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DESIGN AND FABRICATION OF CASCADE REFRIGERATOR: A REVIEW

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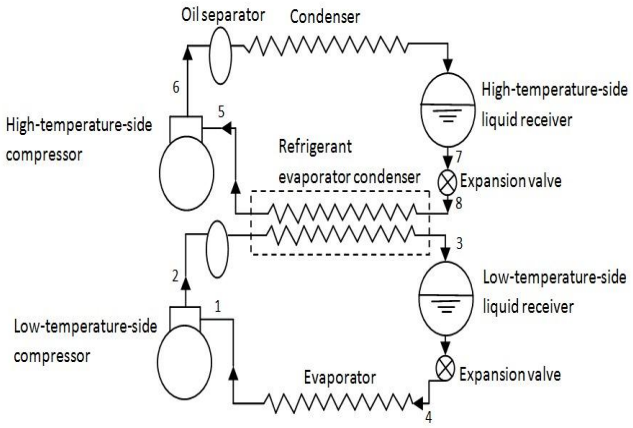
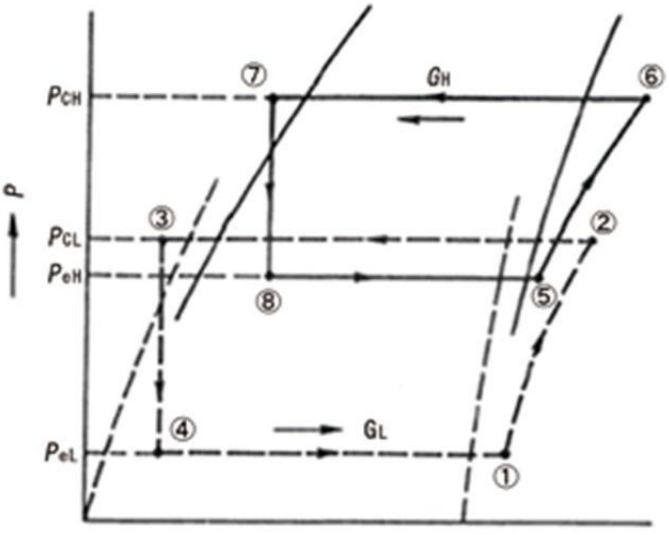
Abstract – This paper is related to cascade refrigeration System. Cascade refrigeration system is the combination of two vapor compression refrigeration system (VCRS). In this system two reciprocating single stage compressor are used. From the cascade refrigeration system -50° and above the same negative temperature can be obtained. This Cascade refrigeration system use two different refrigerant. The Low Temperature Circuit(LTC) use low boiling refrigerants such as R23 and High Temperature Circuit(HTC) use high boiling point refrigerants such R12. Refrigeration system is based on clausius statement on the 2nd law of thermodynamics. This system is used to reduce pollution and to get low temperatures.

Key Words: Cascade refrigeration system, Refrigerant, Low temperature circuit(LTC), High temperature circuit(HTC), Coefficient of performance(COP), Compressor, Condenser, Evaporator, Expansion valve, Capillary tube.

INTRODUCTION

Cascade refrigeration system used to bring very low temperatures. Many refrigeration applications require low temperature for quick freezing medical items, producing of dry ice, petroleum vapors liquefaction, pharmaceutical etc. Types of cascade refrigeration systems are two stage Cascade refrigeration system, three stage cascade refrigeration system, four stage cascade refrigeration system, five stage cascade refrigeration system, may used in system up to many stage. The higher the stage used lower the temperature receive. In this review paper we will talk about two stage cascade refrigeration system. Estimated low temperature -40 to -50. It is not advisable to use any other method to bring such a low temperature. Using cascade refrigeration system the high temperature is tilted towards the low temperature, Cascade refrigeration system is having a high compression ratio. Cascade refrigeration system is a simple type of system that is not complicated. Cascade refrigeration system has two vapor compression refrigeration system(VCRS). In this system 2 hermetically sealed compressor, 1 condenser, 1 evaporator, 2 expansion valve, Cascade heat exchanger (cascade condenser), And copper pipes component are used. Cascade heat exchanger is thermally bounded condenser and evaporator of two different cycle of system. Different refrigerant are used in both the cycle. R23 refrigerant is used in LTC compressor and another compressor is used with R12 refrigerant. The LTC use low boiling refrigerants such as R23 and HTC use high boiling point refrigerants such R12. Cascade refrigeration system work with many other refrigerants such as R744, R717, R440 etc but it harms the environment.





WORKING PRINICPLE:

A cascade refrigeration cycle is a multi-stage refrigeration system. A diagram of system is shown above. The cascade system is employed for devices such as ultra low freezer. In this cascade refrigeration system, two vapor-compression

cycles(VCRS) with different refrigerants are used. In this system there are mainly two cycles are used, (1)High Temperature Circuit(HTC) and (2)Low Temperature Circuit(LTC). The Evaporator of HTC is Thermally connected with the Condenser of LTC which is called cascade heat exchanger. The LTC extract heat from the space or room using an evaporator, and transfers it to a cascade heat exchanger that is cooled by the evaporation of the refrigerant of the HTC. A liquid to liquid or similar heat exchanger can be used. The HTC transfers heat to a main condenser that dissipate the heat output of the system by fan or water-cooled. At the end of cycle very low temperature acquired about -40° to -50° in LTC evaporator.

OBJECTIVE:

- To get ultra low temperature with higher efficiency of system or COP.
- Reduce GWP(Global Warming Potential) risk.
- Less costly from other method.
- To reduce the power consumption for getting same lower temperature.

LITERATURE REVIEW:

A number of experimental studies for development of Cascade refrigeration systems done with the two stage cycle type. Several test setups have been made and tested. First CFC refrigerants were used, but due to environmental consideration these refrigerants are banned, then HCFC refrigerants are used for few more time and are also restricted. Then after, more environmental friendly refrigerants are suggested, e.g. hydrocarbon refrigerant as well as HFC refrigerants and natural refrigerants.

[1] Bansal and getu: Analyzed a carbon dioxide(CO_2)–ammonia(NH_3).R744 is the chemical reference for carbon dioxide (CO_2) used as **refrigerant**–R717 is the chemical reference for ammonia used for refrigerant for cascade system, thermodynamically to determine the optimum condensing temperature of R744 in the low temperature circuit and mass flow ratio, to find out the system maximum coefficient of performance(COP) in terms of superheating, sub cooling, condensing temperature, evaporating temperature and temperature difference in the system cascade condenser. Result conclude an increase of superheat increased mass flow rate but reduces coefficient of performance(COP) of system also an increase in sub cooling increased both coefficient of performance(COP) and mass flow ratio. When the evaporating temperature is below −40°C. Also, the cascade system performance is greatly affected by evaporating temperature.

[2] G.Nicola: A analysis was done between results obtained in different temperature and pressure conditions, At the starting the cycle stage was operated using R23(trifluromethane) in the LTC, then replacing this fluid with the refrigerant binary system R744. Cascade cycle with R744 and R23 would seem an attractive option for future tests studies.

[3][4][5] A. D. Parekh: Analysis of cascade refrigeration system has been carried out using Environmentally friendly refrigerants like R507A and R23. Here R507a is a blend of HFC refrigerant composing different refrigerant mixtures. COP of the system increased from 0.7850 to 1.231 as low temperature circuit evaporator temperature (TE, LT) is varied from - 70 C to -40 C. The thermal design of condenser (HTC), cascade condenser and evaporator (LTC) of cascade refrigeration system has been carried out using two HFC refrigerant R404A-R508B and R410A-R23. The required heat transfer area of the condenser and the cascade condenser for R410A-R23 cascade system is lower than the R404A-R508B cascade system but heat transfer area of evaporator is similar for both the system. The comparison is made for heat transfer area of condenser (HTC), cascade condenser and evaporator (LTC) for both the systems. The effect of condenser and evaporator temperature on heat transfer area of condenser (HTC), cascade condenser and evaporator (LTC) are studied for both the systems.

[6] R. Hanuma Naik: The Objective is to improve & extend the working life. As the Cascade refrigeration system is developing in the field of refrigeration and air conditioning, exceptional comfort and saving are acquired. Maintaining the required low temperature and the cost is low. The low temperature is obtained mostly by VCRS, but it has its own disadvantages in producing low temperature. Hence for low temperature production multiple compression cycle is used namely cascade system. The cooling produced in HTC of system evaporator is used to cool the condenser of LTC, which reduces the temperature of condenser and allow to produce very low temperature for applications. This cooling is used up to 20 hours without power. Thus maintaining the low temperature of the products even without continuous power supply to system. In this project a LTC is designed to produce a temperature of - 50°C to -200°C.

[7] Ashutosh Mate: Proposed that, Cascade refrigeration system is the combination of two refrigeration cycle for maximum refrigeration effect can be obtained. In this system series of single stage vapor compression system(VCRS) are thermally bounded with the evaporator of HTC and condenser of LTC, this combination is known as cascade. This system is used to get temperature up to -50°C for the applications like ultra low temperature freezers and in blood banks and stores. The working fluid in system are R22 (LTC) and R134a (HTC), this particular refrigerant is used due their suitable difference in boiling point for the desirable outcome from the system. These fluids are environment friendly and GWP and ODP is negligible. And these refrigerants are less costly.

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