AC Control System

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INTRODUCTION

The SBC committee of the SSEA club, AC Control team at MSFEA has conducted a study report on the Air Conditioning facilities in order to optimize the efficient consumption at the Faculty of Engineering.

This report shows that while the used AC cycle is efficient, the consumption trends at the faculty are adding up to the costs bill and the life cycle of the installed systems. With only quarter actual usage of the AC systems in offices occupied by professors, the life cycle is lowered to 5 years instead of 20 and is resulting in wear and tear, inefficient heat losses, and extra costs. From here, this report calls for the monitoring and adjustments of the AC system supply in accordance with the actual consumption trends when professors are at their offices which could **save up to $106,850** every 20 years from Bechtel building only.

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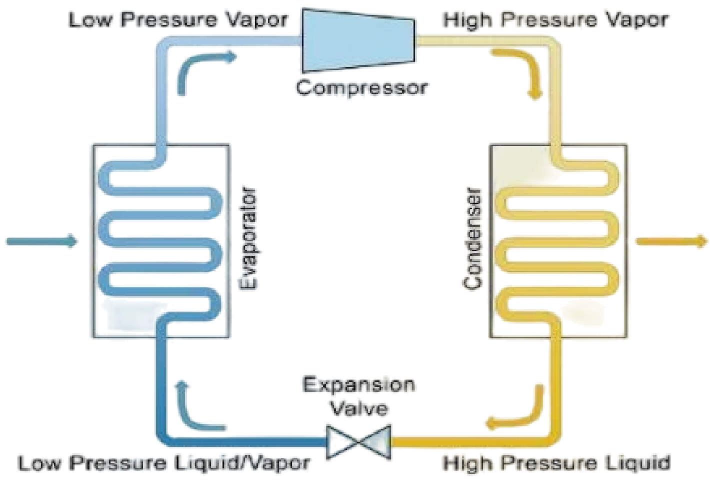
The air conditioning cycle also known as a refrigeration cycle is a means of **removing** heat from a desired area to cool it. This result is achieved by changing the **pressure** and **temperature** of the working refrigerant through cycles of **compression** and **expansion**.

A refrigeration cycle includes four main components: compressor, condenser, expansion valve and evaporator



Refrigeration Cycle

Compressor | 1

The refrigeration cycle begins by taking in the refrigerant gas and increasing its pressure using a compressor. The refrigerant at the inlet of the compressor has both low temperature and low pressure. As the refrigerant passes through the compressor it leaves as a high temperature and high pressure vapor. After this, the gas refrigerant flows to the condenser.

Condenser | 2

The condenser is one of two types of heat exchangers used in a refrigeration loop. After flowing through the compressor, the high-temperature high-pressure, vaporized refrigerant now passes through the condenser. The condenser removes heat from the hot refrigerant vapor gas until it condenses into the saturated liquid state, meaning the refrigerant is now condensed. After this component, the refrigerant represents a high-pressure, low-temperature liquid, which is now sent to the expansion device.

Refrigeration Cycle

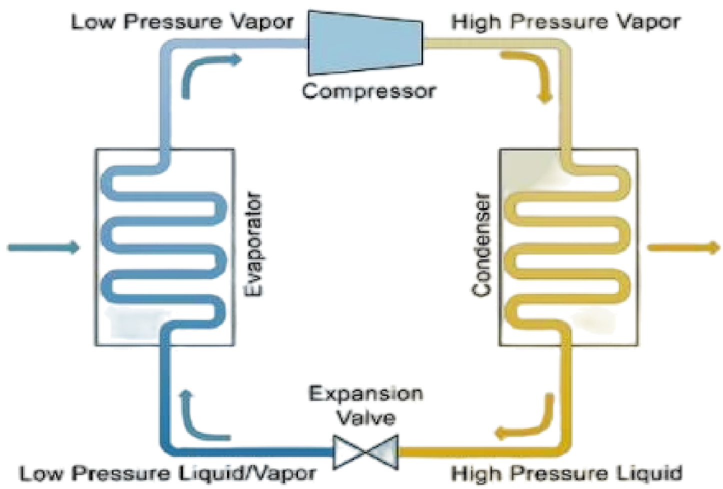
Expansion Valve | 3

The expansion valves have different designs such as thermal expansion valves, orifices, n-capillary tubes, manual valves, automatic valves and electronic valves. Even though there are different designs for expansion valves, they all perform the same job which is to control the flow of the refrigerant passing through. The refrigerant enters the valve as a high-pressure liquid and leaves as a low-pressure liquid/vapor. The purpose of the expansion valve is to slow down the refrigerant. The refrigerant is depressurized and in the liquid-vapor phase as it enters the evaporator.

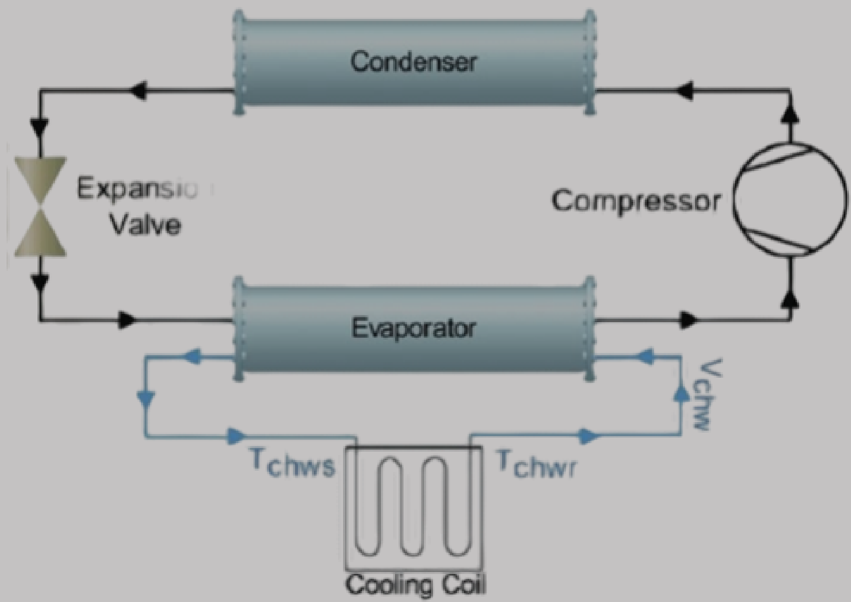
Evaporator | 4

As aforementioned, the refrigeration cycle mainly contains two heat exchangers, with the condenser being the first one. The evaporator is the second heat exchanger in the air conditioning cycle, and its main role is to absorb heat. It represents the last step of the cycle, where the low-temperature and low-pressure liquid-vapor enters the evaporator, and air stream is projected towards the fins of the evaporator by a fan, which cools the air by absorbing heat from the space into the refrigerant. After doing so, the refrigerant now has a high-temperature and low-pressure gas and flows back into the first component of the cycle, the compressor, and the cycle occurs over and over again.

For the air conditioning system at AUB, the water surrounds the evaporator rather than air, the fan reduces the temperature of the water surrounding it. Then, the cool water passes through pipes throughout Bechtel building, into a Fan Coil. As the cool water passes besides the fans, the fans start propelling air over the cool water which in turn lowers the air's temperature. This mechanism is known as a Chiller



What is a Chiller?



Refrigeration Cycle

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Water Cycle

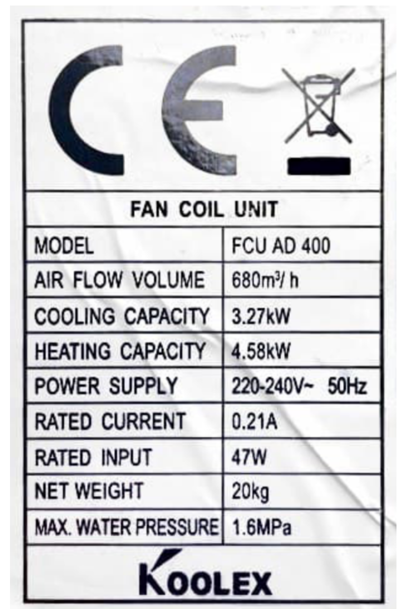
In a chiller, we have all of the four components of the entire air conditioner: A compressor, Evaporator, Condenser, and an Expansion valve. Inside the chiller used at AUB, the refrigerant used is R-134. Now over the evaporator, high temperature water passes. Then due to the evaporator's temperature being low, heat is removed from the water to lower its temperature to $8^{o}C$. Now this cold water is then pumped to the rooms using an external pump placed at the water output of the Chiller. Inside the rooms, the cold water enters inside the coil of the Fan Coil unit. Air from the room is then sucked to flow over the coils; heat is exchanged and the air's temperature drops which in turn cools down the room. Now, water leaving the coils has absorbed the room's high temperature and is then pumped back to the chiller to be cooled again.

Cost Savings

Operating Cost

Now the savings will be done by automatically turning the Fan Coils of the offices off using the motion sensor that is connected to the Building Management System (BMS) when no more motion is being detected in the office.

The data used to calculate costs is based on the Fan Coil Unit specifications shown to the right.



Current (I) = **0.21A**
Voltage (V) = **240V**
=> Power = I * V = 0.21 * 240 = **50.4Whr**

Number of Offices = **42**

Based on the data extracted from the BMS, on average, an instructor uses his/her office for six hours a day, leaving it for **18 hours** unused.

So, the number of offices multiplied by the hours of unused cooling multiplied by power per hour multiplied by 80 days per semester for the offices equals wasted power per semester.

Unused Power = 42 * 50.4 * 18 * 80 = **3,048,192W per Semester**

Current price of fuel for the powerplant at AUB is 0.5$/kW => 0.5 * 2,921.184 = **1525$**

Operation Savings

$1525

Savings per Semester if the automatic system was implemented

Cost Savings

Maintenance Cost

For the maintenance cost, a normal fan lasts 15 - 20 years, but since only six hours out of 24 are used, meaning that 1 over 4 of the life duration is used; this results in the reduction of 15 years from the fan's life cycle. Meaning that, every 5 years, each air conditioner needs a fan change plus maintenance; now with a failure rate of 40% after a fan's life cycle had finished (based on testing data done on the fans), every 5 years 17 (which is 0.4 * 42) fans must be replaced. A cost for a fan replacement is on average $600, therefore, **10,200$** are spent every 5 years instead of every 20 years.

In a 20 year projection the lost costs for maintenance are (10,200 * 4) - 10,200 = **30,600$**

+ Note that the cost of our system has only an installation cost and which is only **1,500$**

Maintenance Savings

$30,600

Savings per 20 years if the automatic system was implemented

Total Savings

Yellow: 72%
(Operational Savings)

Beige: 28%
(Maintenance Savings)

Savings per Semester

Turn-over | 55 days |

Current cost of 70% of a semester is $1,500

System cost is retrieved after 55 days of opertaion.

Conclusion

In conclusion, the Air Conditioning supply cycle at AUB is over-meeting the consumption needed which results in major losses of power and money. From here, it is a vital need to optimize the supply and consumption process that the Air Conditioning monitoring system is operating on. The Fan Coil units must only operate when offices are occupied as when forgotten it results in losses of 18 hours of generation translating to $2,137 per semester. This adaptation will allow for optimal efficiency for Air Conditioning supply to meet actual demand and make our campus comply better to efficient building design standards.

"The key issue when you're looking at cost cutting is to always plan for the future." - **Reid Hoffman**