Characteristics of vapour compression refrigeration cycles engineering essay

This project is a study on a performance of a Vapor Compression Refrigeration System VCRC. The performance of this type of refrigeration system is being investigated by using different type of expansion valves or also known as throttling valves. I am using three types of valves upon conducting this study which are thermostatic expansion valve, capillary tube expansion valve and constant-pressure expansion valve. Performance of refrigeration systems will be investigated on two kind of surrounding which are closed and open surrounding. A light bulb will act as a heating load which will increase the inlet temperature of air on evaporation. This project also discuss about the ideal application of each type of expansion valves. Which mean, where, when and what application the three types of expansion valves should be used for a better result.

Refrigeration is the action of cooling, and in practices this requires removal of heat and discarding it at higher temperature. Therefore, refrigeration is a science of moving heat from low temperature region to the high temperature region.

Refrigeration can be defined as a process of achieving and maintaining a temperature below that of the surroundings, with the aim to cool some product or space to the required temperature. The most important applications of refrigeration are the preservation of perishable food products. Refrigeration systems also used for providing thermal comfort to human beings by using air conditioning. Air Conditioning refers to the treatment of air so as to simultaneously control its temperature, moisture content, cleanliness, odor and circulation, as required by occupants, a process, or products in the space. The subject of refrigeration and air conditioning has

evolved out of human need for food and comfort, and its history dates back to centuries.

In refrigeration system, heat must be removed from the space area specifically the goods or matter we need to cool and released to the environment. Nature of heat movement is, heat always moves from the hotter to the colder space. To transfer heat from hot region to cold region, special device is required. The device is called Refrigerator. Refrigerator is a cyclic device and it is using a fluid called refrigerant as a working fluid.

As known there are two common methods for refrigeration which are natural and mechanical. In natural refrigeration, ice is used to generate a circulation of air around the blocks of ice. Therefore some of the heat from the circulating air is transferred to the ice thus cooling the air. This method particularly used in air conditioning application. As in mechanical refrigeration, refrigerant is used as a working fluid. Refrigerant is a substance that is capable to transfer heat that it absorbs at low temperatures and pressures to a condensing medium. Refrigerator is an example of mechanical refrigeration.

In a refrigerator, coolant is cooled in a condenser; from there it flow to the evaporator, where air is cooled by contact with the coil.

Figure : Example of Refrigerator [©2006 Publications International, Ltd.]

Types of refrigeration cycle

Vapor Compression Refrigeration System

Vapor compression refrigeration system is the most common refrigeration system used nowadays. In vapor compression refrigeration cycle (VCRC), there are four major thermal process take place which is expansion, evaporation, compression and condensation. In all practical applications, the actual VCRC is lower than the ideal cycle. This caused by several factors such as friction losses, heat exchanges between parts on the system and pressure drops in suction and discharge lines.

http://t2. gstatic. com/images? q= tbn: ANd9GcT-X7cy0Nn5FpUh23SVRaPzAFG_o0lp2WxOEMmReUZSPjiYERU&t= 1&usg= __BGAiwbpSspuI0lSI-ZibGb3mh0Q=

Figure : Single stage VCRC [The Full wiki/ refrigeration cycle]

Based on Figure 2, compression process is done on compressor followed by condensation process on condenser, expansion process on expansion valve and lastly evaporation process on evaporator.

Compression Process on Compressor

Low-pressure vapor of refrigerant enters the compressor and then being compressed and moved to condenser as a high-pressure vapor (superheated).

Condensation Process on Condenser

The superheated vapor of refrigerant is then travels through the condenser which first cools and removes the superheat and then condenses the vapor refrigerant into a liquid refrigerant by removing additional heat at constant pressure and temperature.

Expansion Process on expansion Valve

The liquid refrigerant is then goes through the expansion valve which is also known as throttling valve where its pressure will abruptly decreases, causing flash evaporation and auto-refrigeration of, typically, less than half of the liquid. By undergoing expansion process, mixture of liquid and vapor refrigerant is produced at low temperature and pressure.

Evaporation Process on Evaporator

The cold liquid-vapor refrigerant is then travels through the evaporator coil or tubes and it is completely vaporized by cooling the warm air (from the space being refrigerated) and being blown by a fan across the evaporator coil or tubes. The resulting refrigerant vapor returns to the compressor inlet to complete the thermodynamic cycle.

Vapor compression refrigeration system using high-grade energy such as mechanical work. It has more noise and wear is possible to occur in the compressor since moving parts is placed there. Coefficient of performance, COP of VCRC will decrease if the pressure of the evaporator decreases. Performance of VCRC is adversely affected at partial load.

Vapor Absorption Refrigeration System

Vapor Absorption Refrigeration System uses a heat source such as solar and kerosene-fueled flame to provide the energy needed to drive the cooling system. Vapor absorption Refrigeration system is a popular alternative to regular compressor refrigerators where electricity is unreliable, costly, or unavailable, where noise from the compressor is problematic, or where surplus heat is available such as from turbine exhaust or industrial processes. Absorption refrigerators powered by heat from the combustion of liquefied petroleum gas are often used for food storage in recreational vehicles.

There are two type of vapor absorption refrigeration system that is single-effect and double effect. Single-effect absorption system is using neither ammonia or water while double-effect absorption system uses lithium bromide or water.

Since the presence of ammonia or lithium bromide directly into a confined space which is full of human is dangerous, vapor absorption system which used this material should be placed outside the building to be cooled. However, vapor absorption that using ammonia or lithium bromide is not practical to be used on a building since it is impossible to pipe this material into the building. Therefore all absorption cycle equipment is then designed to chill water which is then piped into the building.

The chilled water is piped through to fan coil units in each of the conditioned spaces. The application of vapor absorption system using water is therefore well suited to multiple room systems or large spaces requiring air

conditioning. This is because absorption chillers are a well-established technology that can offer considerable advantages over conventional, mechanically driven, vapor compression chillers.

Absorption cycle is using a fluid pair rather than using a mechanically driven or an electrically powered compressor to be function. The absorption cooling cycle is driven by the heat source, such as gas burner, steam or hot water. This heat source is used to boil and drive the refrigerant out of the refrigerant/absorbent mixture. This mixture is normally termed solution.

The refrigerant is then going through a condenser to remove the latent heat of condensation, thus returning the refrigerant into liquid form. The refrigerant is then passed to the evaporator where evaporation process draws heat from the recirculating chilled water. The resulting vapor from the evaporator is attracted and absorbed by the absorbent solution to complete the cycle. In effect, the mechanical compressor of a conventional vapor compression cycle has been substituted with a ‘ chemical pump’ driven by heat.

http://www. acr-news. com/news/images/651_2. jpg

Figure : Single Effect Absorption Cooling [ACR News]

Steam Jet Refrigeration system

Steam Jet Refrigeration system is using the principle of liquids flashing under vacuum in a chamber. If the flash vapor removed from the chamber, the liquid will cool to the required temperature. In practice, more than one cooling stage is usually present. Steam Jet Refrigeration system will become

more economical when both steam and cooling water is readily available. Steam jet refrigeration system working start with the steam passed through a vacuum ejector of high efficiency to exhaust a separate, closed vessel which forms part of a cooling water circuit. The partial vacuum in the vessel causes some of the water to evaporate, thus giving up heat through evaporative cooling. The chilled water is pumped through the circuit to air coolers, while the evaporated water from the ejector is recovered in separate condensers and returned to the cooling circuit.

In steam jet refrigeration systems, water can be used as the refrigerant. Water is perfectly safe for human. These kinds of systems were applied successfully to refrigeration in the early years of century. At low temperatures the saturation pressures are low (0. 008129 bar at 4°C) and the specific volumes are high (157. 3 m3/kg at 4°C). The temperatures that can be attained using water as a refrigerant are not low enough for most refrigeration applications but are in the range which may satisfy air conditioning, cooling, or chilling requirements. These systems also used in some chemical industries for several processes, such as the removal of paraffin wax from lubricating oils. The application of steam jet refrigeration system also including cooling a hot corrosive liquid efficiently to any desired temperature and the cooling of fruit juices instantaneously. Note that a steam jet refrigeration system is not suitable to be used when the required temperatures are below 5°C.

Steam jet refrigeration systems use steam ejectors to reduce the pressure in a tank containing the return water from a chilled water system. The steam jet ejector utilizes the energy of a fast-moving jet of steam to capture the

flash tank vapor and compress it. Flashing a portion of the water in the tank reduces the liquid temperature. High-pressure steam expands while flowing through the nozzle 1. The expansion causes a drop in pressure and an enormous increase in velocity. Due to the high velocity, flash vapor from the tank is drawn into the swiftly moving steam and the mixture enters the diffuser. The velocity is gradually reduced in the diffuser but the pressure of the steam at the condenser is increased 5-10 times more than that at the entrance of the diffuser (e. g. from 0. 01 bar to 0. 07 bar).

The main advantages of this system are the utilization of mostly low-grade energy and relatively small amounts of shaft work. Using Steam Jet refrigeration system will required negligible maintenance and a plant can be fabricated in any suitable material of construction. In steam jet refrigeration system, there is no moving part involved.

http://www. siit. tu. ac. th/image/4ref. jpg

Figure : Steam Jet Refrigeration System [Sirindhorn International Institute of Technology, Thammasat University]

Thermoelectric Refrigeration System

An effect of refrigeration can also be achieved without using any moving parts. This is done by simply passing a small current through a closed circuit which is made up from two dissimilar metals. This type of effect is called the Peltier effect, and a refrigerator which is works using this kind of principle is called a thermoelectric refrigerator.

The thermoelectric device is like the conventional thermocouple. It is using two dissimilar materials as a medium to transfer heat from one another. In a thermoelectric refrigerator, there are two junction between the two different metals used. One junction is placed in the refrigerated space and the other one is placed in the ambient surrounding. The temperature of the junction which is located in the refrigerated space will decrease when the current passed through and create a potential difference. An opposite effect will occur on the other junction.

Under steady-state operating conditions, heat is transferred from the refrigerated space to the cold junction. The other junction will be at a temperature above the ambient, and heat will be transferred from the junction to the surroundings.

http://china-heatpipe. net/up_files/image/2008-4-24/826639119. jpg

Figure : Thermoelectric Refrigeration Effect

The thermoelectric refrigeration effect are too expensive for a normal domestic and commercial applications which are run only on using a regular household current. This concept normally suited to recreational applications due to the weight of thermoelectric refrigerator which is light, compact and it is also insensitive to motion or tilting. This type of refrigerator also has no moving parts, and can operate directly from 12-volt batteries.

Using thermoelectric refrigerator will give a advantages to the food and beverages. It will keep the food and beverages cold and dry. There also no

wasted space for ice. The advantages of thermoelectric refrigeration system include;

Compact size

Very little space is required by the cooling system.

Lightweight

Can be carried with one hand

Cheap

Use Low Battery to be function.

Comparison between refrigeration system

Feature

Refrigeration System

Compression

Absorption

Steam Jet

Principle of cooling

Vaporizing a Refrigerant

Vaporizing an Ammonia gas

Source of Energy

Mechanical work

Heat

Compactness

Weight

Portability

Heavy

Must be kept level within 2-3 degrees

Price

Battery Drain

Draw more current when running

6. 5-7. 5 amp

Cooling Performance

Most efficient in hot weather

Less efficient at high ambient

Freezing Ice cubes in hot weather

excellent

Not practical

Safety

Leaking of refrigerant

Leaking of refrigerant

Reliability

Exposed to wear

and may require expert servicing from time to time

Service & Maintenance

Required trained mechanics and special service equipment

Components on Vapor Compression Refrigeration Cycle

Vapour compression refrigeration system consist of several mechanical components that helps the systems to be function. Four major components on vapour compression refrigeration system include compressor, condenser, expansion valve and evaporator.

In selection of any components on refrigeration system, there are many factors that we need to consider very carefully, that is:

Maintaining total refrigeration availability while the load varies from 0% to 100%

Frost control for continuous performance application.

Variation in affinity of oil for refrigerant caused by large temperature changes, and oil migration outside the compressor crankcase.

Selection of cooling medium.

Direct expansion refrigerant

Gravity or pump recirculated or flooded refrigerant.

Secondary coolan (e. g. brines, salts and glycol)

System efficiency and maintainability

Type of condenser

Air

Water

Evaporatively cooled

Design of the compressor

Open

Hermetic

Semihermetic motor drive

Reciprocating

Screw

Rotary

Type of system

Single stage

Single economized

Compound or cascade arrangement

Selection of refrigerant.

Type of refrigerant basically chosen based on operating temperature and pressure.

Compressor

Compressor is one of the major components on refrigeration system. There are two main functions of compressors in the refrigeration cycle. The first one is to pump the refrigerant vapour from the evaporator so that the desired temperature and pressure can be maintained in the evaporator. The second function is to increase the pressure of the refrigerant vapour through the process of compression, and simultaneously increase the temperature of the refrigerant vapour. Therefore the pressure will change and make the superheated refrigerant flows through the systems.

Compressor also known as the heart of the vapour compression refrigeration system because it is supplied energies to run the system. Compressor can be divided into two main categories which are displacement compressors and dynamics compressors. Both displacement and dynamics compressors can

be hermetic, semi hermetic or open types. Both compressors also pumps refrigerant throughout the systems and produce substantial increase in the pressure of the refrigerant.

Displacement Compressors

These types of compressors used a shaft work to increase the refrigerant pressure by reducing the compression volume in the chamber. Reciprocating compressors, vane (rotary) compressors and helical rotary (scroll) compressors are including in a group of displacement compressors.

Reciprocating compressors compress the refrigerant gas only on forward stroke. A piston is build to be single acting in a large capacity range up to hundreds of kilowatts.

Condenser

Expansion Valve

Evaporator

Refrigeration Cycle

Expansion valve selection

Thermostatic Expansion valve

Capillary Tube Expansion valve

Constant-pressure Expansion valve

Refrigerant

Types of refrigerant

Characteristics of refrigerants

Selection of refrigerant

Performance of Vapor Compression Refrigeration Cycle

CHAPTER 2

LITERATURE REVIEW

CHAPTER 3

EXPERIMENTAL METHODOLOGY

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Background of Study

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Equipments and Apparatus set up

Standard Operating Procedure

CHAPTER 5: RESULT AND DISCUSSIONS

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

REFFERENCES