THERMODYNAMICS ANALYSES FOR THE COMPRESSION OF AIR REFRIGERATION SYSTEM AND EXISTING VAPOR COMPRESSION REFRIGERATION SYSTEM

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ABSTRACT: Ever since the creation of air conditioning and refrigeration in the late nineteenth century, there has been marvelous interest in increasing system efficiency to reduce the impact these systems have on global energy consumption. Efficiency improvements have been accomplished through component design, refrigerant design, and most recently programming for the investigation. The advance controlling system made impact on the ability to regulate system parameters, resulting in important strides towards efficiency progress.

The dependence on the composition of refrigerant mixtures makes the pressure–temperature relationship in the cycle significant for condensers and evaporators. Cycle performance is affected by the pressure alterations while the ratios of the combine vary at the given temperature. For that reason, the proportion of the components in the mixture is one of the significant factors in the cycle. For comparison of the theoretical R22 are chosen in this paper as reference fluids due to their common usage in cooling systems and prohibition by the Montreal Protocol.

The analysis of the variation of physical properties of pure and blend refrigerants such as evaporation pressure (Pevap), pressure ratio, isentropic compression work (W), refrigerating effect (RE), power per ton of refrigeration, volumetric refrigeration capacity (VRC), suction vapor flow rate (SVFR) and coefficient of performance (COP) is investigated in this theoretical study.

This research presents tools and methodologies for programming development and analysis for air conditioning and refrigeration systems. In this thesis another notable contribution of this thesis is the development of software-in-the-loop load emulation which provides a method to test component and software control loop performance. The theoretical model was verified with the help of simulation program developed in c++ the effect of condition on the performance of air refrigeration system and vapor compression refrigeration system and on various parameters was analysis by plotting curve between different parameters at different condition. A comparison with steady state results of heat exchangers is presented showing a very good agreement.

Keywords- Refrigeration, cycle simulation, vapor-compression cycle, thermodynamic analysis

I. INTRODUCTION

The device of air conditioning and refrigeration (AC&R) in the late nineteenth century has contributed to the higher standard of living that we are provided with today. Every day, society relies on air conditioning systems for human comfort whether it is in our homes, offices, or automobiles. Refrigeration system have also transformed the way we live. For example, these systems allow perishable goods to be transported spatially throughout the world which would otherwise be nearly impossible. These few examples are among a countless list of applications which rely on AC&R systems.

Systems that use vapor compression cycles, such as air conditioners and refrigerators, account for significant portions of the overall energy utilization of industrial, commercial, and residential applications. According to a study released in 2005, 33.2% of residential energy consumption and 34% of profitable energy consumption is from cooling and refrigeration.

This study has also reported that the average household spends about $1800 a year on air conditioning and refrigeration alone. Without doubt, air conditioning and refrigeration systems cover made an enormous impact on our society and will continue to do so into the foreseeable future.

Since the development of the first AC&R systems there has been tremendous interest in improving the efficiency of the vapor compression cycle (VCC). Past research efforts have focused on investigating the effects of refrigerant type, heat exchanger design, component design, and more recently control system design. Improved efficiency of vapor compression systems may be realized through higher control design. As sensors, computers, and actuators become more cost effective, electronic system control is increasingly more practical for implementation on AC&R systems.

Research in this field focuses on formative methods to best use sensor information to control system parameters during system-wide operation. The ability to precisely control system parameters improves effectiveness while also extending the systems lifetime since harmful operating conditions can be avoided.

This thesis makes contributions to both evaporator superheat control design and the development of an alternative AC&R testing method. Evaporator superheat is a key parameter in the vapor compression cycle that is controlled to maximize evaporator efficiency while defensive the system from component damage. A goal of this research is to identify, examine, and further develop the state of the art evaporator superheat control configuration.

Another significant donation of this thesis is the development of hardware-in-the-loop load emulation which provides an alternative method for testing AC&R systems. This method has been developed to test control algorithms and system performance to conditions that are representative of environment that the AC&R system may be subjected to while in service in the field. This method provides a flexible environment for testing with a reduced need for full scale environmental test chambers.

1.1 Air-Conditioning Systems

Depending on applications, there are more than a few options / combinations of air conditioning, which are available for use:

- Air conditioning (for space or machines)
- Split air conditioners
- Fan coil units in a larger system
- Air usage units in a larger system

1.2 Refrigeration Systems (for processes)

The following refrigeration systems exist for industrial process (e.g. chilling plants) and domestic purposes (modular units, i.e. refrigerators):

Small capacity modular units of the direct expansion type similar to domestic refrigerators.

central chilled water plants with chilled water as a secondary coolant for a temperature range over typically 5 oC. They can also be used for ice bank formation.

Brine plants, which use brines as a lower temperature, secondary coolant for typically sub- zero temperature applications, which come as modular unit capacities as well as large central plant capacities.

The plant capacity up to 10 TR (tons of refrigeration) are usually measured as small capacity, 10 – 300 TR as medium capacity and over 300 TR as large capacity units. A large company may have a bank of units, often with common chilled water pumps, condenser water pumps, cooling towers, as an off site utility. The same company may also have two or three levels of refrigeration and air conditioning such as a combination of:

Comfort air conditioning (20 – 25 oC)
Chilled water system (80 – 100 C) Brine system (sub-zero applications)

Types of refrigerant used in vapor solidity systems
A variety of refrigerants are used in vapor compression systems. The mandatory cooling temperature largely determines the choice of fluid commonly used refrigerants are in the family of chlorinated fluorocarbons (CFCs, also called Freon's): R-11, R-12, R-21, R-22 and R-502. The property of these refrigerants are summarized in Table 1 and the presentation of these refrigerants is given in Table.

Refrigerant	**Boiling Point ** (oC)**	**Freezing Point (oC)**	**Vapor Pressure * (kPa)**	**Vapor Volume * (m3 / kg)**	**Enthalpy* Liquid (kJ / kg)**	**Vapor (kJ / kg)**
R-11	-23.82	-111.0	25.73	0.61170	191.40	385.43
R-12	-29.79	-158.0	219.28	0.07702	191.72	347.96
R-22	-40.76	-160.0	354.74	0.06513	188.55	400.83
R-502	-45.40	-----	414.30	0.04234	188.87	342.31
R-7 (Ammonia)	-33.30	-77.7	289.93	0.41949	808.71	487.76

** At -15 oC Evaporator Temperature, and 30 oC Condenser Temperature*

** COP* **carnot** *= Coefficient of Performance = Temp.Evap. / (Temp.Cond. -TempEvap.)*
The choice of refrigerant and the required cooling temperature and load determine the choice of compressor, as well as the design of the condenser, evaporator, and other auxiliaries. Additional factors such as ease of maintenance, physical space requirements and availability of utilities for auxiliaries (water, power, etc.) also influence component selection.

Objective of work Based on lettuce review it is observed that the analysis of vapor compression refrigeration system and air refrigeration system lace on important role for the study of refrigeration plant and cold storage and there is need to compare vapor compression refrigeration system and air refrigeration system with respect to coefficient of performance , power ,and mass flow rate.
And also there is requirement to simulate the calculation process so that repetition of calculation can be avoided.

The objective of our study "**THERMODYANAMIC ANALYSIS FOR THE COMPRESSION OF AIR REFRIGERATION SYSTEM AND EXISTING VAPOR COMPRASSION REFRIGERATION SYSTEM"**
An cooling system has the possible for widespread application in industrial and building because its cools the air without adding moisture to it. This is achieved with the use of some from of heat –exchanger that uses the cool moist air , produced through cooling , to lower the heat of drier air .this cool dry air is then used to cool the environment

METHODOLOGY AND RESULT

a. Problem formulation.
b. Simulation of mathematical model in c++
c. Theoretical analysis and result.

Calculation method

The pressure–enthalpy figure prepared for theoretical data for two different cases is shown in Fig. 1. The ideal refrigeration cycle in Fig. 1 is considered for the working matter that change phase during the cycle. It is identified

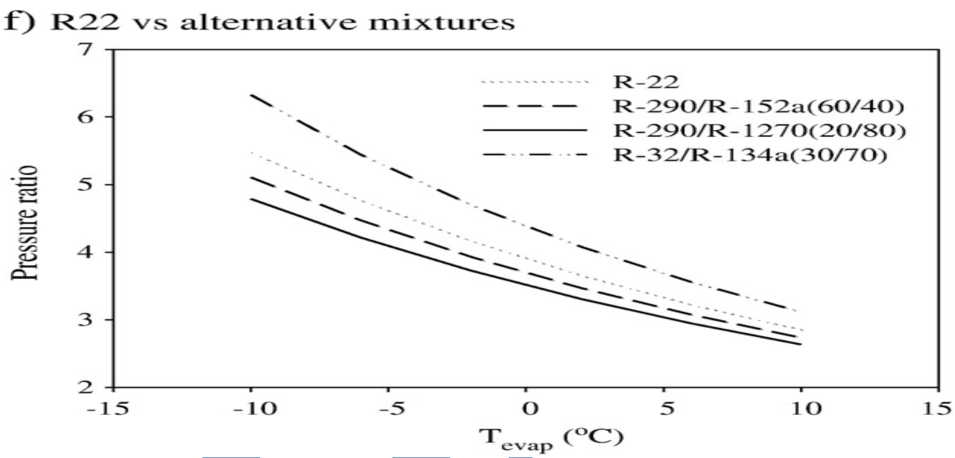


Fig. 1: The pressure–enthalpy

that the actual refrigeration cycle systems have some deviations from the ideal one due to pressure losses of fluid flow and heat transfer exchange between the surroundings. The superheated state of vapor exists at the inlet part of the compressor as the pressure of the liquid at the exit part of the condenser is lower than the pressure at the inlet part of it, there is a pressure drop greater than the ideal one between the condenser and expansion valve, and also a larger pressure drop occurs on the evaporation line. Cycle performance determination is performed to ease the theoretical calculations by means of some assumptions as follows: neglect of the pressure drops and the heat losses to the environment from the devices of evaporators, recuperators, sub cooler, phase separator and condensers; saturated vapor at the low boiling point stream (vapor phase) from the barrier and saturated liquid at the high boiling point stream (liquid phase) from the separator in the isenthalpic flow across the expansion valves; and the considered isentropic efficiency for the compressor. When the thermodynamic properties of each state of the cycle are determined, the equations for the cycle study can be obtained by means of mass and energy conservation. The data decrease of the theoretical results can be analyzed blown the pressure ratio of the cycle can be seen below as follows:

Thepressureratio = Pcod = Pevap: ð1Þ

Isentropic compression work of the compressor (Wcomp) is expressed as follows:

Wcomp = h2−h1:

The refrigerating effect (RE), in other words, the heat transfer rate of the evaporator (Qevap), is calculated as follows:

RE = Qevap = h1−h4: ð3Þ

Power per ton of refrigeration is calculated as follows:

Power per ton of refrigeration = TRÞ = 3:5Wcomp = RE: ð4Þ

In the vapour-compression system in volumetric refrigerating capacity (VRC) is given as:

VRC = ρ1·RE: ð5Þ

Suction vapour flow per kW of refrigeration can be determined as:

SVFR = 1= ρ1ð ·REÞ: ð6Þ

The coefficient of performance (COP) of the refrigeration system's cycle can be determined by:

COP = RE /Wcomp:

<u>Formulation</u>

1. Mass flow rate (Ma)= Total heat/actual heat
   Ma=Q/q

2. power consumption =mass×work done

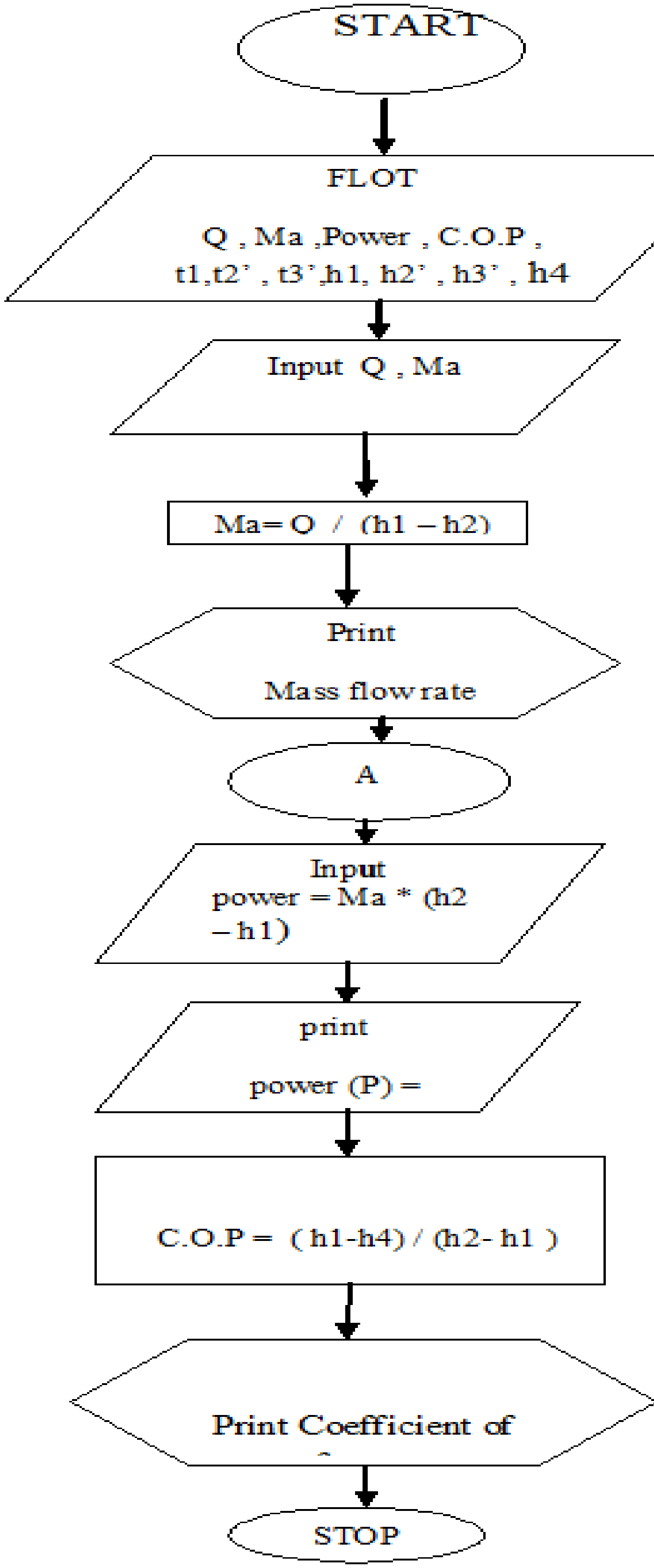
   P=Ma×W

3. c.o.p =R.E/work done

   c.o.p=h1-h4/h2-h1

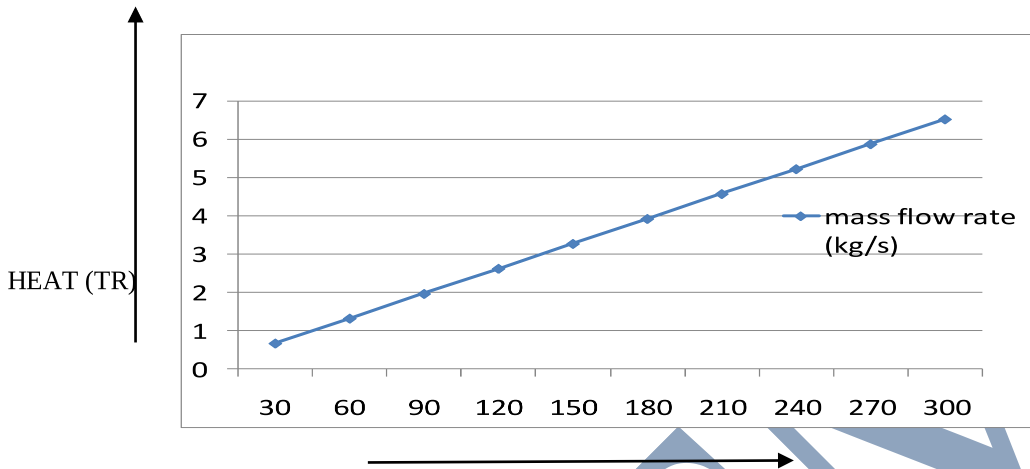
In order to make the task of calculation based on mathematical model easy a user friendly computer program is developed in c++.

RJETM


START
FLOT
Q , Ma ,Power , C.O.P ,
t1,t2' , t3',h1, h2' , h3' , h4
Input Q , Ma
Ma= Q / (h1 – h2)
Print
Mass flow rate
A
Input
power = Ma * (h2
– h1)
print
power (P) =
C.O.P = (h1-h4) / (h2- h1)
Print Coefficient of
STOP

Theoretical Analysis

The result acquired from theoretical analysis using simulation in computer program (C++) as show in table. Are plotted in the from of graphs.



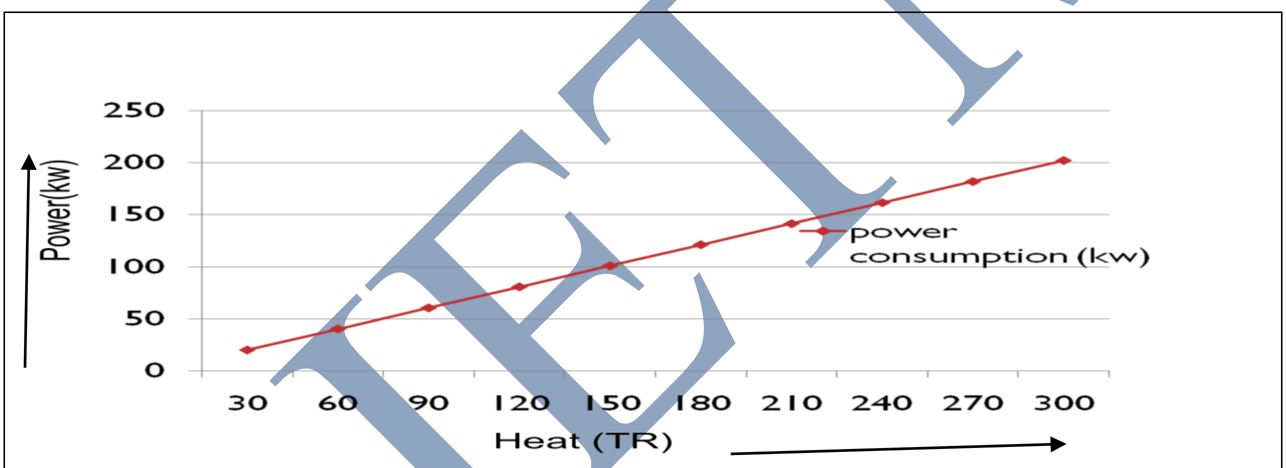


Fig. 2: Heat and power consumption curve.

The observation taken from the figure 2 that power consumption increased in heat capacity linearly increased.

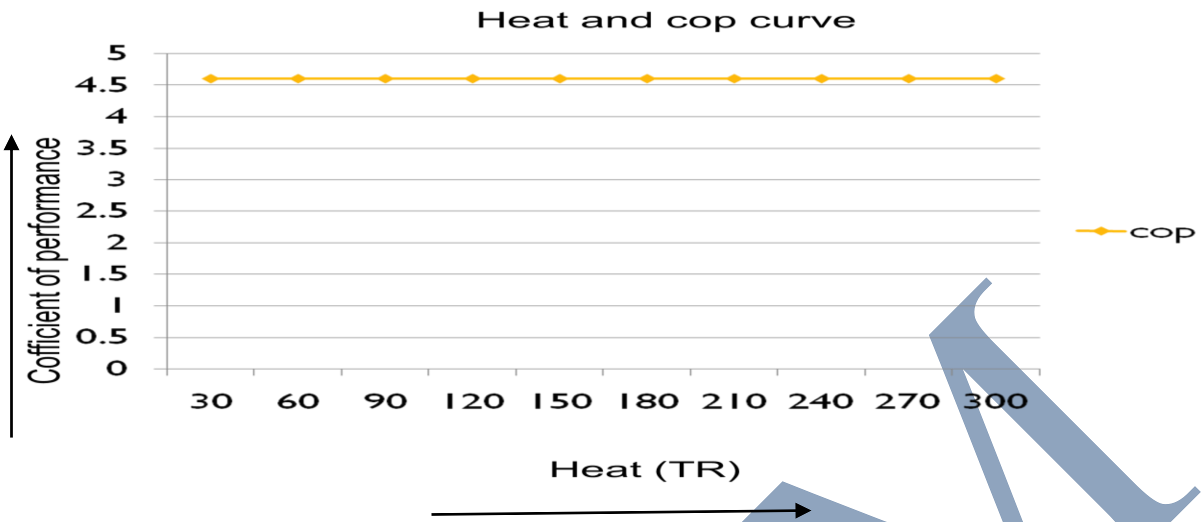


Fig. 3: Heat and cop curve.

The observation taken from the figure 3 that coefficient of performance is constant in heat capacity linearly increased.

V. CONCLUSION

(1) The COP of vapor compression refrigeration system is more than that of air refrigeration system. because the outlet temperature of evaporator increases in the air refrigeration system due to flow of air through evaporator consequentially is the power consumption unit is high in air refrigeration system but the increment in refrigeration effect in air refrigeration system is such as it given lower coefficient of performance for air refrigeration system as compare to vapor compression refrigeration system for same operating condition.

(2) Power consumption is air refrigeration system is more as compare to vapor compression refrigeration system .because of increment in temperature causes rise of enthalpy an hence the work required is more.

(3) Mass flow rate of refrigerant in air refrigeration system is slightly increased due to flow of air over the evaporator section.

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