Important Heat Exchanger and its Effectiveness Formulas PDF

Formulas
Examples
with Units

List of 15
Important Heat Exchanger and its Effectiveness Formulas

1) Capacity Rate Formula

Evaluate Formula

Formula

$$C = \dot{m} \cdot c$$

Example with Units

$$152.25\,\text{W/K} = 101.5\,\text{kg/s} \cdot 1.5\,\text{J/(kg*K)}$$

2) Effectiveness of Counter-Current Heat Exchanger if Cold Fluid is Minimum Fluid Formula

Evaluate Formula

Formula

$$\varepsilon_c = \left(\text{mod}\ us \frac{\left(T_{ci} - T_{co} \right)}{T_{hi} - T_{co}} \right)$$

Example with Units

$$0.5 = \left(\text{mod}\ us \frac{\left(283\,\text{K} - 303\,\text{K} \right)}{343\,\text{K} - 303\,\text{K}} \right)$$

3) Effectiveness of Counter-Current Heat Exchanger if Hot Fluid is Minimum Fluid Formula

Evaluate Formula

Formula

$$\varepsilon_h = \frac{T_{hi} - T_{ho}}{T_{hi} - T_{co}}$$

Example with Units

$$0.5 = \frac{343\,\text{K} - 323\,\text{K}}{343\,\text{K} - 303\,\text{K}}$$

4) Effectiveness of Parallel-Flow Heat Exchanger if Cold Fluid is Minimum Fluid Formula

Evaluate Formula

Formula

$$\varepsilon_c = \frac{T_{co} - T_{ci}}{T_{hi} - T_{ci}}$$

Example with Units

$$0.3333 = \frac{303\,\text{K} - 283\,\text{K}}{343\,\text{K} - 283\,\text{K}}$$

5) Effectiveness of Parallel-Flow Heat Exchanger if Hot Fluid is Minimum Fluid Formula

Evaluate Formula

Formula

$$\varepsilon_h = \left(\frac{T_{hi} - T_{ho}}{T_{hi} - T_{ci}} \right)$$

Example with Units

$$0.3333 = \left(\frac{343\,\text{K} - 323\,\text{K}}{343\,\text{K} - 283\,\text{K}} \right)$$

6) Fouling Factor Formula

Evaluate Formula

Formula

$$R_f = \left(\frac{1}{U_d} \right) - \left(\frac{1}{U} \right)$$

Example with Units

$$1.0006\,\text{m}^2\text{K/W} = \left(\frac{1}{0.975\,\text{W/m}^2\text{*K}} \right) - \left(\frac{1}{40\,\text{W/m}^2\text{*K}} \right)$$

7) Heat Exchanger Effectiveness Formula

Evaluate Formula

Formula

$$\epsilon = \frac{Q_{Actual}}{Q_{Max}}$$

Example with Units

$$0.0167 = \frac{999\,J/s}{60000\,J/s}$$

8) Heat Exchanger Effectiveness for Minimum Fluid Formula

Evaluate Formula

Formula

$$\epsilon = \frac{\Delta T_{Min\ Fluid}}{\Delta T_{Max\ HE}}$$

Example with Units

$$0.9062 = \frac{290\,K}{320\,K}$$

9) Heat Transfer in Heat Exchanger given Cold Fluid Properties Formula

Evaluate Formula

Formula

$$Q = \text{mod}\,us\left(m_c \cdot c_c \cdot \left(T_{ci} - T_{co}\right)\right)$$

Example with Units

$$63000\,J = \text{mod}\,us\left(9\,kg \cdot 350\,J/(kg*K) \cdot \left(283\,K - 303\,K\right)\right)$$

10) Heat Transfer in Heat Exchanger given Hot Fluid Properties Formula

Evaluate Formula

Formula

$$Q = m_h \cdot c_h \cdot \left(T_{hi} - T_{ho}\right)$$

Example with Units

$$48000\,J = 8\,kg \cdot 300\,J/(kg*K) \cdot \left(343\,K - 323\,K\right)$$

11) Heat Transfer in Heat Exchanger given Overall Heat Transfer Coefficient Formula

Evaluate Formula

Formula

$$Q = U \cdot A \cdot \Delta T_m$$

Example with Units

$$4275.2\,J = 40\,W/m^2*K \cdot 6.68\,m^2 \cdot 16\,K$$

12) Maximum Possible Rate of Heat Transfer Formula

Evaluate Formula

Formula

$$Q_{Max} = C_{min} \cdot \left(T_{hi} - T_{ci}\right)$$

Example with Units

$$60000\,J/s = 1000\,W/K \cdot \left(343\,K - 283\,K\right)$$

13) Number of Heat Transfer Units Formula

Evaluate Formula

Formula

$$NTU = \frac{U \cdot A}{C_{min}}$$

Example with Units

$$0.2672 = \frac{40\,W/m^2*K \cdot 6.68\,m^2}{1000\,W/K}$$

14) Overall Heat Transfer Coefficient for Unfinned Tube Formula

Evaluate Formula

Formula

$$U_d = \frac{1}{\left(\frac{1}{h_{outside}}\right) + R_o + \left(\frac{\left(d_o \cdot \left(\ln\left(\frac{d_o}{d_i}\right)\right)\right)}{2 \cdot k}\right) + \left(\frac{R_i \cdot A_o}{A_i}\right) + \left(\frac{A_o}{h_{inside} \cdot A_i}\right)}$$

Example with Units

$$0.9759\,\text{W/m}^2\text{*K} = \frac{1}{\left(\frac{1}{17\,\text{W/m}^2\text{*K}}\right) + 0.001\,\text{m}^2\text{K/W} + \left(\frac{\left(2.68\,\text{m} \cdot \left(\ln\left(\frac{2.68\,\text{m}}{1.27\,\text{m}}\right)\right)\right)}{2 \cdot 10.18\,\text{W/(m*K)}}\right) + \left(\frac{0.002\,\text{m}^2\text{K/W} \cdot 14\,\text{m}^2}{12\,\text{m}^2}\right) + \left(\frac{14\,\text{m}^2}{1.35\,\text{W/m}^2\text{*K} \cdot 12\,\text{m}^2}\right)}$$

15) Rate of Heat Transfer using Correction Factor and LMTD Formula

Evaluate Formula

Formula

$$q = U \cdot A \cdot F \cdot \Delta T_m$$

Example with Units

$$2009.344\,\text{W} = 40\,\text{W/m}^2\text{*K} \cdot 6.68\,\text{m}^2 \cdot 0.47 \cdot 16\,\text{K}$$

Variables used in list of Heat Exchanger and its Effectiveness Formulas above

- **A** Area of Heat Exchanger *(Square Meter)*
- A_i Inside Tube Surface Area *(Square Meter)*
- A_o Outside Tube Surface Area *(Square Meter)*
- **c** Specific Heat Capacity *(Joule per Kilogram per K)*
- **C** Capacity Rate *(Watt per Kelvin)*
- c_c Specific Heat Capacity of Cold Fluid *(Joule per Kilogram per K)*
- c_h Specific Heat Capacity of Hot Fluid *(Joule per Kilogram per K)*
- C_{min} Minimum Capacity Rate *(Watt per Kelvin)*
- d_i Inside Tube Diameter *(Meter)*
- d_o Outside Tube Diameter *(Meter)*
- **F** Correction Factor
- h_{inside} Inside Convection Heat Transfer Coefficient *(Watt per Square Meter per Kelvin)*
- $h_{outside}$ External Convection Heat Transfer Coefficient *(Watt per Square Meter per Kelvin)*
- **k** Thermal Conductivity *(Watt per Meter per K)*
- $\dot{m}$ Mass Flow Rate *(Kilogram per Second)*
- m_c Mass of Cold Fluid *(Kilogram)*
- m_h Mass of Hot Fluid *(Kilogram)*
- **NTU** Number of Heat Transfer Units
- **q** Heat Transfer *(Watt)*
- **Q** Heat *(Joule)*
- Q_{Actual} Actual Rate of Heat Transfer *(Joule per Second)*
- Q_{Max} Maximum Possible Rate of Heat Transfer *(Joule per Second)*
- R_f Fouling Factor *(Square Meter Kelvin per Watt)*
- R_i Fouling Factor on Inside of Tube *(Square Meter Kelvin per Watt)*
- R_o Fouling Factor on Outside of Tube *(Square Meter Kelvin per Watt)*

Constants, Functions, Measurements used in list of Heat Exchanger and its Effectiveness Formulas above

- Functions: **ln**, ln(Number)
  The natural logarithm, also known as the logarithm to the base e, is the inverse function of the natural exponential function.
- Functions: **modulus**, modulus
  Modulus of a number is the remainder when that number is divided by another number.
- Measurement: **Length** in Meter (m)
  Length Unit Conversion
- Measurement: **Weight** in Kilogram (kg)
  Weight Unit Conversion
- Measurement: **Temperature** in Kelvin (K)
  Temperature Unit Conversion
- Measurement: **Area** in Square Meter (m²)
  Area Unit Conversion
- Measurement: **Energy** in Joule (J)
  Energy Unit Conversion
- Measurement: **Power** in Watt (W)
  Power Unit Conversion
- Measurement: **Thermal Conductivity** in Watt per Meter per K (W/(m*K))
  Thermal Conductivity Unit Conversion
- Measurement: **Specific Heat Capacity** in Joule per Kilogram per K (J/(kg*K))
  Specific Heat Capacity Unit Conversion
- Measurement: **Mass Flow Rate** in Kilogram per Second (kg/s)
  Mass Flow Rate Unit Conversion
- Measurement: **Heat Transfer Coefficient** in Watt per Square Meter per Kelvin (W/m²*K)
  Heat Transfer Coefficient Unit Conversion
- Measurement: **Rate of Heat Transfer** in Joule per Second (J/s)
  Rate of Heat Transfer Unit Conversion
- Measurement: **Fouling Factor** in Square Meter Kelvin per Watt (m²K/W)
  Fouling Factor Unit Conversion
- Measurement: **Heat Capacity Rate** in Watt per Kelvin (W/K)

- T_{ci} Inlet Temperature of Cold Fluid *(Kelvin)*
- T_{co} Outlet Temperature of Cold Fluid *(Kelvin)*
- T_{hi} Inlet Temperature of Hot Fluid *(Kelvin)*
- T_{ho} Outlet Temperature of Hot Fluid *(Kelvin)*
- U Overall Heat Transfer Coefficient *(Watt per Square Meter per Kelvin)*
- U_d Overall Heat Transfer Coefficient after Fouling *(Watt per Square Meter per Kelvin)*
- ΔT_m Log Mean Temperature Difference *(Kelvin)*
- $\Delta T_{Max\ HE}$ Maximum Temperature Difference in Heat Exchanger *(Kelvin)*
- $\Delta T_{Min\ Fluid}$ Temperature Difference of Minimum Fluid *(Kelvin)*
- ϵ Effectiveness of Heat Exchanger
- ε_c Effectiveness of HE when Cold Fluid is Min Fluid
- ε_h Effectiveness of HE when Hot Fluid is Min Fluid

Heat Capacity Rate Unit Conversion

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