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Research Paper on

Design, Construction of Combined Air-conditioning and Refrigeration Unit

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ABSTRACT

In recent years, the escalating cost of energy has drawn much more attention on improving the energy efficiency of super market operations. In a supermarket refrigeration system consume a large amount of energy in maintaining chilled and frozen food. Meanwhile a HVAC (heating, ventilating and air conditioning) system is used to assure thermal comfort for occupants and suitable climatic conditions for refrigerated cases. The idea of this project explores the possibility of combining two units i.e. Refrigerator and Air-Conditioner into a single unit, such that the running cost becomes zero or almost negligible. The name of the device is termed as Refrigerator cum Air-Conditioner where both the Refrigerator and Air- Conditioner are working on the cost of only Refrigerator. This is how we can try to make the environment and a common man comfortable.

This paper is about our attempt to merge Domestic Refrigerator and Air conditioner into a combined system. In all metropolitan cities, environment degradation due to automobile & other factors is on the rise, therefore the requirement of air-conditioner has already been felt. The motivation for the project comes from rising energy demands and hence its cost. As we all know that we are lacking of power resources, so this product will help us in tackling this problem as we are trying to make a personalized cooling system which will run at a very low cost that can be afforded by a common man. In minimum construction, maintenance and running cost, this attempt is quite useful for domestic purpose so that our ultimate aim of the project that is those who cannot afford an Air Conditioner can have the comfort of Air Conditioner could be completed. Since all energy cost are on a rise, therefore this project is a way forward in realizing the economic as well as environmental demands. As it is said "the energy saved is the energy produced". On the other hand the common man can have the comfort of Air conditioner.

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I. INTRODUCTION

1.1 Réfrigération

Literal meaning of refrigeration is the production of cold confinement relative to its surroundings. In this, temperature of the space under consideration is maintained at a temperature lower than the surrounding atmosphere. To achieve this, the mechanical device extracts heat from the space that has to be maintained at a lower temperature and rejects it to the surrounding atmosphere that is at a relatively higher temperature. Since the volume of the space which has to be maintained at a lower temperature is always much lower than the environment, the space under consideration experiences relatively higher change in temperature than the environment where it is rejected. The precise meaning of the refrigeration is thus the following: Refrigeration is a process of removal of heat from a space where it is unwanted and transferring the same to the surrounding environment where it makes little or no difference.

1.2 Air Conditioning

Merely lowering or raising the temperature does not provide comfort in general to the machines or its components and living beings in particular. In case of the

machine components, along with temperature, humidity (moisture content in the air) also has to be controlled and for the comfort of human beings along with these two important parameters, air motion and cleanliness also play a vital role. Air conditioning, therefore, is a broader aspect which looks into the simultaneous control all mechanical parameters which are essential for the comfort of human beings or animals or for the proper performance of some industrial or scientific process. The precise meaning of air conditioning can be given as the process of simultaneous control of temperature, humidity, cleanliness and air motion. In some applications, even the control of air pressure falls under the purview of air conditioning. It is to be noted that refrigeration that is control of temperature is the most important aspect of air conditioning.

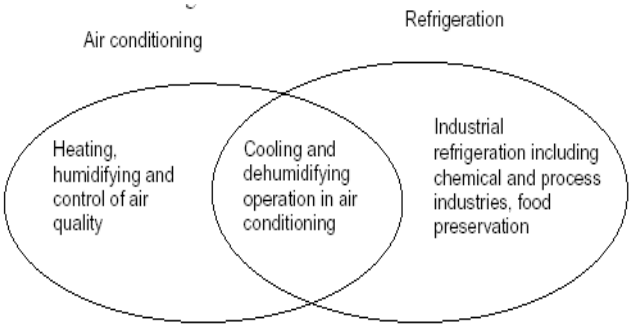

Figure 1.1 : Relationship between the Refrigeration and Air Conditioning

In minimum construction, maintenance and running cost, this attempt is quite useful for domestic purpose so that our ultimate aim of the project that is those who cannot afford an Air Conditioner can have the comfort of Air Conditioner could be completed. Since all energy cost are on a rise, therefore this project is a way forward in realizing the economic as well as environmental demands. As it is said "the energy saved is the energy produced". On the other hand the common man can have the comfort of Air conditioner.

II. LITERATURE REVIEW

Refrigeration system using CO2 was commonly applied in marine sector. At that time, this machine was operated as subcritical cycle. There had been operating problem with this system when the ship was passing through hot water temperature where its cooling capacity drops rapidly (Lorentzen, 1995) [1]. To increase the cooling capacity, some additional CO2 had to be charged into the system and then discharged when air temperature has decreased, which of course was not a good practice from operational practice point of view. This problem has been solved by the invention of Prof. Gustav Lorentzen who suggest transcritical cycle in place of subcritical cycle which make possible to operate the transcritical cycle like subcritical cycle without a need of charging and discharging CO_2 manually.

In air-conditioning system with direct expansion, experimental results showed that CO_2 system has capacity and efficiency similar to that of R22 system (Aarlien and Frivik, 1998) [2]. It is worth to note that the CO_2 system in this experimental study was still in an early stage of research while the baseline R22 system was the state-of-the-art system. Experiments on mobile air-conditioning system have been performed and they showed the performance of CO_2 system was higher at low ambient temperature (below 35°C) but lower at higher ambient temperature (above 35°C) compared to R134a system (Furuya, 1999) [3]. The most promising result of the application of transcritical cycle due to its unique characteristic has been for hot water heat pump where the heat source is at relatively constant temperature (such as ambient air or ground water) and the heat sink is at large gliding temperature. In this situation, transcritical cycle is more efficient cycle compared to subcritical cycle (Neksa et al., 1998)[4].

III.EXPERIMENTAL SETUP LAYOUT

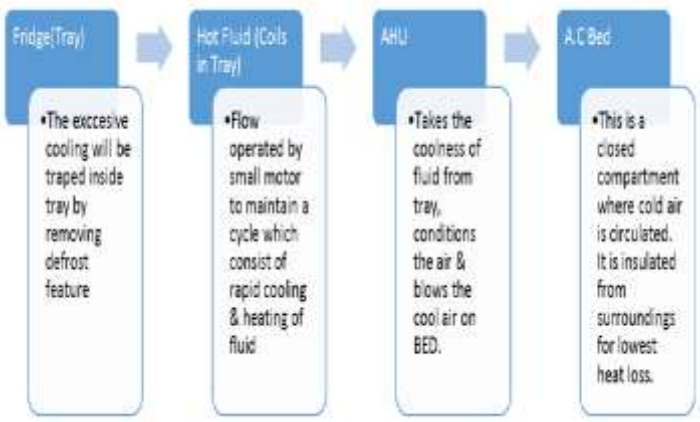

Figure 3.1: Block diagram of whole setup

Components
Refrigerator with Closed Tray
Refrigerator
Compressor = Reciprocating type hermitically sealed
Refrigerant = R-22/R-134a
Throttle Valve = Capillary tube
Condenser = Air cooled type.
Copper Pipes (Coils)
Air Handling Unit
Low Power Pump
A.C Bed
TRAY
In this research, dripping tray is been replaced by a closed tray. A tray is like a closed compartment to use the extra cooling of freezer which is until wasted by defrosting feature of refrigerator. It will set beneath the freezer, where dripping tray is held. The area would be kept same as that of ordinary tray that can easily fit inside the fridge. Specific height is provided to the tray so that it shapes like a box, insulated from each side.

Now the working is simple, the excess coolness is passed inside the closed tray compartment where the conductive coils (Copper tubes) carrying the flowing fluid to be cooled is lying. As the fluid is under room temperature, the heat exchange will take place as a result of temperature gradient. This will cool down the fluid so that it can be employed as a coolant for Air Handling Unit.

AIR HANDLING UNIT

An (AHU) comprises of following components

1) Fans/Blowers – the purpose of fan is related to the movement of air. It may operate at a single speed or may offer different air speeds.

Commonly used types of fans are –

a) Constant air volume (CAV)

b) Variable air volume(VAV)

2) Coils- coils carry the coolant. It is in the coils where heat exchange takes place. Heat exchange may occur in cross flow or counter flow fashion.

Coolant used in the project is water and the material of which coils are made of is copper

3) Dampers – the fan in an AHU create a substantial vibration & duct system could transmit this noise to the occupants of the bed. To avoid this, vibration isolators are used between the fan & the rest of the (AHU).

4) Filters- air filtration is necessary as the air may comprise of dust particles or microbes. If large amount of dust & microbes are present they will make air unfit for breathing.

For maintain air quality the filter has to regard to odour, dust, toxic gasses & bacteria.

AC BED

AC bed is made from a very light weight and having thermal conductivity.

III. THEORY

A vapour compression cycle is used in most household refrigerators, refrigerator–freezers and freezers. In this cycle, a circulating refrigerant enters a compressor as low-pressure vapour at or slightly above the temperature of the refrigerator interior.

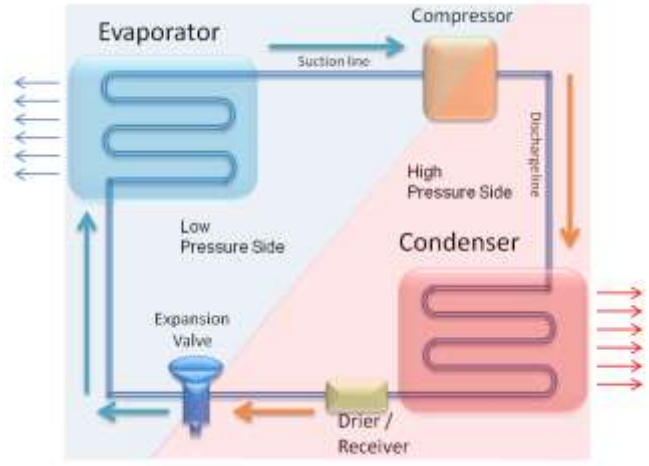

Figure 3.2: Vapour Compression (Referigeration) Plant-flow Diagram

The vapor is compressed and exits the compressor as high-pressure superheated vapor.

The superheated vapor travels under pressure through coils or tubes that make up the condenser; the coils or tubes are passively cooled by exposure to air in the room. The condenser cools the vapor, which liquefies. As the refrigerant leaves the condenser, it is still under pressure but is now only slightly above room temperature.

This liquid refrigerant is forced through a metering or throttling device, also known as an expansion valve (essentially a pin-hole sized constriction in the tubing) to an area of much lower pressure. The sudden decrease in pressure results in explosive-like flash evaporation of a portion (typically about half) of the liquid. The latent heat absorbed by this flash evaporation is drawn mostly from adjacent still-liquid refrigerant, a phenomenon known as auto-refrigeration.

This cold and partially vaporized refrigerant continues through the coils or tubes of the evaporator unit. A fan blows air from the refrigerator or freezer compartment ("box air") across these coils or tubes and the refrigerant completely vaporizes, drawing further latent heat from the box air. This cooled air is returned to the refrigerator or freezer compartment, and so keeps the box air cold. Note that the cool air in the refrigerator or freezer is still warmer than the refrigerant in the evaporator. Refrigerant leaves the evaporator, now fully vaporized and slightly heated, and returns to the compressor inlet to continue the cycle. Domestic refrigerators are extremely reliable because the moving parts and fluids are sealed from the atmosphere for life, with no possibility of leakage or contamination. In comparison, mechanically-driven refrigeration compressors, such as those in automobile air conditioning, inevitably leak fluid and lubricant past the shaft seals. This leads to a requirement for periodic recharging and, if ignored, possible compressor failure.

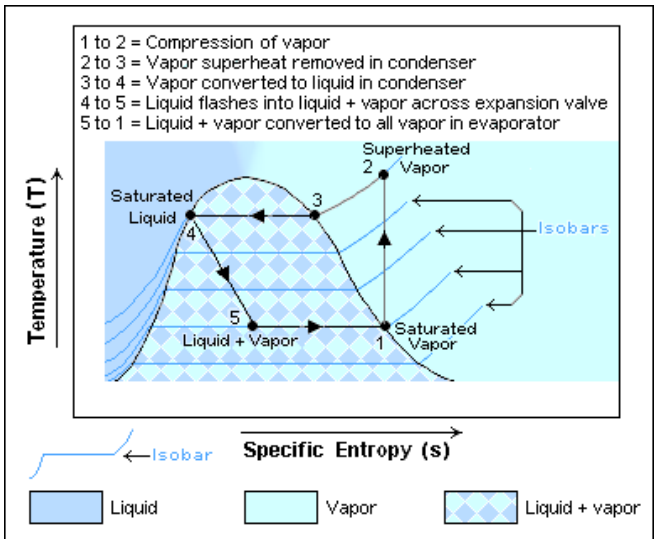

Figure 3.3: Vapour Compression (Referigeration) Temperature-entropy Diagram

Unit of refrigeration

Domestic & commercial refrigerators may be rated in kJ/s, or Btu/h of cooling. One British thermal unit is equal to about 1055 Joules. It is the amount of energy needed to cool or heat one pound (0.453 kg) of water by 1 deg. Fahrenheit. Commercial refrigerators in the US are mostly rated in tons of refrigeration, but elsewhere in kW. One ton of refrigeration can freeze one short ton of water at 0 deg. C in 24 hours i.e. 2000 pounds of ice at 144 BTUs per pound (heat of fusion of water) = 288000 BTUs 288000/24 = 12000 BTUs/hr. or one ton of refrigeration.

Now, an air handling unit (AHU) is device used to regulate & circulate air. It is a part of air conditioning system. They usually connect to duct ventilation system that distributes the conditioned air to the desired area.

AHU are of different types and sizes. They are used to offer cooling as well as heating purposes; also they can be just used to as a ventilation system to provide fresh air into office buildings.

Small AHU may comprise of only air filter, coils & blower & these are called fan coil units. A large air handler that contains 100% outside air & no recalculated air is known as makeup air unit (MAU). An air handler for outdoor use, typically on rooftops is known as rooftop units (RTU).

We allow the cool air to the AC Bed. An AC bed is a thermal insulating covering upon existing beds, like a mosquito net. This bed helps to maintain a certain temperature to make person comfortable so that he can relax better at night and become more productive on next day

IV. CONCLUSION

Domestic refrigerator consumes significant amount of energy in buildings like hospitals, hotels, multifamily buildings. By recovering part of energy for air conditioning effect energy can be saved. Since variation of outdoor air temperature is small in tropical countries, cooling is needed year round. This is the best condition to perform combined effect of refrigerator and air conditioners for energy saving. A prototype combined air-conditioning and refrigeration is designed and built.

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