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Aero Thermal Dynamics Formulas

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List of 16 Aero Thermal Dynamics Formulas

Aero Thermal Dynamics

1) Aerodynamic Heating to Surface

Open Calculator

$$q_w = \rho_e \cdot u_e \cdot St \cdot (h_{aw} - h_w)$$

ex

$$14.4261 W/m^2 = 98.3 kg/m^3 \cdot 8.8 m/s \cdot 0.005956 \cdot (102 J/kg - 99.2 J/kg)$$

2) Chapman-Rubesin Factor

Open Calculator

$$C = \frac{\rho \cdot \nu}{\rho_e \cdot \mu_e}$$

ex

$$0.750003 = \frac{997 kg/m^3 \cdot 7.25 St}{98.3 kg/m^3 \cdot 0.098043 P}$$

3) Coefficient of Friction using Stanton Equation for Incompressible Flow

Open Calculator

$$C_f = \frac{St}{0.5 \cdot Pr^{-\frac{2}{3}}}$$

ex

$$0.009391 = \frac{0.005956}{0.5 \cdot (0.7)^{-\frac{2}{3}}}$$

4) Density Calculation using Chapman-Rubesin Factor

Open Calculator

$$\rho = C \cdot \rho_e \cdot \frac{\mu_e}{\nu}$$

$$996.9959\text{kg/m}^3 = 0.75 \cdot 98.3\text{kg/m}^3 \cdot \frac{0.098043\text{P}}{7.25\text{St}}$$

5) Internal Energy for Hypersonic Flow

Open Calculator

$$U = H + \frac{P}{\rho}$$

$$1.512802\text{KJ} = 1.512\text{KJ} + \frac{800\text{Pa}}{997\text{kg/m}^3}$$

6) Non Dimensional Internal Energy Parameter

Open Calculator

$$e' = \frac{U}{C_p \cdot T}$$

$$0.075187 = \frac{1.51\text{KJ}}{4.184\text{kJ/kg*K} \cdot 4.8\text{K}}$$

7) Non Dimensional Internal Energy Parameter using Wall-to-Freestream Temperature Ratio

Open Calculator

$$e' = \frac{Tw}{T_\infty}$$

$$0.075 = \frac{15\text{K}}{200\text{K}}$$

8) Non Dimensional Static Enthalpy

Open Calculator

fx $$g = \frac{h_o}{he}$$

ex $$3.000992 = \frac{1500\text{J/kg}}{499.8347\text{J/kg}}$$

9) Stanton Equation using Overall Skin Friction Coefficient for Incompressible Flow

Open Calculator

fx $$St = C_f \cdot 0.5 \cdot Pr^{-\frac{2}{3}}$$

ex $$0.005956 = 0.009391 \cdot 0.5 \cdot (0.7)^{-\frac{2}{3}}$$

10) Stanton Number for Incompressible Flow

Open Calculator

fx $$St = 0.332 \cdot \frac{Pr^{-\frac{2}{3}}}{\sqrt{Re}}$$

ex $$0.005956 = 0.332 \cdot \frac{(0.7)^{-\frac{2}{3}}}{\sqrt{5000}}$$

11) Static Density Calculation using Chapman-Rubesin Factor

Open Calculator

fx $$\rho_e = \frac{\rho \cdot \nu}{C \cdot \mu_e}$$

ex $$98.30041\text{kg/m}^3 = \frac{997\text{kg/m}^3 \cdot 7.25\text{St}}{0.75 \cdot 0.098043\text{P}}$$

12) Static Enthalpy

Open Calculator

fx $$he = \frac{H}{g}$$

ex $$499.8347\text{J/kg} = \frac{1.512\text{KJ}}{3.025}$$

13) Static Viscosity Calculation using Chapman-Rubesin Factor

Open Calculator

fx $$\mu_e = \frac{\rho \cdot \nu}{C \cdot \rho_e}$$

ex $$0.098043\text{P} = \frac{997\text{kg/m}^3 \cdot 7.25\text{St}}{0.75 \cdot 98.3\text{kg/m}^3}$$

14) Thermal Conductivity using Prandtl Number

Open Calculator

fx $$k = \frac{\mu_{viscosity} \cdot C_p}{Pr}$$

ex $$6096.686\text{W/(m*K)} = \frac{10.2\text{P} \cdot 4.184\text{kJ/kg*K}}{0.7}$$

15) Viscosity Calculation using Chapman-Rubesin Factor

Open Calculator

fx $$\nu = C \cdot \rho_e \cdot \frac{\mu_e}{\rho}$$

ex $$7.24997\text{St} = 0.75 \cdot 98.3\text{kg/m}^3 \cdot \frac{0.098043\text{P}}{997\text{kg/m}^3}$$

16) Wall Temperature Calculation using Internal Energy Change

Open Calculator

fx $$\mathrm{Tw} = \mathrm{e}' \cdot \mathrm{T}_{\infty}$$

ex $$15\mathrm{K} = 0.075 \cdot 200\mathrm{K}$$

Variables Used

- **C** Chapman–Rubesin factor
- **C_f** Overall Skin-friction Drag Coefficient
- **C_p** Specific Heat Capacity at Constant Pressure *(Kilojoule per Kilogram per K)*
- **e'** Non-Dimensional Internal Energy
- **g** Non Dimensional Static Enthalpy
- **H** Enthalpy *(Kilojoule)*
- **h_{aw}** Adiabatic Wall Enthalpy *(Joule per Kilogram)*
- **h_o** Stagnation Enthalpy *(Joule per Kilogram)*
- **h_w** Wall Enthalpy *(Joule per Kilogram)*
- **he** Static Enthalpy *(Joule per Kilogram)*
- **k** Thermal Conductivity *(Watt per Meter per K)*
- **P** Pressure *(Pascal)*
- **Pr** Prandtl Number
- **q_w** Local Heat Transfer Rate *(Watt per Square Meter)*
- **Re** Reynolds Number
- **St** Stanton Number
- **T** Temperature *(Kelvin)*
- **T_∞** Free Stream Temperature *(Kelvin)*
- **Tw** Wall Temperature *(Kelvin)*
- **U** Internal Energy *(Kilojoule)*
- **u_e** Static Velocity *(Meter per Second)*

- μ_e Static Viscosity *(Poise)*
- $\mu_{viscosity}$ Dynamic Viscosity *(Poise)*
- ν Kinematic Viscosity *(Stokes)*
- ρ Density *(Kilogram per Cubic Meter)*
- ρ_e Static Density *(Kilogram per Cubic Meter)*

Constants, Functions, Measurements used

- 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: **Temperature** in Kelvin (K)
  Temperature Unit Conversion
- Measurement: **Pressure** in Pascal (Pa)
  Pressure Unit Conversion
- Measurement: **Speed** in Meter per Second (m/s)
  Speed Unit Conversion
- Measurement: **Energy** in Kilojoule (KJ)
  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: **Heat Flux Density** in Watt per Square Meter (W/m²)
  Heat Flux Density Unit Conversion
- Measurement: **Dynamic Viscosity** in Poise (P)
  Dynamic Viscosity Unit Conversion
- Measurement: **Kinematic Viscosity** in Stokes (St)
  Kinematic Viscosity Unit Conversion
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m³)
  Density Unit Conversion
- Measurement: **Specific Energy** in Joule per Kilogram (J/kg)
  Specific Energy Unit Conversion

Check other formula lists

- **Aero Thermal Dynamics Formulas**

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