Important Electric Heating Formulas PDF

Formulas
Examples
with Units

List of 14
Important Electric Heating Formulas

1) Dielectric Heating Formulas

1.1) Capacitance Dielectric Formula

Evaluate Formula

Formula

$$C_d = \frac{\varepsilon_r \cdot 8.85 \cdot 10^{-12} \cdot A}{4 \cdot \pi \cdot t_d}$$

Example with Units

$$0.7001\,\mu F = \frac{3.14 \cdot 8.85 \cdot 10^{-12} \cdot 13\,m^2}{4 \cdot 3.1416 \cdot 41.06\,\mu m}$$

1.2) Dielectric Loss Formula

Evaluate Formula

Formula

$$P_l = \frac{V^2}{2 \cdot X_c} \cdot \sin\left(2 \cdot \Phi\right)$$

Example with Units

$$45.5803\,VA = \frac{200\,V^2}{2 \cdot 380\,\Omega} \cdot \sin\left(2 \cdot 60°\right)$$

1.3) Loss Tangent Formula

Evaluate Formula

Formula

$$\tan\delta = \frac{X_c}{R}$$

Example with Units

$$36.8905° = \frac{380\,\Omega}{590.19\,\Omega}$$

1.4) Net Resistance Formula

Evaluate Formula

Formula

$$R = \frac{X_c}{\tan\delta}$$

Example with Units

$$590.1978\,\Omega = \frac{380\,\Omega}{36.89°}$$

1.5) Power Loss Density Formula

Evaluate Formula

Formula

$$P_d = f \cdot \varepsilon_r'' \cdot 8.85418782 \cdot 10^{-12} \cdot F^2$$

Example with Units

$$0.0138\,W/m^3 = 5\,MHz \cdot 0.78 \cdot 8.85418782 \cdot 10^{-12} \cdot 20\,V/m^2$$

1.6) Thickness of Dielectric Formula

Evaluate Formula

Formula

$$t_d = \frac{\varepsilon_r \cdot 8.85 \cdot 10^{-12} \cdot A}{4 \cdot \pi \cdot C_d}$$

Example with Units

$$41.0685\,\mu m = \frac{3.14 \cdot 8.85 \cdot 10^{-12} \cdot 13\,m^2}{4 \cdot 3.1416 \cdot 0.70\,\mu F}$$

2) Furnace Heating Formulas

2.1) Energy Efficiency Formula

Evaluate Formula

Formula

$$\eta = \frac{E_t}{E_a}$$

Example with Units

$$0.5217 = \frac{1.2\,KJ}{2.3\,KJ}$$

2.2) Energy Required by Furnace to Melt Steel Formula

Evaluate Formula

Formula

$$E = \left(m \cdot S_{heat} \cdot \left(T_2 - T_1 \right) \right) + \left(m \cdot L_{heat} \right)$$

Example with Units

$$13.0248\,KJ = \left(35.98\,kg \cdot 138\,J/(kg*K) \cdot \left(299\,K - 300\,K \right) \right) + \left(35.98\,kg \cdot 0.5\,KJ \right)$$

2.3) Equivalent Inductance of Furnace Formula

Evaluate Formula

Formula

$$L = \frac{\pi \cdot 4 \cdot \pi \cdot 10^{-7} \cdot N_{coil}^{\,2} \cdot D_{melt}^{\,2}}{4 \cdot H_{melt}}$$

Example with Units

$$38.1954\,\mu H = \frac{3.1416 \cdot 4 \cdot 3.1416 \cdot 10^{-7} \cdot 24^2 \cdot 10.75\,cm^2}{4 \cdot 17.20\,cm}$$

2.4) Heat Conduction Formula

Evaluate Formula

Formula

$$Q = \frac{k \cdot A_{furnace} \cdot T_{total} \cdot \left(T_1 - T_2 \right)}{t_w}$$

Example with Units

$$1.0975\,W = \frac{11.09\,W/(m*K) \cdot 20.5\,cm^2 \cdot 28\,s \cdot \left(300\,K - 299\,K \right)}{58\,cm}$$

2.5) Heat Radiation Formula

Evaluate Formula

Formula

$$H = 5.72 \cdot e \cdot K \cdot \left(\left(\frac{T_1}{100} \right)^4 - \left(\frac{T_2}{100} \right)^4 \right)$$

Example with Units

$$3.3561\,\text{W/m²*K} = 5.72 \cdot 0.91 \cdot 0.6 \cdot \left(\left(\frac{300\,\text{K}}{100} \right)^4 - \left(\frac{299\,\text{K}}{100} \right)^4 \right)$$

2.6) Operating Frequency Formula

Evaluate Formula

Formula

$$f_{furnace} = \frac{\rho \cdot 10^9}{4 \cdot \pi^2 \cdot t_c^2 \cdot \mu_r}$$

Example with Units

$$2.8453\,\text{kHz} = \frac{113.59\,\mu\Omega\text{*cm} \cdot 10^9}{4 \cdot 3.1416^2 \cdot 10.60\,\text{cm}^2 \cdot 0.9}$$

2.7) Specific Resistance using Operating Frequency Formula

Evaluate Formula

Formula

$$\rho = \frac{f_{furnace} \cdot 4 \cdot \pi^2 \cdot t_c^2 \cdot \mu_r}{10^9}$$

Example with Units

$$113.3789\,\mu\Omega\text{*cm} = \frac{2.84\,\text{kHz} \cdot 4 \cdot 3.1416^2 \cdot 10.60\,\text{cm}^2 \cdot 0.9}{10^9}$$

2.8) Thickness of Cylinder Formula

Evaluate Formula

Formula

$$t_c = \frac{1}{2 \cdot \pi} \cdot \sqrt{\frac{\rho \cdot 10^9}{\mu_r \cdot f_{furnace}}}$$

Example with Units

$$10.6099\,\text{cm} = \frac{1}{2 \cdot 3.1416} \cdot \sqrt{\frac{113.59\,\mu\Omega\text{*cm} \cdot 10^9}{0.9 \cdot 2.84\,\text{kHz}}}$$

Variables used in list of Electric Heating Formulas above

- **A** Surface Area *(Square Meter)*
- $A_{furnace}$ Area of Furnace *(Square Centimeter)*
- C_d Capacitance of Dielectric *(Microfarad)*
- D_{melt} Diameter of Melt *(Centimeter)*
- **e** Emissivity
- **E** Energy *(Kilojoule)*
- E_a Actual Energy *(Kilojoule)*
- E_t Theoretical Energy *(Kilojoule)*
- **f** Frequency *(Megahertz)*
- **F** Electric Field Strength *(Volt per Meter)*
- $f_{furnace}$ Frequency of Induction Furnace *(Kilohertz)*
- **H** Heat Radiation *(Watt per Square Meter per Kelvin)*
- H_{melt} Height of Melt *(Centimeter)*
- **k** Thermal Conductivity *(Watt per Meter per K)*
- **K** Radiating Efficiency
- **L** Inductance *(Microhenry)*
- L_{heat} Latent Heat *(Kilojoule)*
- **m** Mass *(Kilogram)*
- N_{coil} Number of Coil Turns
- P_d Power Density *(Watt Per Cubic Meter)*
- P_l Power Loss *(Volt Ampere)*
- **Q** Heat Conduction *(Watt)*
- **R** Resistance *(Ohm)*
- S_{heat} Specific Heat *(Joule per Kilogram per K)*
- T_1 Temperature of Wall 1 *(Kelvin)*
- T_2 Temperature of Wall 2 *(Kelvin)*
- t_c Thickness of Cylinder *(Centimeter)*
- t_d Thickness of Dielectric *(Micrometer)*
- T_{total} Total Time *(Second)*
- t_w Thickness of Wall *(Centimeter)*
- **tan δ** Loss Tangent *(Degree)*

Constants, Functions, Measurements used in list of Electric Heating Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- Functions: **sin**, sin(Angle) *Sine is a trigonometric function that describes the ratio of the length of the opposite side of a right triangle to the length of the hypotenuse.*
- 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.*
- Measurement: **Length** in Micrometer (µm), Centimeter (cm) *Length Unit Conversion*
- Measurement: **Weight** in Kilogram (kg) *Weight Unit Conversion*
- Measurement: **Time** in Second (s) *Time Unit Conversion*
- Measurement: **Temperature** in Kelvin (K) *Temperature Unit Conversion*
- Measurement: **Area** in Square Meter (m²), Square Centimeter (cm²) *Area Unit Conversion*
- Measurement: **Energy** in Kilojoule (KJ) *Energy Unit Conversion*
- Measurement: **Power** in Volt Ampere (VA), Watt (W) *Power Unit Conversion*
- Measurement: **Angle** in Degree (°) *Angle Unit Conversion*
- Measurement: **Frequency** in Megahertz (MHz), Kilohertz (kHz) *Frequency Unit Conversion*
- Measurement: **Capacitance** in Microfarad (µF) *Capacitance Unit Conversion*
- Measurement: **Electric Resistance** in Ohm (Ω) *Electric Resistance Unit Conversion*
- Measurement: **Inductance** in Microhenry (µH) *Inductance Unit Conversion*

- **V** Voltage *(Volt)*
- X_c Capacitive Reactance *(Ohm)*
- ε_r Relative Permittivity
- ε_r'' Complex Relative Permittivity
- **η** Energy Efficiency
- μ_r Relative Permeability
- **ρ** Specific Resistance *(Microhm Centimeter)*
- **Φ** Phase Difference *(Degree)*

- Measurement: **Electric Field Strength** in Volt per Meter (V/m)
  Electric Field Strength Unit Conversion
- Measurement: **Thermal Conductivity** in Watt per Meter per K (W/(m*K))
  Thermal Conductivity Unit Conversion
- Measurement: **Electric Potential** in Volt (V)
  Electric Potential Unit Conversion
- Measurement: **Electric Resistivity** in Microhm Centimeter (μΩ*cm)
  Electric Resistivity 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/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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