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Air Refrigeration Formulas

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List of 25 Air Refrigeration Formulas

Air Refrigeration

1) C.O.P. of simple air cycle

Open Calculator

fx $$COP_{actual} = \frac{T_6 - T5'}{Tt' - T2'}$$

ex $$0.207792 = \frac{281K - 265K}{350.0K - 273K}$$

2) C.O.P. of simple air evaporative cycle

Open Calculator

fx $$COP_{actual} = \frac{210 \cdot Q}{ma \cdot C_p \cdot (Tt' - T2')}$$

ex $$0.203528 = \frac{210 \cdot 150}{120kg/min \cdot 1.005kJ/kg*K \cdot (350.0K - 273K)}$$

3) Compression or Expansion Ratio

Open Calculator

fx $$r_p = \frac{P_2}{P_1}$$

ex $$25 = \frac{10E6Pa}{4E5Pa}$$

4) Compression Work

Open Calculator

fx $$W_{per\ min} = ma \cdot C_p \cdot (Tt' - T2')$$

ex $$9286.2kJ/min = 120kg/min \cdot 1.005kJ/kg*K \cdot (350.0K - 273K)$$

5) COP of Air Cycle for given Input Power and Tonnage of Refrigeration

Open Calculator

fx $$COP_{actual} = \frac{210 \cdot Q}{P_{in} \cdot 60}$$

ex $$0.203226 = \frac{210 \cdot 150}{155 \text{kJ/min} \cdot 60}$$

6) COP of Air Cycle given Input Power

Open Calculator

fx $$COP_{actual} = \frac{210 \cdot Q}{P_{in} \cdot 60}$$

ex $$0.203226 = \frac{210 \cdot 150}{155 \text{kJ/min} \cdot 60}$$

7) COP of Bell-Coleman Cycle for given Compression Ratio and Adiabatic Index

Open Calculator

fx $$COP_{theoretical} = \frac{1}{r_p^{\frac{\gamma-1}{\gamma}} - 1}$$

ex $$0.662917 = \frac{1}{(25)^{\frac{1.4-1}{1.4}} - 1}$$

8) COP of Bell-Coleman Cycle for given Temperatures, Polytropic Index and Adiabatic Index

Open Calculator

fx $$COP_{theoretical} = \frac{T_1 - T_4}{\left(\frac{n}{n-1}\right) \cdot \left(\frac{\gamma-1}{\gamma}\right) \cdot ((T_2 - T_3) - (T_1 - T_4))}$$

ex $$0.601693 = \frac{300\text{K} - 290\text{K}}{\left(\frac{1.52}{1.52-1}\right) \cdot \left(\frac{1.4-1}{1.4}\right) \cdot ((356.5\text{K} - 326.6\text{K}) - (300\text{K} - 290\text{K}))}$$

9) Energy Performance Ratio of Heat Pump

Open Calculator

fx $$COP_{theoretical} = \frac{Q_{delivered}}{W_{per\ min}}$$

ex $$0.6 = \frac{5571.72 kJ/min}{9286.2 kJ/min}$$

10) Expansion Work

Open Calculator

fx $$W_{per\ min} = ma \cdot C_p \cdot \left(T4 - T5'\right)$$

ex $$9286.2 kJ/min = 120 kg/min \cdot 1.005 kJ/kg{*}K \cdot (342K - 265K)$$

11) Heat Absorbed during Constant Pressure Expansion Process

Open Calculator

fx $$Q_{Absorbed} = C_p \cdot (T_1 - T_4)$$

ex $$10.05 kJ/kg = 1.005 kJ/kg{*}K \cdot (300K - 290K)$$

12) Heat Rejected during Constant pressure Cooling Process

Open Calculator

fx $$Q_R = C_p \cdot (T_2 - T_3)$$

ex $$30.0495 kJ/kg = 1.005 kJ/kg{*}K \cdot (356.5K - 326.6K)$$

13) Heat rejected during cooling process

Open Calculator

fx $$Q_{R,\ Cooling} = ma \cdot C_p \cdot \left(Tt' - T4\right)$$

ex $$16.08 kJ/kg = 120 kg/min \cdot 1.005 kJ/kg{*}K \cdot (350.0K - 342K)$$

14) Initial Mass of Evaporant Required to be Carried for given Flight Time

Open Calculator

fx $$M_{ini} = \frac{Q_r \cdot t}{h_{fg}}$$

ex $$53.53982\text{kg} = \frac{550\text{kJ/min} \cdot 220\text{min}}{2260\text{kJ/kg}}$$

15) Local Sonic or Acoustic Velocity at Ambient Air Conditions

Open Calculator

fx $$a = \left(\gamma \cdot [R] \cdot \frac{T_i}{MW}\right)^{0.5}$$

ex $$340.0649\text{m/s} = \left(1.4 \cdot [R] \cdot \frac{305\text{K}}{0.0307\text{kg}}\right)^{0.5}$$

16) Mass of air to produce Q tonnes of refrigeration

Open Calculator

fx $$M = \frac{210 \cdot Q}{C_p \cdot (T_6 - T5')}$$

ex $$117.5373\text{kg/min} = \frac{210 \cdot 150}{1.005\text{kJ/kg*K} \cdot (281\text{K} - 265\text{K})}$$

17) Mass of air to produce Q tonnes of refrigeration given exit temperature of cooling turbine

Open Calculator

fx $$M = \frac{210 \cdot TR}{C_p \cdot (T_4 - T7')}$$

ex $$117.8507\text{kg/min} = \frac{210 \cdot 47}{1.005\text{kJ/kg*K} \cdot (290\text{K} - 285\text{K})}$$

18) Power Required for Refrigeration System

Open Calculator

fx $$P_{req} = \left(\frac{ma \cdot C_p \cdot (Tt' - T2')}{60} \right)$$

ex $$9286.2\text{kJ/min} = \left(\frac{120\text{kg/min} \cdot 1.005\text{kJ/kg*K} \cdot (350.0\text{K} - 273\text{K})}{60} \right)$$

19) Power required to maintain pressure inside cabin excluding ram work

Open Calculator

fx $$P_{in} = \left(\frac{ma \cdot C_p \cdot T2'}{CE} \right) \cdot \left(\left(\frac{p_c}{p2'} \right)^{\frac{\gamma-1}{\gamma}} - 1 \right)$$

ex $$155.0701\text{kJ/min} = \left(\frac{120\text{kg/min} \cdot 1.005\text{kJ/kg*K} \cdot 273\text{K}}{46.5} \right) \cdot \left(\left(\frac{400000\text{Pa}}{200000\text{Pa}} \right)^{\frac{1.4-1}{1.4}} - 1 \right)$$

20) Power Required to Maintain Pressure inside Cabin including Ram Work

Open Calculator

fx $$P_{in} = \left(\frac{ma \cdot C_p \cdot T_a}{CE} \right) \cdot \left(\left(\frac{p_c}{P_{atm}} \right)^{\frac{\gamma-1}{\gamma}} - 1 \right)$$

ex $$155.7478\text{kJ/min} = \left(\frac{120\text{kg/min} \cdot 1.005\text{kJ/kg*K} \cdot 125\text{K}}{46.5} \right) \cdot \left(\left(\frac{400000\text{Pa}}{101325\text{Pa}} \right)^{\frac{1.4-1}{1.4}} - 1 \right)$$

21) Ram Efficiency

Open Calculator

fx $$\eta = \frac{(p_2') - P_i}{P_f - P_i}$$

ex $$0.866667 = \frac{150000\text{Pa} - 85000\text{Pa}}{160000\text{Pa} - 85000\text{Pa}}$$

22) Refrigeration Effect Produced

Open Calculator

fx $$R_E = ma \cdot C_p \cdot \left(T_6 - T5^{'}\right)$$

ex $$1929.6\text{kJ/min} = 120\text{kg/min} \cdot 1.005\text{kJ/kg*K} \cdot (281\text{K} - 265\text{K})$$

23) Relative Coefficient of Performance

Open Calculator

fx $$COP_{relative} = \frac{COP_{actual}}{COP_{theoretical}}$$

ex $$0.333333 = \frac{0.2}{0.6}$$

24) Temperature Ratio at Start and End of Ramming Process

Open Calculator

fx $$T_{ratio} = 1 + \frac{v_{process}^2 \cdot (\gamma - 1)}{2 \cdot \gamma \cdot [R] \cdot T_i}$$

ex $$1.202801 = 1 + \frac{(60\text{m/s})^2 \cdot (1.4 - 1)}{2 \cdot 1.4 \cdot [R] \cdot 305\text{K}}$$

25) Theoretical Coefficient of Performance of Refrigerator

Open Calculator

fx $$COP_{theoretical} = \frac{Q_{ref}}{w}$$

ex $$0.6 = \frac{600\text{kJ/kg}}{1000\text{kJ/kg}}$$

Variables Used

- **a** Sonic Velocity *(Meter per Second)*
- C_p Specific Heat Capacity at Constant Pressure *(Kilojoule per Kilogram per K)*
- **CE** Compressor Efficiency
- COP_{actual} Actual Coefficient of Performance
- $COP_{relative}$ Relative Coefficient of Performance
- $COP_{theoretical}$ Theoretical Coefficient of Performance
- h_{fg} Latent Heat of Vaporization *(Kilojoule per Kilogram)*
- **M** Mass *(Kilogram per Minute)*
- M_{ini} Initial Mass *(Kilogram)*
- **ma** Mass of Air *(Kilogram per Minute)*
- **MW** Molecular Weight *(Kilogram)*
- **n** Polytropic Index
- P_1 Pressure at Start of Isentropic Compression *(Pascal)*
- p_2' Stagnation Pressure of System *(Pascal)*
- P_2 Pressure at End of Isentropic Compression *(Pascal)*
- P_{atm} Atmospheric Pressure *(Pascal)*
- p_c Cabin Pressure *(Pascal)*
- P_f Final Pressure of System *(Pascal)*
- P_i Initial Pressure of System *(Pascal)*
- P_{in} Input Power *(Kilojoule per Minute)*
- P_{req} Power Required *(Kilojoule per Minute)*
- $p2'$ Pressure of Rammed Air *(Pascal)*
- **Q** Tonnage of Refrigeration in TR
- $Q_{Absorbed}$ Heat Absorbed *(Kilojoule per Kilogram)*
- $Q_{delivered}$ Heat Delivered to Hot Body *(Kilojoule per Minute)*
- Q_r Rate of Heat Removal *(Kilojoule per Minute)*

- **Q_R** Heat Rejected *(Kilojoule per Kilogram)*
- **$Q_{R, Cooling}$** Heat Rejected during Cooling Process *(Kilojoule per Kilogram)*
- **Q_{ref}** Heat Extracted from Refrigerator *(Kilojoule per Kilogram)*
- **R_E** Refrigeration Effect Produced *(Kilojoule per Minute)*
- **r_p** Compression or Expansion Ratio
- **t** Time in Minutes *(Minute)*
- **T_1** Temperature at Start of Isentropic Compression *(Kelvin)*
- **T_2** Ideal Temp at End of Isentropic Compression *(Kelvin)*
- **T_3** Ideal Temp at End of Isobaric Cooling *(Kelvin)*
- **T_4** Temperature at End of Isentropic Expansion *(Kelvin)*
- **T_6** Inside Temperature of Cabin *(Kelvin)*
- **T_a** Ambient Air Temperature *(Kelvin)*
- **T_i** Initial Temperature *(Kelvin)*
- **T_{ratio}** Temperature Ratio
- **$T2'$** Actual Temperature of Rammed Air *(Kelvin)*
- **T4** Temperature at the end of Cooling Process *(Kelvin)*
- **$T5'$** Actual Temperature at end of Isentropic Expansion *(Kelvin)*
- **$T7'$** Actual Exit Temperature of Cooling Turbine *(Kelvin)*
- **TR** Ton of Refrigeration
- **Tt'** Actual End Temp of Isentropic Compression *(Kelvin)*
- **$v_{process}$** Velocity *(Meter per Second)*
- **w** Work Done *(Kilojoule per Kilogram)*
- **$W_{per\ min}$** Work Done per min *(Kilojoule per Minute)*
- **γ** Heat Capacity Ratio
- **η** Ram Efficiency

Constants, Functions, Measurements used

- Constant: **[R]**, 8.31446261815324
  Universal gas constant
- Measurement: **Weight** in Kilogram (kg)
  Weight Unit Conversion
- Measurement: **Time** in Minute (min)
  Time Unit Conversion
- 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: **Power** in Kilojoule per Minute (kJ/min)
  Power Unit Conversion
- Measurement: **Specific Heat Capacity** in Kilojoule per Kilogram per K (kJ/kg*K)
  Specific Heat Capacity Unit Conversion
- Measurement: **Mass Flow Rate** in Kilogram per Minute (kg/min)
  Mass Flow Rate Unit Conversion
- Measurement: **Latent Heat** in Kilojoule per Kilogram (kJ/kg)
  Latent Heat Unit Conversion
- Measurement: **Rate of Heat Transfer** in Kilojoule per Minute (kJ/min)
  Rate of Heat Transfer Unit Conversion
- Measurement: **Specific Energy** in Kilojoule per Kilogram (kJ/kg)
  Specific Energy Unit Conversion

Check other formula lists

- **Air Refrigeration Formulas**
- **Ducts Formulas**

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