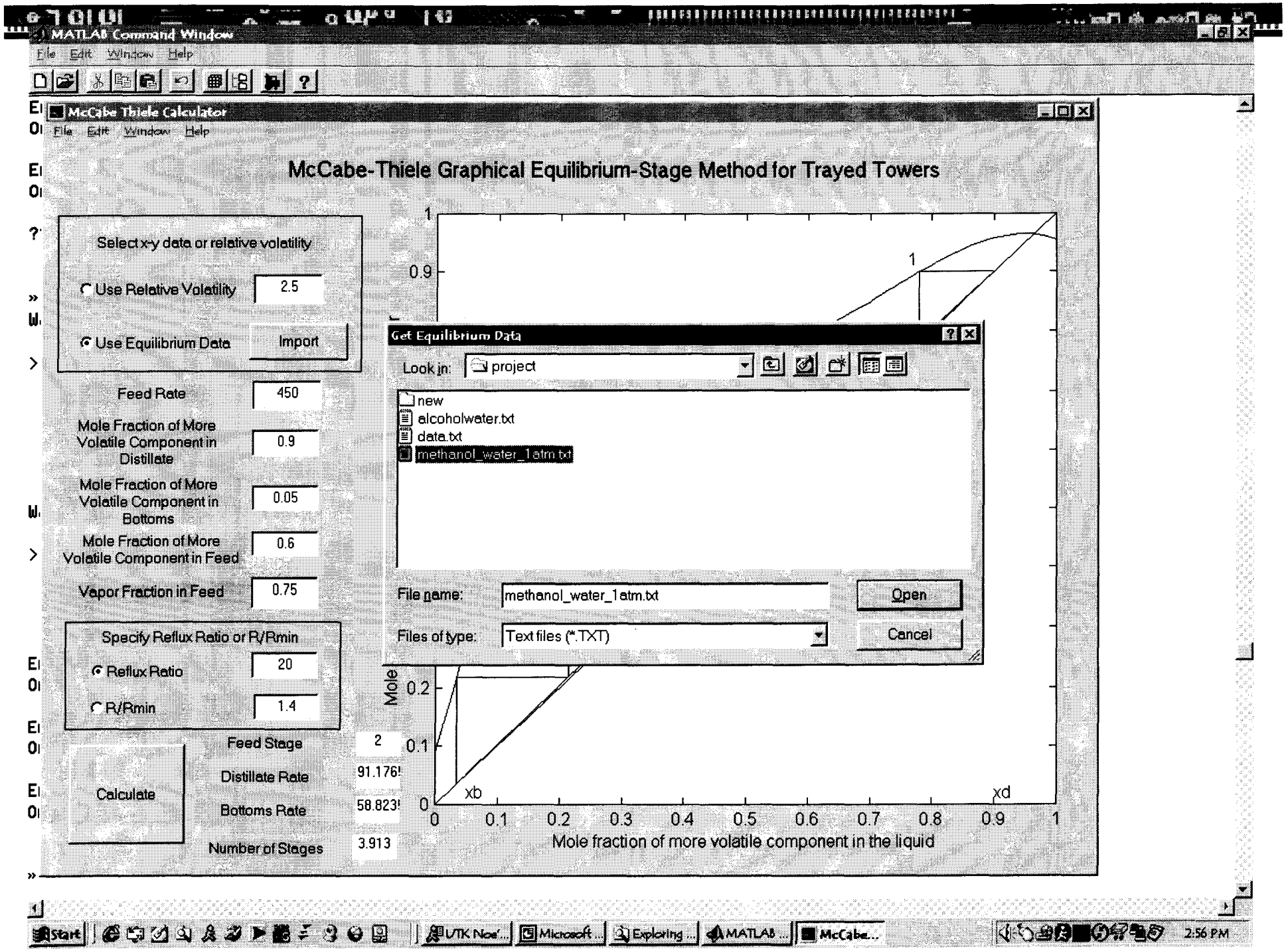
McCabe Thiele Calculator
File Edit Window Help
McCabe-Thiele Graphical Equilibrium-Stage Method for Trayed Towers
Select x-y data or relative volatility
Use Relative Volatility
2.5
Use Equilibrium Data
Import
Feed Rate
450
Mole Fraction of More Volatile Component in Distillate
0.95
Mole Fraction of More Volatile Component in Bottoms
0.05
Mole Fraction of More Volatile Component in Feed
0.6
Vapor Fraction in Feed
0.75
Specify Reflux Ratio or R/Rmin
Reflux Ratio
1.77458
R/Rmin
1.4
Calculate
Feed Stage
6
Distillate Rate
275
Bottoms Rate
175
Number of Stages
11.7369
Rectifying Line
Q-line
45-line
Stripping Line
xb
xd
Mole fraction of more volatile component in the vapor
Mole fraction of more volatile component in the liquid
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1
2
3
4
5
6
7
8
9
10
11
12


MATLAB Command Window
File Edit Window Help
McCabe Thiele Calculator
File Edit Window Help
McCabe-Thiele Graphical Equilibrium-Stage Method for Trayed Towers
Select x-y data or relative volatility
Use Relative Volatility
2.5
Use Equilibrium Data
Import
Feed Rate
450
Mole Fraction of More Volatile Component in Distillate
0.9
Mole Fraction of More Volatile Component in Bottoms
0.05
Mole Fraction of More Volatile Component in Feed
0.6
Vapor Fraction in Feed
0.75
Specify Reflux Ratio or R/Rmin
Reflux Ratio
20
R/Rmin
1.4
Calculate
Feed Stage
2
Distillate Rate
91.176
Bottoms Rate
58.823
Number of Stages
3.913
Get Equilibrium Data
Look in:
project
new
alcoholwater.txt
data.txt
methanol_water_1atm.txt
File name:
methanol_water_1atm.txt
Open
Files of type:
Text files (*.TXT)
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Mole
xb
xd
Mole fraction of more volatile component in the liquid
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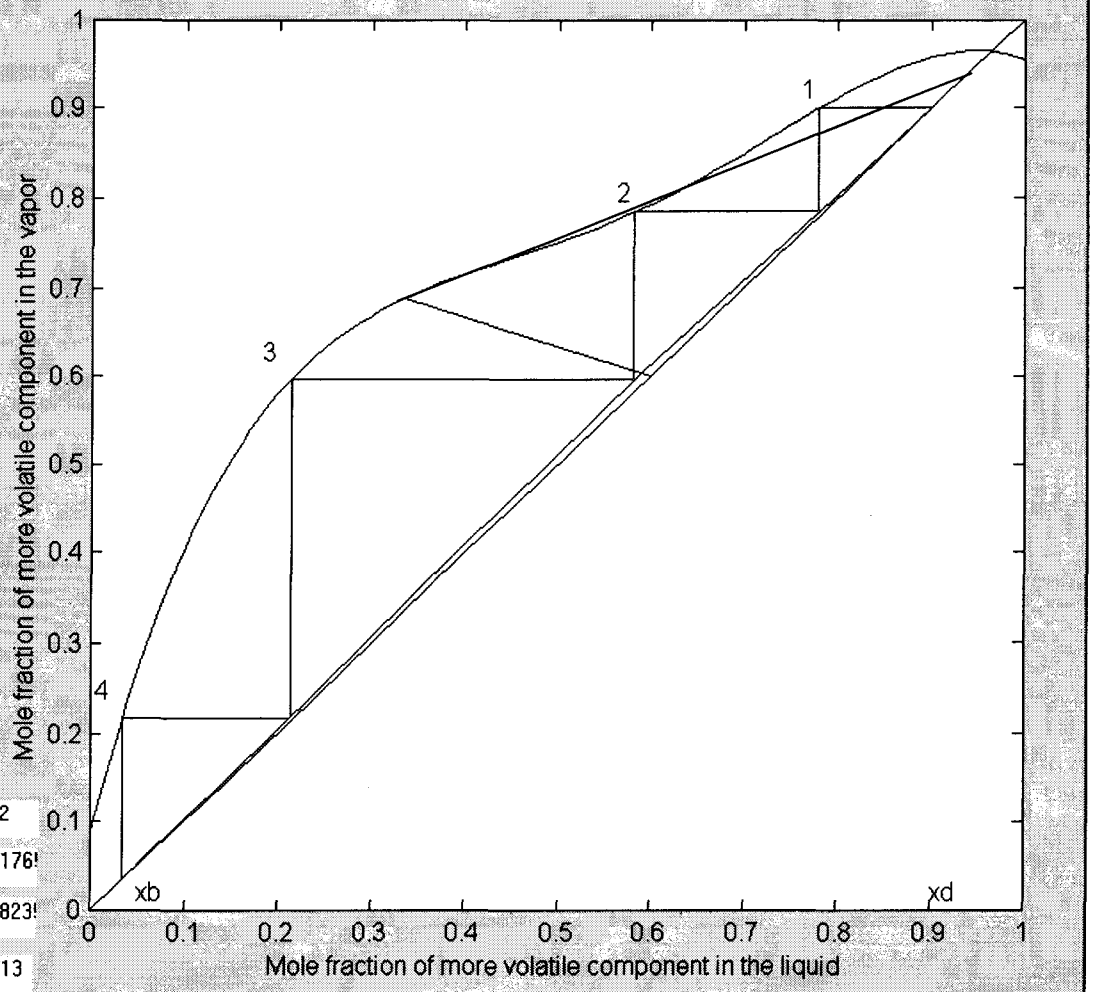
MATLAB Command Window

File Edit Window Help

McCabe Thiele Calculator

File Edit Window Help

McCabe-Thiele Graphical Equilibrium-Stage Method for Trayed Towers



Select x-y data or relative volatility

Use Relative Volatility: 2.5

Use Equilibrium Data: Import

Feed Rate: 450

Mole Fraction of More Volatile Component in Distillate: 0.9

Mole Fraction of More Volatile Component in Bottoms: 0.05

Mole Fraction of More Volatile Component in Feed: 0.6

Vapor Fraction in Feed: 0.75

Specify Reflux Ratio or R/Rmin

Reflux Ratio: 20

R/Rmin: 1.4

Calculate

Feed Stage: 2

Distillate Rate: 91.176

Bottoms Rate: 58.823

Number of Stages: 3.913

Start | UTK Nod... | Microsoft ... | Exploring ... | MATLAB ... | McCabe... | 2:56 PM


Questions?