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Transient Heat Conduction Formulas

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List of 13 Transient Heat Conduction Formulas

Transient Heat Conduction

1) Change in Internal energy of Lumped body

Open Calculator

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

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

2) Instantaneous heat transfer rate

Open Calculator

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

ex $$7.155337\text{W} = 0.04\text{W/m}^2\text{*K} \cdot 18\text{m}^2 \cdot (20\text{K} - 10\text{K}) \cdot \left(\exp\left(-\frac{0.04\text{W/m}^2\text{*K} \cdot 18\text{m}^2 \cdot 12\text{s}}{5.51\text{kg/m}^3 \cdot 63\text{m}^3 \cdot 4\text{J/(kg*K)}}\right)\right)$$

3) Power on exponential of temperature-time relation

Open Calculator

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

ex $$-0.006222 = -\frac{0.04\text{W/m}^2\text{*K} \cdot 18\text{m}^2 \cdot 12\text{s}}{5.51\text{kg/m}^3 \cdot 63\text{m}^3 \cdot 4\text{J/(kg*K)}}$$

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

Open Calculator

fx $$b = -(Bi \cdot Fo)$$

ex $$-0.006222 = -(0.012444 \cdot 0.5)$$

5) Product of Biot and Fourier Number given System Properties

Open Calculator

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

$$0.006222 = \frac{0.04\mathrm{W/m^2*K} \cdot 18\mathrm{m^2} \cdot 12\mathrm{s}}{5.51\mathrm{kg/m^3} \cdot 63\mathrm{m^3} \cdot 4\mathrm{J/(kg*K)}}$$

6) Ratio of temperature difference for given time elapsed

Open Calculator

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

$$0.993797 = \exp\left(-\frac{0.04\mathrm{W/m^2*K} \cdot 18\mathrm{m^2} \cdot 12\mathrm{s}}{5.51\mathrm{kg/m^3} \cdot 63\mathrm{m^3} \cdot 4\mathrm{J/(kg*K)}}\right)$$

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

Open Calculator

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

$$0.993797 = \exp(-(0.012444 \cdot 0.5))$$

8) Temperature after given time elapsed

Open Calculator

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

$$19.93797\mathrm{K} = \left((20\mathrm{K} - 10\mathrm{K}) \cdot \left(\exp\left(-\frac{0.04\mathrm{W/m^2*K} \cdot 18\mathrm{m^2} \cdot 12\mathrm{s}}{5.51\mathrm{kg/m^3} \cdot 63\mathrm{m^3} \cdot 4\mathrm{J/(kg*K)}}\right)\right)\right) + 10\mathrm{K}$$

9) Thermal Capacitance

Open Calculator

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

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

10) Thermal Diffusivity

Open Calculator

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

ex $$0.461887 m^2/s = \frac{10.18 W/(m*K)}{5.51 kg/m^3 \cdot 4 J/(kg*K)}$$

11) Time Constant in unsteady state heat transfer

Open Calculator

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

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

12) Time taken to reach given temperature

Open Calculator

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

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

13) Total Heat Transfer during Time Interval

Open Calculator

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

ex $$2583.765 J = 5.51 kg/m^3 \cdot 120 J/(kg*K) \cdot 63 m^3 \cdot (20 K - 10 K) \cdot (1 - (\exp(-(0.012444 \cdot 0.5))))$$

Variables Used

- **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

- Function: **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.
- Function: **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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- **Conduction in Cylinder Formulas**
- **Conduction in Plane Wall Formulas**
- **Conduction in Sphere Formulas**
- **Conduction Shape Factors for Different Configurations Formulas**
- **Other shapes Formulas**
- **Steady State Heat Conduction with Heat Generation Formulas**
- **Transient Heat Conduction Formulas**

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