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MECH 4880 REFRIGERATION AND AIR CONDITIONING

ASSIGNMENT 2

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Abstract

The report is one based on lab demonstration. The report was divided into two parts according to the two parts of the lab demonstration.

Part Ⅰ summarized the equipment in the refrigeration cycle, discussed their function and the effect to the system when changing parameters.

Part Ⅱ demonstrated the status of an air conditioner based on parameter measured during its cooling cycle. Some ways to improve EER were also discussed.

Part Ⅰ Lab based on refrigeration demonstration system

During the lab session, the refrigeration demonstration system was used. Fig A1 in appendix showed a schematic for the demonstration system.

The components shown in Fig A1 are (start from left bottom, anticlockwise): Compressor; Pressure Gauge; Condenser; Liquid receiver; Sight glass; Electronic magnetic valve; Manual on/off valve; Capillary; Thermal expansion valve; Evaporator; Liquid accumulator.

Fig A2 in appendix showed a simplified refrigeration system.

Compared to a full system, many components are not shown in the simplified system. Those components and their functions are:

- Pressure gauge: The pressure gauges are used to monitor the pressure in the system in different location.
- Liquid receiver: Liquid receiver sits in the liquid line between condenser and expansion valve. It holds excess refrigerant in it to provide stable refrigerant supply.
- Sight glass: Sight glass sits after the liquid receiver; it enables inspection to the liquid refrigerant's flow and indicates the system's moisture. Constant bubbles in the sight glass might indicate an undercharged system or leaking.
- Electronic magnetic valve: This kind of valve is used to control the flow rate of the refrigerant automatically.
- Manual valve: The manual valve acts as a switch.

- Capillary: Capillaries of different length in this demonstration system are used to present different pressure drops. They were introduced in real systems to lower down the pressure of refrigerant before it enters the evaporator.
- Thermal expansion valve: This valve is also a kind of throttling device used to decrease the pressure. However, thermal expansion valve is safer in practice than capillary, because it has lower chance to leak or get stuck.
- Liquid accumulator: The liquid accumulator sits in the suction line between the evaporator and the compressor. Its purpose is preventing slugging liquid from entering the compressor, at the same time metering the oil back in compressor.

By changing the parameters, it can be observed that the P-h diagram will change with the changes in the system.

When the evaporator fan was low, compared to steady state 1, the pressure before (point 1 on diagram) and after the throttling devices (point 2 on diagram) dropped simultaneously. Lower fan speed in the evaporator will lead to lower ambient temperature around the coil, then more refrigerant tend to stay in liquid phase instead of evaporating, thus lower down the overall pressure in the system. Another effect this brought to the system is that the entropy also decreases (point 1&2), thus the evaporator has to perform more work to evaporate the refrigerant (line 2-3). When the evaporator fan was totally off, the effect was exacerbated. The pressure before throttling devices got further decreased (point 1). It can also be noticed that due to the failed fan, the evaporator is now not able to evaporate all the refrigerator in the coil (point 3).

When the condenser fan was low, compared to steady state 2, the pressure before (point 1 on diagram) and after the throttling devices (point 2 on diagram) increased simultaneously. The entropy at those points also increased. Lower fan speed in the condenser caused heat to accumulate around the condensing coil, thus lead to lower condensing efficiency. As less refrigerant vapour gets condensed, the overall pressure will increase. There’s high potential that vapour will enter the evaporator coil, making the evaporator fail to evaporate the liquid refrigerant (point 3).

When one of the capillary is closed, compared to steady state 3, the pressure drop between the throttling devices increased (line 1-2). That’s because the amount of refrigerant passing through the devices decreased. With lower amount of refrigerant entering the evaporator, there is no more capacity for overheating (point 3).

All the p-h diagram for the discussed process above are listed in appendix.

As discussed earlier in the report, capillary and thermal expansion valve are used as throttling devices. Pressure drop can be observed between the inlet and outlet of the devices.

As observed in the lab, superheated value is taken as 5.1°C. For sub-cooling, the value can be calculated using the refrigerant table combined with given parameter: T=30.5°C, P=9.43 bar. As the refrigerant used in this demonstration is R-134a, the saturated temperature for R-134a at 9.43 bar can be found and interpolated from the table as 37.17 °C. The sub-cooling value then can be calculated as 37.17-30.5=6.67°C.

A blocked capillary is a common and always misleading problem for the refrigeration system. It will cause higher pressure drop between the inlet and outlet of the capillary, due to the blockage, pressure before the evaporator would decrease, the behaviour is similar with an under charged system, which will also cause a low pressure before the evaporator.

Another common problem occurred in practice is overcharging the system. The cause of an overcharged system might be misunderstanding of the bubbles in sight glass or low pressure before the evaporator. An overcharged system may damage the compressor, for large amount of liquid refrigerant may fill up the liquid accumulator and they might enter the compressor, washing out the lubricant oil. Overcharged system also has higher potential for leaking or exploding, which is harmful to both the environment and people.

Part Ⅱ Lab based on real air conditioner

The second part of the lab demonstration is based on operating an air conditioner system and measuring the parameters.

The measured temperature and pressure during the cooling cycle is tabulated in Table 1.

Table 1 Measured temperature & pressure

Location	Tempreature °C	Pressure Mpa
Condenser air outlet	25.9	
Evaporator air outlet	16.4	
Suction line	13.6	0.85
Discharge line	49.8	1.9

a): Assume there is no sub cooling, the p-h diagram can then be drawn using those data. The p-h diagram is shown in Fig 1.

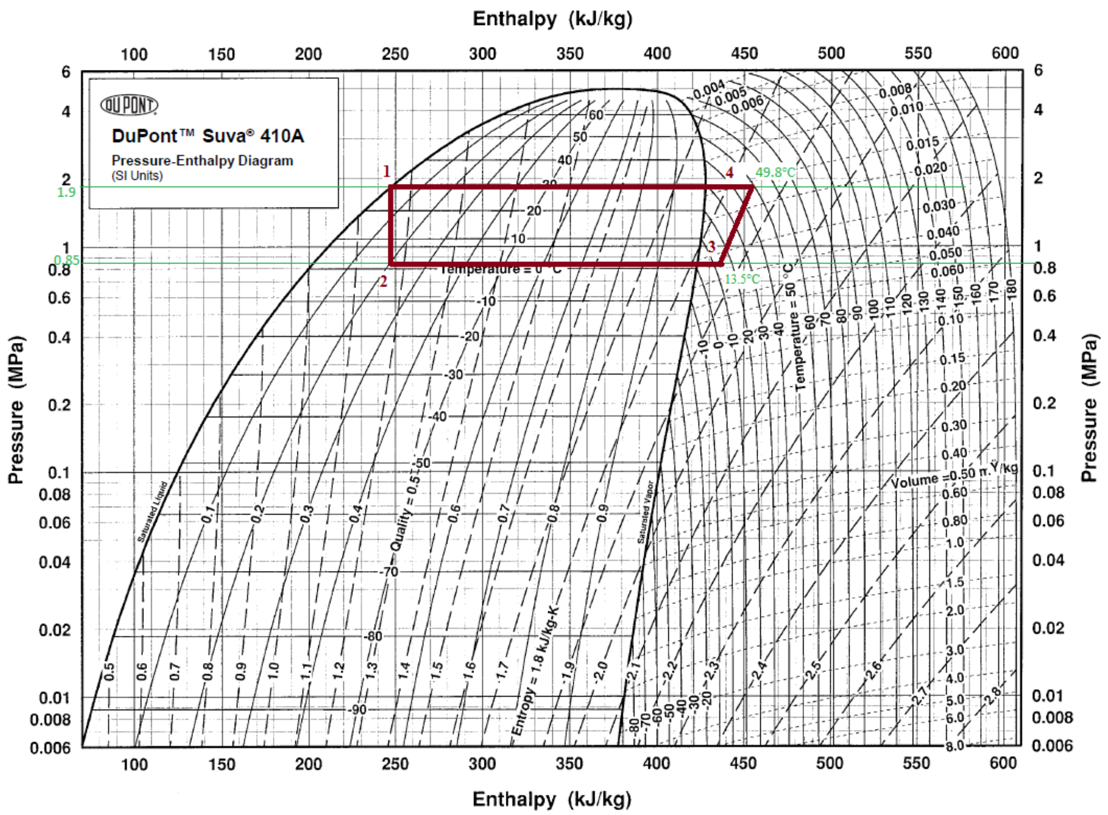

Figure 1 p-h diagram of the cooling cycle

b): Refrigeration occurs during point 2 and 3. The enthalpy change at this stage can be read and calculated from the chart as approximately 430-245 = 185kJ/kg.

c): Heat rejection occurs during point 4 and 1. The enthalpy change at this stage can be read and calculated from the chart as approximately 455-245 = 210kJ/kg.

d): Compression occurs during point 3 and 4. The enthalpy change at this stage can be read and calculated from the chart as approximately 455-430 = 25kJ/kg.

e): $EER = {(h3-h2)}\big/{(h4-h3)} = 185/25 = 7.4$

To get a better performance, EER are expected to be improved by adjusting the system, to do this, practice methods includes:

1: Increase the area of the fins in the condenser by a small amount and increase the fan power by a small amount. Those improvements can contribute together to increase the heat exchange rate in the condenser, thus increase the EER without significantly increasing the initial cost or generate more extra heat.

2. Protect the fins in both condenser and evaporator. Broken fins will lead to less effective heat exchanging area, contributing to a lower EER.

3. Clean the filter in the evaporator regularly. Blocked filter will allow less air flow around the evaporator, contributing to a lower EER.

Appendix

All the figures displayed in appendix was taken from either assignment instruction or lab data.

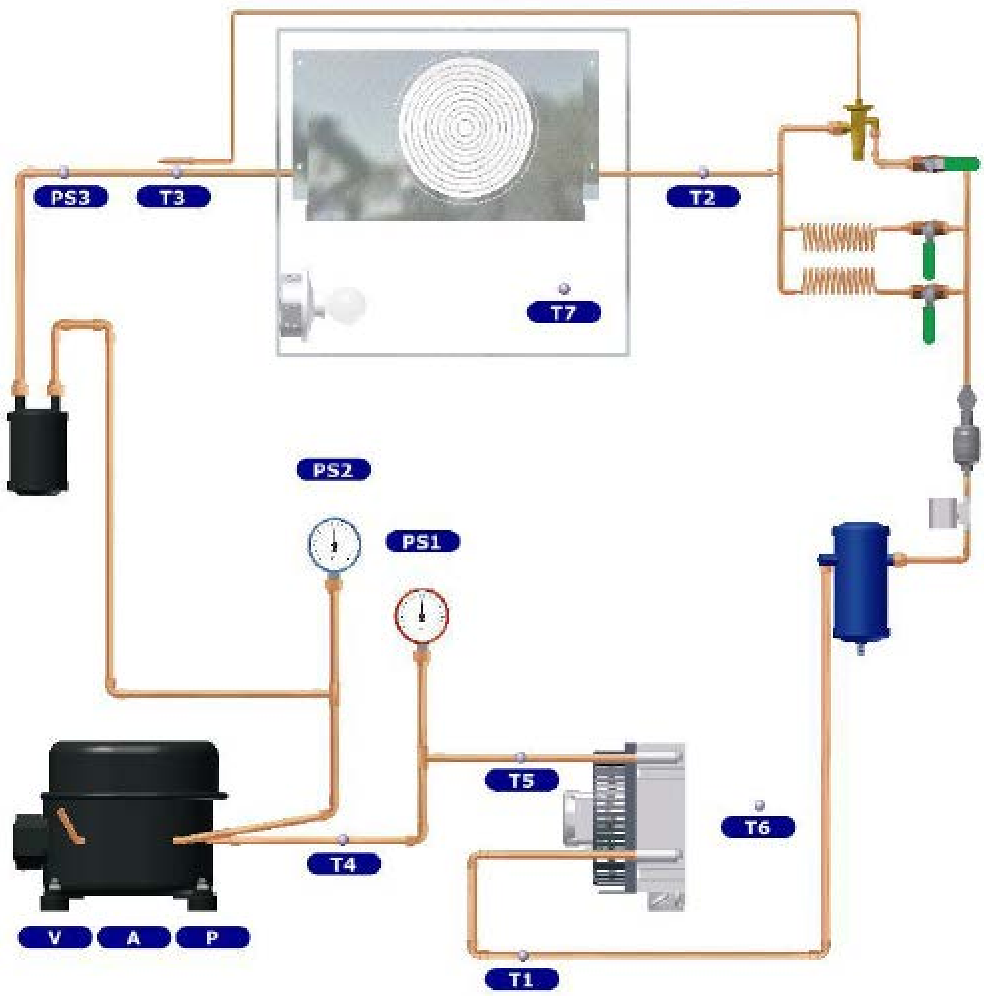

Figure A1 Demonstration System

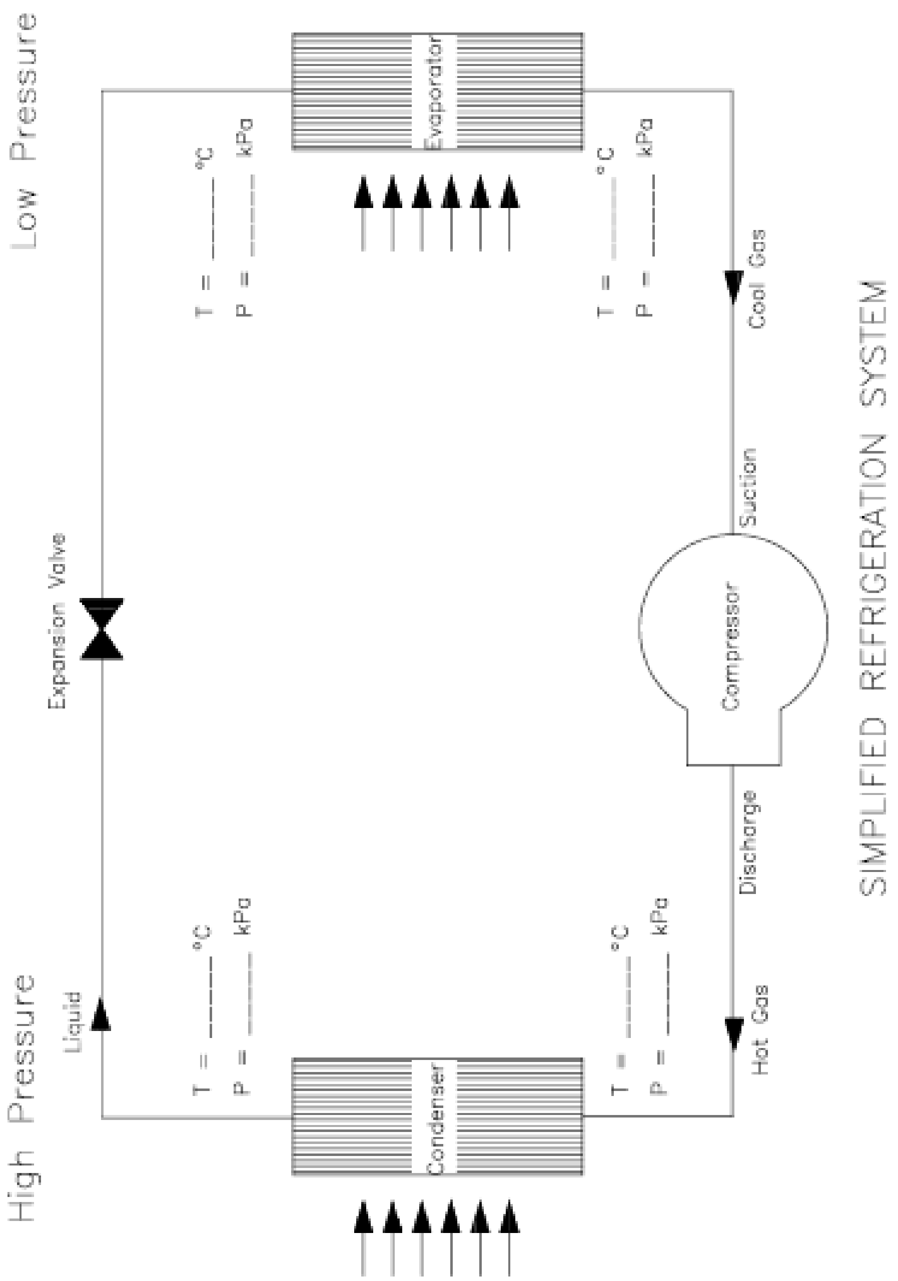

Figure A2 Simplified Refrigeration System

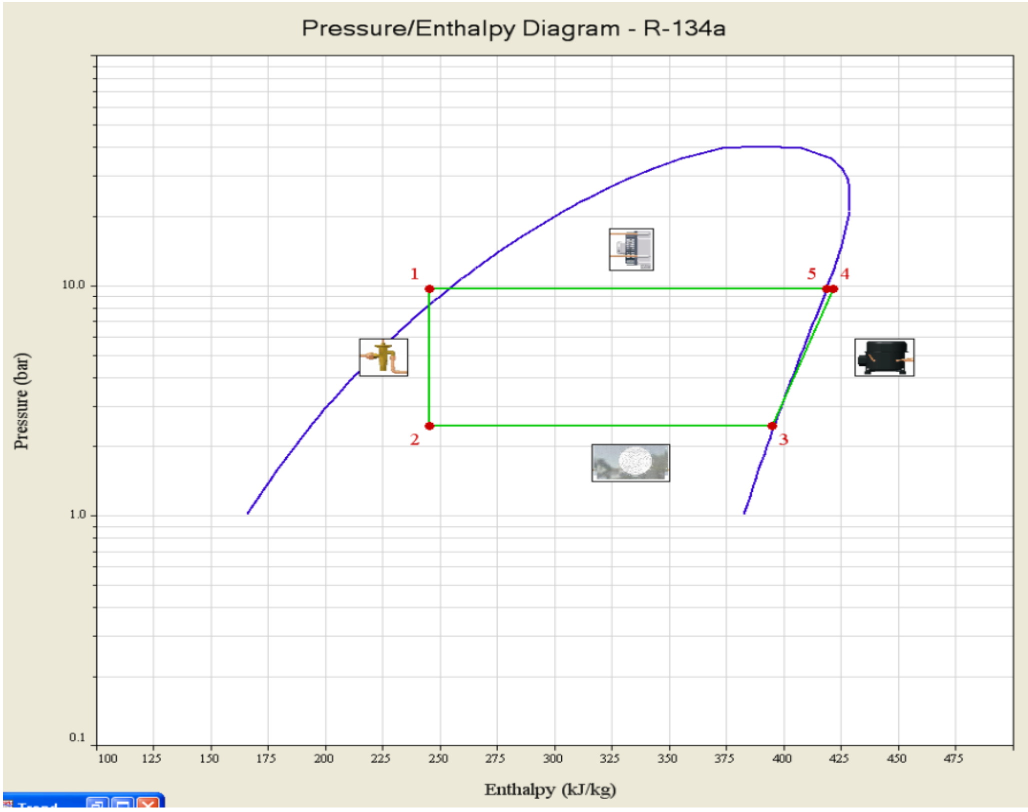

Figure A3 SteadyState 1

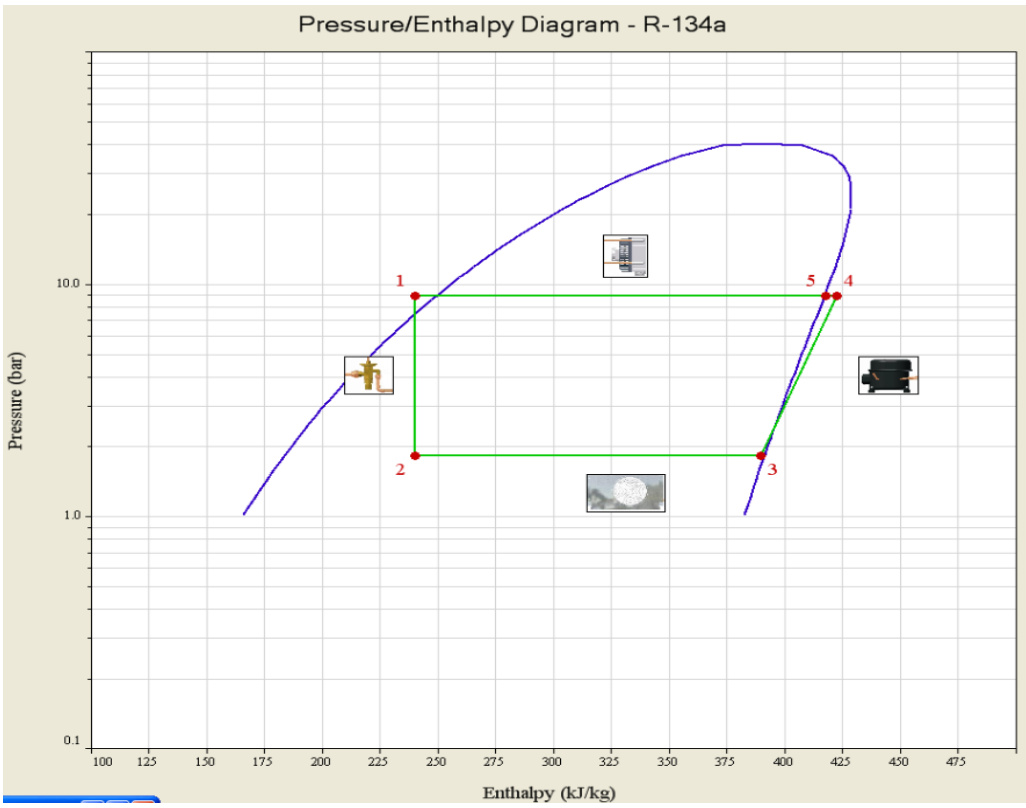

Figure A4 EvapFanLow

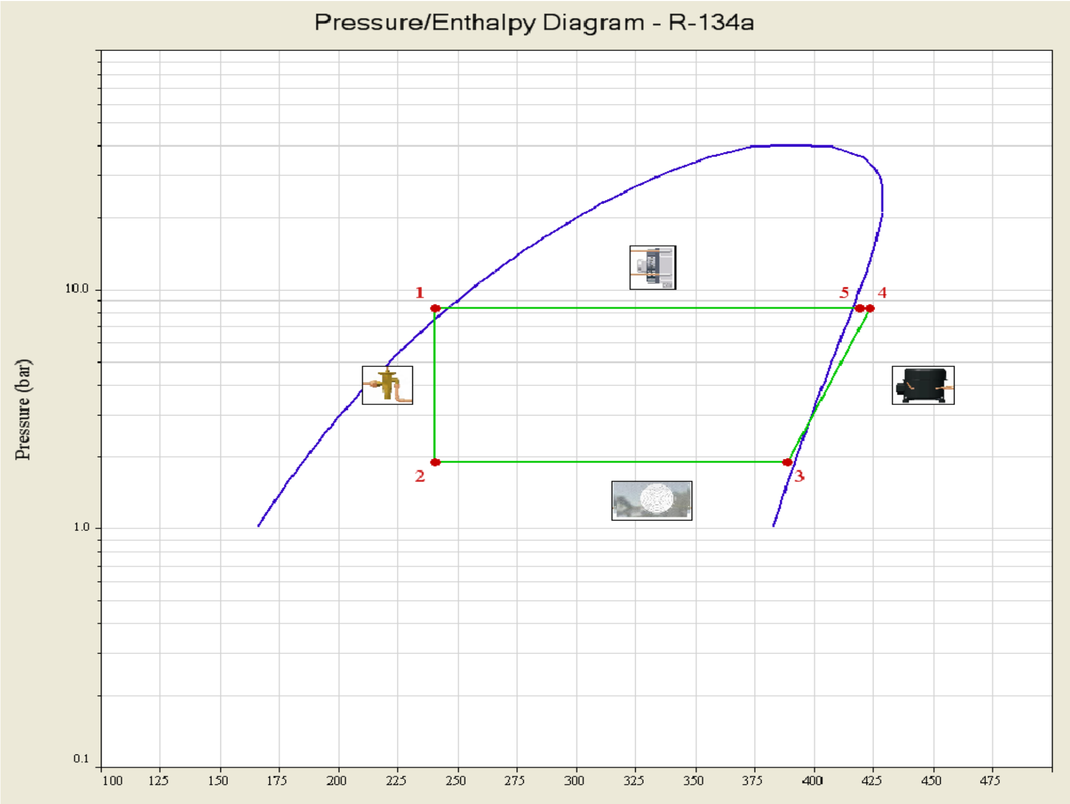

Figure A5 EvapFanOff

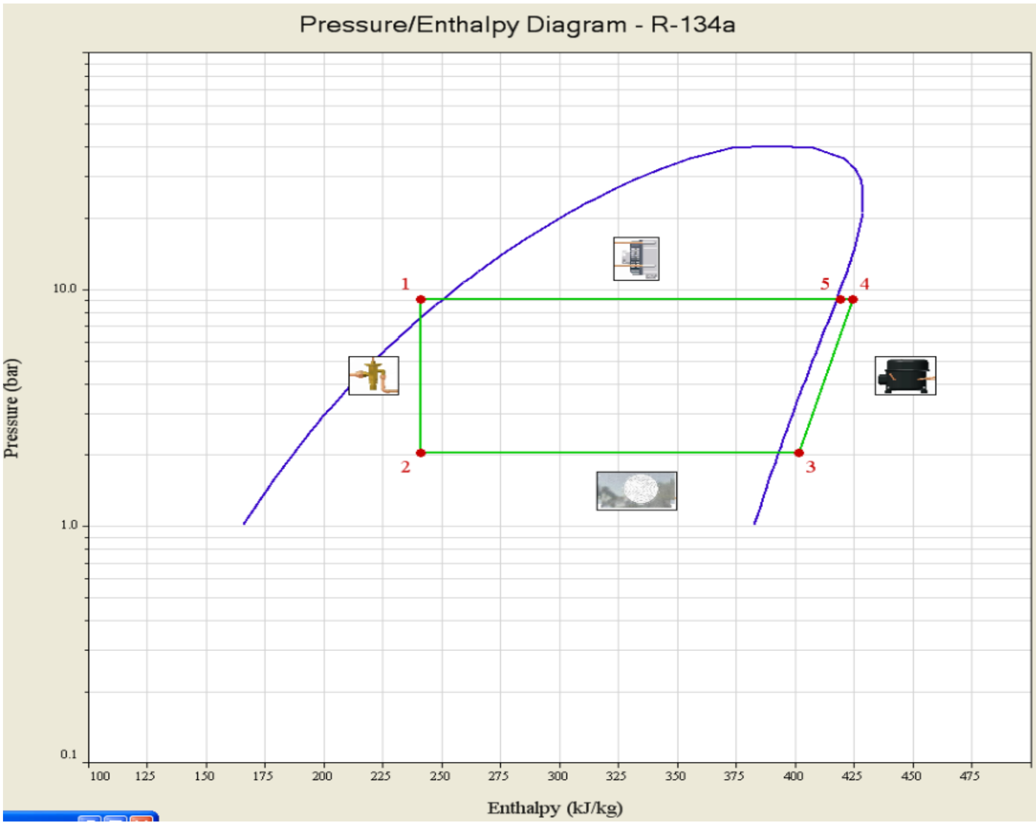

Figure A6 SteadyState2

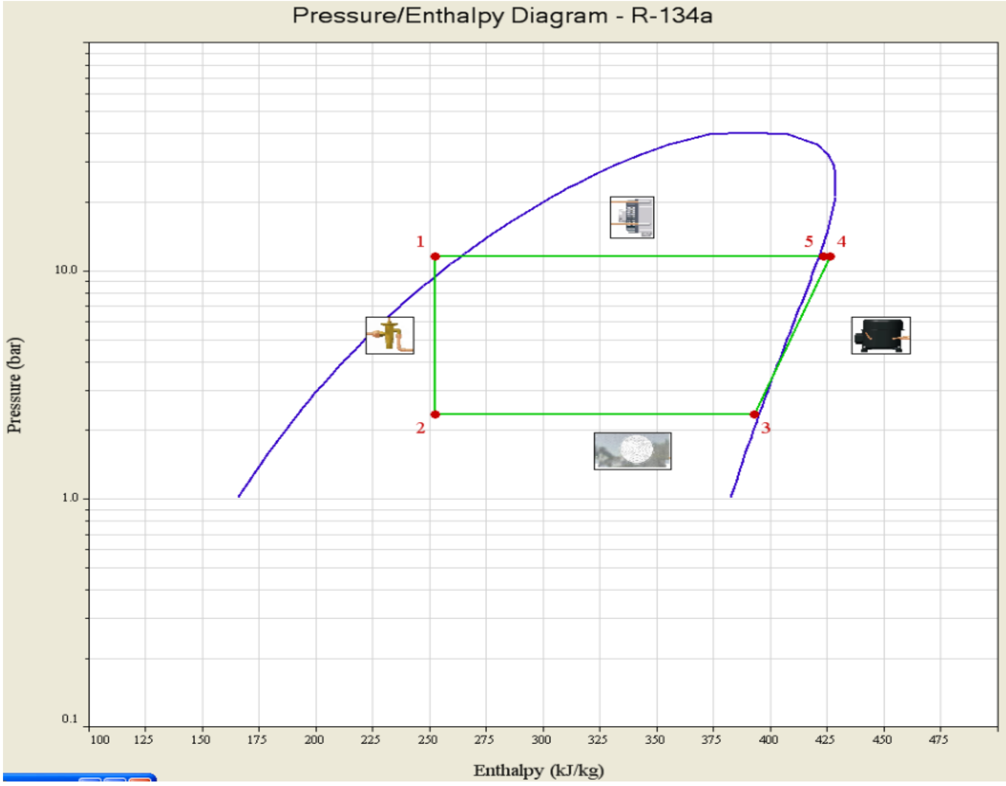

Figure A7 CondensorFanLow

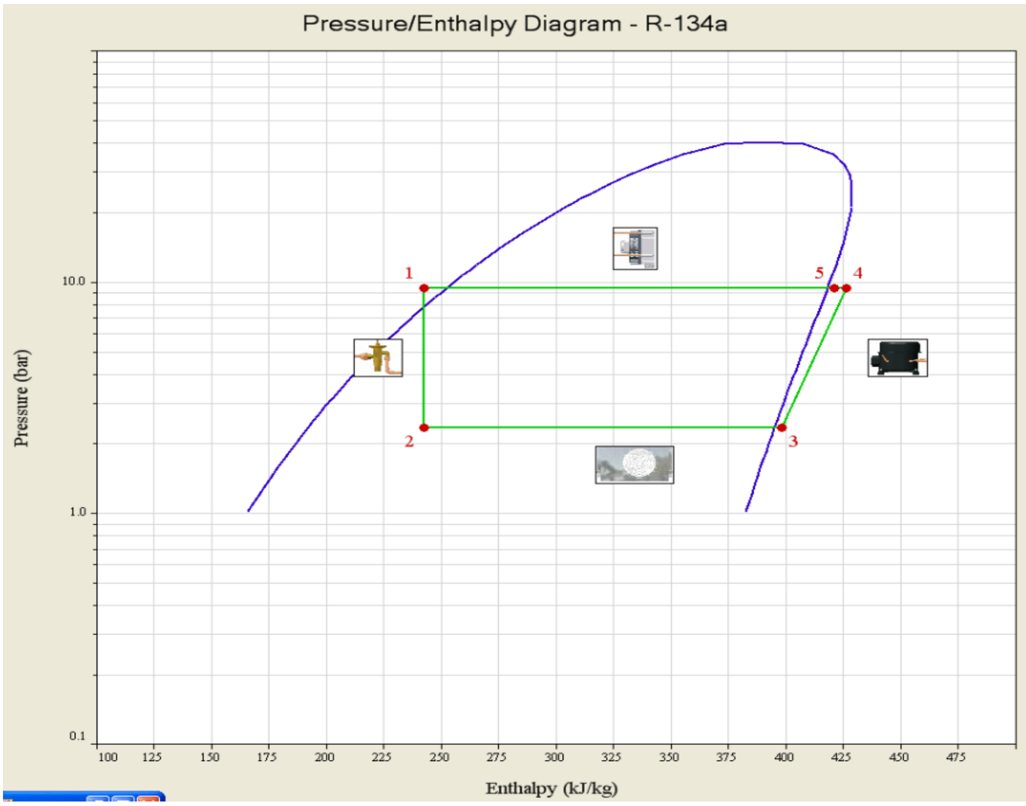

Figure A8 SteadyState3

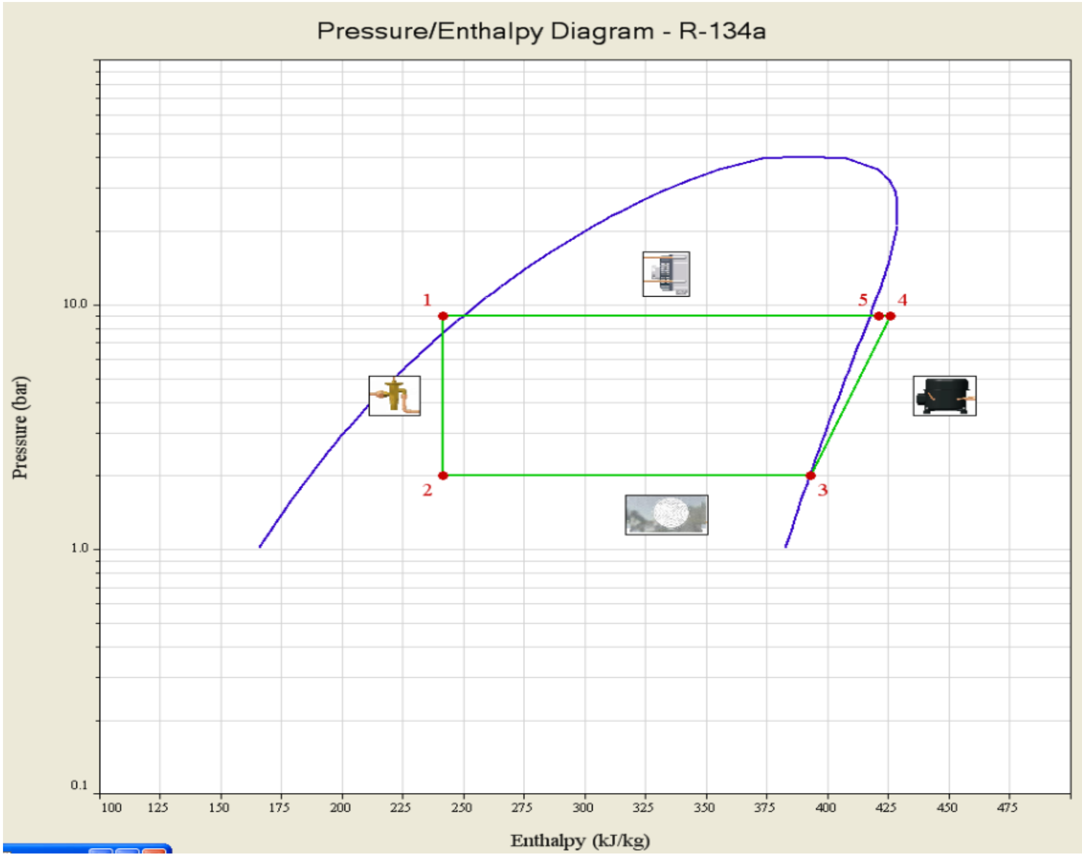

Figure A9 Cap2Closed