Important Heat Flow in Welded Joints Formulas PDF

Formulas
Examples
with Units

List of 13
Important Heat Flow in Welded Joints Formulas

1) Cooling Rate for Relatively Thick Plates Formula

Evaluate Formula

Formula

$$R = \frac{2 \cdot \pi \cdot k \cdot \left(\left(T_c - t_a \right)^2 \right)}{H_{net}}$$

Example with Units

$$13.7116\,^{\circ}C/s = \frac{2 \cdot 3.1416 \cdot 10.18\,W/(m*K) \cdot \left(\left(500\,^{\circ}C - 37\,^{\circ}C \right)^2 \right)}{1000\,J/mm}$$

2) Cooling rate for relatively thin plates Formula

Evaluate Formula

Formula

$$R_c = 2 \cdot \pi \cdot k \cdot \rho \cdot Q_c \cdot \left(\left(\frac{t}{H_{net}} \right)^2 \right) \cdot \left(\left(T_c - t_a \right)^3 \right)$$

Example with Units

$$0.6621\,^{\circ}C/s = 2 \cdot 3.1416 \cdot 10.18\,W/(m*K) \cdot 997\,kg/m^3 \cdot 4.184\,kJ/kg*K \cdot \left(\left(\frac{5\,mm}{1000\,J/mm} \right)^2 \right) \cdot \left(\left(500\,^{\circ}C - 37\,^{\circ}C \right)^3 \right)$$

3) Net Heat Supplied to achieve given Cooling Rates for Thick Plates Formula

Evaluate Formula

Formula

$$H_{net} = \frac{2 \cdot \pi \cdot k \cdot \left(\left(T_c - t_a \right)^2 \right)}{R}$$

Example with Units

$$999.9998\,J/mm = \frac{2 \cdot 3.1416 \cdot 10.18\,W/(m*K) \cdot \left(\left(500\,^{\circ}C - 37\,^{\circ}C \right)^2 \right)}{13.71165\,^{\circ}C/s}$$

4) Net Heat Supplied to achieve given Cooling Rates for Thin Plates Formula

Evaluate Formula

Formula

$$H_{net} = \frac{t}{\sqrt{\frac{R_c}{2 \cdot \pi \cdot k \cdot \rho \cdot Q_c \cdot \left(\left(T_c - t_a \right)^3 \right)}}}$$

Example with Units

$$1001.5595\,\text{J/mm} = \frac{5\,\text{mm}}{\sqrt{\frac{0.66\,\text{°C/s}}{2 \cdot 3.1416 \cdot 10.18\,\text{W/(m*K)} \cdot 997\,\text{kg/m³} \cdot 4.184\,\text{kJ/kg*K} \cdot \left(\left(500\,\text{°C} - 37\,\text{°C} \right)^3 \right)}}}$$

5) Net Heat Supplied to Weld Area to Raise it to given Temperature from Fusion Boundary Formula

Evaluate Formula

Formula

$$H_{net} = \frac{\left(T_y - t_a \right) \cdot \left(T_m - t_a \right) \cdot \sqrt{2 \cdot \pi \cdot e} \cdot \rho \cdot Q_c \cdot t \cdot y}{T_m - T_y}$$

Example with Units

$$1000\,\text{J/mm} = \frac{\left(144.4892\,\text{°C} - 37\,\text{°C} \right) \cdot \left(1500\,\text{°C} - 37\,\text{°C} \right) \cdot \sqrt{2 \cdot 3.1416 \cdot e} \cdot 997\,\text{kg/m³} \cdot 4.184\,\text{kJ/kg*K} \cdot 5\,\text{mm} \cdot 99.99996\,\text{mm}}{1500\,\text{°C} - 144.4892\,\text{°C}}$$

6) Net Heat Supplied using Relative Thickness Factor Formula

Evaluate Formula

Formula

$$Q_{net} = \left(\left(\frac{t}{\tau} \right)^2 \right) \cdot \rho \cdot Q_c \cdot \left(T_c - t_a \right)$$

Example with Units

$$127006.5589\,\text{J} = \left(\left(\frac{5\,\text{mm}}{0.616582} \right)^2 \right) \cdot 997\,\text{kg/m³} \cdot 4.184\,\text{kJ/kg*K} \cdot \left(500\,\text{°C} - 37\,\text{°C} \right)$$

7) Peak Temperature Reached at any Point in Material Formula

Evaluate Formula

Formula

$$T_p = t_a + \frac{H_{net} \cdot \left(T_m - t_a \right)}{\left(T_m - t_a \right) \cdot \sqrt{2 \cdot \pi \cdot e} \cdot \rho_m \cdot t \cdot Q_c \cdot y + H_{net}}$$

Example with Units

$$51.5875\,\text{°C} = 37\,\text{°C} + \frac{1000\,\text{J/mm} \cdot \left(1500\,\text{°C} - 37\,\text{°C} \right)}{\left(1500\,\text{°C} - 37\,\text{°C} \right) \cdot \sqrt{2 \cdot 3.1416 \cdot e} \cdot 7850\,\text{kg/m³} \cdot 5\,\text{mm} \cdot 4.184\,\text{kJ/kg*K} \cdot 99.99996\,\text{mm} + 1000\,\text{J/mm}}$$

8) Position of Peak Temperature from Fusion Boundary Formula

Evaluate Formula

Formula

$$y = \frac{\left(T_m - T_y\right) \cdot H_{net}}{\left(T_y - t_a\right) \cdot \left(T_m - t_a\right) \cdot \sqrt{2 \cdot \pi \cdot e \cdot \rho \cdot Q_c \cdot t}}$$

Example with Units

$$100\,\text{mm} = \frac{\left(1500\,^\circ\text{C} - 144.4892\,^\circ\text{C}\right) \cdot 1000\,\text{J/mm}}{\left(144.4892\,^\circ\text{C} - 37\,^\circ\text{C}\right) \cdot \left(1500\,^\circ\text{C} - 37\,^\circ\text{C}\right) \cdot \sqrt{2 \cdot 3.1416 \cdot e \cdot 997\,\text{kg/m}^3 \cdot 4.184\,\text{kJ/kg*K} \cdot 5\,\text{mm}}}$$

9) Relative Plate Thickness Factor Formula

Evaluate Formula

Formula

$$\tau = t \cdot \sqrt{\frac{\left(T_c - t_a\right) \cdot \rho_m \cdot Q_c}{H_{net}}}$$

Example with Units

$$0.6166 = 5\,\text{mm} \cdot \sqrt{\frac{\left(500\,^\circ\text{C} - 37\,^\circ\text{C}\right) \cdot 7850\,\text{kg/m}^3 \cdot 4.184\,\text{kJ/kg*K}}{1000\,\text{J/mm}}}$$

10) Thermal Conductivity of Base Metal using given Cooling Rate (thick plates) Formula

Evaluate Formula

Formula

$$k = \frac{R \cdot H_{net}}{2 \cdot \pi \cdot \left(\left(T_c - t_a\right)^2\right)}$$

Example with Units

$$10.18\,\text{W/(m*K)} = \frac{13.71165\,^\circ\text{C/s} \cdot 1000\,\text{J/mm}}{2 \cdot 3.1416 \cdot \left(\left(500\,^\circ\text{C} - 37\,^\circ\text{C}\right)^2\right)}$$

11) Thermal Conductivity of Base Metal using given Cooling Rate (thin plates) Formula

Evaluate Formula

Formula

$$k = \frac{R_c}{2 \cdot \pi \cdot \rho \cdot Q_c \cdot \left(\left(\frac{t}{H_{net}}\right)^2\right) \cdot \left(\left(T_c - t_a\right)^3\right)}$$

Example with Units

$$10.1483\,\text{W/(m*K)} = \frac{0.66\,^\circ\text{C/s}}{2 \cdot 3.1416 \cdot 997\,\text{kg/m}^3 \cdot 4.184\,\text{kJ/kg*K} \cdot \left(\left(\frac{5\,\text{mm}}{1000\,\text{J/mm}}\right)^2\right) \cdot \left(\left(500\,^\circ\text{C} - 37\,^\circ\text{C}\right)^3\right)}$$

12) Thickness of Base Metal for Desired Cooling Rate Formula

Evaluate Formula

Formula

$$z = H_{net} \cdot \sqrt{\frac{R}{2 \cdot \pi \cdot k \cdot \rho \cdot Q_c \cdot \left(\left(T_c - t_a \right)^3 \right)}}$$

Example with Units

$$22.7544\,\text{mm} = 1000\,\text{J/mm} \cdot \sqrt{\frac{13.71165\,\text{°C/s}}{2 \cdot 3.1416 \cdot 10.18\,\text{W/(m*K)} \cdot 997\,\text{kg/m}^3 \cdot 4.184\,\text{kJ/kg*K} \cdot \left(\left(500\,\text{°C} - 37\,\text{°C} \right)^3 \right)}}$$

13) Thickness of Base Metal using Relative Thickness Factor Formula

Evaluate Formula

Formula

$$h = \tau \cdot \sqrt{\frac{H_{net}}{\left(T_c - t_a \right) \cdot \rho \cdot Q_c}}$$

Example with Units

$$14.03\,\text{mm} = 0.616582 \cdot \sqrt{\frac{1000\,\text{J/mm}}{\left(500\,\text{°C} - 37\,\text{°C} \right) \cdot 997\,\text{kg/m}^3 \cdot 4.184\,\text{kJ/kg*K}}}$$

Variables used in list of Heat Flow in Welded Joints Formulas above

- **h** Thickness of the Base Metal *(Millimeter)*
- H_{net} Net Heat Supplied Per Unit Length *(Joule per Millimeter)*
- **k** Thermal Conductivity *(Watt per Meter per K)*
- Q_c Specific Heat Capacity *(Kilojoule per Kilogram per K)*
- Q_{net} Net Heat Supplied *(Joule)*
- **R** Cooling Rate of Thick Plate *(Celsius per Second)*
- R_c Cooling Rate of Thin Plate *(Celsius per Second)*
- **t** Thickness of Filler Metal *(Millimeter)*
- t_a Ambient Temperature *(Celsius)*
- T_c Temperature for Cooling Rate *(Celsius)*
- T_m Melting Temperature of Base Metal *(Celsius)*
- T_p Peak Temperature Reached at Some Distance *(Celsius)*
- T_y Temperature Reached at Some Distance *(Celsius)*
- **y** Distance from the Fusion Boundary *(Millimeter)*
- **z** Thickness *(Millimeter)*
- **ρ** Density of Electrode *(Kilogram per Cubic Meter)*
- ρ_m Density of Metal *(Kilogram per Cubic Meter)*
- **τ** Relative Plate Thickness Factor

Constants, Functions, Measurements used in list of Heat Flow in Welded Joints Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- constant(s): **e**, 2.71828182845904523536028747135266249 *Napier's constant*
- 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 Millimeter (mm) *Length Unit Conversion*
- Measurement: **Temperature** in Celsius (°C) *Temperature Unit Conversion*
- Measurement: **Energy** in Joule (J) *Energy Unit Conversion*
- Measurement: **Thermal Conductivity** in Watt per Meter per K (W/(m*K)) *Thermal Conductivity Unit Conversion*
- Measurement: **Specific Heat Capacity** in Kilojoule per Kilogram per K (kJ/kg*K) *Specific Heat Capacity Unit Conversion*
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m³) *Density Unit Conversion*
- Measurement: **Rate of Temperature Change** in Celsius per Second (°C/s) *Rate of Temperature Change Unit Conversion*
- Measurement: **Energy per Unit Length** in Joule per Millimeter (J/mm) *Energy per Unit Length Unit Conversion*

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