MEC 5008
Laboratory Experiments

Refregeration and Mechanical Heat Pump

Object:

To investigate the heat balances in a mechanical heat pump and determine the refrigeration and heat pump COP's.

Apparatus:

Hilton Mechanical Heat Pump

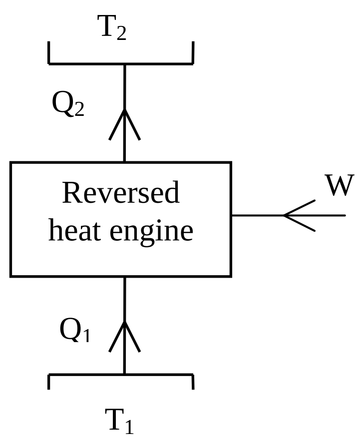
Referring to the attached figure, the setup incorporates
refrigerant compressor, refrigerant R12
condenser and condensing tank
manually variable expansion valve
evaporator and evaporating tank
refrigerant and water flowmeters
refrigerant and water thermometers
refrigerant pressure gauges

Procedure

The apparatus is in a setup as shown in the attached figure. Open the water supply to the condensing and evaporating water tanks and leave to settle. Then switch on the heat pump, i.e. the compressor. Allow the system to reach steady conditions in terms of temperatures, flow rates and pressures, then take a full set of readings.
Repeat the experiment for say three different refrigerant flow rates.

Theory

The refrigerator or heat pump are thermal cycles intended to make heat transfer against the natural gradient, i.e. heat is made to flow from a low temperature reservoir to a higher temperature reservoir by the utilization of mechanical power. Therefore a refrigerator or heat pump performs the opposite of a heat engine cycle.



By the 1st law, $W + Q_1 = Q_2$
Coefficient of Performance, COP, is given by

$$COP_{refrigerator} = \frac{Q_1}{W}$$

$$COP_{heatpump} = \frac{Q_2}{W}$$

and $COP_{heatpump} = COP_{refrigerator} + 1$

For the electrical kWhr power meter used,
$1kWhr = 166\tfrac{2}{3}revolutions$, $1kWhr = 3600kJ$ hence $1rev = 21.6kJ$
In the test rig, the Work input measured is the electrical input and not the true work on the refrigerant. Therefore the measured Work is larger than the work going into the cycle because of the motor and mechanical inefficiencies.

Results

Plot the cycle on the p-h diagram for the test with the highest refrigerant flow rate. Using the p-h diagram evaluate the enthalpy before and after the condenser and evaporator. Hence calculate the quantities Q_2 and Q_1 and W from the determined enthalpies. The measurement of the refrigerant flowrate with the installed flow meter has to be converted from graduations to water volume flow rate and then further corrected for density from water density to refrigerant density. Refer to additional flow meter calibration sheet.

Do the same calculation based on the enthalpy determined from the ph diagram for the other flow rates.
Perform a check on Q_1 and Q_2 determined from the refrigerant by also calculating Q_1 and Q_2 from the water, i.e make a first law analyses on the evaporator and condenser.
Calculate the COP's for refrigerator and heat pump based on Q_2 Q_1 and W prom the ph diagram
estimate the true work input into the cycle, and the overall motor&mech efficiency

Conclusions

Draw your own conclusions on the experiment and results obtained.

Readings

Ambient temperature: ^0C (only for reference)
Atmospheric pressure: cmHg (only for reference)

Refrigerant							Water					Electrical Power	
Flow g/s	Pressures kN/m^2		Temperatures ^oC				Flow		Temperatures ^oC			Power kWh	Time
	Cond	Evap	Inlet Cond	Out Cond	Inlet Evap	Out Evap	Cond kg/hr	Evap kg/hr	Common In	Cond Out	Evap Out	No. of revs	Δt s