Important Boiling Formulas PDF

Formulas
Examples
with Units

List of 14
Important Boiling Formulas

1) Correlation for Heat Flux proposed by Mostinski Formula

Evaluate Formula

Formula

$$h_b = 0.00341 \cdot \left(P_c^{2.3} \right) \cdot \left(T_e^{2.33} \right) \cdot \left(P_r^{0.566} \right)$$

Example with Units

$$110240.4213\,\text{W/m}^{2*\circ\text{C}} = 0.00341 \cdot \left(5.9\,\text{Pa}^{2.3} \right) \cdot \left(10\,^{\circ}\text{C}^{2.33} \right) \cdot \left(1.1^{0.566} \right)$$

2) Critical Heat Flux by Zuber Formula

Evaluate Formula

Formula

$$q_{Max} = \left(\left(0.149 \cdot L_v \cdot \rho_v \right) \cdot \left(\frac{\left(\sigma \cdot [g] \right) \cdot \left(\rho_L - \rho_v \right)}{\rho_v^2} \right)^{\frac{1}{4}} \right)$$

Example with Units

$$58.1713\,\text{W/m}^2 = \left(\left(0.149 \cdot 19\,\text{J/mol} \cdot 0.5\,\text{kg/m}^3 \right) \cdot \left(\frac{\left(72.75\,\text{N/m} \cdot 9.8066\,\text{m/s}^2 \right) \cdot \left(1000\,\text{kg/m}^3 - 0.5\,\text{kg/m}^3 \right)}{0.5\,\text{kg/m}^3{}^2} \right)^{\frac{1}{4}} \right)$$

3) Excess Temperature in Boiling Formula

Evaluate Formula

Formula

$$T_{excess} = T_{surface} - T_{Sat}$$

Example with Units

$$297\,\text{K} = 670\,\text{K} - 373\,\text{K}$$

4) Heat Flux in Fully Developed Boiling State for Higher Pressures Formula

Evaluate Formula

Formula

$$q_{rate} = 283.2 \cdot A \cdot \left(\left(\Delta T_x \right)^3 \right) \cdot \left(\left(p_{HT} \right)^{\frac{4}{3}} \right)$$

Example with Units

$$150.3508\,\text{W} = 283.2 \cdot 5\,\text{m}^2 \cdot \left(\left(2.25\,^\circ\text{C} \right)^3 \right) \cdot \left(\left(3\text{E-}8\,\text{MPa} \right)^{\frac{4}{3}} \right)$$

5) Heat Flux in Fully Developed Boiling State for Pressure upto 0.7 Megapascal Formula

Evaluate Formula

Formula

$$q_{rate} = 2.253 \cdot A \cdot \left(\left(\Delta T_x \right)^{3.96} \right)$$

Example with Units

$$279.495\,\text{W} = 2.253 \cdot 5\,\text{m}^2 \cdot \left(\left(2.25\,^\circ\text{C} \right)^{3.96} \right)$$

6) Heat Transfer Coefficient for Forced Convection Local Boiling Inside Vertical Tubes Formula

Evaluate Formula

Formula

$$h = \left(2.54 \cdot \left(\left(\Delta T_x \right)^3 \right) \cdot \exp\left(\frac{p}{1.551} \right) \right)$$

Example with Units

$$29.0456\,\text{W/m}^2\text{*°C} = \left(2.54 \cdot \left(\left(2.25\,^\circ\text{C} \right)^3 \right) \cdot \exp\left(\frac{0.00607\,\text{MPa}}{1.551} \right) \right)$$

7) Heat Transfer Coefficient given Biot Number Formula

Evaluate Formula

Formula

$$h_{transfer} = \frac{Bi \cdot k}{\ell}$$

Example with Units

$$4.4678\,\text{W/m}^2\text{*K} = \frac{2.19 \cdot 10.18\,\text{W/(m*K)}}{4.99\,\text{m}}$$

8) Modified Heat of Vaporization Formula

Evaluate Formula

Formula

$$\lambda = \left(h_{fg} + \left(c_{pv} \right) \cdot \left(\frac{T_w - T_{Sat}}{2} \right) \right)$$

Example with Units

$$2636\,\text{J/kg} = \left(2260\,\text{J/kg} + \left(23.5\,\text{J/(kg*K)} \right) \cdot \left(\frac{405\,\text{K} - 373\,\text{K}}{2} \right) \right)$$

9) Modified Heat Transfer Coefficient under Influence of Pressure Formula

Evaluate Formula

Formula

$$h_p = \left(h_1\right) \cdot \left(\left(\frac{p_s}{p_1}\right)^{0.4}\right)$$

Example with Units

$$44.9539\,\text{W/m²*K} = \left(10.9\,\text{W/m²*K}\right) \cdot \left(\left(\frac{3.5\,\text{Pa}}{0.101325\,\text{Pa}}\right)^{0.4}\right)$$

10) Radiation Heat Transfer Coefficient Formula

Evaluate Formula

Formula

$$h_r = \left(\frac{[\text{Stefan-BoltZ}] \cdot \varepsilon \cdot \left(\left(\left(T_w\right)^4\right) - \left(\left(T_{Sat}\right)^4\right)\right)}{T_w - T_{Sat}}\right)$$

Example with Units

$$12.7051\,\text{W/m²*K} = \left(\frac{5.7\text{E-}8 \cdot 0.95 \cdot \left(\left(\left(405\,\text{K}\right)^4\right) - \left(\left(373\,\text{K}\right)^4\right)\right)}{405\,\text{K} - 373\,\text{K}}\right)$$

11) Radius of Vapour Bubble in Mechanical Equilibrium in Superheated Liquid Formula

Evaluate Formula

Formula

$$r = \frac{2 \cdot \sigma \cdot [R] \cdot \left(T_{Sat}^2\right)}{P_l \cdot L_v \cdot \left(T_l - T_{Sat}\right)}$$

Example with Units

$$0.1415\,\text{m} = \frac{2 \cdot 72.75\,\text{N/m} \cdot 8.3145 \cdot \left(373\,\text{K}^2\right)}{200000\,\text{Pa} \cdot 19\,\text{J/mol} \cdot \left(686\,\text{K} - 373\,\text{K}\right)}$$

12) Saturated Temperature given Excess Temperature Formula

Evaluate Formula

Formula

$$T_{Sat} = T_{surface} - T_{excess}$$

Example with Units

$$373\,\text{K} = 670\,\text{K} - 297\,\text{K}$$

13) Surface Temperature given Excess Temperature Formula

Evaluate Formula

Formula

$$T_{surface} = T_{Sat} + T_{excess}$$

Example with Units

$$670\,\text{K} = 373\,\text{K} + 297\,\text{K}$$

14) Total Heat Transfer Coefficient Formula

Evaluate Formula

Formula

$$h_T = h_{FB} \cdot \left(\left(\frac{h_{FB}}{h_{transfer}} \right)^{\frac{1}{3}} \right) + h_r$$

Example with Units

$$5449.994\,\text{W/m}^2\text{*K} = 921\,\text{W/m}^2\text{*K} \cdot \left(\left(\frac{921\,\text{W/m}^2\text{*K}}{4.476\,\text{W/m}^2\text{*K}} \right)^{\frac{1}{3}} \right) + 12.70\,\text{W/m}^2\text{*K}$$

Variables used in list of Boiling Formulas above

- **A** Area *(Square Meter)*
- **Bi** Biot Number
- c_{pv} Specific Heat of Water Vapor *(Joule per Kilogram per K)*
- **h** Heat Transfer Coefficient for Forced Convection *(Watt per Square Meter per Celcius)*
- h_1 Heat Transfer Coefficient at Atmospheric Pressure *(Watt per Square Meter per Kelvin)*
- h_b Heat Transfer Coefficient For Nucleate Boiling *(Watt per Square Meter per Celcius)*
- h_{FB} Heat Transfer Coefficient in Film Boiling Region *(Watt per Square Meter per Kelvin)*
- h_{fg} Latent Heat of Vaporization *(Joule per Kilogram)*
- h_p Heat Transfer Coefficient at Some Pressure P *(Watt per Square Meter per Kelvin)*
- h_r Radiation Heat Transfer Coefficient *(Watt per Square Meter per Kelvin)*
- h_T Total Heat Transfer Coefficient *(Watt per Square Meter per Kelvin)*
- $h_{transfer}$ Heat Transfer Coefficient *(Watt per Square Meter per Kelvin)*
- **k** Thermal Conductivity *(Watt per Meter per K)*
- L_v Enthalpy of Vaporization of Liquid *(Joule Per Mole)*
- **p** System Pressure in Vertical Tubes *(Megapascal)*
- p_1 Standard Atmospheric Pressure *(Pascal)*
- P_c Critical Pressure *(Pascal)*
- p_{HT} Pressure *(Megapascal)*
- P_l Pressure of Superheated Liquid *(Pascal)*
- P_r Reduced Pressure
- p_s System Pressure *(Pascal)*
- q_{Max} Critical Heat Flux *(Watt per Square Meter)*
- q_{rate} Rate of Heat Transfer *(Watt)*

Constants, Functions, Measurements used in list of Boiling Formulas above

- constant(s): **[g]**, 9.80665
  Gravitational acceleration on Earth
- constant(s): **[Stefan-BoltZ]**, 5.670367E-8
  Stefan-Boltzmann Constant
- constant(s): **[R]**, 8.31446261815324
  Universal gas constant
- Functions: **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.
- Measurement: **Length** in Meter (m)
  Length Unit Conversion
- Measurement: **Temperature** in Celsius (°C), Kelvin (K)
  Temperature Unit Conversion
- Measurement: **Area** in Square Meter (m²)
  Area Unit Conversion
- Measurement: **Pressure** in Pascal (Pa), Megapascal (MPa)
  Pressure Unit Conversion
- Measurement: **Temperature Difference** in Degree Celsius (°C)
  Temperature Difference 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 Flux Density** in Watt per Square Meter (W/m²)
  Heat Flux Density Unit Conversion
- Measurement: **Heat Transfer Coefficient** in Watt per Square Meter per Celcius (W/m²*°C), Watt per Square Meter per Kelvin (W/m²*K)
  Heat Transfer Coefficient Unit Conversion
- Measurement: **Surface Tension** in Newton per Meter (N/m)
  Surface Tension Unit Conversion

- **r** Radius of Vapor Bubble *(Meter)*
- T_e Excess Temperature in Nucleate Boiling *(Celsius)*
- T_{excess} Excess Temperature in Heat Transfer *(Kelvin)*
- T_l Temperature of Superheated Liquid *(Kelvin)*
- T_{Sat} Saturation Temperature *(Kelvin)*
- $T_{surface}$ Surface Temperature *(Kelvin)*
- T_w Plate Surface Temperature *(Kelvin)*
- ΔT_x Excess Temperature *(Degree Celsius)*
- **ε** Emissivity
- **λ** Modified Heat of Vaporization *(Joule per Kilogram)*
- ρ_L Density of Liquid *(Kilogram per Cubic Meter)*
- ρ_v Density of Vapor *(Kilogram per Cubic Meter)*
- **σ** Surface Tension *(Newton per Meter)*
- ℓ Thickness of Wall *(Meter)*

- Measurement: **Density** in Kilogram per Cubic Meter (kg/m³)
  Density Unit Conversion
- Measurement: **Latent Heat** in Joule per Kilogram (J/kg)
  Latent Heat Unit Conversion
- Measurement: **Energy Per Mole** in Joule Per Mole (J/mol)
  Energy Per Mole Unit Conversion
- Measurement: **Rate of Heat Transfer** in Watt (W)
  Rate of Heat Transfer Unit Conversion

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