Heat Exchanger Sizing

Introduction

This program sizes Shell and Tube heat exchangers and Plate and Frame heat exchangers. Heat transfer between two materials requires one material to be at a different temperature than the other. This temperature differential is the driving force behind heat transfer. When transferring heat between materials through a barrier (metal tube, etc.) the rate of heat transfer is affected by the thermal conductivity of the barrier. The barrier includes the vessel or tube wall and stagnant fluid films at the surface of the wall. When two fluids are flowing on either sides of this barrier, the surface area required to transfer the required quantity of heat is defined by the rate at which this barrier will transmit heat. These relationships are summarized in the heat transfer equation: $Q = U\,A\,dT$ where Q, the rate of heat transfer, is expressed in terms of the overall heat transfer coefficient (U), the heat transfer area (A), and the temperature difference (dT).

Shell and Tube Heat Exchangers

The Shell and Tube heat exchangers are sized based on performance, pressure drop, and dimensional constraints. It can be used for any combination of liquid, gas, condensing, or boiling on either the shell or tube side (except phase change on both the sides and superheating or sub-cooling of either fluid). Accurate sizing can be done without supplying the thermal conductivity or heat transfer coefficient data. The program provides an easy way to size a custom heat exchanger to meet your specific needs (so that it can be more accurately specified to exchanger vendors for their sizing and process guarantee) or for rating existing heat exchangers for a new service.

Empirical equations for film heat transfer coefficients are combined with heat balance equations and equations defining exchanger mechanical characteristics. The number of tubes in the heat exchanger are then increased until this combination of equations represents a valid heat exchanger design based on the available temperature driving force. This method allows you to perform heat exchanger sizing without knowing the heat transfer coefficient. All that is required are the incoming flows and fluid physical properties. For sensible heat transfer, the user must provide the flow rate of the secondary stream so that its temperature drop can be determined. Existing exchangers can be analyzed by entering the physical data, required flows, required heat transfer, and the existing heat exchanger physical specifications. If the number of tubes

calculated by the program is less than the actual number of tubes available then the heat exchanger should meet the required demand. The amount of excess capacity can be estimated by increasing the flow rates until the calculated number of tubes equals the corresponding actual value.

Plate and Frame Heat Exchangers

The Plate and Frame Heat Exchangers use the comprehensive Alfa Laval method for sizing. Accurate results can be obtained by specifying a minimal set of data. The program allows you to perform rating calculations and design calculations. A number of different plates are available for selection. The results also provide a recommended Alfa Laval heat exchanger unit suitable for the specified service conditions.

Shell and Tube Heat Exchangers

This section describes the interface for Shell and Tube heat exchangers. You may perform calculations for other heat exchanger types available under the **Exchanger** menu.

Window Description

Heat Exchanger Sizing Window

Heat Exchanger Sizing Screen

Physical and Mechanical Data

Enter the required physical and mechanical data in the input data fields provided. The **Properties** button allows the user to import the file containing the properties of the fluid present on the primary side selected in the **Option** menu. The properties have to be determined in the property window accessible from the Smartdraw screen and then saved in a file before closing that window. Clicking on the column for the desired fluid (either shellside or tubeside) will also direct the properties to be imported into that column. Repeat this process for the other side of the exchanger (two property files required). Alternatively, the user may manually enter the properties in the respective input fields. Clicking the **Calculate** button initiates the computation and brings up the **Heat Exchanger Capacity** window (next section). The **Convert** button will load the Conversion Calculator, and the **Specify** button will transfer all pertinent sizing data directly to the Specification Writer.

Heat Exchanger Capacity Window

Heat Exchanger Capacity Window for Liquid No Phase Change and Shellside Primary

In this window, enter the outlet conditions of the primary stream as the target values for the program. The program will also prompt the user for the flow rate or the latent heat to determine the total heat to be transferred by the heat exchanger. If the "Data Out of Range" error occurs, check to verify that enough energy is available in the secondary stream to provide the necessary heat transfer. The iterative indicator will appear after selecting the **Proceed** button. When the indicator equals 1.0, the correct number of tubes has been determined. If this value doesn't appear to be approaching 1.0 fairly quickly, it is likely that the limitations are too great on the exchanger to accomplish the required transfer in a reasonably sized heat exchanger. Select the **Exit** button to return to the data input/output screen so that the input can be modified (data will remain as entered).

Boiling Liquid Window

Heat Exchanger Capacity Window for Boiling Liquids

When the *Boiling Liquid* option is selected from the **Option** menu, the window shown above appears when a computation is initiated. Enter the required data and select the boiling surface material (for boiling liquid option only) before clicking the **Proceed** button.

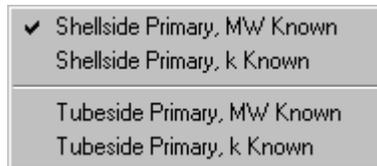**Note:** You cannot use boiling and condensing simultaneously

Menu Description

File Menu

```
New
Open        Ctrl+O
Save        Ctrl+S
Printout               ▶
Help                   ▶

Copy Field  Ctrl+C
Paste Field Ctrl+V

Exit        Ctrl+E
```

The first section of this menu offers choices to clear the screen and restart the program, open and save calculations, print the results, and access the help screen. The *Change Units* option converts between English and Metric units. In the second section, *Copy* and *Paste*, are used to transfer data to or from other fields and the Conversion Calculator. *Exit* shuts down the heat exchanger sizing module.

Options Menu

```
✓ Shellside Primary, MW Known
  Shellside Primary, k Known

  Tubeside Primary, MW Known
  Tubeside Primary, k Known
```

This pull down menu is used to specify whether the tube side or the shell side is the primary stream. The primary stream is the one in which a given heat transfer is required while the secondary stream is used to accomplish the heat transfer in the primary stream. Also, the option to enter either the molecular weight or the thermal conductivity (if known) is provided. The Weber equation is used to calculate the thermal conductivity (from molecular weight) and vice-versa. Using molecular weight as an input improves accuracy.

Note: The *k Known* option cannot be used for gases.

Shell Menu

```
✓ Liquid, Crossflow, Tri-Pitch
  Liquid, Crossflow, Sq-Pitch
  Liquid, Parallel Flow

  Water, Crossflow, Tri-Pitch
  Water, Crossflow, Sq-Pitch
  Water, Parallel Flow

  Gas, Crossflow, Tri-Pitch
  Gas, Crosslfow, Sq-Pitch
  Gas, Parallel Flow

  Condensing Vapor, Vertical
  Condensing Vapor, Horizontal

  Condensing Steam, Vertical
  Condensing Steam, Horizontal

  Boiling Liquid, Horizontal
```

This pull down menu is used to specify the fluid state on the shell side and the shell side flow conditions. The limitations of the calculation are indicated for each state. Water and steam require separate correlations to provide accurate results. For condensing fluid, the empirical correlation uses the Liquid Phase fluid properties.

**Note:** For condensing steam, enter the density, viscosity and sensible heat for water at the steam temperature.

Tube Menu

```
✓ Liquid, No Phase Change
  Water, No Phase Change
  Gas, No Phase Change

  Condensing Vapor, Vertical
  Condensing Vapor, Horizontal

  Condensing Steam, Vertical
  Condensing Steam, Horizontal

  Boiling Liquid, Vertical
```

This pull down menu is used to specify the fluid state on the tube side and the tube type of the exchanger. The limitations of the calculation are indicated for each state.
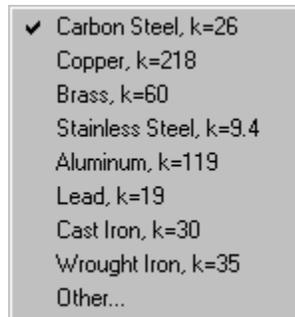
Type Menu
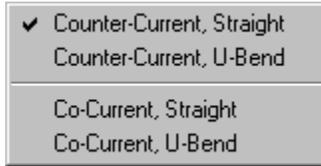
Choose the type of tube bundle (straight or U-bend) and the type of flow (co-current or counter-current) with this pull down menu.

Note: For U-bend tubes, the minimum number of tube passes is two, and the output is given in cross sectional number of tubes (which is actually twice the number of U-bend tube elements).
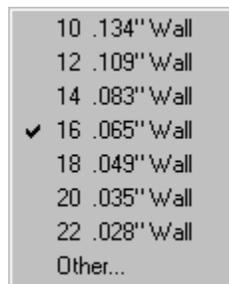
Material Menu

The tube material is chosen in this menu. The equivalent "k" factor (tube thermal conductivity in BTU/hr/ft/F degrees or Watts/Meter-K degrees) for each material is listed. A higher k value provides greater heat transfer. Select *Other* to specify a value not in the menu.

BWG Menu

This pull down menu is used to specify the BWG wall thickness. Select *Other* to specify a wall thickness not in the menu.

OD Menu

```
1/4 inch
3/8 inch
1/2 inch
5/8 inch
3/4 inch
✔ 7/8 inch
1 inch
1-1/2 inch
2 inch
Other...
```

Specify the tube outside diameter (OD) in inches or mm in this menu.
Typically, the smallest diameter tube size that will not result in plugging or
fouling is chosen. The smaller the tube diameter, the greater the heat transfer.
In addition, a smaller tube wall thickness (chosen from the **BWG** menu above)
will result in greater heat transfer, however, the tube life may be reduced due to
corrosion. The selection of the tubes for each exchanger is based largely on
experience with exchangers handling similar fluids. Select *Other* to specify a
tube OD value not in the menu.

Calculation Basis

This program is based upon a method developed by C. H. Gilmour. The accuracy of this method is limited by the accuracy of predicting fouling factors, fluid properties, and fabrication tolerances.

Assumptions

1. The Weber equation is used to estimate thermal conductivity from molecular weight (Equation 1). This is an empirical equation based on experimental data and is best suited for organic liquids. For water and steam, where the Weber equation does not give accurate results, a physical property factor as a function of temperature is used.

2. If the thermal conductivity is known, a pseudo molecular weight is obtained (Equation 2) to solve for the physical property factor.

3. Tube pitch for both triangular and square-pitch arrangements is assumed to be 1.25 times the tube diameter. This is the standard pitch used in most shell and tube heat exchangers.

4. Shell diameter is based on the number of tubes and is calculated using an empirical equation (Equation 3). This gives the approximate shell diameter for a packed floating-head exchanger. The diameter will differ slightly for a fixed tubesheet, U-bend, or a multipass shell. For greater accuracy, tube-layout tables can be used to obtain shell diameters.

Limitations

1. Calculations are for Shell and Tube type exchangers only

2. Design is based on a baffle cut of 20%.

3. Design is based on complete condensation or boiling.

Recommendations

1. Input molecular weight instead of thermal conductivity to obtain better results.

2. Avoid designs in the transitional flow range. Experimental data available in the transitional range (2100 < Reynold's No. < 10,000) show wide scatter and design in this range must be avoided as operation is unpredictable.

3. Liquid properties must be used whenever there is a phase change. Do not use gas properties.

4. Properties of the shell side and tube side fluids must be entered at the inlet temperature and pressure conditions and not at the average temperatures and pressures.

5. Density and viscosity of the process fluids must be accurate. If the properties are obtained using the Physical Property Library, make certain that the values are reasonable as compared to field conditions. Often process fluids may contain solids and unreasonable values of density and viscosity will greatly affect the design.

6. Select options from the menus that best describe your system. For example, if the tube side fluid is cooling water, select the *Water, No Phase Change* option rather than the *Liquid, No Phase Change* option as different equations are used in each case.

Optimization Tips

TO REDUCE THE NUMBER OF EXCHANGER TUBES:

1. Increase the number of shells.
2. Increase the number of passes.
3. Increase the exchanger length.
4. Reduce the baffle spacing.
5. Reduce the tube diameter.
6. Use a tube material with a higher thermal conductivity.
7. Use a thinner walled tube.
8. Use triangular versus square pitched tubes.
9. Use self cleaning tubes to provide lower scaling factors.

Equations

The equations referred to in the preceding sections are given below. Other equations may be obtained from the references mentioned.

Empirical heat transfer relationships for rating heat exchangers:

Inside the tubes:

(1) No phase change (liquid), Re > 10,000

$$\frac{h}{cG} = 0.023(\text{Re})^{-0.2}(\text{Pr})^{\frac{-2}{3}}$$

(2) No phase change (gas), Re > 10,000

$$h = 0.0144 G^{0.8} D_i^{-0.2} c_p$$

(3) No phase change (gas), 2,100 < Re < 10,000

$$h = 0.0059\left[(\text{Re})^{\frac{2}{3}} - 125\right]\left[1 + \left(\frac{D}{L}\right)^{\frac{2}{3}}\right]\left(\frac{c_p}{D_i}\right)\left(\frac{\mu_f}{\mu_b}\right)^{-0.14}$$

(4) No phase change (liquid), 2,100 < Re < 10,000

$$\frac{h}{cG} = 0.116\left[\frac{(\text{Re})^{\frac{2}{3}} - 125}{\text{Re}}\right]\left[1 + \left(\frac{D}{L}\right)^{\frac{2}{3}}\right](\text{Pr})^{\frac{-2}{3}}\left(\frac{\mu_f}{\mu_b}\right)^{-0.14}$$

(5) No phase change (liquid), Re < 2,100

$$\frac{h}{cG} = 1.86(\text{Re})^{-\frac{2}{3}}(\text{Pr})^{-\frac{2}{3}}\left(\frac{L}{D_i}\right)^{-\frac{1}{3}}\left(\frac{\mu_f}{\mu_b}\right)^{-0.14}$$

(6) Condensing vapor, vertical, Re < 2,100

$$h = 0.925k\left(\frac{g\rho_i^2}{\mu\Gamma}\right)^{\frac{1}{3}}$$

(7) Condensing vapor, horizontal, Re < 2,100

$$h = 0.76k\left(\frac{g\rho_i^2}{\mu\Gamma}\right)^{\frac{1}{3}}$$

(8) Nucleate boiling, vertical

$$\frac{h}{cG} = 4.02(\text{Re})^{-0.3}(\text{Pr})^{-0.6}\left(\frac{\rho_L\sigma}{P^2}\right)^{-0.425}\Sigma$$

Outside the tubes (shellside):

(9) Nucleate boiling, horizontal

$$\frac{h}{cG} = 4.02(\text{Re})^{-0.3}(\text{Pr})^{-0.6}\left(\frac{\rho_L\sigma}{P^2}\right)^{-0.425}\Sigma$$

(10) No phase change (liquid), crossflow

$$\frac{h}{cG} = 0.33(\text{Re})^{-0.4}(\text{Pr})^{-\frac{2}{3}}(0.6)$$

(11) No phase change (gas), crossflow

$$h = 0.11G^{0.6}D^{-0.4}c_p(0.6)$$

(12) No phase change (gas), parallel flow

$$h = 0.0144G^{0.8}D^{-0.2}c_p(1.3)$$

(13) No phase change (liquid), parallel flow

$$\frac{h}{cG} = 0.023(\text{Re})^{-0.2}(\text{Pr})^{-\frac{2}{3}}(1.3)$$

(14) Condensing vapor, vertical, Re < 2,100

$$h = 0.925k\left(\frac{g\rho_L^2}{\mu\Gamma}\right)^{\frac{1}{3}}$$

(15) Condensing vapor, horizontal, Re < 2,100

$$h = 0.76k\left(\frac{g\rho_L{}^2}{\mu\Gamma}\right)^{\frac{1}{3}}$$

Tube wall:

(16) Sensible heat transfer

$$h = \frac{(24k_w)}{(d_o - d_i)}$$

(17) Latent heat transfer

$$h = \frac{(24k_w)}{(d_o - d_i)}$$

Fouling:

(18) Sensible and latent heat transfer

h = assumed

Empirical pressure drop relationships for rating heat exchangers

Inside the tubes:

(19) No phase change, Re > 10,000

$$\Delta P = \frac{Z_i{}^{0.2}}{S_i}\left(\frac{W_i}{n}\right)^{1.8}\frac{N_{PT}\left[\dfrac{L_o}{d_i} + 25\right]}{(5.4d_i)^{3.8}}$$

for U-bends use $(L_o/d_i + 16)$ instead of $(L_o/d_i + 25)$

(20) No phase change, 2,100 < Re < 10,000

$$\Delta P = \left(\frac{Z_i}{S_i}\right)\left(\frac{W_i}{n}\right)\frac{N_{PT}\left[\dfrac{L_o}{d_i} + 25\right]\left[Re^{\frac{2}{3}} - 125\right]}{(50.2d_i)^3}$$

(21) No phase change, Re < 2,100

$$\Delta P = \frac{Z_b{}^{0.526}Z_f{}^{0.14}}{S_i}\left(\frac{W_i}{n}\right)^{\frac{4}{3}}\frac{N_{PT}L_o{}^{\frac{2}{3}}}{(5.62d_i)^4}$$

(22) Condensing

$$\Delta P = \frac{Z_i{}^{0.2}}{S_i}\left(\frac{W_i}{n}\right)^{1.8}\frac{N_{PT}\left[\dfrac{L_o}{d_i} + 25\right]}{(5.4d_i)^{3.8}} \times 0.5$$

for U-bends use $(L_o/d_i + 16)$ instead of $(L_o/d_i + 25)$

Shellside:

(23) No phase change, crossflow

$$\Delta P = \frac{0.326}{S_o} W_o{}^2 \frac{L_o}{P_B{}^3 D_o}$$

(24) No phase change, parallel flow

$$\Delta P = \frac{Z_o{}^{0.2}}{S_o} \left(\frac{W_o}{n}\right)^{1.8} \left[\frac{n^{0.366} L_o}{N_{PT}{}^{1.434}(4.912 d_o)^{4.8}} + \frac{0.31 n^{0.0414} W_o{}^{0.2} L_o}{d_o N_{PT}{}^{1.76}(4.912 d_o)^4 Z^{0.2} B_o{}^2} \right]$$

where B_o is equal to the fraction of flow area through baffle and the number of baffles

$N_B = 0.48 \ (L_o/d_o)$

(25) Condensing

$$\Delta P = \frac{0.081}{S_o} W_o{}^2 \frac{L_o}{P_B{}^3 D_o}$$

Nomenclature

c, c_p	specific heat (constant pressure), Btu/[lb (deg F)]
d	tube diameter, inches
D_i	tube inner diameter, ft.
D_o	shell inner diameter, ft.
g	acceleration due to gravity, ft./hr^2
G	mass velocity, lb/[hr (sq. ft. of cross-sectional area)]
h	film coefficient of heat transfer, Btu/[hr (sq. ft.) (deg F)]
k	thermal conductivity, Btu/[hr (sq.ft.) (deg F/ft.)]
L	total series length of tubes, $(L_o * N_{PT} *$number of shells), ft.
L_o	length of shell, ft.
n	number of tubes per pass (or in parallel)
N_{PT}	number of tube passes per shell
Re	Reynolds number, DG/μ
P	pressure, psia
P_B	baffle spacing, inches
Pr	Prandtl number, $c\mu/k$
ΔP	pressure drop, psi
s	specific gravity referred to water at 20 deg C
W	flowrate, lb/hr/1,000

Z	viscosity, cp
Γ	tube loading, lb/hr ft.
μ	viscosity, lb/hr ft.
ρ	density, lb/cu.ft.
ρ_L	liquid density, lb/cu.ft.
σ	surface tension, dynes/cm
Σ	surface condition factor (copper and steel = 1, stainless steel = 1.7,
	polished surfaces = 2.5)

Subscripts

b	bulk fluid
f	film fluid
i	pertaining to tubeside or inside tubes
o	pertaining to shellside or outside tubes
w	wall or tube material

References

1. Gilmour, C. H., *Chem. Eng*., 144 (Oct. 1952); 226 (March 1953); 214 (April 1953); 203 (Oct. 1953); 190 (Feb. 1954); 209 (March 1954); 199 (Aug. 1954).

2. Donahue, D. A., *Petrol. Process*., 101 (March 1956).

3. Whitley, D. L., *Chem. Eng. Progr*., 59 (Sept. 1961).

4. The Engineer's Reference Library, a Power Handbook on Heat Exchangers, 129, McGraw-Hill, New York.

5. Perry, J. H, et al., Chemical Engineers' Handbook, 3rd. ed., McGraw-Hill, New York (1950).

6. Vincent Cavaseno, et. al., Process Heat Exchange, Chemical Engineering, McGraw-Hill, New York.

7. Kern, D. Q., Process Heat Transfer, McGraw-Hill, New York (1950).

Example Problem

Example 1

Heat Exchanger Data:

Tube side primary, MW known; Inlet Temp: 104 F

Shell Side: Condensing steam, horizontal; Temp: 284 F

Tube Side: Liq. dichloromethane with suspended solids (viscosity = 824 cP)

Type: Counter-current straight; 6 Tube passes

Material: Monel (k = 8.66 BTU/hr-ft-deg F); BWG: 16; OD: 1 inch

Fouling Factors, Hr-ft^2-F/BTU:- Tube side:.002; Shell side: .0005

Baffle Spacing: 7inches; Tube Length: 8 ft.

Dichloromethane contains solids and has a viscosity of 824 CP

Capacity Data:

Tube side flow rate: 88.2 lbs/hr

Shell side latent heat: 925.1209 BTU/lb

Tube side Outlet Temperature: 165 F

Step by Step Solution Procedure

1. Open the Properties window from the Smartdraw screen and determine the properties of the shellside (liquid water at 284 F) and tubeside fluids. Save them in two different files and exit the Properties window. Depending on the property database that was used, fluid properties may vary slightly.

Inputs and Outputs of Example 1

CAPACITY DATA

TUBESIDE FLOWRATE, 1000 LBS/HR	88.2
SHELLSIDE LATENT HEAT, BTU/LB	925.1209
TUBESIDE OUTLET TEMP., DEG.F.	165

ITERATIVE INDICATOR
NUMBER OF TUBES/SHELL

PROCEED   EXIT

Capacity Data for Example 1

2. Click the Heat Exchanger Sizing button on the bottom toolbar in the Smartdraw screen.

3. From the **Options** menu, select *Tube side Primary, MW known.*

4. From the **Shell** menu, select *Condensing Steam, Horizontal;* from the **Tube** Menu select *Liquid, No Phase Change*; from the **Type** menu, select *Counter-Current Straight* tubes.

5. From the **Material** menu, select *Other.* Type in 8.66 for the thermal conductivity. Select 16 from the **BWG** menu and an outer tube diameter as 1 inch from the **OD** menu.

6. Import the tube side fluid properties by clicking on the Properties button and opening the file containing the tubeside fluid properties. As the viscosity desired is higher than that which is retrieved, delete the value and type in 824. From the Option menu select *Shellside Primary* and import the properties of the shellside fluid.

7. Revert to *Tubeside Primary* option before clicking the Calculate button to initiate the computation. Enter the requisite data in the Heat Exchanger Capacity window that appears and click the **Proceed** button to view the results.

Plate and Frame Heat Exchangers

This section describes the interface for Plate and Frame heat exchangers. You may perform calculations for other heat exchanger types by selecting the appropriate heat exchanger option under the **Exchanger** menu. This inerface accesses the Alfa Laval model for performing Plate and Frame heat exchanger calculations.

General Description

This program provides a simple easy to use interface for performing Plate and Frame heat exchanger calculations. It uses methods developed and used by Alfa Laval for doing sizing calculations.

Obtaining Help

Click on the **Help** menu at any time to view all the help topics or read the **User Guide Help Manual**.

Accessing the Conversion Calculator

Inputs may be specified in several different types of units. If a desired unit option is not available, you can access the Conversion Calculator by clicking **Convert** to convert to a set of units available in the list for a particular input field.

Using the Program

This section describes how to specify inputs, perform computations and perform file-handling operations in a step by step manner.

Accessing the Plate and Frame Heat Exchanger Program: Step 1

If you are currently in the Shell and Tube Heat Exchanger program, click on **Exchanger ➜Plate and Frame**. This will display the Plate and Frame Heat Exchanger module.

Specifying Inputs: Step 2

The inputs are specified in red and the output is displayed in blue. The required inputs can be divided in basically four categories:

1. Type of calculation to be performed
2. Fluid conditions for the hot and cold sides
3. Fluid properties
4. Mechanical Details

Hot Side

The hot side refers to the fluid whose inlet temperature is higher than its outlet temperature.

Cold Side

The cold side refers to the fluid whose inlet temperature is lower than its outlet temperature.

Specifying the Heat Load: Step 2a

You may either specify the heat duty or have it calculated.

To specify the heat duty, check the **Set Heat Load** check box, select the units in which the heat duty is known and specify the heat duty in the adjoining input field. When the heat duty is known, you only have to specify either the outlet temperature or the flow rate on both the hot and cold sides.

To have the heat duty computed, do not check the **Set Heat Load** check box. When the heat duty is unknown, you must specify both the flow and outlet temperature on either the hot or cold side, and one parameter on the other side (flow or outlet temperature).

Specifying Inlet Temperatures: Step 2b

Select the units in which the inlet temperature is to be specified from the list of available units. Next specify the inlet temperatures on the hot and cold sides.

Specifying Outlet Temperatures and Flow Rates: Step 2c

When Heat Duty is Known

When the heat duty is known, specifying outlet temperatures on either the hot or cold sides is optional. If the outlet temperature is not specified on either side, they will be computed. In this case, the flow rates on both sides must be specified. To specify the outlet temperatures, first select the units in which the outlet temperature is to be specified from the list of available units. Next specify the inlet temperatures on the hot and/or cold sides. If the temperature is specified on one side (or both sides), the corresponding flows on each side will

be computed and vice versa. Check the appropriate box for which input is to be specified.

When Heat Duty is Unknown

When the heat duty is unknown, both flow and temperature must be specified on one side and only one of these parameters must be specified on the other side. The unknown parameter will be computed. Select a set of units in which input is available and check the appropriate box for which input is to be specified.

Specifying the Maximum Pressure Drop: Step 2d

Select the units in which pressure drop will be specified and input the maximum pressure drop that would want across the exchanger on the hot and cold sides.

Specifying Fluid Properties: Step 2e

If you have already defined a fluid before, it should be available in the list on both the hot and cold sides. To specify a new fluid:

1. Click on this button or select **Stream Data File** from the **File** menu to display the **Stream Property** screen. On this screen fluid properties must be specified as detailed below. Once this is completed, the fluid streams specified will be available in the fluid property stream lists on both the hot and cold side. If no fluid is selected on either side, the fluid is assumed to be water.

Completing inputs on the Stream Property screen

1. Specify the fluid name.

2. Specify the minimum and maximum temperatures the fluid may possibly encounter during heat transfer, either specific to this exchanger or in general in the process plant. For example, the minimum and maximum temperature limits for water can be specified as 32^oF and 212^oF respectively.

3. Specify three temperatures between the specified mimimum and maximum temperatures and input the corresponding values of density, specific heat capacity, thermal conductivity and viscosity at these three reference temperatures.

4. Click the **Create Data File** button or select **File ➔ Save** to generate the property data file. Specify a filename for this fluid stream in the File Save dialog box.

5. To specify information for any other stream at this time, repeat the steps above.

6. Click **OK** to return to the main screen. The fluid streams specified will now appear in the fluid property stream lists on both the hot and cold side.
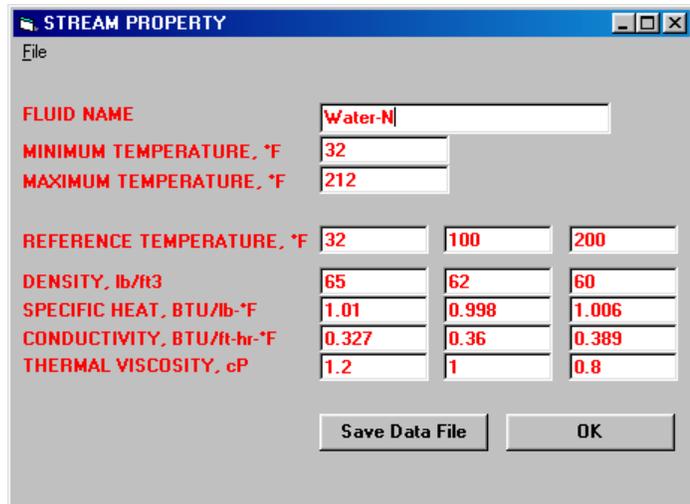
Figure showing the screen for specifying stream properties

Opening a previously saved file for modification

1. Click **File ➔ Open**. Select the property file to be opened for modification in the File Open dialog box.

2. Data from this file will be displayed in the input fields and may be modified. Save the modified file.

Specifying the Maximum Number of Plate and Frame units available: Step 2e

Type the mamimum number of plate and frame units that may be used for heat exchange for the specified heat transfer case. The program will recommend how many should be used for this system.

Specifying the Fouling Factor: Step 2f

Select the units in which the fouling factor is known and input the fouling factor in the corresponding input field. If this field is left blank, no fouling will be assumed.

Specifying the Alfa Laval Plate Type: Step 2g

You may select a specify plate from the list or you can have the program recommend a plate type. To specify a plate type, check the Alfa Laval Plate Type check box and select from the available list of plates.

Specify the Plate Material: Step 2h

You must specify an appropriate material for the plates from the available list depending on the fluid and/or application.

Performing Calculations and Viewing Results: Step 3

Once the input is complete, click on **Calculate** to obtain results. The results are displayed in blue in the list below. Scroll down this list to view all the

computed results. Note any error or warning messages encountered in the
Error/Warning Messages list.

Saving Your File: Step 4

You may save your plate and frame heat excanger at any time by selecting **File
➔ Save** or **File ➔ Save As**. The specified filename will be saved with the
.PHE file extension.

Printing Inputs and Results: Step 5

Once computations are complete, you may print the inputs and results by
clicking **File ➔ Print**.

Example Problem

Design a Plate and Frame heat exchanger to cool ethylene glycol from $120\,^oF$ to
$90\,^oF$ using cooling water at $70\,^oF$. The flowrate of ethylene glycol is 12,000
lb/hr and the outlet temperature for the cooling water is $80\,^oF$. The maximum
pressure drop on either side must not exceed 5 psi. The total fouling factor is
0.0005 hr-ft2- ^oF/BTU.

Step by Step Solution Procedure

1. Complete the specified inputs. Inputs for ethylene glycol must be
   specified on the hot side while that of cooling water on the cold
   side. Inputs must be specified in the appropriate set of units. You
   may select the units from the list box corresponding to each input
   field.

2. As the outlet temperatures for ethylene glycol and cooling water
   are known and the flow of ethylene glycol is known, check the
   three corresponding check boxes and type in the input values. The
   required flow of cooling water will be computed.

3. From the list of fluids, select ethylene glycol (eth_glycol) on the
   hot side and water on the cold side.

4. As the type of plate to be used is not known, you can leave the
   corresponding check box unchecked.

5. Select AISI 316 as the plate material.

6. Click **Calculate** to obtain results.

Figure showing the inputs and results for Example 1