International Journal of Future Generation Communication and Networking
Vol. 13, No. 2s, (2020), pp. 657–661

Water To Water Heat Pump

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Abstract

Air-to-air heat pumps do have their limitations when it comes to space heating. The colder the outside air the less heat each pound of refrigerant picks up as it circulates through the system. Heating capacity, as well as efficiency, decreases as outdoor temperatures fall. This inescapable constraint of thermodynamics often requires air- source heat pumps to be equipped with supplemental heat sources to handle peak loads in cold northern climates. If that supplemental heat is provided by electric resistance elements, the overall efficiency of the system can be reduced substantially. Air-to-air heat pumps also require a defrost cycle to remove frost from the outdoor heat exchanger during cold weather. Hot refrigerant gas is periodically recirculated in the outdoor coil to melt the frost. The energy used to defrost also lowers overall system efficiency.

Keyword- *COP, Condesation,VCR cycle,Efficiency,Heat Pumps,Refrigerants.*

I. INTRODUCTION

Heat pumps are used to move heat from one medium where it's readily available to another medium that can accept it. The medium donating the heat is called the "source," while the one receiving the heat is called the "sink."

Water to water heat pump device can extract heat from a flowing source of low temperature water and deliver that heat to another, higher temperature water stream. The low temperature source may be ground water, cooling water from an industrial process or even process water that needs to be chilled before use. Almost any situation where heat is available in the form of low temperature water, in combination with a simultaneous load to which heat can be delivered in the form of higher temperature water, is a possible application for a water-to-water heat pump.

The 21st century is facing huge problems of energy crisis. Due to this, there are advancements in almost every field of engineering. One of that field which has great importance is Refrigeration and Air conditioning. This paper comprises of detailed case study about reversible heat pumps and their different types along with applications. Geothermal heat pump is one of the recent innovations that have been being researched on large scale in European countries. ***Scope for this project is as follows:-***

1. To develop a high temperature water heating heat pump by condensation technique.
2. Reduce load on condenser
3. Increase efficiency.

II. METHODOLOGY

1. Study on different types of heat pumps , Air-Air, Air-Water, And study of Water to Water heat pump.
2. Study on refrigerants used in heat pumps and its selection for the system.
3. Calculation of cooling load as per required application.
4. Selection of components such as compressor, condenser, capillary tube and evaporator.
5. fabrication of physical model as per selection.
6. Experimental analysis of the system with analytical calculation.
7. Optimization of system.

ISSN: 2233-7857 IJFGCN

III. LITERATURE SURVEY

Heat Pumps are used in the market for various residential, commercial and industrial purposes. In residential purposes, water heating is majorly achieved by solar heating and electric geyser. Today, due to its high efficiency, cost savings, space savings and high productivity, heat pumps are replacing the current methods of producing hot water. Space heating is another comfort need that is must during the cold climates and rainy seasons. For overall comfort needs, the above-mentioned requirement plays a major role.

In today's world, where space savings , highly efficient and low wastage compact machines can reward with a great benefit. Instead of using three different devices for three different needs it would be more flexible, profitable and efficient if a single device can produce all the required results .

Improvements in the characterization of the efficiency degradation of water-to- water heat pumps under cyclic conditions :-

This paper presents a study on the characterization of the performance of a water- to-water heat pump of 40.5 kW fixed heating capacity under different cycling conditions scenarios. Semi-virtual laboratory experiments were conducted to analyse the influence of inertia ohm 1.23 to 24.7 L/kW on the efficiency of the heat pump operating at partial load. These parameterizations will lead to significant performance over prediction in the case of real installations where start-up losses may be significant.[1]

A study on the performance characteristics of the testing facility for a water o water heat pump :-

In this study, the performance characteristics of the testing facility for a water-to- water heat pump are investigated according to the variation of heat pump capacity and COP in both cooling and heating operating modes. The objective is to analyze the energy consumption of the test facility used to investigate the performance of a water-to-water heat pump unit.

The analysis of experimental test results showed that the total energy consumption rate of the heat pump test facility increased as capacity and COP of heat pump increased in both cooling and heating modes. In study, a water-to-water ground source heat pump unit with variation in capacity from 3 to 9 kW and COP from 3 to 6 was tested in a conventional heat pump testing facility in both cooling and heating operating modes

The total energy consumption rate in heating mode was about 15% and 20% higher than in cooling mode as heat pump COP and capacity increased respectively. Also, , the total energy consumption rate of the test facility was about 10 times more than the energy consumption rate of the heat pump test unit itself. This implied that, conventionally, the test facility for a heat pump unit consumes so much energy to evaluate the performance of a heat pump unit. [2]

Improved water to water heat pump design for low temperature waste heat pump design for low temperature waste heat recovery based on subcooling control *;-*

This work presents the experimental results of a new water-to-water heat pump composed by the basic heat pump components (condenser, compressor, evaporator, expansion valve and liquid reliever) able to adapt its performance depending on the required water temperature lift. Result Show COP values up to 5.5 at the design condition (20- 15ºC at the inlet-outlet of the evaporator and 10-60ºC at the inlet-outlet of the condenser) and an optimal degree of subcooling of 47K.

The developed prototype is a water-to-water heat pump for heating water from 10ºC 60ºC from the heat recovery of any low temperature water source which controls the subcooling with the expansion valve in order to maximize the efficiency.

The obtained results show that the proposed heat pump configuration with the proposed control system for the expansion valve could increase significantly the efficiency of the heat pump overall when a high water temperature lift is imposed by the application.[3]

Performance of R407C as an Alternate to R22:

In this paper Calculation related to the exergy for both R22 and R407C vapour compression plant and they reported that the overall exergetic performance of R22 was significantly better by maximum of 45% to a minimum of 7%. Exergy destroyed in the overall plant for R407C is greater than R22.

Exergy flow destroyed in the compressor is always greater for R407C in the range of 4-13 % due to higher power consumption or irreversibility. The exergy flow destroyed in the evaporator and

ISSN: 2233-7857 IJFGCN

condenser working with R407C was always higher than R22 in the range of 4-10% and 2-19% respectively.
They concluded that the evaporator and compressor must be optimized in order to improve the overall plant performance.[4]

IV. THEORETICAL APPROACH

Water heating is a heat transfer process that uses an energy source to heat water above its initial temperature. Typical domestic uses of hot water include cooking, cleaning, bathing, and space heating. In industry, hot water and water heated to steam have many uses.
These metal vessels that heat a batch of water do not produce a continual supply of heated water at a preset temperature. Fossil fuels (natural gas, liquefied petroleum gas, oil), or solid fuels are commonly used for heating water. These may be consumed directly or may produce electricity that, in turn, heats water. Electricity to heat water may also come from any other electrical source, such as nuclear power or renewable energy.
Alternative energy such as solar energy, heat pumps, hot water heat recycling, and geothermal heating can also heat water, often in combination with backup systems powered by fossil fuels or electricity.[5]

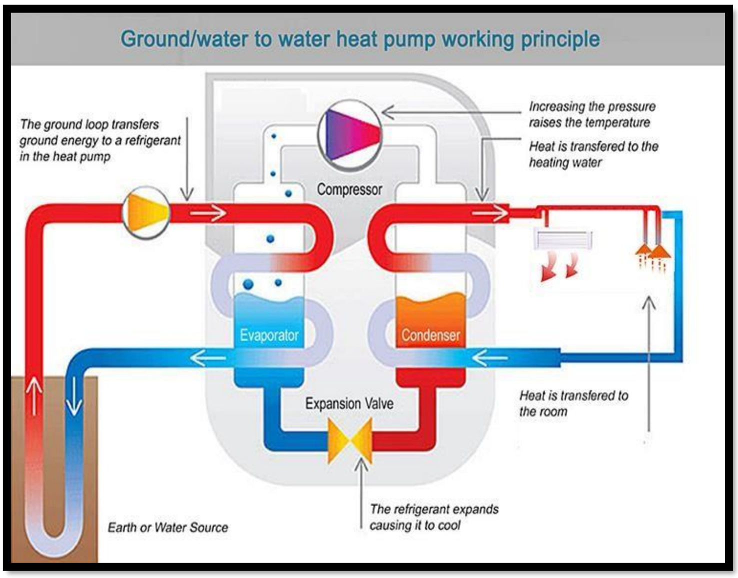

Figure no- 1 : Working of Heat Pump

Design Calculation:

1. <u>Assumed parameter before design and selection</u>:
2. <u>Refrigerant: - R407</u>
3. <u>Condensing temperature:- 60°C</u>
4. <u>Evaporating temperature: - 5°C</u>
5. <u>Initial water temperature: -30°C</u>
6. <u>Final water temperature: -15°C</u>
7. <u>Assumed time to reach final: 3600sec water temperature sec.</u>
8. <u>Water to be cooled in liters:-200 liter</u>

<u>Compressor selection: -</u>

Energy input required= m.Cp.ΔT
= 200*4.187*15
=12561 KJ

<u>Capacity of heat pump = energy input/ time</u>

= 12561/3600

= 3.48 KW
From selection report of compressor,
For 5°C evaporating temperature and 60°C condensing temperature.

<u>Compressor selection values: -</u>

Parameter Values
Condensing capacity (KW)= 4.93
Input power (KW) =2.59
Evaporating capacity (KW)=6.98

<u>Operating characteristics of compressor:</u>

Compressor – ZR28K3E-PFJ
Mass flow rate – 133.13kJ/kg
Maxm high pressure- 29.5 bar
Suction pressure – 20 bar
Low side temperature - 5°c

From above values plotting P-H chart for R407c refrigerant we get

<u>At state 1:</u>

P_1=2.785bar
T_1=50°C
h_1=410kJ/kg

<u>At state 2 :</u>

P_2=29.5bar
T_2=110°C
h_2=480kJ/kg

<u>At state 3 :</u>

T_3=62°C
P_3=29.5bar
h_3=300kJ/kg

Heat rejected to water from P-H chart

$Q=m*(h2-h1)$
$=133.13*(480-300)/3600$
$=6.656$kw

<u>At state 4 :</u>

P_4=2.785
T_4=-18°C
h_4=300kJ/kg
$Q=m*(h2-h1)$
$=133.13*(410-300)$
$=4.07$kw

COP of System

COP=Heating Capacity/Input power
=4.93/2.59
=1.903

V. CONCLUSION

1. Water source Heat Pump, Water Heater is designed and prototype is fabricated.
2. Tests are performed on developed prototype is well conditioned test facility.
3. Calculated values are validated with test results.
4. This device can be directly used in place of Electrical Water Heater in standard Indian house.
5. Heat Pump can be best choice for water heating, if technology is properly promoted , by the government through advertisement and subsidy.The drawback being higher initial cost, subsidizing the heat pump will make it able to compete even with Solar Water Heater.

ISSN: 2233-7857 IJFGCN

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ISSN: 2233-7857 IJFGCN