Safety Hazards
Thermal Systems Laboratory Rooms 106 & 110

HAZARD: Rotating Equipment

Be aware of pinch points and possible entanglement

Personal Protective Equipment: Safety Goggles; Standing Shields, Sturdy Shoes
No: Loose clothing; Neck Ties/Scarves; Jewelry (remove); Long Hair (tie back)

HAZARD: Projectiles / Ejected Parts

Articles in motion may dislodge and become airborne

Personal Protective Equipment: Safety Goggles; Standing Shields

HAZARD: Heating - Burn

Be aware of hot surfaces

Personal Protective Equipment: Safety Goggles**;** High Temperature Gloves;

HAZARD: Electrical - Burn / Shock

Care with electrical connections, particularly with grounding and not using frayed electrical cords, can reduce hazard. Use GFCI receptacles near water.

HAZARD: High Pressure Air-Fluid / Gas Cylinders / Vacuum

Inspect system integrity before operating any pressure / vacuum equipment. Gas cylinders must be secured at all times. Use appropriate equipment guards.

Personal Protective Equipment: Safety Goggles

HAZARD: Water / Slip Hazard

Clean any spills immediately.

HAZARD: Noise

Personal Protective Equipment: Use Rated Ear Plugs

ME 406: Experiment 2

PERFORMANCE TEST OF A VAPOR COMPRESSION REFRIGERATION CYCLE

I. Objective:

To evaluate the performance of a basic vapor cycle and to determine the effects on this performance of varying the operation of several of the system components.

II. Background:

The vapor Compression refrigeration cycle is so-named because it utilizes as a working fluid a refrigerant that undergoes a phase change from liquid to superheated vapor and back to liquid as it passes steadily through the various components that comprise the system. The changes of phase assist in the heat transfer processes whereas the compression of a superheated vapor affords a sizeable temperature change associated with a pressure change.

There are only four components and their interconnecting piping required in the simplest form of the cycle (exclusive of Controls) and these are described below:

a) The low pressure, low temperature heat exchanger in which an initial mixture of liquid and vapor is “boiled” as it transfers heat at nearly constant pressure from the medium which is to be cooled. This heat exchanger is commonly called an Evaporator.
b) The high pressure, high temperature heat exchanger in which the initially superheated vapor is cooled and condensed to a liquid at nearly constant pressure as it transfers heat is commonly called a Condenser.
c) The Compressor, positioned between the exit of the Evaporator and the entrance to the Condenser. The Compressor raises the pressure of the vapor and hence its temperature to bring about the difference in temperature required to operate the heat exchangers. It is usually selected to operate on vapor only without the presence of any liquid.
d) The expansion device positioned between the exit of the Condenser and the entrance of the Evaporator. Its purpose is to reduce the pressure from the level in the Condenser to the level found in the Evaporator which, because some of the liquid flashes into vapor, is accompanied by the large temperature drop required for their operation. It is usually assumed to be a process in which the initial and final values of enthalpy are nearly equal.

III. Equipment:

The experiment is to be carried out on a Carrier Refrigeration Cycle Trainer, a bread board model of a cycle in which the components are laid out in a vertical plane for ease of visualization. The refrigerant used is R12 or R-134a. A volumetric flow-meter has been included to measure its movement. The second fluid medium for the heat exchanger is in both cases room air which is forced across the tubes by means of two fans mounted behind the panel board. The flow rates and psychrometric properties of the air before and after each heat exchanger will have to be measured. There are three expansion devices available on the panel board; a thermostatic expansion valve, an oversized thermostatic expansion valve, and a capillary tube. Thus, it is possible for the student (with the instructor's approval) to perform experiments other than those suggested in the following procedure.

IV. Procedure:

In the following suggested sequence of tests the reference case is to be taken as the thermostatic expansion valve and maximum air flows through both heat exchangers. In order to set up for this arrangement, the valve to this device (number 1) must be opened and the other devices made inoperative by closing valves 2 and 3.

The standard expansion valve requires the use of the liquid receiver mounted to the left of the Condenser so that you will have to open valves 4 and 6 while closing the receiver by-pass valve 5.

This mode of operation does not require the accumulator or the oil reservoir, mounted to the left of the Evaporator so that you will close valves 7, 9 and 10, while opening the accumulator by-pass valve 8. (SEE NOTE) These valve settings are sufficient for all operations with the standard expansion valve.

Turn on both fan speed switches to high.
Turn on the compressor switch.
Wait until thermal equilibrium is obtained.
Record all data.

Two tests are to be performed to see what varying the airflow over the Evaporator does to the performance. Thus, the fan switch is to be set to medium and then to low, in each case waiting for equilibrium and then recording all data.

Two more tests varying the airflow over the Condenser are to be made by switching its fan speed to medium and than to low. In all four of these the fan speed of the other heat exchanger is to be kept on high.

Finally, a test is to be made using the capillary tube as the expansion device. This requires resetting the breadboard configuration because use of the capillary tube does not require the liquid receiver but does need the accumulator. Shut down the compressor and open valve 2 to the capillary tube while closing valves 1 and 3 eliminating the thermostatic expansion valves.

Close off the liquid receiver by shutting valves 4 and 6 and open the receiver by-pass valve 5.

Open valve 7 to the accumulator and close the accumulator by-pass valve 8.

The oil reservoir remains out of the circuit so valves 9 and 10 remain closed.

Switch both -Fans to high speed, turn on the compressor, and after equilibrium is established, record all data.

NOTE: The compressor is lubricated with oil. A sight glass is located on the lower side of the compressor for visual verification of the oil level. The "freons" however, have high affinity for oil and while this is beneficial in the lubrication of the compressor, it can result in the oil migrating from the compressor crankcase to other locations in the cycle. This can result in an insufficient supply of oil in the crankcase. The first indication of this, other than examining the sight glass, is a rough and loud audible sound from the compressor – a loud rapping sound. Should this be present at the startup or develop during running, it is expedient to return some oil to the compressor. The oil is normally trapped in the accumulator and oil reservoir during or following the use of a capillary tube. Should this happen to you, please consult the instructor immediately to prevent damage from occurring

SAMPLE LOG SHEET

ITEM	ENTRY		TEST 1	TEST 2	TEST 3
	COMPRESSOR				
1	Entering temperature	F			
2	Entering pressure	PSIG			
3	Leaving temperature	F			
4	Leaving pressure	PSIG			
	EVAPORATOR (refrigerant-side)				
5	Entering temperature	F			
6	Entering pressure	PSIG			
7	Leaving temperature	F			
8	Leaving pressure and	PSIG			
8A	Temperature corresponding	F			
	CONDENSER (refrigerant-side)				
9	Entering temperature	F			
10	Entering pressure	PSIG			
11	Leaving temperature	F			
12	Leaving pressure and	PSIG			
	ELECTRICAL				
13	Line voltage	VOLTS			
14	Back E.M.F.	VOLTS			
15	Wattage	WATTS			
16	Amperes	AMPS			
	AIR-SIDE				
	Air quantities (average)				
17	Cubic feet per minute across condenser	CFM			
18	Cubic feet per minute across evaporator	CFM			
	Air temperature (average)				
19	Dry bulb entering condenser	F			
20	Dry bulb leaving condenser	F			
21	Wet bulb entering evaporator	F			
22	Wet bulb leaving evaporator	F			
23	Dry bulb leaving evaporator	F			
	DETERMINATIONS				
24	Evaporator superheat	F			
25	Evaporator pressure drop	PSI			
26	Suction line pressure drop	PSI			
27	Heat rejection (condenser)	BTU/MIN			
28	Heat absorption (evaporator)	BTU/MIN			

V. Analysis

For each of the six test points, determine the following:

a) Refrigerant mass flow rate
b) Refrigerant enthalpies at all points
c) Air mass flow rate
d) All air enthalpies from psychrometeric properties
e) Heat transfer rates in each heat exchanger from both air-side and refrigerant side property changes
f) Power input to cycle from refrigerant properties and from electrical input measurements
g) COP from refrigerant side data, operating as a refrigeration cycle
h) COP as above, operating as a heat pump
i) An overall COP, operating as a refrigeration cycle, using electrical power input and air-side Evaporator data
j) Capacity of the system as a refrigeration cycle in "Tons" of refrigeration (refrigerant-side data)
k) Each student is to sketch, for a different test point, the actual refrigerant-side test data on a Pressure-Enthalpy diagram for the appropriate refrigerant