Important Transient Heat Conduction Formulas PDF

Formulas
Examples
with Units

List of 13
Important Transient Heat Conduction Formulas

1) Change in Internal energy of Lumped body Formula

Evaluate Formula

Formula

$$\Delta U = \rho \cdot c \cdot V_T \cdot \left(T_o - t_f \right) \cdot \left(1 - \left(\exp\left(- \left(Bi \cdot Fo \right) \right) \right) \right)$$

Example with Units

$$2583.765\,\text{J} = 5.51\,\text{kg/m}^3 \cdot 120\,\text{J/(kg*K)} \cdot 63\,\text{m}^3 \cdot \left(20\,\text{K} - 10\,\text{K} \right) \cdot \left(1 - \left(\exp\left(- \left(0.012444 \cdot 0.5 \right) \right) \right) \right)$$

2) Instantaneous heat transfer rate Formula

Evaluate Formula

Formula

$$Q_{rate} = h \cdot A \cdot \left(T_o - t_f \right) \cdot \left(\exp\left(- \frac{h \cdot A \cdot t}{\rho \cdot V_T \cdot C_o} \right) \right)$$

Example with Units

$$7.1553\,\text{W} = 0.04\,\text{W/m}^2\text{*K} \cdot 18\,\text{m}^2 \cdot \left(20\,\text{K} - 10\,\text{K} \right) \cdot \left(\exp\left(- \frac{0.04\,\text{W/m}^2\text{*K} \cdot 18\,\text{m}^2 \cdot 12\,\text{s}}{5.51\,\text{kg/m}^3 \cdot 63\,\text{m}^3 \cdot 4\,\text{J/(kg*K)}} \right) \right)$$

3) Power on exponential of temperature-time relation Formula

Evaluate Formula

Formula

$$b = - \frac{h \cdot A \cdot t}{\rho \cdot V_T \cdot C_o}$$

Example with Units

$$-0.0062 = - \frac{0.04\,\text{W/m}^2\text{*K} \cdot 18\,\text{m}^2 \cdot 12\,\text{s}}{5.51\,\text{kg/m}^3 \cdot 63\,\text{m}^3 \cdot 4\,\text{J/(kg*K)}}$$

4) Power on Exponential of Temperature-time Relation given Biot and Fourier Number Formula

Evaluate Formula

Formula

$$b = - \left(Bi \cdot Fo \right)$$

Example

$$-0.0062 = - \left(0.012444 \cdot 0.5 \right)$$

5) Product of Biot and Fourier Number given System Properties Formula

Evaluate Formula

Formula

$$BiFo = \frac{h \cdot A \cdot t}{\rho \cdot V_T \cdot C_o}$$

Example with Units

$$0.0062 = \frac{0.04\,\text{W/m}^2\text{*K} \cdot 18\,\text{m}^2 \cdot 12\,\text{s}}{5.51\,\text{kg/m}^3 \cdot 63\,\text{m}^3 \cdot 4\,\text{J/(kg*K)}}$$

6) Ratio of temperature difference for given time elapsed Formula

Evaluate Formula

Formula

$$T_{ratio} = \exp\left(- \frac{h \cdot A \cdot t}{\rho \cdot V_T \cdot C_o} \right)$$

Example with Units

$$0.9938 = \exp\left(- \frac{0.04\,\text{W/m}^2\text{*K} \cdot 18\,\text{m}^2 \cdot 12\,\text{s}}{5.51\,\text{kg/m}^3 \cdot 63\,\text{m}^3 \cdot 4\,\text{J/(kg*K)}} \right)$$

7) Ratio of Temperature difference for Time Elapsed given Biot and Fourier Number Formula

Evaluate Formula

Formula

$$T_{ratio} = \exp(- (Bi \cdot Fo))$$

Example

$$0.9938 = \exp(- (0.012444 \cdot 0.5))$$

8) Temperature after given time elapsed Formula

Evaluate Formula

Formula

$$T = \left(\left(T_o - t_f \right) \cdot \left(\exp\left(- \frac{h \cdot A \cdot t}{\rho \cdot V_T \cdot C_o} \right) \right) \right) + t_f$$

Example with Units

$$19.938\,\text{K} = \left(\left(20\,\text{K} - 10\,\text{K} \right) \cdot \left(\exp\left(- \frac{0.04\,\text{W/m}^2\text{*K} \cdot 18\,\text{m}^2 \cdot 12\,\text{s}}{5.51\,\text{kg/m}^3 \cdot 63\,\text{m}^3 \cdot 4\,\text{J/(kg*K)}} \right) \right) \right) + 10\,\text{K}$$

9) Thermal Capacitance Formula

Evaluate Formula

Formula

$$C = \rho \cdot C_o \cdot V$$

Example with Units

$$26.448\,\text{J/K} = 5.51\,\text{kg/m}^3 \cdot 4\,\text{J/(kg*K)} \cdot 1.2\,\text{m}^3$$

10) Thermal Diffusivity Formula

Evaluate Formula

Formula

$$\alpha = \frac{k}{\rho \cdot C_o}$$

Example with Units

$$0.4619\,\text{m}^2\text{/s} = \frac{10.18\,\text{W/(m*K)}}{5.51\,\text{kg/m}^3 \cdot 4\,\text{J/(kg*K)}}$$

11) Time Constant in unsteady state heat transfer Formula

Evaluate Formula

Formula

$$T_c = \frac{\rho \cdot C_o \cdot V_T}{h \cdot A}$$

Example with Units

$$1928.5 = \frac{5.51\,\text{kg/m}^3 \cdot 4\,\text{J/(kg*K)} \cdot 63\,\text{m}^3}{0.04\,\text{W/m}^2\text{*K} \cdot 18\,\text{m}^2}$$

12) Time taken to reach given temperature Formula

Evaluate Formula

Formula

$$t = \ln\left(\frac{T_f - t_f}{T_o - t_f}\right) \cdot \left(\frac{\rho \cdot V_T \cdot c}{h \cdot A}\right)$$

Example with Units

$$12\,\text{s} = \ln\left(\frac{20.002074366\,\text{K} - 10\,\text{K}}{20\,\text{K} - 10\,\text{K}}\right) \cdot \left(\frac{5.51\,\text{kg/m}^3 \cdot 63\,\text{m}^3 \cdot 120\,\text{J/(kg*K)}}{0.04\,\text{W/m}^2\text{*K} \cdot 18\,\text{m}^2}\right)$$

13) Total Heat Transfer during Time Interval Formula

Evaluate Formula

Formula

$$Q = \rho \cdot c \cdot V_T \cdot \left(T_o - t_f\right) \cdot \left(1 - \left(\exp\left(-\left(Bi \cdot Fo\right)\right)\right)\right)$$

Example with Units

$$2583.765\,\text{J} = 5.51\,\text{kg/m}^3 \cdot 120\,\text{J/(kg*K)} \cdot 63\,\text{m}^3 \cdot \left(20\,\text{K} - 10\,\text{K}\right) \cdot \left(1 - \left(\exp\left(-\left(0.012444 \cdot 0.5\right)\right)\right)\right)$$

Variables used in list of Transient Heat Conduction Formulas above

- **A** Surface Area *(Square Meter)*
- **b** Constant B
- **Bi** Biot Number
- **BiFo** Product of Biot And Fourier Numbers
- **c** Specific Heat *(Joule per Kilogram per K)*
- **C** Thermal Capacitance *(Joule per Kelvin)*
- C_o Specific Heat Capacity *(Joule per Kilogram per K)*
- **Fo** Fourier Number
- **h** Convection Heat Transfer Coefficient *(Watt per Square Meter per Kelvin)*
- **k** Thermal Conductivity *(Watt per Meter per K)*
- **Q** Heat Transfer *(Joule)*
- Q_{rate} Heat Rate *(Watt)*
- **t** Time Elapsed *(Second)*
- **T** Temperature *(Kelvin)*
- T_c Time Constant
- t_f Fluid Temperature *(Kelvin)*
- T_f Final Temperature *(Kelvin)*
- T_o Initial Temperature *(Kelvin)*
- T_{ratio} Temperature Ratio
- **V** Volume *(Cubic Meter)*
- V_T Total Volume *(Cubic Meter)*
- **α** Thermal Diffusivity *(Square Meter Per Second)*
- **ΔU** Change in Internal Energy *(Joule)*
- **ρ** Density *(Kilogram per Cubic Meter)*

Constants, Functions, Measurements used in list of Transient Heat Conduction Formulas above

- Functions: **exp**, exp(Number)
  n an exponential function, the value of the function changes by a constant factor for every unit change in the independent variable.
- 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: **Time** in Second (s)
  Time Unit Conversion
- Measurement: **Temperature** in Kelvin (K)
  Temperature Unit Conversion
- Measurement: **Volume** in Cubic Meter (m^3)
  Volume Unit Conversion
- Measurement: **Area** in Square Meter (m^2)
  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: **Heat Transfer Coefficient** in Watt per Square Meter per Kelvin (W/m^2*K)
  Heat Transfer Coefficient Unit Conversion
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m^3)
  Density Unit Conversion
- Measurement: **Diffusivity** in Square Meter Per Second (m^2/s)
  Diffusivity Unit Conversion
- Measurement: **Heat Capacity** in Joule per Kelvin (J/K)
  Heat Capacity Unit Conversion

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