Heat Pump & Air Cooler

University of Jordan

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★ Objectives:

To find out the coefficient of performance for Heat Pump & Air Cooler.

★ Introduction & Theory

In this experiment, we'll learn more about the principles and applications of one of the most innovative technologies in modern engineering which is the heat pump. From understanding the fundamental concepts of heat transfer to witnessing the practical implications of energy efficiency, this experiment promises to unveil the secrets behind heat pumps' remarkable ability to regulate temperature.

Theory:

We start defining the Steady State Flow Equation Components:

$$Q^*_H - W^*_C - W^*_F = Q^*_L$$

Q^*_H & Q^*_L can be solved as follows:

$Q^*_H = m^*_a(h_2-h_1)+m^*_a w(h_{v2}-h_{v1})$ &
$Q^*_L = m^*_W(h_{f4}-h_{f3})$.

Where

m^*_a is Mass flow rate of Dry air (kg/s).
m^*_w is Mass flow rate of Cooling water in condenser (kg/s).
h_1 & h_2 are enthalpies of dry air at inlet and exit conditions (kJ/kg).
w is the Humidity ratio of air at air inlet and exit conditions (kg/kg of

dry air).

h_{v1} & h_{v2} = Enthalpies of water vapor carried by air at inlet condition (h_{g1}) and exit condition (h_{g2}) kJ/kg.

W^*_c is Electrical input to compressor (kW).
W^*_F is Electrical input to compressor (kW).

Finally we define COP as follows

$$\beta^1 = \frac{Q^*_H}{Q^*_H - Q^*_L} - \frac{Q^*_H}{W^*_C - W^*_F}$$

comparing it then with the ideal performance COP based on temperature difference across refrigerator circuit

$$(COP_{HP})_{max} = \frac{T_{10}}{T_{10} - T_8}$$

★ Apparatus&Equipment

Heat Pump : A heat pump is a device that utilizes energy to move thermal energy from a colder area to a warmer one via a refrigeration cycle. This effectively cools the colder space while simultaneously warming the warmer space. In colder seasons, it can draw heat from the chilly outdoor surroundings to heat a structure, and conversely, during warmer weather, it can transfer heat from the structure to the warmer outdoors. Because they transfer heat rather than generate it, heat pumps are known for their energy efficiency compared to other methods of heating or cooling homes.

★Data collection

Location	Temp (°C)	
Air in	T1	20
Air out	T2	37
Water inlet	T3	18
Water outlet	T4	11.5
Compressor inlet	T6	19
Compressor outlet	T5	58
Heat Ex. Water (comp. End)	T7	18.5
Heat Ex. Water (valve. End)	T8	6
Heat Ex. Air (comp. End)	T9	61
Heat Ex. Air (valve End)	T10	47.5
Inlet dry bulb temp.	TI,db	20
Inlet wey bulb temp.	TI,wb	22
Exit dry bulb temp.	Te,db	37
Exit wet bulb temp.	Te,wb	35

Manometer reading H_I = 36.5 mm H_2O
Compressor Power $W°_C$ = 1 kW
Total Electric Power $W°_T$ = 1.5 kW
Fan Power = 0.5 kW

Mass Flow Rate

Dry Air $m°_a = 0.00105*\sqrt{\frac{H_I}{T2}}$

- 0.00105 *(36.5/37)^0.5 = 0.986 kg/s.
- Circulating water $m°_w$ = 4 kg/s.
- h_1= 55 kj/kg.
- h_{v1} = 49 kj/kg.
- h_2 = 56 kJ/kg.
- h_{v2} = 49.83 kj/kg.
- Circulating water at inlet = 6 kJ/kg.
- Circulating water at outlet = 2 kJ/kg.

$\Rightarrow$ COP = $\frac{0.985*(56-55)+0.985*(49.83-49)}{1.5}$

$\Rightarrow$ COP = 1.20

COP Theoretical = (47.5)/(47.5-6)
= 1.14

Values almost identical.

Sample of Calculations