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Thermal Power Plant Formulas

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List of 12 Thermal Power Plant Formulas

Thermal Power Plant

1) Consumption of Coal per Hour

Open Calculator

fx $$\mathrm{CCP_{coal}} = \frac{\mathrm{Q_h}}{\mathrm{CV_{coal}}}$$

ex $$1.490434\mathrm{AT\ (UK)} = \frac{311.6\mathrm{J/K}}{6400\mathrm{J/K}}$$

2) Current Density from Cathode to Anode

Open Calculator

fx $$\mathrm{J_c} = \mathrm{A} \cdot \mathrm{T_c^2} \cdot \exp\left(-\frac{[\mathrm{Charge\text{-}e}] \cdot \mathrm{V_c}}{[\mathrm{BoltZ}] \cdot \mathrm{T_c}}\right)$$

ex $$0.471396\mathrm{A/cm^2} = 120 \cdot (1350\mathrm{K})^2 \cdot \exp\left(-\frac{[\mathrm{Charge\text{-}e}] \cdot 1.25\mathrm{V}}{[\mathrm{BoltZ}] \cdot 1350\mathrm{K}}\right)$$

3) Maximum Electron Current per Unit Area

Open Calculator

fx $$\mathrm{J} = \mathrm{A} \cdot \mathrm{T}^2 \cdot \exp\left(-\frac{\Phi}{[\mathrm{BoltZ}] \cdot \mathrm{T}}\right)$$

ex $$3.138127\mathrm{A/cm^2} = 120 \cdot (1100\mathrm{K})^2 \cdot \exp\left(-\frac{0.8\mathrm{eV}}{[\mathrm{BoltZ}] \cdot 1100\mathrm{K}}\right)$$

4) Minimum Energy required by Electron to Leave Cathode

Open Calculator

fx $$Q = J_c \cdot V_c$$

ex $$0.5875\text{W/cm}^2 = 0.47\text{A/cm}^2 \cdot 1.25\text{V}$$

5) Net Kinetic Energy of Electron

Open Calculator

fx $$Q_e = J_c \cdot \left(\frac{2 \cdot [\text{BoltZ}] \cdot T_c}{[\text{Charge-e}]} \right)$$

ex $$0.109354\text{W/cm}^2 = 0.47\text{A/cm}^2 \cdot \left(\frac{2 \cdot [\text{BoltZ}] \cdot 1350\text{K}}{[\text{Charge-e}]} \right)$$

6) Output Voltage given Anode and Cathode Voltages

Open Calculator

fx $$V_{out} = V_c - V_a$$

ex $$0.27\text{V} = 1.25\text{V} - 0.98\text{V}$$

7) Output Voltage given Anode and Cathode Work Functions

Open Calculator

fx $$V_{out} = \Phi_c - \Phi_a$$

ex $$0.27\text{V} = 1.42\text{V} - 1.15\text{V}$$

8) Output Voltage given Fermi Energy Levels

Open Calculator

fx $$V_{out} = \frac{\varepsilon f_a - \varepsilon f_c}{[Charge\text{-}e]}$$

ex $$0.27V = \frac{2.87eV - 2.6eV}{[Charge\text{-}e]}$$

9) Overall Efficiency of Power Station

Open Calculator

fx $$\eta_{overall} = \eta_{thermal} \cdot \eta_{electrical}$$

ex $$0.276 = 0.3 \cdot 0.92$$

10) Power Output from Generator

Open Calculator

fx $$P_{out} = V_{out} \cdot (J_c - J_a)$$

ex $$0.0567W/cm^2 = 0.27V \cdot (0.47A/cm^2 - 0.26A/cm^2)$$

11) Rankine Cycle Efficiency

Open Calculator

fx $$\eta_R = \frac{W_{net}}{q_s}$$

ex $$0.995775 = \frac{947.35}{951.37}$$

12) Thermal Efficiency of Power Station

Open Calculator

fx $$\eta_{thermal} = \frac{\eta_{overall}}{\eta_{electrical}}$$

ex $$0.3 = \frac{0.276}{0.92}$$

Variables Used

- **A** Emission Constant
- **CCP_{coal}** Consumption of Coal per Hour *(Ton (Assay) (UK))*
- **CV_{coal}** Calorific Value of Coal *(Joule per Kelvin)*
- **J** Current Density *(Ampere per Square Centimeter)*
- **J_a** Anode Current Density *(Ampere per Square Centimeter)*
- **J_c** Cathode Current Density *(Ampere per Square Centimeter)*
- **P_{out}** Power Output *(Watt per Square Centimeter)*
- **Q** Net Energy *(Watt per Square Centimeter)*
- **Q_e** Electron Net Energy *(Watt per Square Centimeter)*
- **Q_h** Heat Input per Hour *(Joule per Kelvin)*
- **q_s** Heat Supplied
- **T** Temperature *(Kelvin)*
- **T_c** Cathode Temperature *(Kelvin)*
- **V_a** Anode Voltage *(Volt)*
- **V_c** Cathode Voltage *(Volt)*
- **V_{out}** Output Voltage *(Volt)*
- **W_{net}** Net Work Output
- **εf_a** Anode Fermi Energy Level *(Electron-Volt)*
- **εf_c** Cathode Fermi Energy Level *(Electron-Volt)*
- **$\eta_{electrical}$** Electrical Efficiency
- **$\eta_{overall}$** Overall Efficiency

- η_R Rankine Cycle Efficiency
- $\eta_{thermal}$ Thermal Efficiency
- Φ Work Function *(Electron-Volt)*
- Φ_a Anode Work Function *(Volt)*
- Φ_c Cathode Work Function *(Volt)*

Constants, Functions, Measurements used

- Constant: **[BoltZ]**, 1.38064852E-23 Joule/Kelvin
  Boltzmann constant
- Constant: **[Charge-e]**, 1.60217662E-19 Coulomb
  Charge of electron
- Function: **exp**, exp(Number)
  Exponential function
- Measurement: **Weight** in Ton (Assay) (UK) (AT (UK))
  Weight Unit Conversion
- Measurement: **Temperature** in Kelvin (K)
  Temperature Unit Conversion
- Measurement: **Energy** in Electron-Volt (eV)
  Energy Unit Conversion
- Measurement: **Surface Current Density** in Ampere per Square Centimeter (A/cm²)
  Surface Current Density Unit Conversion
- Measurement: **Electric Potential** in Volt (V)
  Electric Potential Unit Conversion
- Measurement: **Heat Capacity** in Joule per Kelvin (J/K)
  Heat Capacity Unit Conversion
- Measurement: **Intensity** in Watt per Square Centimeter (W/cm²)
  Intensity Unit Conversion

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