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Cascade Refrigeration System "For Blood Storage"

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Abstract- **Cascade refrigeration systems are used for very low temperature applications where the desired temperatures are in range of -30 °C to -80 °C. The objective of this project is to design and develop a two stage cascade refrigeration system using R404 and R22 as refrigerants. R404and R22 are selected for this study as the high temperature and low temperature refrigerant respectively. The design of major components including the cascade condenser, the tube in tube heat exchanger and the LTC evaporator is carried out. A fully instrumented experimental facility has been created to carry out detailed experimentation on two stage cascade systems. Air cooled condenser of split window air conditioner is taken as the 1-1TC condenser. The cascade condenser is designed as a flooded shell and tube heat exchanger, while LTC evaporator is a fin and tube type heat exchanger. The LTC evaporator and cascade condenser are hydraulically tested at pressures of 120 bar. The instrumentation is connected to a data acquisition system for continuous recording and monitoring of data.**

Keywords: *Cascade, compressor, condenser, evaporator, tube in tube heat exchanger accumulator, Drier filter.*

I. INTRODUCTION

Refrigeration is defined as the process of removing heat from a body or enclosed space so that its temperature is first lowered and then maintained at a level below temperature of surrounding.

For some medical applications that require moderately low temperatures with a considerably large temperature and pressure difference, then the single stage vapor-compression refrigeration cycles become impractical. One of the solutions for such cases is to perform the refrigeration in two or more stages which operate in series. These refrigeration cycles are called cascade refrigeration cycles. A cascade refrigeration system consists of two independently operated single-stage refrigeration system

II. DESCRIPTION OF MODEL

Fig. 1 Cascade cyle , Actual Model and reading of project.

Compressor: It is used to compress the vapour refrigerant from the evaporator and to raise the pressure so that the corresponding saturation temperature is higher than that of the cooling medium. It also continually circulates the refrigerant through the refrigerating system. Since the compression of refrigerant requires some work to be done on it, therefore a compressor are must be driven by some prime mover.

Condenser: The condenser is an important device used in high pressure side of a refrigeration system. Its function is to remove heat of the hot vapour refrigerant discharge from the compressor. The heat from the hot vapour refrigerant in a condenser is removed first by transferring it to the walls of the condenser tubes and then from the tubes to the condensing or cooling medium.

Evaporator: The evaporator is used in the low vapour side of refrigeration system. The liquid refrigerant from the expansion valve enters in to the evaporator where it boils and changes in to vapour. The function of evaporator is absorbing heat from the surrounding location of medium which is cooled, by means of refrigerant.

Expansion Device : It reduce high pressure liquid refrigerant to low pressure liquid refrigerant before being fed in to evaporator. It maintains the desired pressure difference between the high and low pressure sides of the system, so that liquid refrigerant vaporize at the designed pressure in the evaporator. It controls the flow of refrigerant according to the load on the evaporator.

Pressure Gauges: Many techniques have been developed for the measurement of pressure and vacuum. Instruments used to measure and display pressure in an integral unit are called pressure gauges or vacuum gauges.

Dryer: A compressed air dryer is used for removing water vapor from compressed air. Compressed air dryers are commonly found in a wide range of industrial and commercial facilities. The process of air compression concentrates atmospheric contaminants, including water vapor.

Temperature indicator: The controller contains a temperature control where the signal can be received from one temperature sensor. The sensor is placed in the cold air flow after the evaporator or in the warm air flow just before the evaporator. The controller controls the def rost with either natural defrost or electric defrost. Renewed cetin after defrost can be accomplished based on time or temperature. A measurement of the defrost temperature can be obtained directly through the use of an S5 sensor.

Refrigerant: Refrigerant is a heat transporting medium which during their cycle (compression, condensation, expansion and evaporation) in the refrigeration system absorbs heat from a low temperature system and discard the heat so absorbed to a to a higher temperature system. We are using R404a & R22 Refrigerant for Low And High Temp. Cycle respectively.

III.WORKING

Fig.2 shows the cascade refrigeration system in which low pressure and low temperature LTS(low temp. cycle) refrigerant vapour in superheated form at state 1 enters into compressor where it compressed to high pressure and temperature at state 2. It is then condensed and sub-cooled in cascade condenser from state 2 to state 3 by transferring heat to HTS (high temp. cycle) refrigerant. LTS refrigerant is further expanded in expansion device from state 3 to 4. HTS refrigerant in a superheated form at state 5 compressed to high pressure and high temperature vapour at state 6. It is further condensed and sub-cooled to state 6 to 7 in Air cooled condenser. HTS refrigerant is further expanded in expansion device from state 7 to 8.

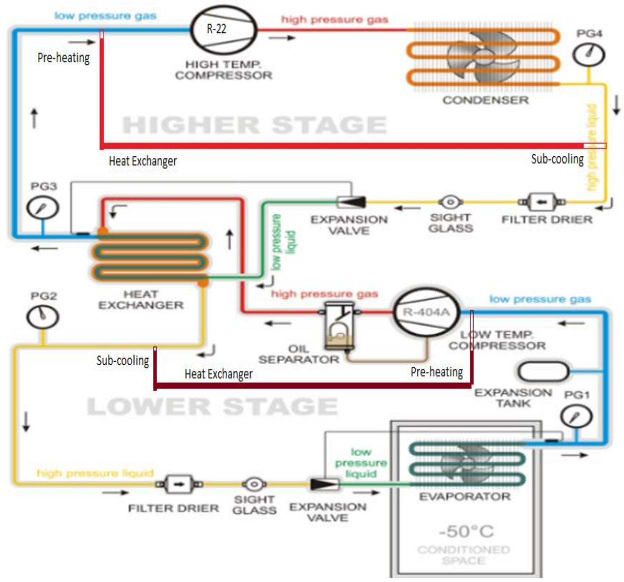

Fig. 2 Working cycle.

It is then evaporated to state 5 in cascade condenser by extracting heat from LTS refrigerant. HTS refrigerant is further expanded in expansion device from state 3 to 4. Design of cascade system has been carried out for evaporating temperature (Te) of -80 *C, condensing temperature (Tc) of 32 *C, cooling capacity of 0.5 kW, superheating and sub cooling of 10 *C for both HTS and LTS, compressor efficiency of 80% for HTS and 85% for LTS. Air inside the cabinet is cooled by evaporator coil is made of copper material having outer diameter of 1/4 inch. In cascade condenser LTS refrigerant flowing through the inner tube of diameter 3/8 inch and is surrounded by HTS refrigerant flowing through outer tube of diameter ½ inch. Thermal conductivity of copper tube is taken 386 W/m K.

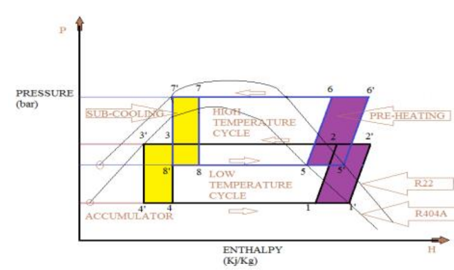

Fig 3 Modified P-H Diagram

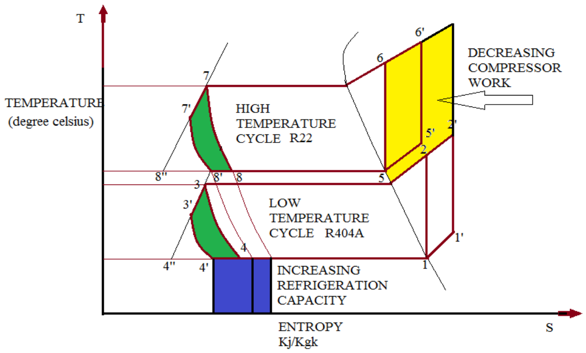

Fig 4 Modified T-S Diagram

IV. THERMODYNAMIC ANALYSIS

Following assumptions are considered for the thermodynamic analysis of two stage cascade refrigeration system. Adiabatic and irreversible compression with an isentropic efficiency of 0.8 for both high and low temperature compressors. Negligible pressure and heat drop in the piping or system components. Isenthalpic expansion of refrigerants in expansion valves. Heat transfer process in heat exchanger is isobaric. Changes in kinetic and potential energy are negligible. By using COOL PACK software:

For Low Temperature Cycle:

H1	**337.36**
H2	398.00
H3	273.00
H4	273.00
Qe	64.741
Qc	125.182
COP	1.07
W	60.440

For High Temperature Cycle:

H5	**405.62**
H6	469.29
H7	268.02
H8	268.02
Qe	137.738
Qc	201.497
COP	2.16
W	63.759

Mass Flow Rate in Low Temp. Cycle:
M1 = (Re*211)/(H1-H4)
M1 = (1*211)/(337.36-273)
M1 = 3.2784 Kg/min.
Mass Flow Rate in High Temp. Cycle:
M2 = M1* [(398-273)/(405.62-268.02)]
M2 = 2.9781 Kg/min.
Total Compressor Work = W = Wc1 + Wc2 = (H2 – H1) + (H6 – H5)
= (398 – 337.36) + (469.29 – 405.62)
= 124.31 kj/kg
Total Compressor Power = P = Pc1 + Pc2 = M1(H2 – H1) + M2(H6 – H5)
= 3.2784(398 – 337.36) +2.9781(469.29 – 405.62)
= 388.41kw
Overall COP (Coefficient of Performance) of the System:
COP = RE *211 / P
= 1 * 211 / 388.41 = 0.5432
Also, We know that

COP for low temp. cycle = 1.07 COP for high temp. cycle = 2.16

COP = (COP)LT*(COP)HT / 1+(COP)LT+(COP)HT

= 1.07*2.16 / 1+1.07+2.16

= 0.5432

= 54.32%

V. RESULT

A Computerized program has been developed to find the effect of particular parameter on the performance of a system by considering other parameters of a system as constant.

Refrigerant Effect RE = 1 TR = 1*211 = 211 Kj/min.

For Low Temperature Cycle:

T1 = Compressor inlet temperature = -25 degree C
T2 = Compressor outlet temperature = 45 degree C
T3 = Condenser outlet temperature = 7.1 degree C
T4 = Evaporator temperature = -50 degree C

P1 = Suction Pressure = -5PSI= -0.3445 Bar

P2 = Discharge Pressure = 80PSI = 5.512 Bar

COP (Coefficient of Performance) = 1.07

For High Temperature Cycle:

T5 = Compressor inlet temp.= 6.8 degree C

T6 = Compressor outlet temp.= 53.3 degree C

T7 = Condenser outlet temp. = 35.2 degree C

T8 = Evaporator temp. = 0.7 degree C

P1 = Suction Pressure = 20PSI = 1.378 Bar

P2 = Discharge Press. = 270PSI = 18.603 Bar

COP (Coefficient of Performance) = 2.16

Overall COP = 0.5432

VI. CONCLUSION

Impact on cop :- Introduction of a heat exchanger to bring the inlet of compressor and throttling device in physical contact in order to superheat the refrigerant entering the compressor and pre cool it before introducing to the throttling device. This helps achieve a better COP and long durability of the system.

L-Ratio:-The original condenser length responsible for the subsequent phase change of the refrigerant, was reduced so as to make the system compact. The performance variation by doing so was compensated and even improved by application of a high CFM motor fan.

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REFERENCES

[1] A. D. Parekh, P. R. TailorWorld Academy of Science, Engineering and Technology International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering Vol:5, No:10, 2011.
[2]B.L.Singhal, U.H.Sakhalkar "Refrigeration and Air Conditioning" Tech-Max Publication, January 2006(For Pune University) and First edition June 2015 ISBN 978-93-5224-057-9.
[3] Gajendrasinh G.Parmar, Dr. R. G. Kapadia "International Journal of Innovative Research in Science, Engineering and Technology" (An ISO 3297: 2007 Certified Organization) Vol. 4, PP.1839-1845, Special Issue 6, May 2015. ISSN (Online) 2319-8753, ISSN (Print) 2347-6710.
[4] Gulshan Sachdeva, Vaibhav Jain, S. S. KachhwahaWorld Academy of Science, Engineering and Technology International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering Vol:8, No:3, 2014.
[5] Mrs. J.S.JadhavMs. A.D.Apte novateur publications international journal of innovations in engineering research and technology [ijiert] issn: 2394-3696 volume 2, issue 6, june-2015.
[6] Prof. P.L. BALLANEY "Refrigeration and Air Conditioning" Khanna publication, First edition 1972 ISBN 81-7409-136—X.