Important Conduction in Plane Wall Formulas PDF

Formulas
Examples
with Units

List of 22
Important Conduction in Plane Wall Formulas

1) 2 Layers Formulas

1.1) Area of Composite Wall of 2 Layers Formula

Evaluate Formula

Formula

$$A_{w2} = \frac{Q_{l2}}{T_{i2} - T_{o2}} \cdot \left(\frac{L_1}{k_1} + \frac{L_2}{k_2} \right)$$

Example with Units

$$866.6667\,\text{m}^2 = \frac{120\,\text{W}}{420.75\,\text{K} - 420\,\text{K}} \cdot \left(\frac{2\,\text{m}}{1.6\,\text{W/(m*K)}} + \frac{5\,\text{m}}{1.2\,\text{W/(m*K)}} \right)$$

1.2) Heat Flow Rate through Composite Wall of 2 Layers in Series Formula

Evaluate Formula

Formula

$$Q_{l2} = \frac{T_{i2} - T_{o2}}{\frac{L_1}{k_1 \cdot A_{w2}} + \frac{L_2}{k_2 \cdot A_{w2}}}$$

Example with Units

$$120\,\text{W} = \frac{420.75\,\text{K} - 420\,\text{K}}{\frac{2\,\text{m}}{1.6\,\text{W/(m*K)} \cdot 866.6667\,\text{m}^2} + \frac{5\,\text{m}}{1.2\,\text{W/(m*K)} \cdot 866.6667\,\text{m}^2}}$$

1.3) Inner Surface Temperature of Composite Wall for 2 Layers in Series Formula

Evaluate Formula

Formula

$$T_{i2} = T_{o2} + Q_{l2} \cdot \left(\frac{L_1}{k_1 \cdot A_{w2}} + \frac{L_2}{k_2 \cdot A_{w2}} \right)$$

Example with Units

$$420.75\,\text{K} = 420\,\text{K} + 120\,\text{W} \cdot \left(\frac{2\,\text{m}}{1.6\,\text{W/(m*K)} \cdot 866.6667\,\text{m}^2} + \frac{5\,\text{m}}{1.2\,\text{W/(m*K)} \cdot 866.6667\,\text{m}^2} \right)$$

1.4) Interface Temperature of Composite Wall of 2 Layers given Inner Surface Temperature Formula

Evaluate Formula

Formula

$$T_2 = T_1 - \frac{Q_{l2} \cdot L_1}{k_1 \cdot A_{w2}}$$

Example with Units

$$420.5769\,\text{K} = 420.74997\,\text{K} - \frac{120\,\text{W} \cdot 2\,\text{m}}{1.6\,\text{W/(m*K)} \cdot 866.6667\,\text{m}^2}$$

1.5) Interface Temperature of Composite Wall of 2 Layers given Outer Surface Temperature Formula

Evaluate Formula

Formula

$$T_2 = T_{o2} + \frac{Q_{l2} \cdot L_2}{k_2 \cdot A_{w2}}$$

Example with Units

$$420.5769\,\text{K} = 420\,\text{K} + \frac{120\,\text{W} \cdot 5\,\text{m}}{1.2\,\text{W/(m*K)} \cdot 866.6667\,\text{m}^2}$$

1.6) Length of 2nd Layer of Composite Wall in Conduction through Walls Formula

Evaluate Formula

Formula

$$L_2 = k_2 \cdot A_{w2} \cdot \left(\frac{T_{i2} - T_{o2}}{Q_{l2}} - \frac{L_1}{k_1 \cdot A_{w2}} \right)$$

Example with Units

$$5\,\text{m} = 1.2\,\text{W/(m*K)} \cdot 866.6667\,\text{m}^2 \cdot \left(\frac{420.75\,\text{K} - 420\,\text{K}}{120\,\text{W}} - \frac{2\,\text{m}}{1.6\,\text{W/(m*K)} \cdot 866.6667\,\text{m}^2} \right)$$

1.7) Outer Surface Temperature of Composite Wall of 2 Layers for Conduction Formula

Evaluate Formula

Formula

$$T_{o2} = T_{i2} - Q_{l2} \cdot \left(\frac{L_1}{k_1 \cdot A_{w2}} + \frac{L_2}{k_2 \cdot A_{w2}} \right)$$

Example with Units

$$420\,\text{K} = 420.75\,\text{K} - 120\,\text{W} \cdot \left(\frac{2\,\text{m}}{1.6\,\text{W/(m*K)} \cdot 866.6667\,\text{m}^2} + \frac{5\,\text{m}}{1.2\,\text{W/(m*K)} \cdot 866.6667\,\text{m}^2} \right)$$

1.8) Thermal Resistance of Composite Wall with 2 Layers in Series Formula

Evaluate Formula

Formula

$$R_{th2} = \frac{L_1}{k_1 \cdot A_{w2}} + \frac{L_2}{k_2 \cdot A_{w2}}$$

Example with Units

$$0.0062\,\text{K/W} = \frac{2\,\text{m}}{1.6\,\text{W/(m*K)} \cdot 866.6667\,\text{m}^2} + \frac{5\,\text{m}}{1.2\,\text{W/(m*K)} \cdot 866.6667\,\text{m}^2}$$

2) 3 Layers Formulas

2.1) Area of Composite Wall of 3 Layers Formula

Evaluate Formula

Formula

$$A_{w3} = \frac{Q_{l3}}{T_{i3} - T_{o3}} \cdot \left(\frac{L_1}{k_1} + \frac{L_2}{k_2} + \frac{L_3}{k_3} \right)$$

Example with Units

$$1383.3333\,\text{m}^2 = \frac{150\,\text{W}}{300.75\,\text{K} - 300\,\text{K}} \cdot \left(\frac{2\,\text{m}}{1.6\,\text{W/(m*K)}} + \frac{5\,\text{m}}{1.2\,\text{W/(m*K)}} + \frac{6\,\text{m}}{4\,\text{W/(m*K)}} \right)$$

2.2) Heat Flow Rate through Composite Wall of 3 Layers in Series Formula

Evaluate Formula

Formula

$$Q_{l3} = \frac{T_{i3} - T_{o3}}{\frac{L_1}{k_1 \cdot A_{w3}} + \frac{L_2}{k_2 \cdot A_{w3}} + \frac{L_3}{k_3 \cdot A_{w3}}}$$

Example with Units

$$150\,\text{W} = \frac{300.75\,\text{K} - 300\,\text{K}}{\frac{2\,\text{m}}{1.6\,\text{W/(m*K)} \cdot 1383.33333\,\text{m}^2} + \frac{5\,\text{m}}{1.2\,\text{W/(m*K)} \cdot 1383.33333\,\text{m}^2} + \frac{6\,\text{m}}{4\,\text{W/(m*K)} \cdot 1383.33333\,\text{m}^2}}$$

2.3) Inner Surface Temperature of Composite Wall of 3 Layers in Series Formula

Evaluate Formula

Formula

$$T_{i3} = T_{o3} + Q_{l3} \cdot \left(\frac{L_1}{k_1 \cdot A_{w3}} + \frac{L_2}{k_2 \cdot A_{w3}} + \frac{L_3}{k_3 \cdot A_{w3}} \right)$$

Example with Units

$$300.75\,\text{K} = 300\,\text{K} + 150\,\text{W} \cdot \left(\frac{2\,\text{m}}{1.6\,\text{W/(m*K)} \cdot 1383.33333\,\text{m}^2} + \frac{5\,\text{m}}{1.2\,\text{W/(m*K)} \cdot 1383.33333\,\text{m}^2} + \frac{6\,\text{m}}{4\,\text{W/(m*K)} \cdot 1383.33333\,\text{m}^2} \right)$$

2.4) Length of 3rd Layer of Composite Wall in Conduction through Walls Formula

Evaluate Formula

Formula

$$L_3 = k_3 \cdot A_{w3} \cdot \left(\frac{T_{i3} - T_{o3}}{Q_{l3}} - \frac{L_1}{k_1 \cdot A_{w3}} - \frac{L_2}{k_2 \cdot A_{w3}} \right)$$

Example with Units

$$6\,\text{m} = 4\,\text{W/(m*K)} \cdot 1383.33333\,\text{m}^2 \cdot \left(\frac{300.75\,\text{K} - 300\,\text{K}}{150\,\text{W}} - \frac{2\,\text{m}}{1.6\,\text{W/(m*K)} \cdot 1383.33333\,\text{m}^2} - \frac{5\,\text{m}}{1.2\,\text{W/(m*K)} \cdot 1383.33333\,\text{m}^2} \right)$$

2.5) Outer Surface Temperature of Composite Wall of 3 Layers for Conduction Formula

Evaluate Formula

Formula

$$T_{o3} = T_{i3} - Q_{l3} \cdot \left(\frac{L_1}{k_1 \cdot A_{w3}} + \frac{L_2}{k_2 \cdot A_{w3}} + \frac{L_3}{k_3 \cdot A_{w3}} \right)$$

Example with Units

$$300\,\text{K} = 300.75\,\text{K} - 150\,\text{W} \cdot \left(\frac{2\,\text{m}}{1.6\,\text{W/(m*K)} \cdot 1383.33333\,\text{m}^2} + \frac{5\,\text{m}}{1.2\,\text{W/(m*K)} \cdot 1383.33333\,\text{m}^2} + \frac{6\,\text{m}}{4\,\text{W/(m*K)} \cdot 1383.33333\,\text{m}^2} \right)$$

2.6) Thermal Resistance of Composite Wall with 3 Layers in Series Formula

Evaluate Formula

Formula

$$R_{th3} = \frac{L_1}{k_1 \cdot A_{w3}} + \frac{L_2}{k_2 \cdot A_{w3}} + \frac{L_3}{k_3 \cdot A_{w3}}$$

Example with Units

$$0.005\,\text{K/W} = \frac{2\,\text{m}}{1.6\,\text{W/(m*K)} \cdot 1383.33333\,\text{m²}} + \frac{5\,\text{m}}{1.2\,\text{W/(m*K)} \cdot 1383.33333\,\text{m²}} + \frac{6\,\text{m}}{4\,\text{W/(m*K)} \cdot 1383.33333\,\text{m²}}$$

3) Single Plane Wall Formulas

3.1) Area of Plane Wall Required for Given Temperature Difference Formula

Evaluate Formula

Formula

$$A_{w1} = \frac{Q \cdot L}{k \cdot \left(T_i - T_o \right)}$$

Example with Units

$$50\,\text{m²} = \frac{125\,\text{W} \cdot 3\,\text{m}}{10\,\text{W/(m*K)} \cdot \left(400.75\,\text{K} - 400\,\text{K} \right)}$$

3.2) Inner Surface Temperature of Plane Wall Formula

Evaluate Formula

Formula

$$T_i = T_o + \frac{Q \cdot L}{k \cdot A_{w1}}$$

Example with Units

$$400.75\,\text{K} = 400\,\text{K} + \frac{125\,\text{W} \cdot 3\,\text{m}}{10\,\text{W/(m*K)} \cdot 50\,\text{m²}}$$

3.3) Outer Surface Temperature of Wall in Conduction through Wall Formula

Evaluate Formula

Formula

$$T_o = T_i - \frac{Q \cdot L}{k \cdot A_{w1}}$$

Example with Units

$$400\,\text{K} = 400.75\,\text{K} - \frac{125\,\text{W} \cdot 3\,\text{m}}{10\,\text{W/(m*K)} \cdot 50\,\text{m²}}$$

3.4) Temperature at Distance x from Inner Surface in Wall Formula

Evaluate Formula

Formula

$$T = T_i - \frac{x}{L} \cdot \left(T_i - T_o \right)$$

Example with Units

$$400.375\,\text{K} = 400.75\,\text{K} - \frac{1.5\,\text{m}}{3\,\text{m}} \cdot \left(400.75\,\text{K} - 400\,\text{K} \right)$$

3.5) Thermal Conductivity of Material Required to Maintain Given Temperature Difference Formula

Evaluate Formula

Formula

$$k = \frac{Q \cdot L}{\left(T_i - T_o \right) \cdot A_{w1}}$$

Example with Units

$$10\,\text{W/(m*K)} = \frac{125\,\text{W} \cdot 3\,\text{m}}{\left(400.75\,\text{K} - 400\,\text{K} \right) \cdot 50\,\text{m²}}$$

3.6) Thermal Resistance of Wall Formula

Evaluate Formula

Formula

$$R_{th} = \frac{L}{k \cdot A}$$

Example with Units

$$0.0231\,\text{K/W} = \frac{3\,\text{m}}{10\,\text{W/(m*K)} \cdot 13\,\text{m²}}$$

3.7) Thickness of Plane Wall for Conduction through Wall Formula

Evaluate Formula

Formula

$$L = \frac{\left(T_i - T_o\right) \cdot k \cdot A_{w1}}{Q}$$

Example with Units

$$3\,\text{m} = \frac{\left(400.75\,\text{K} - 400\,\text{K}\right) \cdot 10\,\text{W/(m*K)} \cdot 50\,\text{m}^2}{125\,\text{W}}$$

3.8) Total Thermal Resistance of Plane Wall with Convection on Both Sides Formula

Evaluate Formula

Formula

$$r_{th} = \frac{1}{h_i \cdot A_{w1}} + \frac{L}{k \cdot A_{w1}} + \frac{1}{h_o \cdot A_{w1}}$$

Example with Units

$$0.0229\,\text{K/W} = \frac{1}{1.35\,\text{W/m²*K} \cdot 50\,\text{m²}} + \frac{3\,\text{m}}{10\,\text{W/(m*K)} \cdot 50\,\text{m²}} + \frac{1}{9.8\,\text{W/m²*K} \cdot 50\,\text{m²}}$$

Variables used in list of Conduction in Plane Wall Formulas above

- **A** Cross-Sectional Area *(Square Meter)*
- A_{w1} Area of Wall *(Square Meter)*
- A_{w2} Area of 2 Layer Wall *(Square Meter)*
- A_{w3} Area of 3 Layer Wall *(Square Meter)*
- h_i Inside Convection *(Watt per Square Meter per Kelvin)*
- h_o External Convection *(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** Length *(Meter)*
- L_1 Length 1 *(Meter)*
- L_2 Length 2 *(Meter)*
- L_3 Length 3 *(Meter)*
- **Q** Heat Flow Rate *(Watt)*
- Q_{l2} Heat Flow Rate 2 Layer *(Watt)*
- Q_{l3} Heat Flow Rate 3 Layer *(Watt)*
- r_{th} Thermal Resistance with Convection *(Kelvin per Watt)*
- R_{th} Thermal Resistance *(Kelvin per Watt)*
- R_{th2} Thermal Resistance of 2 Layer *(Kelvin per Watt)*
- R_{th3} Thermal Resistance of 3 Layer *(Kelvin per Watt)*
- **T** Temperature *(Kelvin)*
- T_1 Temperature of Surface 1 *(Kelvin)*
- T_2 Temperature of Surface 2 *(Kelvin)*
- T_i Inner Surface Temperature *(Kelvin)*
- T_{i2} Inner Surface Temperature 2 layer wall *(Kelvin)*
- T_{i3} Inner Surface Temperature 3 Layer Wall *(Kelvin)*
- T_o Outer Surface Temperature *(Kelvin)*
- T_{o2} Outer Surface Temperature of 2 Layer *(Kelvin)*
- T_{o3} Outer Surface Temperature 3 Layer *(Kelvin)*

Constants, Functions, Measurements used in list of Conduction in Plane Wall Formulas above

- 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: **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

- **x** Distance from Inner Surface *(Meter)*

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