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Heat Flow in Welded Joints Formulas

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List of 13 Heat Flow in Welded Joints Formulas

Heat Flow in Welded Joints

1) Cooling Rate for Relatively Thick Plates

Open Calculator

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

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

2) Cooling rate for relatively thin plates

Open Calculator

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

ex $$0.66206\,^\circ C/s = 2 \cdot \pi \cdot 10.18 W/(m*K) \cdot 997 kg/m^3 \cdot 4.184 kJ/kg*K \cdot \left(\left(\frac{5mm}{1000 J/mm} \right)^2 \right) \cdot \left((500\,^\circ C - 37\,^\circ C)^3 \right)$$

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

Open Calculator

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

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

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

Open Calculator

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

ex $$1001.56 J/mm = \frac{5mm}{\sqrt{\frac{0.66\,^\circ C/s}{2 \cdot \pi \cdot 10.18 W/(m*K) \cdot 997 kg/m^3 \cdot 4.184 kJ/kg*K \cdot \left((500\,^\circ C - 37\,^\circ C)^3 \right)}}}$$

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

Open Calculator

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

ex $$1000\text{J/mm} = \frac{(144.4892^\circ\text{C} - 37^\circ\text{C}) \cdot (1500^\circ\text{C} - 37^\circ\text{C}) \cdot \sqrt{2 \cdot \pi \cdot e} \cdot 997\text{kg/m}^3 \cdot 4.184\text{kJ/kg*K} \cdot 5\text{mm} \cdot 99.99}{1500^\circ\text{C} - 144.4892^\circ\text{C}}$$

6) Net Heat Supplied using Relative Thickness Factor

Open Calculator

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

ex $$127006.6\text{J} = \left(\left(\frac{5\text{mm}}{0.616582}\right)^2\right) \cdot 997\text{kg/m}^3 \cdot 4.184\text{kJ/kg*K} \cdot (500^\circ\text{C} - 37^\circ\text{C})$$

7) Peak Temperature Reached at any Point in Material

Open Calculator

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

ex $$51.58746^\circ\text{C} = 37^\circ\text{C} + \frac{1000\text{J/mm} \cdot (1500^\circ\text{C} - 37^\circ\text{C})}{(1500^\circ\text{C} - 37^\circ\text{C}) \cdot \sqrt{2 \cdot \pi \cdot e} \cdot 7850\text{kg/m}^3 \cdot 5\text{mm} \cdot 4.184\text{kJ/kg*K} \cdot 99.99996\text{mm} + 100}$$

8) Position of Peak Temperature from Fusion Boundary

Open Calculator

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

ex $$99.99996\text{mm} = \frac{(1500^\circ\text{C} - 144.4892^\circ\text{C}) \cdot 1000\text{J/mm}}{(144.4892^\circ\text{C} - 37^\circ\text{C}) \cdot (1500^\circ\text{C} - 37^\circ\text{C}) \cdot \sqrt{2 \cdot \pi \cdot e} \cdot 997\text{kg/m}^3 \cdot 4.184\text{kJ/kg*K} \cdot 5\text{mm}}$$

9) Relative Plate Thickness Factor

Open Calculator

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

ex $$0.616582 = 5\text{mm} \cdot \sqrt{\frac{(500^\circ\text{C} - 37^\circ\text{C}) \cdot 7850\text{kg/m}^3 \cdot 4.184\text{kJ/kg*K}}{1000\text{J/mm}}}$$

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

Open Calculator

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

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

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

Open Calculator

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

$$10.14832\text{W/(m*K)} = \frac{0.66\,^\circ\text{C/s}}{2 \cdot \pi \cdot 997\text{kg/m}^3 \cdot 4.184\text{kJ/kg*K} \cdot \left(\left(\frac{5\text{mm}}{1000\text{J/mm}}\right)^2\right) \cdot \left((500\,^\circ\text{C} - 37\,^\circ\text{C})^3\right)}$$

12) Thickness of Base Metal for Desired Cooling Rate

Open Calculator

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

$$22.75444\text{mm} = 1000\text{J/mm} \cdot \sqrt{\frac{13.71165\,^\circ\text{C/s}}{2 \cdot \pi \cdot 10.18\text{W/(m*K)} \cdot 997\text{kg/m}^3 \cdot 4.184\text{kJ/kg*K} \cdot \left((500\,^\circ\text{C} - 37\,^\circ\text{C})^3\right)}}$$

13) Thickness of Base Metal using Relative Thickness Factor

Open Calculator

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

$$14.02998\text{mm} = 0.616582 \cdot \sqrt{\frac{1000\text{J/mm}}{(500\,^\circ\text{C} - 37\,^\circ\text{C}) \cdot 997\text{kg/m}^3 \cdot 4.184\text{kJ/kg*K}}}$$

Variables Used

- **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

- Constant: **pi**, 3.14159265358979323846264338327950288
  Archimedes' constant
- Constant: **e**, 2.71828182845904523536028747135266249
  Napier's constant
- Function: **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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- **Heat Flow in Welded Joints Formulas**
- **Heat Input in Welding Formulas**

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