2006

Design and Optimization of a Walk In Refrigeration System

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ABSTRACT

The purpose of this paper is to discuss the design of an optimized refrigerant systems using R404A in a walk in refrigeration unit. Different parameters setting will affect system performance therefore there is the need to investigate the effect of such behavior. The parameters uses in investigating the optimized performance were airflow, superheat setting and refrigerant charge. The optimized conditions were recommended for the design of a walk in refrigeration unit.

1. INTRODUCTION

The vapor-compression cycle is usually the refrigeration system of choice for walk in types of applications. In order to optimize the refrigeration system design, understanding the system cycle is fundamental to understanding the behavior of the system individual components as to choose the optimize points of operations. A walk in refrigeration unit was constructed and installed on to a walk in cooler box. The test unit is used for the investigation on the effect of different parameters towards system performance. The parameters investigated were condenser airflow, superheat setting and refrigerant charge. These conditions were changed and their effects were discussed and recommendations of optimized conditions were presented.

2. REFRIGERATION SYSTEM

The refrigeration test system was constructed with pressure transducers and thermocouples installed into the refrigerating circuit. The electrical power usage by the system was also recorded to be use as performance comparison. The test unit was installed in a prefabricated walk in cooler room (3 X 3 x 3 m) for performance testing. Airflow measurement was conducted in a standard test room using the differential air pressure and nozzle coefficient. Figure 1; show the location of the sensors installed for data acquisition. Pressure reading were recorded for both suction and discharge pressure. The temperature readings measured were discharge, suction, condenser outlet, evaporator inlet and evaporator outlet temperatures. These reading are vitals in providing the thermodynamics properties at each stage of vapor-compression cycle. Figure 2; show the completed test unit before any instrumentation were installed for performance comparison.

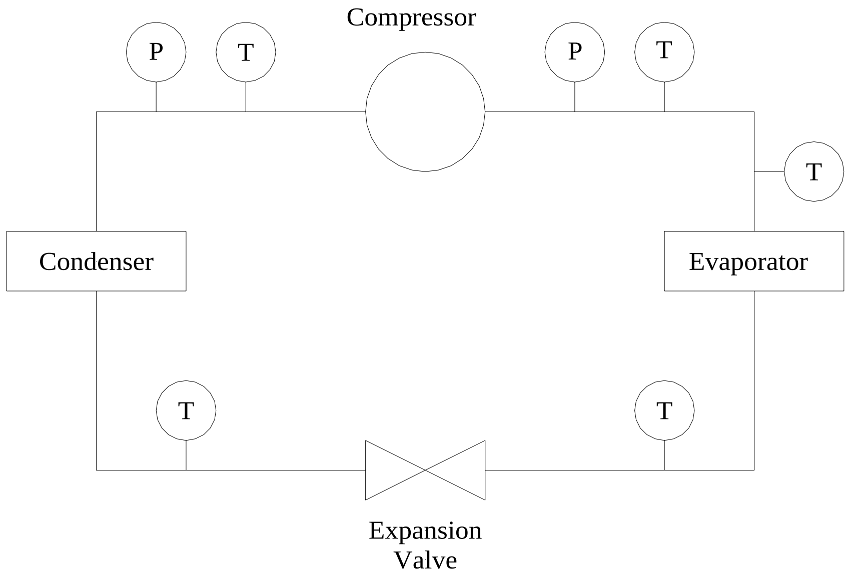

Figure 1: Schematic Diagram of Thermocouples And Pressure Transducer Location

Figure 2: Test Unit

3. RESULTS AND DISCUSSION

3.1 Air Flow Effect

The condenser airflow was used as one of the parameter that has an impact on the refrigerant system design as it can determine the amount of heat rejection. In this test, the room ambient was varied as to provide an indication on the airflow effect with different operating conditions. The airflow was varied thru the usage of a voltage regulator to control the speed of the fan motors. The differential pressure was measured with a pitot tube connected to the nozzle inlet and outlet. The airflow was obtained by multiplying the flow coefficient with the recorded pressure difference.

Figure 3 shows the relation between power consumption and airflow. At a lower airflow, we can see the trends that the power consumed was higher compare to the higher airflow values. Therefore, it is not advisable to use low airflow rate in the design. The power consumption seems to stabilize after the airflow reached 308 L/s. This provide an indication that the optimize airflow should be set around 310 L/s.

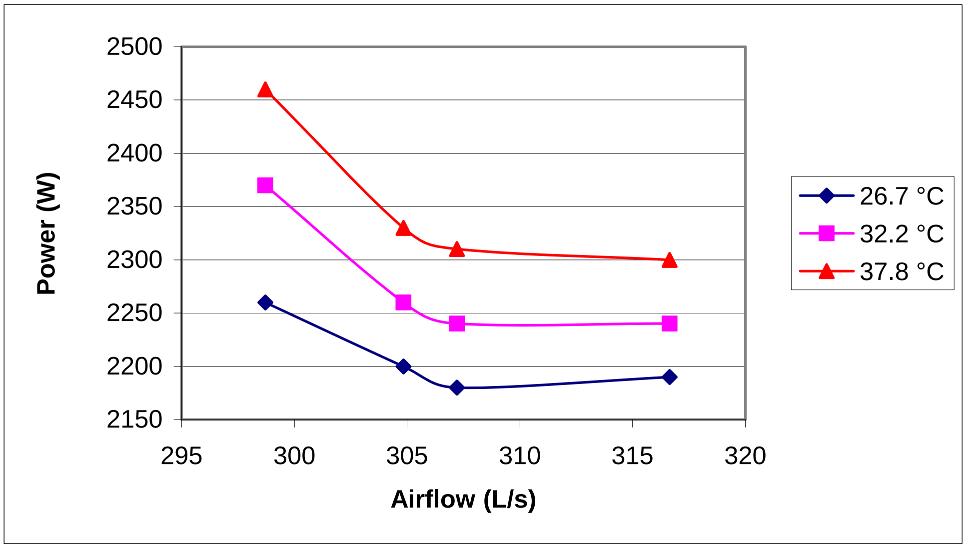

Figure 3: Relation Between Power Consumption And Air Flow

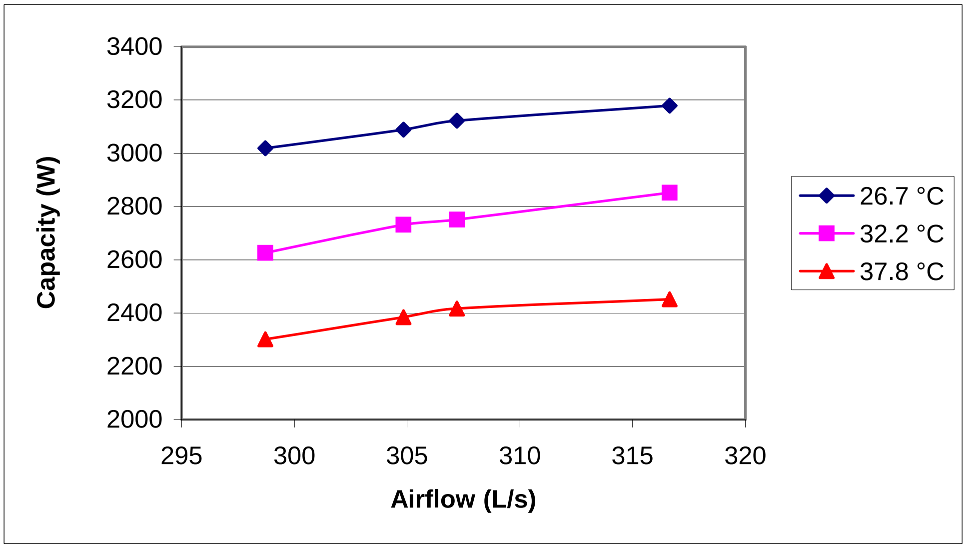

Figure 4: Relation Between Capacity And Air Flow

Based on figure 4, we noticed that the capacity of the system was highest at an ambient temperature of 26.7 °C. This can be used as main design point, however in actual field operations the ambient temperature ranges from 26.7 °C to 37.8 °C. Typically, this type of application is place near the roof of the building and the ambient temperature is closely related to the environment it operates on. Therefore, we recommended using an ambient temperature of 32.2 °C as design point for indoor walk in refrigeration system.

3.2 Superheat Effect

Superheat of the refrigerant was investigated in this application to determine the best superheat setting for such a systems. The reason for this is to prevent refrigerant from being superheated vapor where it can lower the capacity of the systems. The right amount of superheat is needed to enable the system to work in an optimum operating conditions. The tests were carried out with varied superheat temperatures while the ambient temperature and the refrigerant charge was fixed at 26.7 °C and .765 kg. The walk in cooler room temperature of 1 °C was maintained through out the test. By turning the adjusting stem in the thermostatic expansion valve, we are able to vary the superheats setting.

The superheat temperatures were obtained from temperature using suction pressure minus the evaporator outlet temperature. The power consumption was recorded using data acquisition. Figure 4 shows the relation between superheat temperature and power consumption. The trend indicates that, the lower the superheat setting, the higher the refrigeration unit power consumption. This is true due to the fact that with a lower superheat, the mass flow of the system increase thus lead to higher power consumption as the compressor had to move more flow. Based on this observation, we recommend a superheat setting of 10 °C that will satisfy all the design criteria.

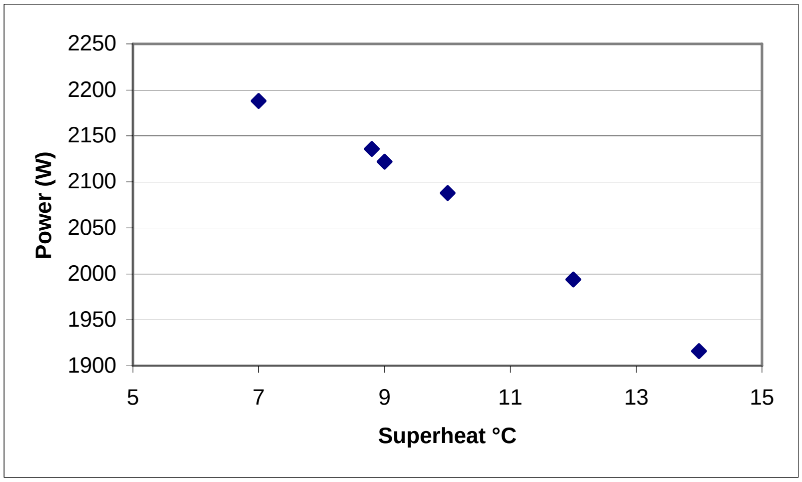

Figure 4: Relation Between Superheat and Power Consumption

3.3 Refrigerant Charge Effect

The purpose of investigating the refrigerant charge effect is to prevent an undercharged system design because it can lead to lower capacity and efficiency. In the refrigerant charge investigation, the tests were carried out with different charges while the ambient temperature was fixed at 26.7 °C. The superheat setting was varied between 9 °C and 14 °C. The cooler compartment temperature was maintained at 1 °C. From figure 5, we can see that the two different superheat setting converges on to a single point at .765kg. We can conclude that the operating point should be design with a refrigerant charge of .765kg.

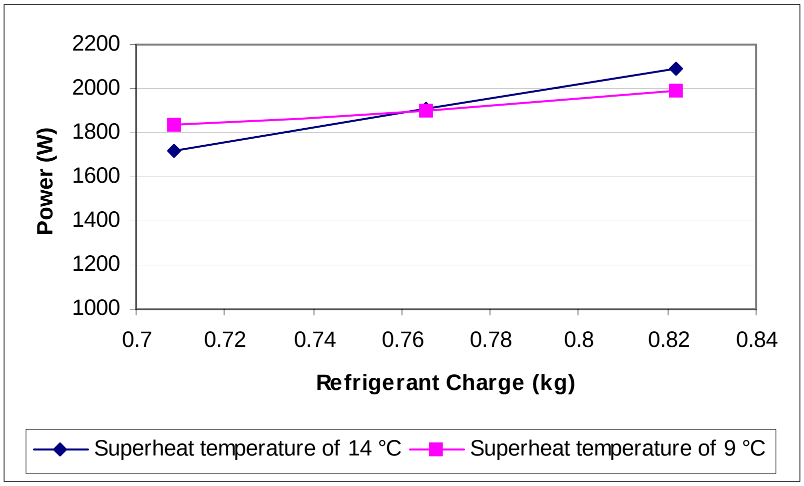

Figure 5: Relation Between Refrigerant Charge and Power Consumption

4. CONCLUSION

The recommendations for the optimization design of a walk in refrigeration system are summarized in the following.

1. Design the condenser air flow rate to be 310 L/s
2. Design for an ambient temperature of 32.2 °C for indoor application
3. Design the refrigeration system with a superheat temperature setting of 10 °C
4. Design using the refrigerant charge of .765 kilograms for system with capacity between 2600 to 2800 Watts.

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SPECIAL THANKS

The author thanks Mr. Randy Ries for his help with installation and instrumentation of the refrigeration unit.