Important Heat Transfer from Extended Surfaces (Fins), Critical Thickness of Insulation and Thermal Resistance Formulas PDF

Formulas Examples with Units

List of 20 Important Heat Transfer from Extended Surfaces (Fins), Critical Thickness of Insulation and Thermal Resistance Formulas

1) Biot Number using Characteristic Length Formula

Evaluate Formula

Formula

$$Bi = \frac{h_{transfer} \cdot L_{char}}{k_{fin}}$$

Example with Units

$$0.389 = \frac{13.2\,\mathrm{W/m^2{*}K} \cdot 0.3\,\mathrm{m}}{10.18\,\mathrm{W/(m{*}K)}}$$

2) Correction Length for Cylindrical Fin with Non-Adiabatic Tip Formula

Evaluate Formula

Formula

$$L_{cylindrical} = L_{fin} + \left(\frac{d_{fin}}{4}\right)$$

Example with Units

$$5.75\,\mathrm{m} = 3\,\mathrm{m} + \left(\frac{11\,\mathrm{m}}{4}\right)$$

3) Correction Length for Square Fin with Non-Adiabatic Tip Formula

Evaluate Formula

Formula

$$L_{sqaure} = L_{fin} + \left(\frac{w_{fin}}{4}\right)$$

Example with Units

$$4.75\,\mathrm{m} = 3\,\mathrm{m} + \left(\frac{7\,\mathrm{m}}{4}\right)$$

4) Correction Length for Thin Rectangular Fin with Non-Adiabatic Tip Formula

Evaluate Formula

Formula

$$L_{rectangular} = L_{fin} + \left(\frac{t_{fin}}{2}\right)$$

Example with Units

$$3.6\,\mathrm{m} = 3\,\mathrm{m} + \left(\frac{1.2\,\mathrm{m}}{2}\right)$$

5) Critical Radius of Insulation of Cylinder Formula

Evaluate Formula

Formula

$$R_c = \frac{K_{insulation}}{h_{outside}}$$

Example with Units

$$2.1429\,\mathrm{m} = \frac{21\,\mathrm{W/(m{*}K)}}{9.8\,\mathrm{W/m^2{*}K}}$$

6) Critical Radius of Insulation of Hollow Sphere Formula

Evaluate Formula

Formula

$$R_c = 2 \cdot \frac{K_{insulation}}{h_{outside}}$$

Example with Units

$$4.2857\,\mathrm{m} = 2 \cdot \frac{21\,\mathrm{W/(m{*}K)}}{9.8\,\mathrm{W/m^2{*}K}}$$

7) Heat Dissipation from Fin Insulated at End Tip Formula

Evaluate Formula

Formula

$$Q_{fin} = \left(\sqrt{\left(P_{fin} \cdot h_{transfer} \cdot k_{fin} \cdot A_c\right)}\right) \cdot \left(T_w - T_s\right) \cdot \tanh\left(\left(\sqrt{\frac{P_{fin} \cdot h_{transfer}}{k_{fin} \cdot A_c}}\right) \cdot L_{fin}\right)$$

Example with Units

$$37945.9256\,\mathrm{W} = \left(\sqrt{\left(25\,\mathrm{m} \cdot 13.2\,\mathrm{W/m^2{*}K} \cdot 10.18\,\mathrm{W/(m{*}K)} \cdot 10.2\,\mathrm{m^2}\right)}\right) \cdot \left(305\,\mathrm{K} - 100\,\mathrm{K}\right) \cdot \tanh\left(\left(\sqrt{\frac{25\,\mathrm{m} \cdot 13.2\,\mathrm{W/m^2{*}K}}{10.18\,\mathrm{W/(m{*}K)} \cdot 10.2\,\mathrm{m^2}}}\right) \cdot 3\,\mathrm{m}\right)$$

8) Heat Dissipation from Fin Losing Heat at End Tip Formula

Evaluate Formula

Formula

$$Q_{fin} = \left(\sqrt{P_{fin} \cdot h_{transfer} \cdot k_{fin} \cdot A_c}\right) \cdot \left(T_w - T_s\right) \cdot \frac{\tanh\left(\left(\sqrt{\frac{P_{fin} \cdot h_{transfer}}{k_{fin} \cdot A_c}}\right) \cdot L_{fin}\right) + \frac{h_{transfer}}{k_{fin} \cdot \left(\sqrt{P_{fin} \cdot \frac{h_{transfer}}{k_{fin}} \cdot A_c}\right)}}{1 + \tanh\left(\left(\sqrt{\frac{P_{fin} \cdot h_{transfer}}{k_{fin} \cdot A_c}}\right) \cdot L_{fin} \cdot \frac{h_{transfer}}{k_{fin} \cdot \left(\sqrt{\frac{P_{fin} \cdot h_{transfer}}{k_{fin} \cdot A_c}}\right)}\right)}$$

Example with Units

$$20334.4597\,\text{W} = \left(\sqrt{25\,\text{m} \cdot 13.2\,\text{W/m}^2\text{*K} \cdot 10.18\,\text{W/(m*K)} \cdot 10.2\,\text{m}^2}\right) \cdot \left(305\,\text{K} - 100\,\text{K}\right) \cdot \frac{\tanh\left(\left(\sqrt{\frac{25\,\text{m} \cdot 13.2\,\text{W/m}^2\text{*K}}{10.18\,\text{W/(m*K)} \cdot 10.2\,\text{m}^2}}\right) \cdot 3\,\text{m}\right) + \frac{13.2\,\text{W/m}^2\text{*K}}{10.18\,\text{W/(m*K)} \cdot \left(\sqrt{25\,\text{m} \cdot \frac{13.2\,\text{W/m}^2\text{*K}}{10.18\,\text{W/(m*K)}} \cdot 10.2\,\text{m}^2}\right)}}{1 + \tanh\left(\left(\sqrt{\frac{25\,\text{m} \cdot 13.2\,\text{W/m}^2\text{*K}}{10.18\,\text{W/(m*K)} \cdot 10.2\,\text{m}^2}}\right) \cdot 3\,\text{m} \cdot \frac{13.2\,\text{W/m}^2\text{*K}}{10.18\,\text{W/(m*K)} \cdot \left(\sqrt{\frac{25\,\text{m} \cdot 13.2\,\text{W/m}^2\text{*K}}{10.18\,\text{W/(m*K)} \cdot 10.2\,\text{m}^2}}\right)}\right)}$$

9) Heat Dissipation from Infinitely Long Fin Formula

Evaluate Formula

Formula

$$Q_{fin} = \left(\left(P_{fin} \cdot h_{transfer} \cdot k_{fin} \cdot A_c\right)^{0.5}\right) \cdot \left(T_w - T_s\right)$$

Example with Units

$$37947.643\,\text{W} = \left(\left(25\,\text{m} \cdot 13.2\,\text{W/m}^2\text{*K} \cdot 10.18\,\text{W/(m*K)} \cdot 10.2\,\text{m}^2\right)^{0.5}\right) \cdot \left(305\,\text{K} - 100\,\text{K}\right)$$

10) Heat Transfer in Fins given Fin Efficiency Formula

Evaluate Formula

Formula

$$Q_{fin} = U_{overall} \cdot A \cdot \eta \cdot \Delta T$$

Example with Units

$$32400\,\text{W} = 6\,\text{W/m}^2\text{*K} \cdot 50\,\text{m}^2 \cdot 0.54 \cdot 200\,\text{K}$$

11) Inner Heat Transfer Coefficient given Inner Thermal Resistance Formula

Evaluate Formula

Formula

$$h_{inside} = \frac{1}{A_{inside} \cdot R_{th}}$$

Example with Units

$$1.3736\,\text{W/m}^2\text{*K} = \frac{1}{0.14\,\text{m}^2 \cdot 5.2\,\text{K/W}}$$

12) Inside Area given Thermal Resistance for Inner Surface Formula

Evaluate Formula

Formula

$$A_{inside} = \frac{1}{h_{inside} \cdot R_{th}}$$

Example with Units

$$0.1425\,\text{m}^2 = \frac{1}{1.35\,\text{W/m}^2\text{*K} \cdot 5.2\,\text{K/W}}$$

13) Newton's Law of Cooling Formula

Evaluate Formula

Formula

$$q' = h_{transfer} \cdot \left(T_w - T_f\right)$$

Example with Units

$$396\,\text{W/m}^2 = 13.2\,\text{W/m}^2\text{*K} \cdot \left(305\,\text{K} - 275\,\text{K}\right)$$

14) Outside Area given Outer Thermal Resistance Formula

Evaluate Formula

Formula

$$A_{outside} = \frac{1}{h_{outside} \cdot R_{th}}$$

Example with Units

$$0.0196\,\text{m}^2 = \frac{1}{9.8\,\text{W/m}^2\text{*K} \cdot 5.2\,\text{K/W}}$$

15) Outside Heat Transfer Coefficient given Thermal Resistance Formula

Evaluate Formula

Formula

$$h_{outside} = \frac{1}{R_{th} \cdot A_{outside}}$$

Example with Units

$$10.1215\,\text{W/m}^2\text{*K} = \frac{1}{5.2\,\text{K/W} \cdot 0.019\,\text{m}^2}$$

16) Thermal Resistance for Conduction at Tube Wall Formula

Evaluate Formula

Formula

$$R_{th} = \frac{\ln\left(\frac{r_2}{r_1}\right)}{2 \cdot \pi \cdot k \cdot l}$$

Example with Units

$$0.0195\,K/W = \frac{\ln\left(\frac{12.5\,m}{2.5\,m}\right)}{2 \cdot 3.1416 \cdot 2.15\,W/(m^*K) \cdot 6.1\,m}$$

17) Thermal Resistance for Convection at Inner Surface Formula

Evaluate Formula

Formula

$$R_{th} = \frac{1}{A_{inside} \cdot h_{inside}}$$

Example with Units

$$5.291\,K/W = \frac{1}{0.14\,m^2 \cdot 1.35\,W/m^{2*}K}$$

18) Thermal Resistance for Convection at Outer Surface Formula

Evaluate Formula

Formula

$$R_{th} = \frac{1}{h_{outside} \cdot A_{outside}}$$

Example with Units

$$5.3706\,K/W = \frac{1}{9.8\,W/m^{2*}K \cdot 0.019\,m^2}$$

19) Total Thermal Resistance Formula

Evaluate Formula

Formula

$$\Sigma R_{thermal} = \frac{1}{U_{overall} \cdot A}$$

Example with Units

$$0.0033\,K/W = \frac{1}{6\,W/m^{2*}K \cdot 50\,m^2}$$

20) Volumetric Heat Generation in Current Carrying Electrical Conductor Formula

Evaluate Formula

Formula

$$q_g = \left(i^2\right) \cdot \rho$$

Example with Units

$$17\,W/m^3 = \left(1000\,A/m^{2\,2}\right) \cdot 0.000017\,\Omega^*m$$

Variables used in list of Heat Transfer from Extended Surfaces (Fins), Critical Thickness of Insulation and Thermal Resistance Formulas above

- **A** Area *(Square Meter)*
- **A_c** Cross Sectional Area *(Square Meter)*
- **A_{inside}** Inside Area *(Square Meter)*
- **$A_{outside}$** Outside Area *(Square Meter)*
- **Bi** Biot Number
- **d_{fin}** Diameter of Cylindrical Fin *(Meter)*
- **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)*
- **$h_{transfer}$** Heat Transfer Coefficient *(Watt per Square Meter per Kelvin)*
- **i** Electric Current Density *(Ampere per Square Meter)*
- **k** Thermal Conductivity *(Watt per Meter per K)*
- **k_{fin}** Thermal Conductivity of Fin *(Watt per Meter per K)*
- **$K_{insulation}$** Thermal Conductivity of Insulation *(Watt per Meter per K)*
- **l** Length of Cylinder *(Meter)*
- **L_{char}** Characteristic Length *(Meter)*
- **$L_{cylindrical}$** Correction Length for Cylindrical Fin *(Meter)*
- **L_{fin}** Length of Fin *(Meter)*
- **$L_{rectangular}$** Correction Length for Thin Rectangular Fin *(Meter)*
- **L_{sqaure}** Correction Length for Sqaure Fin *(Meter)*
- **P_{fin}** Perimeter of Fin *(Meter)*
- **q'** Heat Flux *(Watt per Square Meter)*
- **Q_{fin}** Fin Heat Transfer Rate *(Watt)*
- **q_g** Volumetric Heat Generation *(Watt Per Cubic Meter)*
- **r_1** Inner Radius of Cylinder *(Meter)*
- **r_2** Outer Radius of Cylinder *(Meter)*
- **R_c** Critical Radius of Insulation *(Meter)*
- **R_{th}** Thermal Resistance *(Kelvin per Watt)*
- **T_f** Temperature of Characteristic Fluid *(Kelvin)*
- **t_{fin}** Thickness of Fin *(Meter)*
- **T_s** Surrounding Temperature *(Kelvin)*
- **T_w** Surface Temperature *(Kelvin)*
- **$U_{overall}$** Overall Heat Transfer Coefficient *(Watt per Square Meter per Kelvin)*
- **w_{fin}** Width of Fin *(Meter)*
- **ΔT** Overall Difference in Temperature *(Kelvin)*
- **η** Fin Efficiency
- **ρ** Resistivity *(Ohm Meter)*
- **$\Sigma R_{thermal}$** Total Thermal Resistance *(Kelvin per Watt)*

Constants, Functions, Measurements used in list of Heat Transfer from Extended Surfaces (Fins), Critical Thickness of Insulation and Thermal Resistance Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288
  Archimedes' 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.
- Functions: **sqrt**, sqrt(Number)
  A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- Functions: **tanh**, tanh(Number)
  The hyperbolic tangent function (tanh) is a function that is defined as the ratio of the hyperbolic sine function (sinh) to the hyperbolic cosine function (cosh).
- Measurement: **Length** in Meter (m)
  Length Unit Conversion
- Measurement: **Temperature** in Kelvin (K)
  Temperature Unit Conversion
- Measurement: **Area** in Square Meter (m²)
  Area Unit Conversion
- Measurement: **Power** in Watt (W)
  Power Unit Conversion
- Measurement: **Surface Current Density** in Ampere per Square Meter (A/m²)
  Surface Current Density 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: **Electric Resistivity** in Ohm Meter (Ω*m)
  Electric Resistivity Unit Conversion
- Measurement: **Heat Flux Density** in Watt per Square Meter (W/m²)
  Heat Flux Density Unit Conversion
- Measurement: **Heat Transfer Coefficient** in Watt per Square Meter per Kelvin (W/m²*K)
  Heat Transfer Coefficient Unit Conversion
- Measurement: **Power Density** in Watt Per Cubic Meter (W/m³)
  Power Density Unit Conversion

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