Important Condensation Formulas PDF

Formulas
Examples
with Units

List of 22
Important Condensation Formulas

1) Average Heat Transfer Coefficient for Condensation Inside Horizontal Tubes for Low Vapor Velocity Formula

Evaluate Formula

Formula

$$\bar{h} = 0.555 \cdot \left(\frac{\rho_f \cdot \left(\rho_f - \rho_v \right) \cdot [g] \cdot h'_{fg} \cdot \left({k_f}^3 \right)}{L \cdot D_{Tube} \cdot \left(T_{Sat} - T_w \right)} \right)^{0.25}$$

Example with Units

$$14.4255\,\mathrm{W/m^2{*}K} = 0.555 \cdot \left(\frac{96\,\mathrm{kg/m^3} \cdot \left(96\,\mathrm{kg/m^3} - 0.5\,\mathrm{kg/m^3} \right) \cdot 9.8066\,\mathrm{m/s^2} \cdot 3100000\,\mathrm{J/kg} \cdot \left(0.67\,\mathrm{W/(m{*}K)}^3 \right)}{65\,\mathrm{m} \cdot 9.71\,\mathrm{m} \cdot \left(373\,\mathrm{K} - 82\,\mathrm{K} \right)} \right)^{0.25}$$

2) Average Heat Transfer Coefficient for Film Condensation on Plate for Wavy Laminar Flow Formula

Evaluate Formula

Formula

$$\bar{h} = 1.13 \cdot \left(\frac{\rho_f \cdot \left(\rho_f - \rho_v \right) \cdot [g] \cdot h_{fg} \cdot \left({k_f}^3 \right)}{L \cdot \mu_f \cdot \left(T_{Sat} - T_w \right)} \right)^{0.25}$$

Example with Units

$$116.0939\,\mathrm{W/m^2{*}K} = 1.13 \cdot \left(\frac{96\,\mathrm{kg/m^3} \cdot \left(96\,\mathrm{kg/m^3} - 0.5\,\mathrm{kg/m^3} \right) \cdot 9.8066\,\mathrm{m/s^2} \cdot 2260000\,\mathrm{J/kg} \cdot \left(0.67\,\mathrm{W/(m{*}K)}^3 \right)}{65\,\mathrm{m} \cdot 0.029\,\mathrm{N{*}s/m^2} \cdot \left(373\,\mathrm{K} - 82\,\mathrm{K} \right)} \right)^{0.25}$$

3) Average Heat Transfer Coefficient for Laminar Film Condensation of Tube Formula

Evaluate Formula

Formula

$$\bar{h} = 0.725 \cdot \left(\frac{\rho_f \cdot \left(\rho_f - \rho_v \right) \cdot [g] \cdot h_{fg} \cdot \left(k_f^{3} \right)}{D_{Tube} \cdot \mu_f \cdot \left(T_{Sat} - T_w \right)} \right)^{0.25}$$

Example with Units

$$119.8098 \, \mathrm{W/m^2{*}K} = 0.725 \cdot \left(\frac{96 \, \mathrm{kg/m^3} \cdot \left(96 \, \mathrm{kg/m^3} - 0.5 \, \mathrm{kg/m^3} \right) \cdot 9.8066 \, \mathrm{m/s^2} \cdot 2260000 \, \mathrm{J/kg} \cdot \left(0.67 \, \mathrm{W/(m{*}K)}^{3} \right)}{9.71 \, \mathrm{m} \cdot 0.029 \, \mathrm{N{*}s/m^2} \cdot \left(373 \, \mathrm{K} - 82 \, \mathrm{K} \right)} \right)^{0.25}$$

4) Average Heat Transfer Coefficient for Laminar Film Condensation on Outside of Sphere Formula

Evaluate Formula

Formula

$$\bar{h} = 0.815 \cdot \left(\frac{\rho_f \cdot \left(\rho_f - \rho_v \right) \cdot [g] \cdot h_{fg} \cdot \left(k_f^{3} \right)}{D_{Sphere} \cdot \mu_f \cdot \left(T_{Sat} - T_w \right)} \right)^{0.25}$$

Example with Units

$$134.6481 \, \mathrm{W/m^2{*}K} = 0.815 \cdot \left(\frac{96 \, \mathrm{kg/m^3} \cdot \left(96 \, \mathrm{kg/m^3} - 0.5 \, \mathrm{kg/m^3} \right) \cdot 9.8066 \, \mathrm{m/s^2} \cdot 2260000 \, \mathrm{J/kg} \cdot \left(0.67 \, \mathrm{W/(m{*}K)}^{3} \right)}{9.72 \, \mathrm{m} \cdot 0.029 \, \mathrm{N{*}s/m^2} \cdot \left(373 \, \mathrm{K} - 82 \, \mathrm{K} \right)} \right)^{0.25}$$

5) Average Heat Transfer Coefficient for Vapor Condensing on Plate Formula

Evaluate Formula

Formula

$$\bar{h} = 0.943 \cdot \left(\frac{\rho_f \cdot \left(\rho_f - \rho_v \right) \cdot [g] \cdot h_{fg} \cdot \left(k_f^{3} \right)}{L \cdot \mu_f \cdot \left(T_{Sat} - T_w \right)} \right)^{0.25}$$

Example with Units

$$96.8819 \, \mathrm{W/m^2{*}K} = 0.943 \cdot \left(\frac{96 \, \mathrm{kg/m^3} \cdot \left(96 \, \mathrm{kg/m^3} - 0.5 \, \mathrm{kg/m^3} \right) \cdot 9.8066 \, \mathrm{m/s^2} \cdot 2260000 \, \mathrm{J/kg} \cdot \left(0.67 \, \mathrm{W/(m{*}K)}^{3} \right)}{65 \, \mathrm{m} \cdot 0.029 \, \mathrm{N{*}s/m^2} \cdot \left(373 \, \mathrm{K} - 82 \, \mathrm{K} \right)} \right)^{0.25}$$

6) Average Heat Transfer Coefficient given Reynolds Number and Properties at Film Temperature Formula

Evaluate Formula

Formula

$$h^{-} = \frac{0.026 \cdot \left(P_f^{\frac{1}{3}}\right) \cdot \left(Re_m^{\ 0.8}\right) \cdot \left(K_f\right)}{D_{Tube}}$$

Example with Units

$$0.7828\,\mathrm{W/m^2{*}K} = \frac{0.026 \cdot \left(0.95^{\frac{1}{3}}\right) \cdot \left(2000^{0.8}\right) \cdot \left(0.68\,\mathrm{W/(m{*}K)}\right)}{9.71\,\mathrm{m}}$$

7) Condensation Number Formula

Evaluate Formula

Formula

$$Co = \left(h^{-}\right) \cdot \left(\left(\frac{\left(\mu_f\right)^2}{\left(k^3\right) \cdot \left(\rho_f\right) \cdot \left(\rho_f - \rho_v\right) \cdot [g]}\right)^{\frac{1}{3}}\right)$$

Example with Units

$$0.0238 = \left(115\,\mathrm{W/m^2{*}K}\right) \cdot \left(\left(\frac{\left(0.029\,\mathrm{N{*}s/m^2}\right)^2}{\left(10.18\,\mathrm{W/(m{*}K)}^3\right) \cdot \left(96\,\mathrm{kg/m^3}\right) \cdot \left(96\,\mathrm{kg/m^3} - 0.5\,\mathrm{kg/m^3}\right) \cdot 9.8066\,\mathrm{m/s^2}}\right)^{\frac{1}{3}}\right)$$

8) Condensation Number for Horizontal Cylinder Formula

Evaluate Formula

Formula

$$Co = 1.514 \cdot \left(\left(Re_f\right)^{-\frac{1}{3}}\right)$$

Example

$$0.2262 = 1.514 \cdot \left(\left(300\right)^{-\frac{1}{3}}\right)$$

9) Condensation Number for Vertical Plate Formula

Evaluate Formula

Formula

$$Co = 1.47 \cdot \left(\left(Re_f\right)^{-\frac{1}{3}}\right)$$

Example

$$0.2196 = 1.47 \cdot \left(\left(300\right)^{-\frac{1}{3}}\right)$$

10) Condensation Number given Reynolds Number Formula

Evaluate Formula

Formula

$$Co = \left((C)^{\frac{4}{3}} \right) \cdot \left(\left(\frac{4 \cdot \sin(\Phi) \cdot \left(\left(\frac{A_{cs}}{P} \right) \right)}{L} \right)^{\frac{1}{3}} \right) \cdot \left((Re_f)^{-\frac{1}{3}} \right)$$

Example with Units

$$0.1393 = \left((1.5)^{\frac{4}{3}} \right) \cdot \left(\left(\frac{4 \cdot \sin(1.55\,\text{rad}) \cdot \left(\left(\frac{25\,\text{m}^2}{9.6\,\text{m}} \right) \right)}{65\,\text{m}} \right)^{\frac{1}{3}} \right) \cdot \left((300)^{-\frac{1}{3}} \right)$$

11) Condensation Number when Turbulence is Encountered in Film Formula

Evaluate Formula

Formula

$$Co = 0.0077 \cdot \left((Re_f)^{0.4} \right)$$

Example

$$0.0754 = 0.0077 \cdot \left((300)^{0.4} \right)$$

12) Film Thickness given Mass Flow of Condensate Formula

Evaluate Formula

Formula

$$\delta = \left(\frac{3 \cdot \mu_f \cdot \dot{m}}{\rho_L \cdot (\rho_L - \rho_v) \cdot [g]} \right)^{\frac{1}{3}}$$

Example with Units

$$0.0023\,\text{m} = \left(\frac{3 \cdot 0.029\,\text{N*s/m}^2 \cdot 1.40\,\text{kg/s}}{1000\,\text{kg/m}^3 \cdot (1000\,\text{kg/m}^3 - 0.5\,\text{kg/m}^3) \cdot 9.8066\,\text{m/s}^2} \right)^{\frac{1}{3}}$$

13) Film Thickness in Film Condensation Formula

Evaluate Formula

Formula

$$\delta = \left(\frac{4 \cdot \mu_f \cdot k \cdot x \cdot (T_{Sat} - T_w)}{[g] \cdot h_{fg} \cdot (\rho_L) \cdot (\rho_L - \rho_v)} \right)^{0.25}$$

Example with Units

$$0.001\,\text{m} = \left(\frac{4 \cdot 0.029\,\text{N*s/m}^2 \cdot 10.18\,\text{W/(m*K)} \cdot 0.06\,\text{m} \cdot (373\,\text{K} - 82\,\text{K})}{9.8066\,\text{m/s}^2 \cdot 2260000\,\text{J/kg} \cdot (1000\,\text{kg/m}^3) \cdot (1000\,\text{kg/m}^3 - 0.5\,\text{kg/m}^3)} \right)^{0.25}$$

14) Heat Transfer Coefficient for Condensation on Flat Plate for Nonlinear Temperature Profile in Film Formula

Evaluate Formula

Formula

$$h'_{fg} = \left(h_{fg} + 0.68 \cdot c \cdot \left(T_{Sat} - T_w \right) \right)$$

Example with Units

$$3.1E+6\,\mathrm{J/kg} = \left(2260000\,\mathrm{J/kg} + 0.68 \cdot 4184\,\mathrm{J/(kg{*}K)} \cdot \left(373\,\mathrm{K} - 82\,\mathrm{K} \right) \right)$$

15) Heat Transfer Rate for Condensation of Superheated Vapors Formula

Evaluate Formula

Formula

$$q = h^{-} \cdot A_{plate} \cdot \left(T_s' - T_w \right)$$

Example with Units

$$28658\,\mathrm{W} = 115\,\mathrm{W/m^2{*}K} \cdot 35.6\,\mathrm{m^2} \cdot \left(89\,\mathrm{K} - 82\,\mathrm{K} \right)$$

16) Mass Flow of Condensate through any X Position of Film Formula

Evaluate Formula

Formula

$$\dot{m} = \frac{\rho_L \cdot \left(\rho_L - \rho_v \right) \cdot [g] \cdot \left(\delta^3 \right)}{3 \cdot \mu_f}$$

Example with Units

$$1.4069\,\mathrm{kg/s} = \frac{1000\,\mathrm{kg/m^3} \cdot \left(1000\,\mathrm{kg/m^3} - 0.5\,\mathrm{kg/m^3} \right) \cdot 9.8066\,\mathrm{m/s^2} \cdot \left(0.00232\,\mathrm{m}^3 \right)}{3 \cdot 0.029\,\mathrm{N{*}s/m^2}}$$

17) Mass Flow Rate through Particular Section of Condensate Film given Reynolds Number of Film Formula

Evaluate Formula

Formula

$$\dot{m}_1 = \frac{Re_f \cdot P \cdot \mu}{4}$$

Example with Units

$$7200\,\mathrm{kg/s} = \frac{300 \cdot 9.6\,\mathrm{m} \cdot 10\,\mathrm{N{*}s/m^2}}{4}$$

18) Reynolds Number for Condensate Film Formula

Evaluate Formula

Formula

$$Re_f = \frac{4 \cdot \dot{m}_1}{P \cdot \mu}$$

Example with Units

$$300 = \frac{4 \cdot 7200\,\mathrm{kg/s}}{9.6\,\mathrm{m} \cdot 10\,\mathrm{N{*}s/m^2}}$$

19) Reynolds Number using Average Heat Transfer Coefficient for Condensate Film Formula

Evaluate Formula

Formula

$$Re_f = \left(\frac{4 \cdot \bar{h} \cdot L \cdot \left(T_{Sat} - T_w \right)}{h_{fg} \cdot \mu_f} \right)$$

Example with Units

$$132.7571 = \left(\frac{4 \cdot 115\,\mathrm{W/m^2{*}K} \cdot 65\,\mathrm{m} \cdot \left(373\,\mathrm{K} - 82\,\mathrm{K} \right)}{2260000\,\mathrm{J/kg} \cdot 0.029\,\mathrm{N{*}s/m^2}} \right)$$

20) Viscosity of Film given Mass Flow of Condensate Formula

Evaluate Formula

Formula

$$\mu_f = \frac{\rho_L \cdot \left(\rho_L - \rho_v \right) \cdot [g] \cdot \left(\delta^3 \right)}{3 \cdot \dot{m}}$$

Example with Units

$$0.0291\,\mathrm{N{*}s/m^2} = \frac{1000\,\mathrm{kg/m^3} \cdot \left(1000\,\mathrm{kg/m^3} - 0.5\,\mathrm{kg/m^3} \right) \cdot 9.8066\,\mathrm{m/s^2} \cdot \left(0.00232\,\mathrm{m}^3 \right)}{3 \cdot 1.40\,\mathrm{kg/s}}$$

21) Viscosity of Film given Reynolds Number of Film Formula

Evaluate Formula

Formula

$$\mu_f = \frac{4 \cdot \dot{m}_1}{P \cdot Re_f}$$

Example with Units

$$10\,\mathrm{N{*}s/m^2} = \frac{4 \cdot 7200\,\mathrm{kg/s}}{9.6\,\mathrm{m} \cdot 300}$$

22) Wetted Perimeter given Reynolds Number of Film Formula

Evaluate Formula

Formula

$$P = \frac{4 \cdot \dot{m}_1}{Re_f \cdot \mu}$$

Example with Units

$$9.6\,\mathrm{m} = \frac{4 \cdot 7200\,\mathrm{kg/s}}{300 \cdot 10\,\mathrm{N{*}s/m^2}}$$

Variables used in list of Condensation Formulas above

- A_{cs} Cross Sectional Area of Flow *(Square Meter)*
- A_{plate} Area of Plate *(Square Meter)*
- **c** Specific Heat Capacity *(Joule per Kilogram per K)*
- **C** Constant for Condensation Number
- **Co** Condensation Number
- D_{Sphere} Diameter of Sphere *(Meter)*
- D_{Tube} Diameter of Tube *(Meter)*
- $\bar{h}$ Average Heat Transfer Coefficient *(Watt per Square Meter per Kelvin)*
- h_{fg} Latent Heat of Vaporization *(Joule per Kilogram)*
- h'_{fg} Corrected Latent Heat of Vaporization *(Joule per Kilogram)*
- **k** Thermal Conductivity *(Watt per Meter per K)*
- k_f Thermal Conductivity of Film Condensate *(Watt per Meter per K)*
- K_f Thermal Conductivity at Film Temperature *(Watt per Meter per K)*
- **L** Length of Plate *(Meter)*
- $\dot{m}$ Mass Flow Rate *(Kilogram per Second)*
- $\dot{m}_1$ Mass Flow of Condensate *(Kilogram per Second)*
- **P** Wetted Perimeter *(Meter)*
- P_f Prandtl Number at Film Temperature
- **q** Heat Transfer *(Watt)*
- Re_f Reynolds Number of Film
- Re_m Reynolds Number for Mixing
- T_s' Saturation Temperature for Superheated Vapor *(Kelvin)*
- T_{Sat} Saturation Temperature *(Kelvin)*
- T_w Plate Surface Temperature *(Kelvin)*
- **x** Height of Film *(Meter)*
- **δ** Film Thickness *(Meter)*

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

- constant(s): **[g]**, 9.80665
  Gravitational acceleration on Earth
- 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.
- 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: **Angle** in Radian (rad)
  Angle 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: **Mass Flow Rate** in Kilogram per Second (kg/s)
  Mass Flow Rate Unit Conversion
- Measurement: **Heat Transfer Coefficient** in Watt per Square Meter per Kelvin (W/m²*K)
  Heat Transfer Coefficient Unit Conversion
- Measurement: **Dynamic Viscosity** in Newton Second per Square Meter (N*s/m²)
  Dynamic Viscosity Unit Conversion
- 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

- **μ** Viscosity of Fluid *(Newton Second per Square Meter)*
- **μ_f** Viscosity of Film *(Newton Second per Square Meter)*
- **ρ_f** Density of Liquid Film *(Kilogram per Cubic Meter)*
- **ρ_L** Density of Liquid *(Kilogram per Cubic Meter)*
- **ρ_V** Density of Vapor *(Kilogram per Cubic Meter)*
- **Φ** Inclination Angle *(Radian)*

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