Utilization of Heat Energy in R & AC Systems

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Abstract: ***Green energy plays a vital role in our day today economic life for the future reforms of the world. This proposal is a venture in refrigeration and Air conditioning systems where waste heat is used at an efficient manner. Hence vapor compression cycle makes the basic principle behind refrigeration and air conditioning systems. Moreover, the world energy crisis has led to the utilization of waste heat, solar energy, bio energy, wind energy etc. for the functioning of some of refrigeration systems. This proposal is a concerted for various government and private agencies to develop eco energy in the commercial environment by grooving the requirements of refrigeration and decreasing the dependence on conventional energy resources .This proposal mainly enhances in waste heat recovery in Refrigeration and Air Conditioning systems. With a single input from the compressor we extract three efficient outputs viz. 1) Hot water 2) Cold Water and 3) Air Conditioning. The refrigerant used in the component is R290 blended with R134a which is equivalent to R22. An evaporative cooler produces effective cooling by combining a naturals process water evaporation with a simple, reliable air moving system evaporative coolingis the most economical and effective means of refrigeration and air cooling since its inception particularly in the areas where climatic conditions are hot and dry. The energy saving by doing so is saved more than 30 W. It is referred as a small size Desert cooler.***

Keywords: Refrigeration, Air conditioning, evaporater, compressor, vapour.

1. Introduction

In the olden around 2500 years BC Indians, Egyptians etc. were producing ice by keeping water in porous pots open to cold atmosphere during the night periods. The evaporation of water is almost cool dry air accompanied with radioactive heat transfer in the clear night caused the formation of ice even when the ambient temperature was above the freezing temperature. Further the development of refrigeration aforesaid methods has led to the latest advancement methods in air conditioning and refrigeration systems. This system can be used simultaneously. By implementing our proposal there is no need of going for an individual air conditioner and water cooler. As both functions are

Served by a single unit, the price is lowered to a reasonable level. This proposal can be widely used for high efficiency and lower economic costs. It plays a major role in saving green energy.

The term air conditioning refers to the control of temperature, humidity, motion and purity of atmosphere in the confined space. Out of all the refrigeration systems, the vapour compression system is the most important system from the view point of commercial and domestic utility. It is the most practical form of refrigeration. In this system the working fluid is a vapour. It readily evaporates and condenses or changes alternatively between the vapour and liquid phases without leaving the refrigerating plant. During evaporation, it absorbs heat from the cold body. This heat is used as its latent heat for converting it from the liquid to vapour. In condensing or cooling or liquefying, it rejects heat to external body, thus creating a cooling effect in the working fluid. This refrigeration system thus acts as a latent heat pump since it pumps its latent heat from the cold body or brine and rejects it or delivers it to the external hot body or cooling medium. The low pressure in dry state is drawn from the evaporator during the suction stroke of the compressor. During compression stroke the pressure and temperature increases until the vapour temperature is greater than the temperature of the condenser cooling medium.

Types of refrigeration systems:

1. Ice refrigeration.
2. Air refrigeration.
3. Vapour compression refrigeration system.
4. Vapour absorption refrigeration system.
5. Special refrigeration system
   (i) Adsorption refrigeration system
   (ii) Cascade refrigeration system
   (iii) Mixed refrigeration system

2. Literature Review

2.1 Studies on Energy Efficiency

The major studies carried out so far in the areas like energy efficiency, waste heat recovery from the industrial sector, various means of waste heat recovery processes and mainly waste heat recovery from air conditioners are reviewed in this chapter. Arif and Yildiz (2009) have reviewed the heat pump water heating systems (HPWH) and concluded that the HPWHs have considerable promise for use in both residential and commercial applications. Residential HPWH units have been available for more than 20 years, but have experienced limited success in the marketplace. Commercial-scale HPWHs are a very promising technology. However, their present market share is extremely low, and only two or three manufacturers are seriously involved in the market. The market needs further conditioning for successful market transformation. The next step in this market conditioning is likely to be further demonstrations and developing additional, well-documented case studies that will support sales efforts to designers and customers.Liu et al (2010) have studied on active low grade energy recovery potential for building energy conservation and said that the technologies of low grade thermal energy recovery for refrigeration, heating and dehumidifying are promising. Waste heat and cold recovery facilities in air conditioning room and thermoelectric technology are employed to perform the low grade energy

Recovery. Novel energy conservation window-type air conditioners were 4designed and built combining with waste heat recovery facility. Precooling/heating fresh air is an effective way to simultaneously enhance eventilation and energy conservation, which is the final objective of this thermal energy recovery window-type air conditioner for an occupied open plan space.

Up to date, technologies of heat recovery, mass recovery and multi-stage recovery are promising for improving the COP of thermoelectric units. Wang et al (2011) have developed a thermally activated cooling system, using micro channel heat transfer components and combining an Organic Rankine Cycle (ORC) with a vapour compression cycle. The system can be used to recover and convert waste heat directly into cooling. Based on laboratory testing using a hot oil circulating loop as the heat input, the system has operated at steady state conditions and delivered up to 5 kW of cooling. The highest overall system COP achieved during experiments was 0.8.

Srinivas (2003) has made several different approaches to meet the related goals of reducing greenhouse gas emissions and ozone-depletion attributable to space-conditioning systems. The approaches include reducing refrigerant inventories, miniaturization of components using micro channel components, increasing energy efficiency through enhanced heat exchanger performance, waste heat utilization, and coupling the heat pump to a ground source/sink.

Omar et al (2004) made a survey on energy efficient strategies for effective air conditioning and presented methods for lowering the energy consumed during air conditioning of buildings. Some of these strategies can be implemented during the design stage; others can be used to retrofit existing AC systems; and still others can be applied with hardly any changes on existing equipment. The methods that are discussed include heat recovery and utilization, absorption refrigeration systems, thermal cool storage, liquid5(refrigerant) pressure amplification, reprogramming of the AC control systems, economical methods of removal of moisture from the air and initiation of awareness programs for the conservation of A/C energy.

Parisarn (2010) studied the improvement of the air conditioning system performance by using the heat pipe for cooling air before entering the condenser. By comparing with a conventional air conditioning system, the air conditioning system with three rows of heat pipe gives the highest COP and EER with increasing of 6.4%, 17.5%, respectively.

2.2 Principle of Operation

Refrigeration: The science of producing and maintaining temperatures below that of surrounding atmosphere. In simple words, refrigeration means cooling of or removal of heat from the system. Principle: It works based on the principle of vapour compression cycle. In this system it readily evaporates and condenses or changes alternatively between vapour and liquid phases without leaving the refrigeration plant. In simple vapour compression system fundamental processes are completed in one cycle. They are (i) compression, (ii) condensation, (iii) expansion, (iv) vaporization.

2.3 Parts of Vapour Compression System

The following are the various parts of a vapour compression systems, (i) compressor, (ii) discharge line, (iii) condenser, (iv) receiver tank,(v) liquid line, (vi) expansion valve, (vii) evaporator, (viii) suction line.

Compressor: The function of the compressor is to remove the vapour from the evaporator, and to raise its temperature and pressure to a point such that it(vapour) can be condensed with available condensing media.

Discharge line: A hot gas or discharge line delivers the high pressure, high temperature vapour from the discharge of the compressor to the condenser.

Condenser: The function of a censor is to provide a heat transfer surface through which heat passes from the hot refrigerant vapour to the condensing medium.

Receiver tank: A receiver tank is used to provide storage for a condensed liquid so that a constant supply of liquid is available to the evaporator as required.

Liquid line: A liquid line carriers the liquid refrigerant from the receiver tank to the refrigerant flow control.

Expansion valve: It"s also called as refrigerant flow control valve. Its function is to meter the progress amount of refrigerant to the evaporator and to reduce 8the pressure of the liquid entering the evaporator so that liquid will vaporize in the evaporator at the desired low temperature and take out sufficient amount of heat.

Evaporator: An evaporator provides a heat transfer surface through which heat can pass from the refrigerant space into the vaporizing refrigerant.

Suction line: The suction line conveys the low temperature vapor from the evaporator to the suction inlet of the compressor.

2.4 Actual Vapour Compression Cycle

The actual vapour compression cycle differs from the theoretical cycle in several ways because of the following reasons:

1) Frequently the liquid refrigerant is sub cooled before it is allowed to enter the expansion valve, and usually the gas leaving the evaporator is superheated a few degrees before it enters the compressor. This super heating may occur as a result of the type of expansion control used or through a pick of heat in the suction line between the evaporator and compressor.
2) Compression, although usually assumed to be isentropic, may actually prove to be neither isentropic nor polytrophic.
3) Both the compressor suction and discharge valve are actuated by pressure difference and this process requires the actual suction pressure inside the compressor to be

slightly below that of the evaporator and the discharge pressure to be above that of the condenser.

4) Although isentropic compression assumes no transfer of heat between the refrigerant and the cylinder walls, actually the cylinder walls are hotter than the incoming gases from the evaporator and colder than the compressed gases discharged to the condenser.
5) Pressure drop and liquid line piping and any vertical difference in head created by locating the evaporator and condenser at different elevations.

2.5 Advantages and Disadvantages of Vapour Compression Refrigeration

Advantages:

1) The coefficient of performance is quite high as the working cycle of this system is near the Carnot cycle
2) The among of refrigerant circulated is less per ton of refrigeration than air refrigeration system because the heat carried away by the refrigerant is the latent heat. As a result of this, the size of evaporator is smaller for the same refrigerating effect.
3) This system can be employed over a large range of temperatures. By adjusting the expansion valve of the same unit, the required temperature in the evaporator can be achieved.
4) The running cost of this system is less than air refrigerating system.

Disadvantages:

1) Prevention of leakage of refrigerant in this system is the major problem.
2) First investment cost is high than the air refrigeration system.

2.6 Design Calculations

Volume of water collected = 200 ml. Time taken for 200 ml of water = 84 sec.

Mass flow rate (m) = ρ / V = 1000 * 200/84 = 2.38 * 103

Power input of the compressor (Pi) = 230* 0.5 = 0.1035 KW

Difference in Temperature from compressor to condenser = 13^0C

Quantity of heat extracted from the refrigerant systems Q1 = m * (C p) * ΔT

= $2.38 * 10^3 * 0.95 * 13$

= 0.19 KJ/s

Heat transfer co-efficient (h) = A * Q1

= $\pi * (0.105)^2 * 0.19 = 0.23184$ W/m^2/^{0}C

Coefficient of Performance = Heat extracted from the evaporator / Work inputof the compressor.

COP = 0.23184 / 0.1035 COP = 2.24

Ton of Refrigeration = COP / 3.5 = 2.24 / 3.5

Ton of Refrigeration = 0.64 TOR41

3. Results and Conclusion

From the results obtained by the prototype the cop obtained as 2.24. Thus this proposal is very much reusable and eco-friendly which can be used in our day to day life and also an important factor in power consumption. This proposal provides better usage in desert regions. This is one maiden venture in the field of refrigeration system from the stream of mechanical engineering as term leads to change in the recent trends. About 200 litres of hot water at a temperature of about 58ºCover a day from the outlet of water cooled condenser and this modification made the household refrigerator to be work as both refrigerator and water heater. The hot water which was obtained from the water cooled condenser can be utilized for household applications like cleaning, dish washing, laundry, bathing etc.

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Author Profile

M. Yaswanth, Student of Final year Mechanical Department from Panimalar Institute of Technology (Affiliated to Anna University), Chennai, India. He has received **The National Award in Sustainable Energy Development for the Academic Year 2014, by ISTE** and alsohas participated & won in many National level Technical Papers.He has an adverse knowledge and interest in the field of Refrigeration and Air Condtitoning Systems. He has also published two International Journal and presented 3 papers in international conferences.