Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 205 (2017) 373–380

Procedia Engineering

www.elsevier.com/locate/procedia

10th International Symposium on Heating, Ventilation and Air Conditioning, ISHVAC2017, 19-22 October 2017, Jinan, China

Theoretical And Experimental Research On High Efficiency Screw Chiller Used In Subway Station

Xiantai Wen[a,b,*], Liang Cai[b], Xiaosong Zhang[b], Pengfei Yu[a,b] and Xianqi Cao[b]

[a]*School of Energy and Power Engineering, Nanjing Institute of Technology, Nanjing, 211167,China*
[b]*School of Energy and Environment, Southeast University, Nanjing, 210096, China*

Abstract

As an important part of urban public transport, how to reduce energy consumption of rail transit becomes a focused issue. Considered with the operating characteristic of air conditioning in subway station, solution method with large temperature difference and high outlet temperature of 10/17 Celsius in evaporator is put forward. Two condensers and evaporators are linked in series and both of them are in countercurrent form, in which condition the energy efficiency can be improved greatly. Simultaneously high efficiency chiller with two different capacities of compressor heads is designed to improve the energy efficiency in part load. Experimental research of high efficiency chiller is conducted and the results show that: With the decrease of load percentage, COP (coefficient of performance) is fluctuated from 6.2 to 7.0. With the increase of outlet chilled water, COP increases greatly; while with the increase of outlet cooling water, COP decreases greatly. In this system at the design condition, COP can reach as high as 7.01, which can supply database for utilization of chiller in subway station air conditioning system.

Peer-review under responsibility of the scientific committee of the 10th International Symposium on Heating, Ventilation and Air Conditioning.

Keywords: Subway station; High efficiency; Countercurrent; Different compressor heads;

1. Introduction

With the development of our society, subway becomes more and more important for our people. From the first subway in 1863 to now, it has been a necessary part for our city's transportation. However the energy consumption is increased greatly in subway station. Through analyzing the operation of subway station, the energy consumption

* Corresponding author.
E-mail address: wenxiantai@163.com

1877-7058
Peer-review under responsibility of the scientific committee of the 10th International Symposium on Heating, Ventilation and Air Conditioning.
10.1016/j.proeng.2017.10.386

of air conditioning has the largest proportion, which is as high as 25%-35% [1]. So how to reduce the energy consumption and improve energy efficiency becomes the focus of our researchers' attention.

Compared with the traditional office building region, the subway station region has different suitable temperature and humidity because of its characteristic of high mobility and open space. Han et al [2] studied the comfort temperature and humidity in the subway station. Results show that in the subway station, the ideal average dry-bulb temperature is 27.1 Celsius, and the idea average relative humidity is 63.1%, which is much higher than the traditional office building's suitable temperature and humidity (dry-bulb temperature is 26 Celsius and relative humidity is 60%).The explanation for this phenomenon is that: the subway is in the open state, great air movement can be generated by movement of subway, movement of personnel and movement of elevator. In this condition, the heat dissipation and humidity dissipation accelerates greatly, and therefore a higher air-bulb temperature and wet-bulb temperature are needed.

Considered with the special condition of subway station, it has great significance to develop and design a high efficiency chiller which is suitable for subway station. A lot of researchers have carried on some research on chillers. Zhao et al [3] build the steady-state model of screw chiller with economizer and verify the model by experiments. The simulation results and experimental results have difference less than 5%. Results show that mathematic model has high accuracy for simulating the screw chiller system. Liu et al [4] build the mathematic model of screw compressor based on the operation parameters and design parameters. Compared with experimental date, the error of volumetric displacement date form simulation is less than 2%. The error of input power in full load is less than 3%. The error of input power and refrigeration flow rate in part load is less than 4%. Chen et al [5] have carried on some theoretical analysis and experimental study on screw compressor in part load. Mathematic model of slide valve on part load condition is built. Theoretical and experimental contrastive analyses in different operation condition are carried on and the simulation result tallies better with the experiment. Results show that the installation angle and effective length of slide valve have great influence on the performance of screw compressor. Yu et al [6,7] study the optimized performance of multiple chillers in the air conditioning building. Based on the characteristic of chiller, the optimized operation condition under different condition is analyzed, which can supply data and theoretical basement for chiller system operation. 5 chillers and its auxiliary equipment (cooling tower, chiller pump, cooling water pump) in one building in 2012 are studied, and the results show that the optimized chiller system can save as high as 5.34% energy. Liu et al [8] put forward the energy intensity for the air conditioning system. Results show that the energy intensity ratio of chiller is 64.11% for the whole system. Effective method to decrease the energy consumption of chiller in the air conditioning system is more and more important.

Therefore considering with the characteristic of energy using in subway station, a high efficiency screw chiller suitable for subway station should be studied and developed.

2. Characterisitc of high efficiency chiller system

Considering the practical condition, a high efficiency chiller with different compressor heads in countercurrent and cascade is put forward to realize the high efficiency subway station. The design of inlet and outlet chiller temperature is 17 / 10 Celsius degree and the design of inlet and outlet cooling water temperature is 30.5 / 35.5 Celsius degree. In this condition, from 30% to 100% load percentage, the chiller performance can be as high as possible. Comparing with the traditional chiller, the average pressure can be decreased greatly and the energy efficiency of chiller can be improved greatly.

Figure 1 is the schematic of high efficiency chiller. As we can see, it includes two independent refrigerating systems. Each system includes the parts of compressor, condenser, expansive valve, evaporator, dry filter, ball valve, visual liquid lens and so on. The ratio of cooling capacity in compressor 1 to cooling capacity in compressor 2 is 6:4. Two independent evaporators are linked in series and two independent condensers are linked in series. The evaporator 1 is linked with inlet evaporator pipe (17 Celsius degree) and the condenser 1 is linked with outlet condenser pipe (35.5 Celsius degree). Simultaneously the evaporator 2 is linked with outlet evaporator pipe (10 Celsius degree) and the condenser 2 is linked with inlet condenser pipe (30.5 Celsius degree). The average evaporating temperature is increased greatly and the average condensing temperature is decreased greatly which will lead to a high energy efficiency for the chiller system. The advantage of the high efficiency chiller system can be included as follows: