HEATOOLS SPREADSHEET

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HEATOOLS is a spreadsheet which provides calculations of heat transfer from bare pipe to air, Reynolds Numbers and film coefficients for the bare pipe to air situation, and heat loss from ponds (pools).

The first screen is directed at the calculation of heat output from a bare pipe to surrounding air. The second screen calculates Reynolds Number and film coefficients for both the air and water sides of the bare pipe to air application.

The third screen calculates heat loss from an outdoor pond (or pool) under steady state conditions and includes an allowance for a floating cover.

The fourth screen calculates heat loss from an indoor pond (or pool).

In general, input areas appear in blue, output areas in red and intermediate calculations appear in a box outlined in black.

HEAT LOSS-BARE PLASTIC PIPE-TO-AIR

This screen calculates the heat output of a bare (uninsulated) pipe to the surrounding air. Using input concerning the tube size, length, water flow, water temperature and air temperature, the spreadsheet calculates the temperature drop (water), heat output (radiant, convective and total), and the outlet water temperature.

Calculations assume the tube wall constitutes approximately 7°F of the total thermal resistance (inside film + tube wall + outside film). This would be appropriate to a plastic material. For steel and copper, heat output would be higher than indicated by these calculations.

INPUT

1. Tube OD. Enter the outside diameter of the tube in inches.

2. Air Temperature. Enter the temperature of the air in °F.

3. Entering Water Temperature. Enter the temperature of the water at the beginning of the tube in °F.

4. Water Flow. Enter the flow rate in gallons per minute for the tube.

5. Emissivity of the Pipe Surface. Enter the emissivity of the pipe surface.

6. Horizontal (1.016), Vertical (1.235). Enter the value appropriate to the orientation of the tube, 1.016 for a horizontal tube, 1.235 for a vertical tube.

7. Tube Length. Enter the length, in feet, of the tube to be analyzed.

OUTPUT

1. Total Unit Output. The value displayed is the average total heat output of the line in Btu/hr*lf. The actual output will be higher at the beginning of the line and lower at the end of the line due to temperature drop. This value is the sum of Outputs 2 and 3.

2. Convective Heat Output. The value displayed is the average convective heat output of the line in Btu/hr*lf.

3. Radiant Unit Output. The value displayed is the average radiant heat output of the line in Btu/hr*lf. The radiant output is calculated using the pipe surface temperature and the air temperature as the effective ΔT.

4. Total Output. The value displayed is the total output in Btu/hr for the length of line specified in Input #7 * Input #1.

5. Delta T. The value displayed is the temperature drop calculated by dividing the heat output (Output #4) by the mass flow determined by the flow rate specified in Input #4.

6. Outlet Temperature. The value displayed is the temperature arrived at by subtracting the Delta T (Output #5) from the entering temperature specified in Input #3.

The table at the bottom of the screen in the box is an iterative calculation of the output values displayed in 1 through 6 above.

REYNOLDS NUMBER AND FILM COEFFICIENTS

This screen calculates the inside Reynolds Number and inside/outside film coefficients for the case of a bare tube carrying water on the inside and exposed to air on the outside. The air side coefficient is based upon natural convection.

Water

Input

1. Diameter. Enter the tube inside diameter in inches.

2. Velocity. Enter the velocity of the water inside the tube in ft/sec.

3. Temperature. Enter the temperature of the water inside the tube.

Output

1. Reynolds Number. Displayed value is the water side Reynolds Number.

2. Viscosity. Displayed value is the calculated water viscosity in lb/ftChr at the specified temperature (Input #3).

3. Density. Displayed value is the calculated water density in lb/ft^3 at the specified temperature.

4. Internal Film Coefficient. Displayed value is the water side film coefficient in Btu/hr ft^2 ^{o}F.

Air

Input

1. Diameter. Enter the outside diameter of the tube in inches.

2. Temperature. Enter the temperature of the air surrounding the tube in ^{o}F.

3. Elevation. Enter the elevation, in feet (above mean sea level), of the location where the tube will be installed.

Output

1. Viscosity. Displayed value is the calculated viscosity of the air, in lb/ft*hr, at the temperature specified.

2. Density. Displayed value is the calculated density of the air at the temperature and elevation specified.

3. Exterior Film Coefficient (Nat. Conv.). Displayed value is the calculated, natural convection, film coefficient for the air on the outside of the tube in Btu/hr ft^2 ^{o}F.

HEAT LOSS FROM OPEN PONDS

This screen calculates the steady state heat loss from an open (outdoor) pond in the evaporative, convective and radiant modes. Conduction through the walls and bottom of the pond to the soil is also included. The spreadsheet can accommodate the use of a floating-type pool cover at the user's discretion. The spreadsheet was developed primarily for spa and aquaculture ponds, where geothermal water is delivered directly to the pond for heating purposes.

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Input

3. Resource Temperature. Enter the temperature (°F) of the geothermal water that will be used for heating the pond. This value is used to determine the geothermal water flow requirement to heat the pond. It is not required for heat loss calculations.

4. Length. Enter the length of the pond in ft. The spreadsheet assumes that the long dimension of the pond is oriented perpendicular to the wind. If the pond is installed with the long dimension parallel to the wind, enter the value for the long dimension at Input #2 (Width), and the short dimension here.

5. Width. Enter the width of the pond in feet.

6. Water Temperature. Enter the water temperature in °F.

7. Wind Velocity. Enter the wind velocity in miles per hour. Due to the large thermal mass of the pond, the maximum daily average wind speed is appropriate here.

8. Air Temperature. Enter the temperature of the air in °F.

9. Cover Thickness. If a cover is used, enter its thickness in inches. If no cover is used, enter zero.

10. Cover "k". If a cover is used, enter the value for the conductivity of the material in Btu-in/hr*ft^2 °F. If no cover is used, enter zero.

11. Relative Humidity. Enter the relative humidity of the air at design heating conditions

12. Calculated Water Vapor Pressure (pond water). The spreadsheet automatically calculates the water vapor pressure based on the input water temperature.

Output

1. Evaporative Loss. Displayed value is the heat loss, in Btu/hr, associated with the evaporation from the water surface. The specification of a cover in Inputs 6 and 7 will cause the evaporative loss to be zero.

2. Convective Loss. Displayed value is the heat loss, in Btu/hr, associated with the convective heat transfer from the surface of the pond to the air.

3. Radiant Loss. Displayed value is the heat loss, in Btu/hr, associated with the radiant transfer from the surface of the pond to the air.

4. Conductive Loss. Displayed value is the heat loss, in Btu/hr, associated with the transfer between the pond water and the soil surrounding the pond.

5. Total Loss. Displayed value is the sum of Outputs 1 through 4.

   Note: For each of the outputs described above, a second value is displayed to the right. This is the heat loss per square foot of pond surface. In each case, the calculated value (to the left) is divided by the surface area to arrive at the loss per square foot.

6. Required Flow Rate. The calculated flow of geothermal water (in gpm at the temperature specified at Input #1) to maintain pond temperature at the conditions specified. This assumes that the geothermal water is delivered directly to the pond rather than through a heat exchanger.

Heat loss for outdoor ponds can be extremely high at typical aquaculture temperatures for ponds in northern climates. Due to the large thermal mass of the ponds, the impacts of solar gain and the nature of diurnal temperature changes, it may not be necessary to use extreme values for air temperature and wind velocity to determine heating requirements. In may cases, average daily temperature and wind velocity are more realistic values for these calculations

For additional details on calculations of this type, you may wish to request "Chapter 15 - Aquaculture" of the *Geothermal Direct-Use Engineering and Design Guidebook*, 3rd Edition, from the Geo-Heat Center. This document is available on the Center's website at: http://geoheat.oit.edu.

ENCLOSED PONDS

This screen calculates the same values for ponds as in Screen 3. In this case, the calculations assume that the pond (or pool) is located in an enclosed building such that evaporative and convective losses are driven only by natural convection of the air.

Input

1. Resource Temperature. Temperature of the geothermal fluid to be used in heating the pond.

2. Surface Area. Enter the surface area of the pond in ft^2.

3. Water Temperature. Enter the temperature of the pond water in ^oF.

4. Air Temperature. Enter the temperature of the air inside the building in °F.

5. Calculated Water Vapor Pressure. The spreadsheet automatically calculates the value from the input water temperature.

6. Relative Humidity. Enter the relative humidity of the air inside the structure housing the pond.

Output

1. Evaporative Loss. Displayed value is the heat loss, in Btu/hr, associated with the evaporative for the water surface.

2. Convective Loss. Displayed value is the heat loss, in Btu/hr, associated with the convective heat transfer for the surface of the pond to the air.

3. Radiant Loss. Displayed value is the heat loss, in Btu/hr, associated with the radiant transfer for the surface of the pond to the air.

4. Conductive Loss. Displayed value is the heat loss, in Btu/hr, associated with the transfer between the pond water and the soil surrounding the pond.

5. Total Loss. Displayed value is the sum of Outputs 1 through 4.

   Note: For each of the outputs described above, a second value is displayed to the right. This is the heat loss per square foot of pond surface. In each case, the calculated value (to the left) is divided by the surface area to arrive at the loss per square foot.

6. Water Flow Requirement. The calculated flow of geothermal water (at the temperature specified at Input #1) to maintain pond temperature at the conditions specified. This assumes that the geothermal water is delivered directly to the pond rather than through a heat exchanger.

Due to the use of different references for evaporation from open ponds and enclosed ponds, there will be some difference between the results obtained from the open ponds and enclosed ponds even when the input conditions are similar.

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