Important Conduction in Cylinder Formulas PDF

Formulas
Examples
with Units

List of 16
Important Conduction in Cylinder Formulas

1) Convection Resistance for Cylindrical Layer Formula

Evaluate Formula

Formula

$$R_{th} = \frac{1}{h \cdot 2 \cdot \pi \cdot R \cdot l_{cyl}}$$

Example with Units

$$1.1304\,\mathrm{K/W} = \frac{1}{2.2\,\mathrm{W/m^2{*}K} \cdot 2 \cdot 3.1416 \cdot 0.160\,\mathrm{m} \cdot 0.4\,\mathrm{m}}$$

2) Critical Thickness of Insulation for Cylinder Formula

Evaluate Formula

Formula

$$r_c = \frac{k}{h_t}$$

Example with Units

$$0.7712\,\mathrm{m} = \frac{10.18\,\mathrm{W/(m{*}K)}}{13.2\,\mathrm{W/m^2{*}K}}$$

3) Heat Flow Rate through Cylindrical Composite Wall of 2 Layers Formula

Evaluate Formula

Formula

$$Q = \frac{T_i - T_o}{\frac{\ln\left(\frac{r_2}{r_1}\right)}{2 \cdot \pi \cdot k_1 \cdot l_{cyl}} + \frac{\ln\left(\frac{r_3}{r_2}\right)}{2 \cdot \pi \cdot k_2 \cdot l_{cyl}}}$$

Example with Units

$$9.2765\,\mathrm{W} = \frac{305\,\mathrm{K} - 300\,\mathrm{K}}{\frac{\ln\left(\frac{12\,\mathrm{m}}{0.8\,\mathrm{m}}\right)}{2 \cdot 3.1416 \cdot 1.6\,\mathrm{W/(m{*}K)} \cdot 0.4\,\mathrm{m}} + \frac{\ln\left(\frac{8\,\mathrm{m}}{12\,\mathrm{m}}\right)}{2 \cdot 3.1416 \cdot 1.2\,\mathrm{W/(m{*}K)} \cdot 0.4\,\mathrm{m}}}$$

4) Heat Flow Rate through Cylindrical Composite Wall of 3 Layers Formula

Evaluate Formula

Formula

$$Q = \frac{T_i - T_o}{\frac{\ln\left(\frac{r_2}{r_1}\right)}{2 \cdot \pi \cdot k_1 \cdot l_{cyl}} + \frac{\ln\left(\frac{r_3}{r_2}\right)}{2 \cdot \pi \cdot k_2 \cdot l_{cyl}} + \frac{\ln\left(\frac{r_4}{r_3}\right)}{2 \cdot \pi \cdot k_3 \cdot l_{cyl}}}$$

Example with Units

$$8.4081\,\mathrm{W} = \frac{305\,\mathrm{K} - 300\,\mathrm{K}}{\frac{\ln\left(\frac{12\,\mathrm{m}}{0.8\,\mathrm{m}}\right)}{2 \cdot 3.1416 \cdot 1.6\,\mathrm{W/(m{*}K)} \cdot 0.4\,\mathrm{m}} + \frac{\ln\left(\frac{8\,\mathrm{m}}{12\,\mathrm{m}}\right)}{2 \cdot 3.1416 \cdot 1.2\,\mathrm{W/(m{*}K)} \cdot 0.4\,\mathrm{m}} + \frac{\ln\left(\frac{14\,\mathrm{m}}{8\,\mathrm{m}}\right)}{2 \cdot 3.1416 \cdot 4\,\mathrm{W/(m{*}K)} \cdot 0.4\,\mathrm{m}}}$$

5) Heat Flow Rate through Cylindrical Wall Formula

Evaluate Formula

Formula

$$Q = \frac{T_i - T_o}{\frac{\ln\left(\frac{r_2}{r_1}\right)}{2 \cdot \pi \cdot k \cdot l_{cyl}}}$$

Example with Units

$$47.239\,\mathrm{W} = \frac{305\,\mathrm{K} - 300\,\mathrm{K}}{\frac{\ln\left(\frac{12\,\mathrm{m}}{0.8\,\mathrm{m}}\right)}{2 \cdot 3.1416 \cdot 10.18\,\mathrm{W/(m{*}K)} \cdot 0.4\,\mathrm{m}}}$$

6) Inner Surface Temperature of Cylindrical Wall in Conduction Formula

Evaluate Formula

Formula

$$T_i = T_o + \frac{Q \cdot \ln\left(\frac{r_2}{r_1}\right)}{2 \cdot \pi \cdot k \cdot l_{cyl}}$$

Example with Units

$$300.9812\,\text{K} = 300\,\text{K} + \frac{9.27\,\text{W} \cdot \ln\left(\frac{12\,\text{m}}{0.8\,\text{m}}\right)}{2 \cdot 3.1416 \cdot 10.18\,\text{W/(m*K)} \cdot 0.4\,\text{m}}$$

7) Length of Cylindrical Wall for given Heat Flow Rate Formula

Evaluate Formula

Formula

$$l_{cyl} = \frac{Q \cdot \ln\left(\frac{r_2}{r_1}\right)}{2 \cdot \pi \cdot k \cdot (T_i - T_o)}$$

Example with Units

$$0.0785\,\text{m} = \frac{9.27\,\text{W} \cdot \ln\left(\frac{12\,\text{m}}{0.8\,\text{m}}\right)}{2 \cdot 3.1416 \cdot 10.18\,\text{W/(m*K)} \cdot (305\,\text{K} - 300\,\text{K})}$$

8) Outer Surface Temperature of Cylindrical Composite Wall of 2 Layers Formula

Evaluate Formula

Formula

$$T_o = T_i - Q \cdot \left(\frac{\ln\left(\frac{r_2}{r_1}\right)}{2 \cdot \pi \cdot k_1 \cdot l_{cyl}} + \frac{\ln\left(\frac{r_3}{r_2}\right)}{2 \cdot \pi \cdot k_2 \cdot l_{cyl}}\right)$$

Example with Units

$$300.0035\,\text{K} = 305\,\text{K} - 9.27\,\text{W} \cdot \left(\frac{\ln\left(\frac{12\,\text{m}}{0.8\,\text{m}}\right)}{2 \cdot 3.1416 \cdot 1.6\,\text{W/(m*K)} \cdot 0.4\,\text{m}} + \frac{\ln\left(\frac{8\,\text{m}}{12\,\text{m}}\right)}{2 \cdot 3.1416 \cdot 1.2\,\text{W/(m*K)} \cdot 0.4\,\text{m}}\right)$$

9) Outer Surface Temperature of Cylindrical Wall given Heat Flow Rate Formula

Evaluate Formula

Formula

$$T_o = T_i - \frac{Q \cdot \ln\left(\frac{r_2}{r_1}\right)}{2 \cdot \pi \cdot k \cdot l_{cyl}}$$

Example with Units

$$304.0188\,\text{K} = 305\,\text{K} - \frac{9.27\,\text{W} \cdot \ln\left(\frac{12\,\text{m}}{0.8\,\text{m}}\right)}{2 \cdot 3.1416 \cdot 10.18\,\text{W/(m*K)} \cdot 0.4\,\text{m}}$$

10) Thermal Conductivity given Critical Thickness of Insulation for Cylinder Formula

Evaluate Formula

Formula

$$k = r_c \cdot h_o$$

Example with Units

$$6.545\,\text{W/(m*K)} = 0.77\,\text{m} \cdot 8.5\,\text{W/m}^2\text{*K}$$

11) Thermal Conductivity of Cylindrical Wall given Temperature Difference Formula

Evaluate Formula

Formula

$$k = \frac{Q \cdot \ln\left(\frac{r_2}{r_1}\right)}{2 \cdot \pi \cdot l_{cyl} \cdot (T_i - T_o)}$$

Example with Units

$$1.9977\,\text{W/(m*K)} = \frac{9.27\,\text{W} \cdot \ln\left(\frac{12\,\text{m}}{0.8\,\text{m}}\right)}{2 \cdot 3.1416 \cdot 0.4\,\text{m} \cdot (305\,\text{K} - 300\,\text{K})}$$

12) Thermal Resistance for Radial Heat Conduction in Cylinders Formula

Evaluate Formula

Formula

$$R_{th} = \frac{\ln\left(\frac{r_o}{r_i}\right)}{2 \cdot \pi \cdot k \cdot l_{cyl}}$$

Example with Units

$$0.023\,\text{K/W} = \frac{\ln\left(\frac{9\,\text{m}}{5\,\text{m}}\right)}{2 \cdot 3.1416 \cdot 10.18\,\text{W/(m*K)} \cdot 0.4\,\text{m}}$$

13) Thickness of Cylindrical Wall to Maintain given Temperature Difference Formula

Evaluate Formula

Formula

$$t = r_1 \cdot \left(e^{\frac{(T_i - T_o) \cdot 2 \cdot \pi \cdot k \cdot l_{cyl}}{Q}} - 1\right)$$

Example with Units

$$787656.992\,\text{m} = 0.8\,\text{m} \cdot \left(e^{\frac{(305\,\text{K} - 300\,\text{K}) \cdot 2 \cdot 3.1416 \cdot 10.18\,\text{W/(m*K)} \cdot 0.4\,\text{m}}{9.27\,\text{W}}} - 1\right)$$

14) Total Thermal Resistance of 2 Cylindrical Resistances Connected in Series Formula

Evaluate Formula

Formula

$$R_{th} = \frac{\ln\left(\frac{r_2}{r_1}\right)}{2 \cdot \pi \cdot k_1 \cdot l_{cyl}} + \frac{\ln\left(\frac{r_3}{r_2}\right)}{2 \cdot \pi \cdot k_2 \cdot l_{cyl}}$$

Example with Units

$$0.539\,\text{K/W} = \frac{\ln\left(\frac{12\,\text{m}}{0.8\,\text{m}}\right)}{2 \cdot 3.1416 \cdot 1.6\,\text{W/(m*K)} \cdot 0.4\,\text{m}} + \frac{\ln\left(\frac{8\,\text{m}}{12\,\text{m}}\right)}{2 \cdot 3.1416 \cdot 1.2\,\text{W/(m*K)} \cdot 0.4\,\text{m}}$$

15) Total Thermal Resistance of 3 Cylindrical Resistances Connected in Series Formula

Evaluate Formula

Formula

$$R_{th} = \frac{\ln\left(\frac{r_2}{r_1}\right)}{2 \cdot \pi \cdot k_1 \cdot l_{cyl}} + \frac{\ln\left(\frac{r_3}{r_2}\right)}{2 \cdot \pi \cdot k_2 \cdot l_{cyl}} + \frac{\ln\left(\frac{r_4}{r_3}\right)}{2 \cdot \pi \cdot k_3 \cdot l_{cyl}}$$

Example with Units

$$0.5947\,\text{K/W} = \frac{\ln\left(\frac{12\,\text{m}}{0.8\,\text{m}}\right)}{2 \cdot 3.1416 \cdot 1.6\,\text{W/(m*K)} \cdot 0.4\,\text{m}} + \frac{\ln\left(\frac{8\,\text{m}}{12\,\text{m}}\right)}{2 \cdot 3.1416 \cdot 1.2\,\text{W/(m*K)} \cdot 0.4\,\text{m}} + \frac{\ln\left(\frac{14\,\text{m}}{8\,\text{m}}\right)}{2 \cdot 3.1416 \cdot 4\,\text{W/(m*K)} \cdot 0.4\,\text{m}}$$

16) Total Thermal Resistance of Cylindrical Wall with Convection on Both Sides Formula

Evaluate Formula

Formula

$$R_{th} = \frac{1}{2 \cdot \pi \cdot r_1 \cdot l_{cyl} \cdot h_i} + \frac{\ln\left(\frac{r_2}{r_1}\right)}{2 \cdot \pi \cdot k \cdot l_{cyl}} + \frac{1}{2 \cdot \pi \cdot r_2 \cdot l_{cyl} \cdot h_{ext}}$$

Example with Units

$$0.4776\,\text{K/W} = \frac{1}{2 \cdot 3.1416 \cdot 0.8\,\text{m} \cdot 0.4\,\text{m} \cdot 1.35\,\text{W/m²*K}} + \frac{\ln\left(\frac{12\,\text{m}}{0.8\,\text{m}}\right)}{2 \cdot 3.1416 \cdot 10.18\,\text{W/(m*K)} \cdot 0.4\,\text{m}} + \frac{1}{2 \cdot 3.1416 \cdot 12\,\text{m} \cdot 0.4\,\text{m} \cdot 9.8\,\text{W/m²*K}}$$

Variables used in list of Conduction in Cylinder Formulas above

- **h** Convection heat transfer *(Watt per Square Meter per Kelvin)*
- h_{ext} External Convection Heat Transfer Coefficient *(Watt per Square Meter per Kelvin)*
- h_i Inside Convection Heat Transfer Coefficient *(Watt per Square Meter per Kelvin)*
- h_o Heat Transfer Coefficient at Outer Surface *(Watt per Square Meter per Kelvin)*
- h_t Heat Transfer Coefficient *(Watt per Square Meter per Kelvin)*
- **k** Thermal Conductivity *(Watt per Meter per K)*
- k_1 Thermal Conductivity 1 *(Watt per Meter per K)*
- k_2 Thermal Conductivity 2 *(Watt per Meter per K)*
- k_3 Thermal Conductivity 3 *(Watt per Meter per K)*
- l_{cyl} Length of Cylinder *(Meter)*
- **Q** Heat Flow Rate *(Watt)*
- **R** Cylinder Radius *(Meter)*
- r_1 Radius of 1st Cylinder *(Meter)*
- r_2 Radius of 2nd Cylinder *(Meter)*
- r_3 Radius of 3rd Cylinder *(Meter)*
- r_4 Radius of 4th Cylinder *(Meter)*
- r_c Critical Thickness of Insulation *(Meter)*
- r_i Inner Radius *(Meter)*
- r_o Outer Radius *(Meter)*
- R_{th} Thermal Resistance *(Kelvin per Watt)*
- **t** Thickness *(Meter)*
- T_i Inner Surface Temperature *(Kelvin)*
- T_o Outer Surface Temperature *(Kelvin)*

Constants, Functions, Measurements used in list of Conduction in Cylinder Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- constant(s): **e**, 2.71828182845904523536028747135266249 *Napier's constant*
- 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.*
- Measurement: **Length** in Meter (m) *Length Unit Conversion*
- Measurement: **Temperature** in Kelvin (K) *Temperature Unit Conversion*
- Measurement: **Power** in Watt (W) *Power Unit Conversion*
- Measurement: **Thermal Resistance** in Kelvin per Watt (K/W) *Thermal Resistance Unit Conversion*
- Measurement: **Thermal Conductivity** in Watt per Meter per K (W/(m*K)) *Thermal Conductivity Unit Conversion*
- Measurement: **Heat Transfer Coefficient** in Watt per Square Meter per Kelvin (W/m²*K) *Heat Transfer Coefficient Unit Conversion*

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