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Experimental Investigation on the Performance of Ground-source Heat Pump with the Refrigerant R410A

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Contents

1. Introduction

- Based on the gradual attention to environmental issues, the research of R22 substitutes has been carried out, such as R410A, R407C, and so on. As a mixed refrigerant, R410A is recognized as one of the R22 alternatives.

- Not only the performance of thermal performance is good, do not destroy the ozone layer, and the operation is safe and reliable.

- The higher working pressure is also one of the characteristics of R410A, so the development of the refrigerant has also brought about the improvement of the heat pump system components.

1. Introduction

- The first popularity of R410A country is Japan around the world. It has a very good performance in the small and large air conditioning market, in a variety of ways to reduce the condensing temperature so that the R410A can be more efficient. Heat pump system is mainly used in residential and public facilities.
- Although the acceptance of R410A is late in Europe and the United States, it has made some considerable research. Copeland company in terms of R410A flexible digital scroll compressor research and manufacturing technology is leading, has already been mature market in the United States. In some countries of Europe and the United States universities and research institutions launched a theoretical and applied research, making basic research and product development of ground source heat pump (GSHP) go hand in hand, and to develop the corresponding industry standards.

1. Introduction

- Compared with foreign countries, because of national conditions and market reasons, acceptance rate improved in recent years in China about R410A. Because R410A has high working pressure, if the general application, system and its components need to be redesigned. If the compressor is equipped with domestic R410A system, four valve, selection of thermal expansion valve and other components was no more than R22, high work pressure also led to selection of tube material has some problems.
- At the same time, system the use of R410A is protected by patent restrictions in the process of production and sales, the cost is higher than that of R22 system. To some extent, these problems hinder the development of R410A heat pump system. However, Chinese in 2030 to stop the production and use of all R22, so to find a suitable replacement is irresistible that trend. These problems will get further overcome.

1. Introduction

- Gradually in recent years in the market penetration of R410A scroll chiller under different conditions of rated operation are mainly researched in the paper. For small and medium heat pump unit of experimental research, R410A scroll type heat pump unit test rig is built. Test method and measuring instrument is introduced.

- The units were tested under different conditions, and the data were recorded and processed in detail. The change trends of the unit's cooling capacity, input power, COP and other parameters were summarized, and the reasons for the emergence of some kind of trend were analyzed.

2. Test Rig

In this paper, we build a test rig for testing data. It uses the improved design of the ground source / water source heat pump unit, main application features are:

- 1) In view of the ground source / water source conditions of the design; the use of ground source soil, such as the storage of geothermal resources as a heat source;
- 2) Relative to the air conditioning, the installation is simple, comfortable to use;
- 3) Units built in pumps, expansion tanks and other water fittings, the whole installation is simple;
- 4) Internal water system pipeline using PP-R material, to ensure that the user's water quality.

2. Test Rig

Test rig is overall layout and filling refrigerant R410A, unit is equipped with two compressors, two independent systems in common use on both sides of the heat exchanger. It is single stage compression refrigeration, variable conditions experimental study using the prototype.

The system is divided into for refrigerant loop, the loop of cooling water and chilled water loop. Heating condition and cooling condition can conversion through the four-way reversing valve.

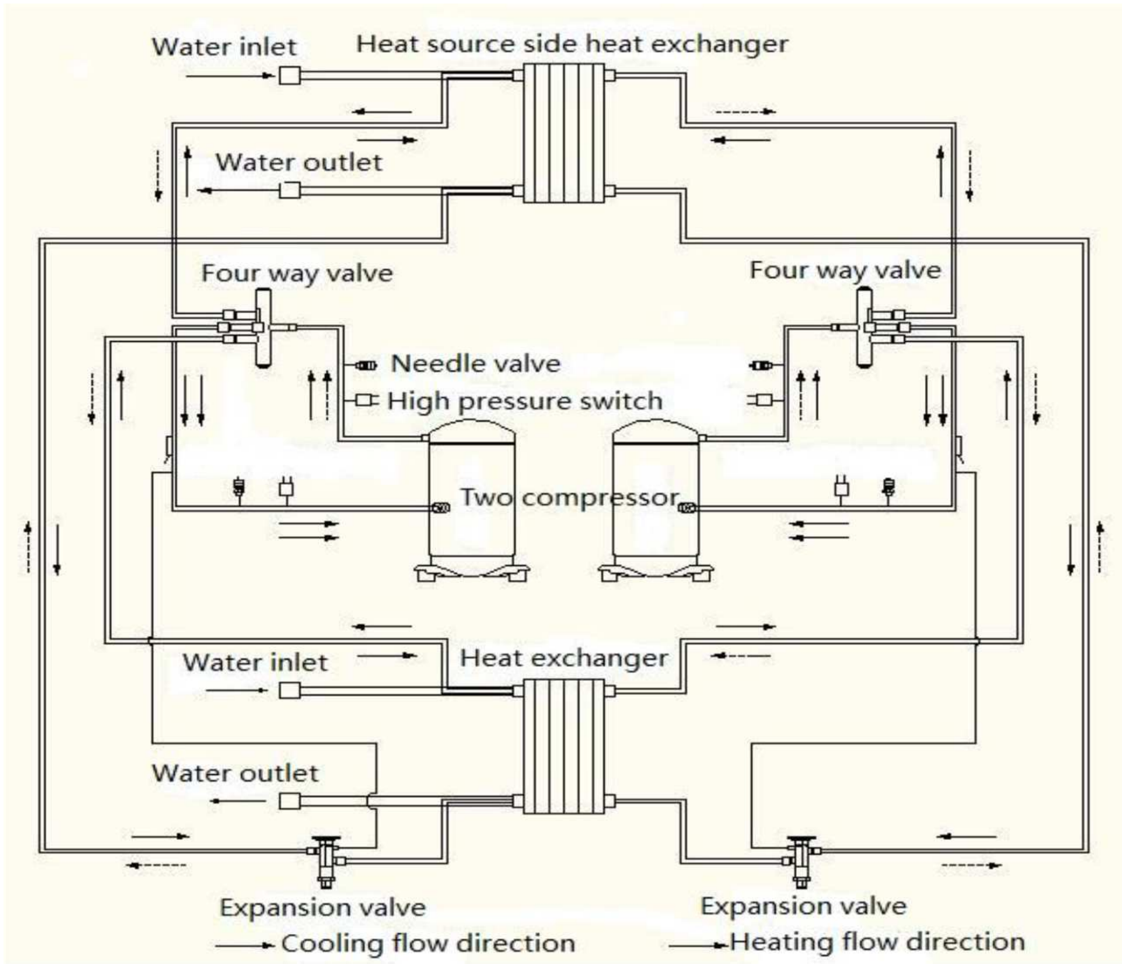


Fig. 1 Schematic of the test rig

2. Test Rig

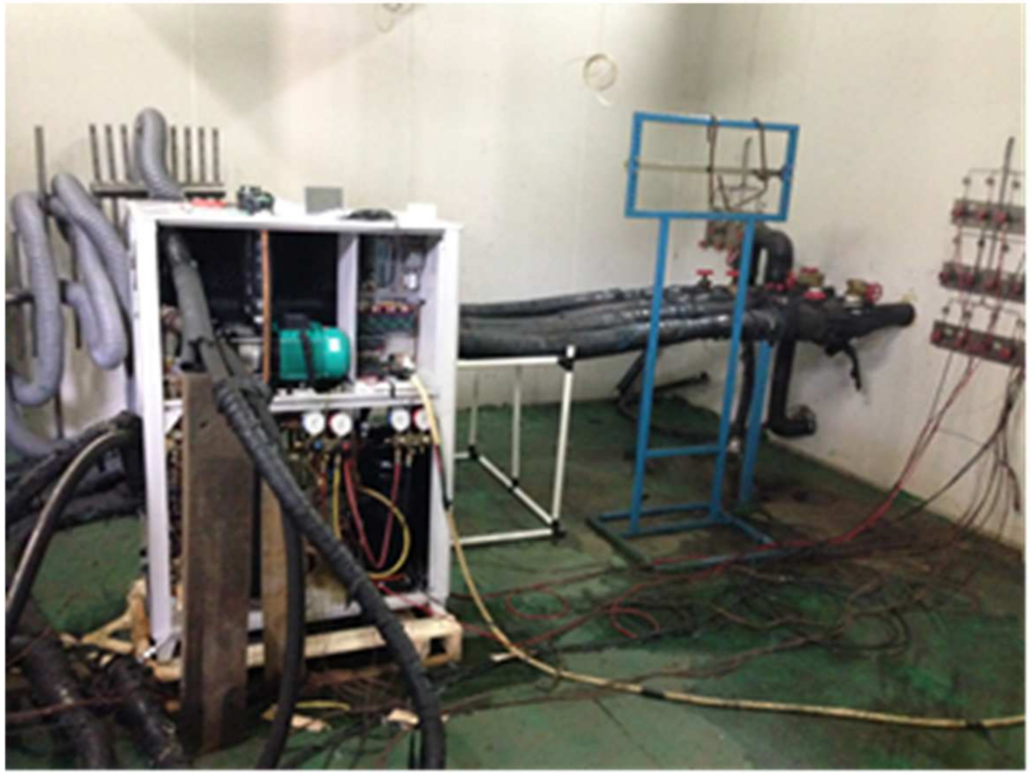


Fig. 2 Photograph of the test rig

Firstly, R410A heat pump unit shall be the reliability experiment after the completion of the assembly. It is mainly divided into the circuit reliability and reliability test of the system test, the circuit control and the system's maximum, minimum heating / cooling system test, ensure the stable operation of the prototype and the reliability of the data.

The experiment was conducted based on the requirement of the Chinese National Standard involving GB/T 19409-2013.

2. Test Rig

- 1) Upon completion of the reliability experiment, at nominal operating conditions were tested unit from water loop type and ground loop type to groundwater loop type. Cooling conditions to ensure that the use-side water temperature 7 ℃, heating condition using side water temperature is 45 ℃.
- 2) To change the use-side water temperature, under the specified water temperature in the different forms of heat source, the unit was measured under maximum cooling / heating conditions and the minimum cooling / heating conditions. Under maximum cooling condition, use-side water temperature is 15℃, and when minimum cooling condition, use-side water temperature is 5 ℃. The use-side water temperature is 50 ℃ under maximum heating condition, the use-side water temperature is 40 ℃ under minimum heating condition.
- 3) Change the a certain conditions, other conditions according to the nominal working condition of flow and temperature conditions tested and test results collected, plotted as not less than four measuring values of a chart.

3. Results and Discussion

3.1 Effect of Condensation Temperature Change on Performance

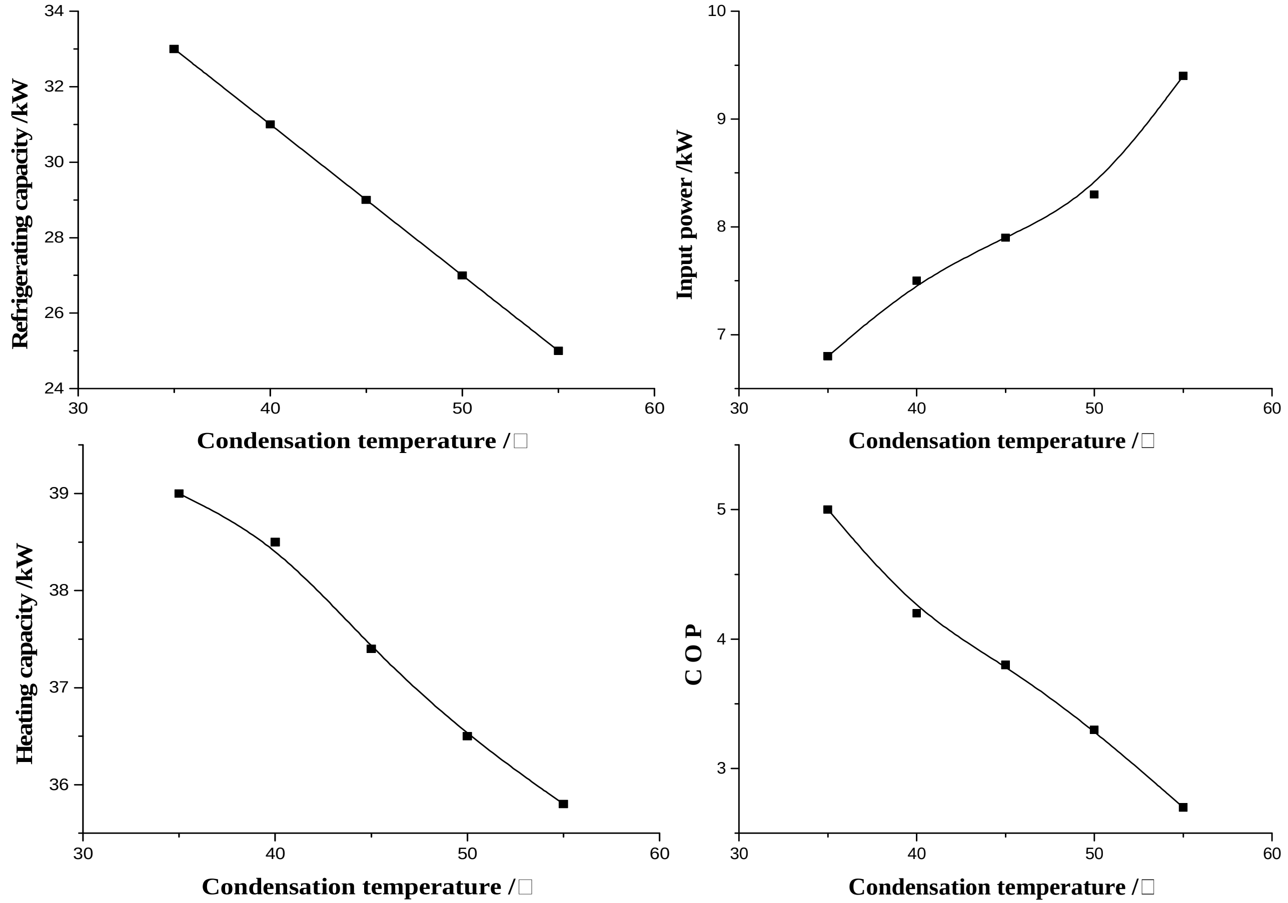


Fig.3 Condensing temperature at various refrigerating capacity, input power, heating capacity and COP

3. Results and Discussion

3.2 Effect of Evaporation Temperature Change on Performance

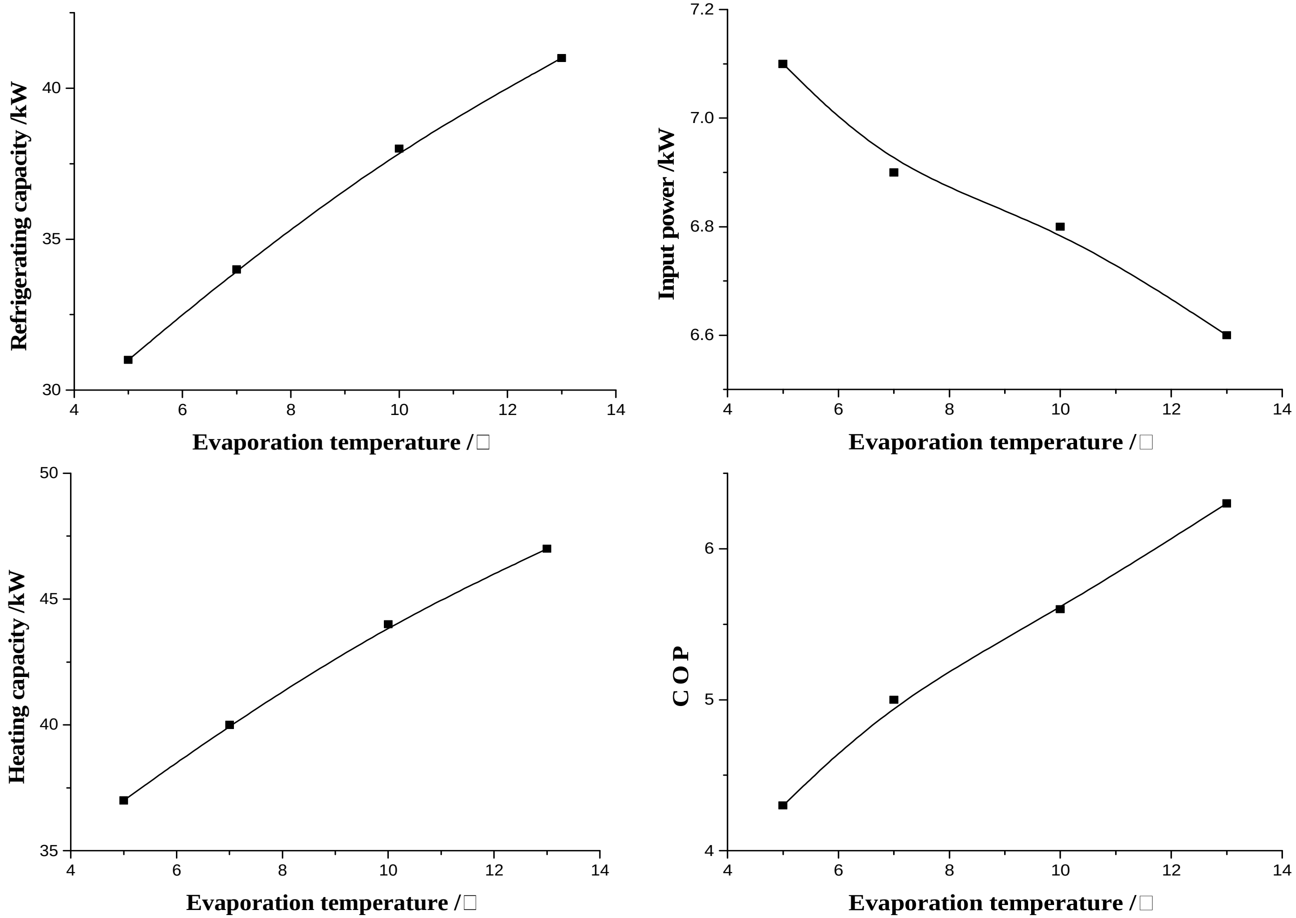
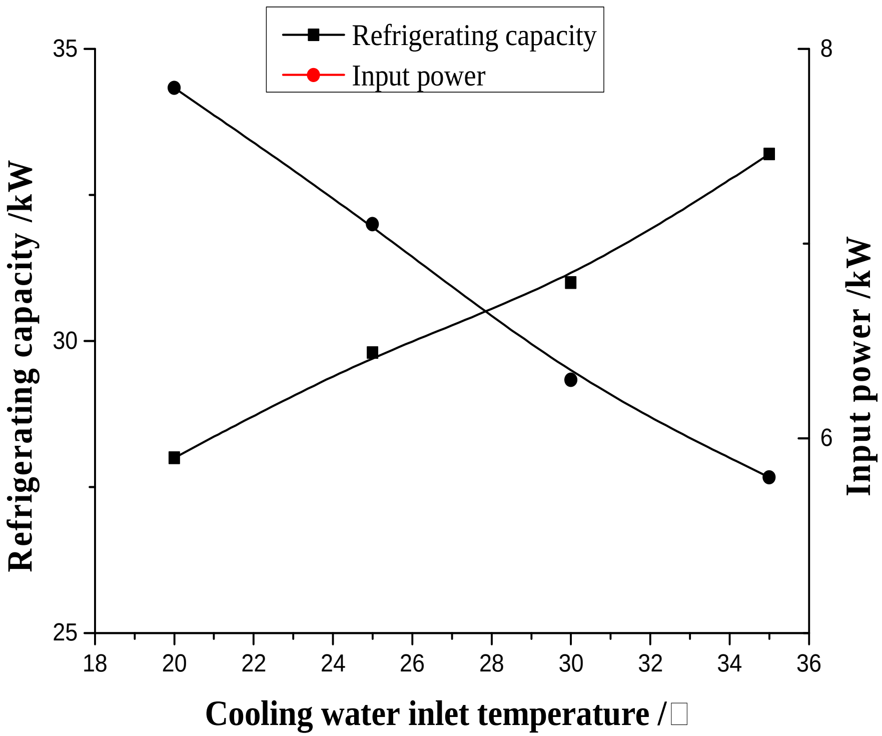


Fig.4 Evaporation temperature at various refrigerating capacity, input power, heating capacity and COP

3. Results and Discussion

3.3 Effect of Cooling Water Inlet Temperature on the Cooling Performance



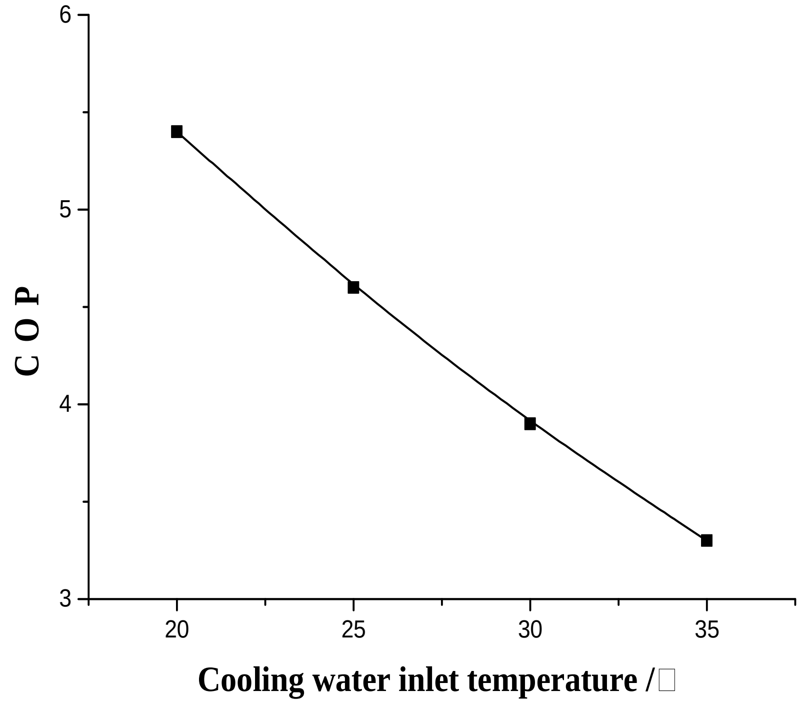


Fig.5 Cooling water inlet temperature at various refrigerating capacity, input power, and COP

3. Results and Discussion

3.4 Effect of Chilled Water Inlet Temperature on the Cooling Performance

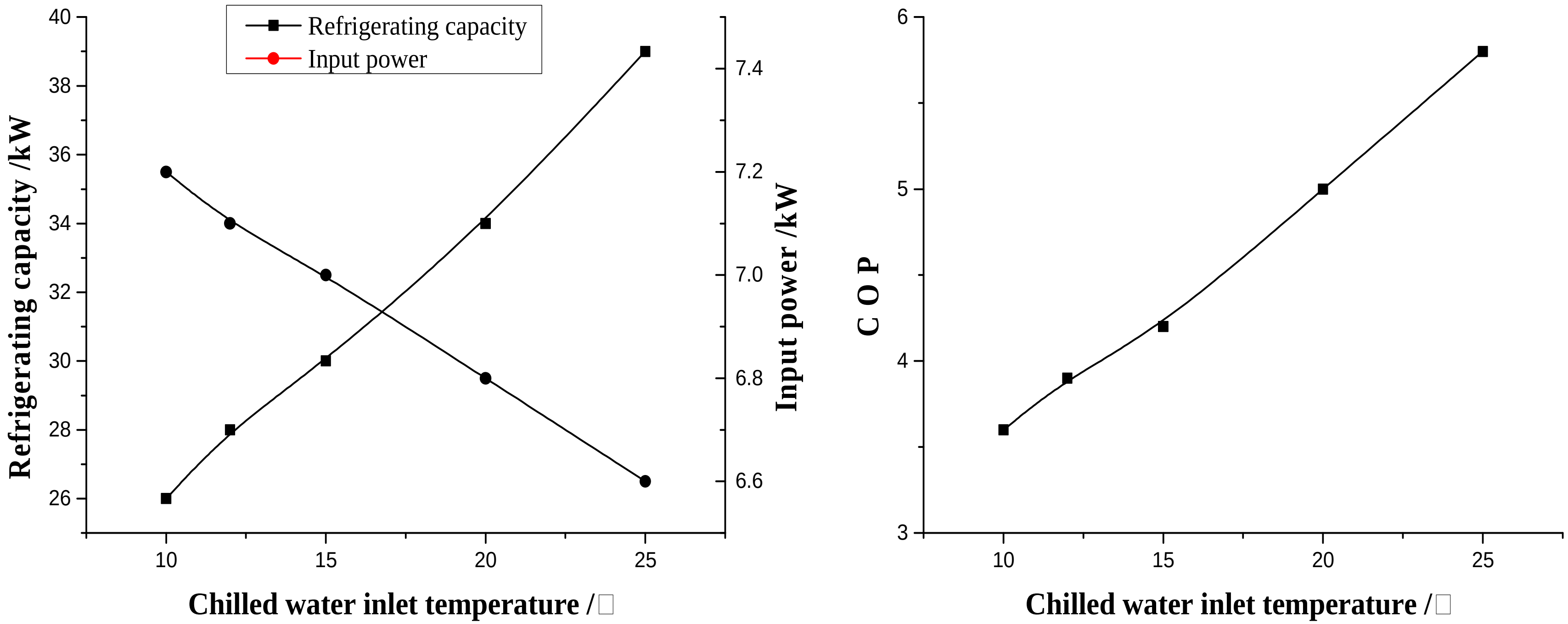


Fig.6 Chilled water inlet temperature at various refrigerating capacity, input power, and COP

3. Results and Discussion

3.4 Effect of Chilled Water Inlet Temperature on the Cooling Performance

Figure 7 is rated conditions of water, chilled water flow remains constant, chilled water outlet temperature varies with the inlet temperature. High water temperature will not reach the indoor cooling and dehumidification effect. Therefore, when considering raising the chilled water inlet temperature to bring energy savings must be considered chilled water flow changes on the system.

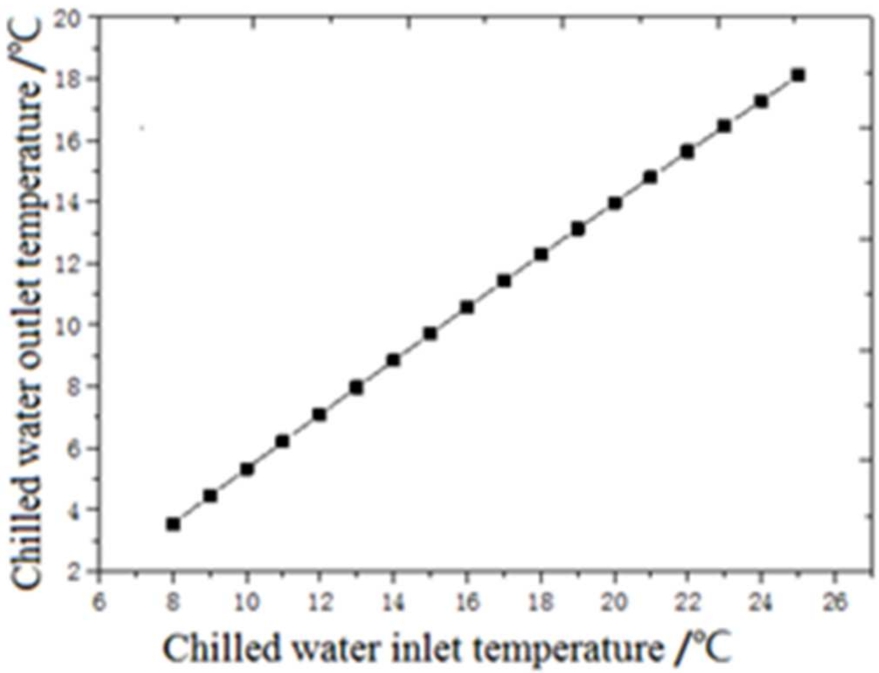


Fig.7 Chilled water inlet temperature at various chilled water outlet temperature

4. Conclusions

Based on the analytical and experimental investigation reported in this paper, the conclusions are as follows.

- When the system evaporation temperature stabilized at about 5 ℃, with increasing condensation temperature, cooling capacity appeared the downward trend. From the figure, when the condensing temperature rises from 30 ℃ to 60 ℃, the cooling capacity decreased by about 12kW, a decline of 33%; the input power increased by about 5.5kW, rise 97.8%, while the energy efficiency ratio decreased from 6.58 to 2.23, a decrease of 66%.

4. Conclusions

- When the evaporation temperature and pressure increase, will make the suction volume ratio is reduced, reducing the compressor pressure ratio, exhaust temperature is reduced, increasing cooling capacity per unit mass. The evaporation temperature from 0 ℃ to rise to 12.5 ℃, the cooling capacity increase of 15kW, an increase of 55%. The results show that the evaporation temperature of the unit should be controlled at 2 ℃ above the unit to achieve design standards.
- When chilled water inlet temperature changes from 10 ℃ to 25 ℃, cooling capacity increased by 10 kW, while the compressor input power dropped nearly 2kW, so that COP has improved in this range. The results show that when the water temperature from 10 ℃ to 25 ℃, increase energy efficiency by 63%. High water temperature will not reach the indoor cooling and dehumidification effect. Therefore, when considering raising the chilled water inlet temperature to bring energy savings must be considered chilled water flow changes on the system.

Thank you !

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