Experimental Investigation on High-temperature Heat Pump Water Heater of R1234ze

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Abstract: The high temperature heat pump water heater experiment of R1234ze was established, and the performance of water heater was studied on different conditions. The experimental results show that the water heater of R1234ze has shown good performance, which the discharge temperature is no more than 110˚Cand the highest water temperature can reach 85˚C, the performance parameters of the water heater can be improved when ambient temperature rises.

Introduction

Heat pump is consumed as part of high-quality energy (mechanical energy, electricity, etc.) or high potential for cost, through the thermodynamic cycle, the heat is transfered from the low-temperature objects to objects with high energy utilization system. At present, the heat pump technology can improve the energy grade, and has the advantages of simple implementation, technology is relatively mature, so it has been widely studied and applied[1-4].The development trend of high temperature heat pump at high temperature has a broad prospect. Many scholars have introduced the thermal physical properties, synthesis and research progress of R1234ze in China[5-8].But there are few studies on the high temperature air source heat pump in the direction of refrigerant system. Therefore, the experiment on the performance of high temperature heat pump water heater of R1234ze was studied on different conditions in this paper. The results of this study provide a reference for the development and popularization of high temperature air source heat pump.

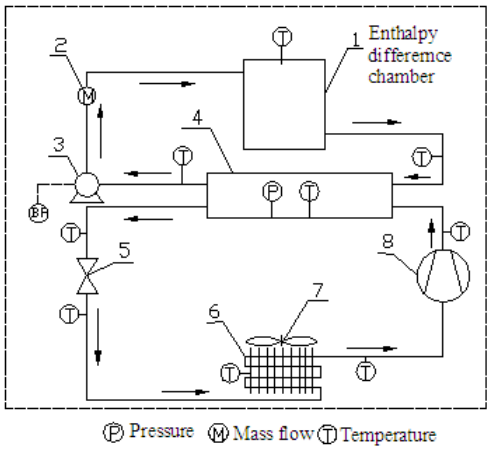
The molecular formula R1234ze is CF_3CH, molecular weight is 114, non-toxic, noncombustible, ODP value is 0, GWP value is 6, the atmospheric residence time is 11 days, the chemical properties of stability, far less than other commonly used tools, it has a great advantage in the environmental protection. Table 1 is the basic properties of the refrigerant.

Table.1 The basic properties of the refrigerant.［9］

Refrigerant	R1234ze	R124	R134a	R142b	R152a	R245fa
Critical temperature (˚C)	109.4	122.27	101.06	137.1	113.26	154.1
Critical pressure (MPa)	3.632	3.624	4.059	4.06	4.517	3.651
Normal boiling point (˚C)	-19 /9	-11.96	-26.07	-9.3	-24.02	15.14
Relative molecular weight	114	136.48	102.03	100.48	66.05	134
Safety level	A1	A1	A1	A2	A2	B1
Atmospheric life (year)	＜1	601	14	19	1.5	8.4
ODP	0	0.02	0	0.07	0	0
GWP	6	609	1430	2310	124	950

Experimental system

In the 5P high temperature heat pump experiment, the refrigerant is R1234ze, the volume of hot water tank is 2000L, the rated flow of water pump for 3m^3/h. The temperature sensor is used the Pt resistance, which its pressure sensor is range from 0 to 4MPa and its precision is±0.5％.The test conditions of the experiment is dry/wet bulb temperature 20/15˚Cor 25/19˚C.Tested room is based on national standards GB/T 21362-2008 and GB/T 23137-2008. The tested parameters are included heated power, compressor power consumption, discharge temperature, discharge pressure, the average temperature of the water tank. The test principle of the experiment is shown in Fig.1.



1-Heat water tank, 2-Mass flow meter, 3-Pump, 4-Heat exchanger,5-Expansion value, 6-Heat exchanger,7-Fan, 8-Compressor

Fig.1 Scheme of experimental apparatus

Data processing

Operation of heat pump water heater when the quantity of heat transfer and power consumption is a change in the value of energy efficiency, therefore, the score for the instantaneous energy efficiency ratio (*COP*) and the average performance ratio, the former is a time heating quantity and the compressor power consumption to water ratio, can be expressed as follow.

$$COP_t = \frac{Q_c(t)}{P(t)} \tag{1}$$

$$P(t) = f(T_e, T_c) \tag{2}$$

$$Q_c(t) = K_c A_c \frac{T_2 - T_1}{In\dfrac{T_c - T_{t1}}{T_c - T_2}} \tag{3}$$

T_1 is the inlet water temperature of condenser, T_2 is the outlet water temperature of condenser,˚C.

The average energy efficiency ratio reaches the set temperature of the water tank, the total heat transfer quantity and total power consumption ratio is calculated by the following formula.

$$COP_{av} = \frac{MC(T_{u2} - T_{u1})}{\sum P \cdot t} = \frac{MC(T_{u2} - T_{u1})}{W} \tag{4}$$

M is water mass flow，(kg), T_{u1} is the beginning of heating temperature of water tank, T_{u2} is the ending of heating temperature of water tank,(˚C), W is power consumption, (kW·s).

Results and disscussion

In the process of the experiment, water temperature is raised from 35˚C to 85˚C and the data are recorded at 10˚C for each interval, which is 35˚C, 45˚C,55˚C, 65˚C, 75˚Cand 85˚C respectively. Because the high temperature air source heat pump water heater is basically running in the variable conditions, so the impact of the outlet water temperature on other parameters is indicated. The input power, heating power and *COP* is on the average performance coefficient during the experimental process, the discharge temperature is instantaneous value. The tested results are showed in the Fig.2. When the test conditions of the experiment is dry/wet bulb temperature 20/15˚C, the tested experimental results show the high temperature air source heat pump water heater has shown good performance when the hot water temperature difference between the inlet and outlet is relatively small. The reasons are that heat transfer temperature difference between the refrigerant and heat water is larger, the high temperature and high pressure of the refrigerant will be faster condensed, the corresponding degree of super cooling is also larger. In the evaporator side of the low temperature heat source air side, the refrigerant can quickly absorb the heat of low temperature heat source, the compressor of the compression is relatively small. The COP will decrease when the water temperature of the circulating coefficient is reduced, based on that heat transfer temperature difference becomes smaller. When the water temperature reaches 45˚C or higher, the average performance coefficient is minimum, the higher the outlet water temperature, the smaller performance coefficient.

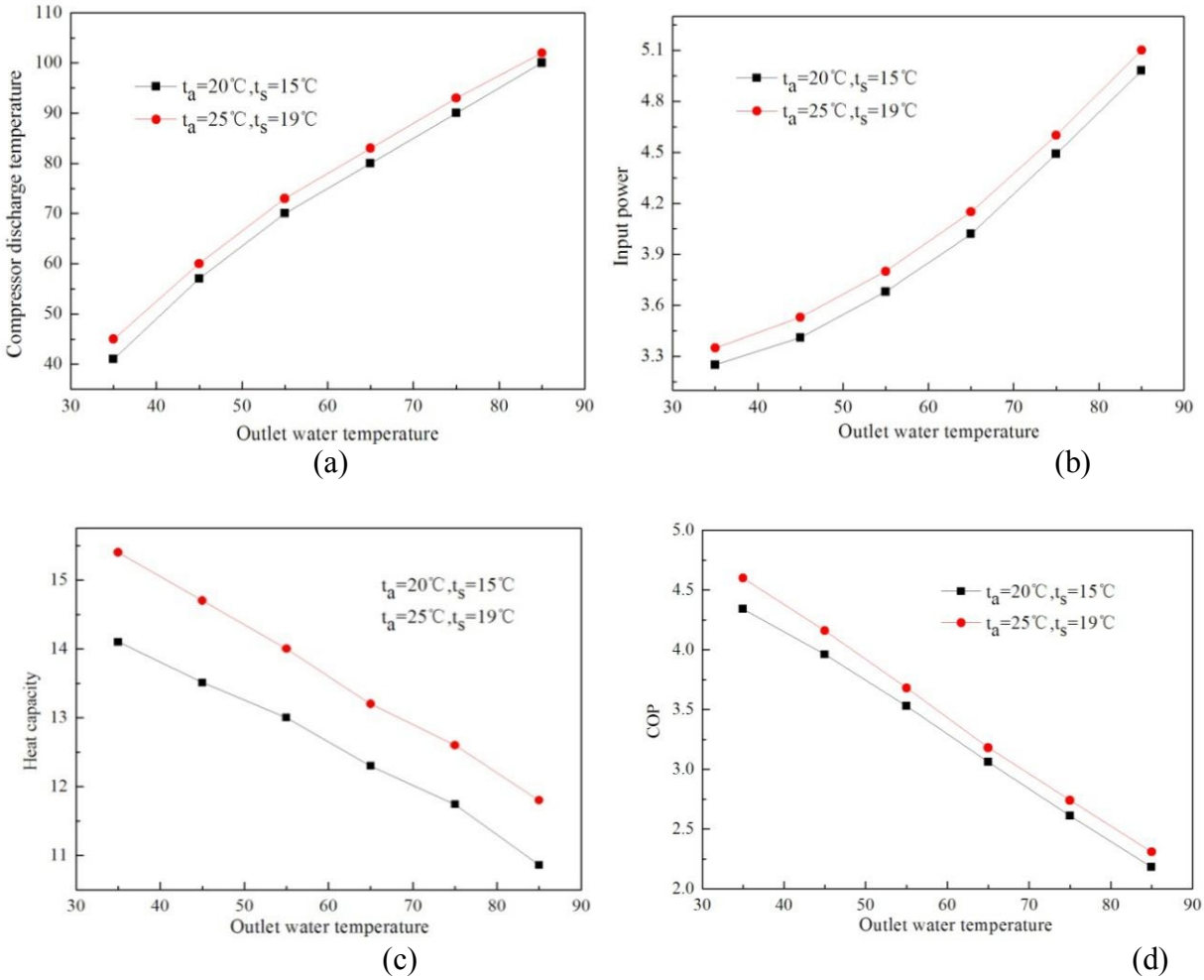


Fig.2 The relationships between outlet water temperature and performance parameters

When the test conditions of the experiment is dry/wet bulb temperature 25/19˚C, the tested experimental results show the heat exchange between the refrigerant and air will be enhanced with the ambient temperature increasing, the suction air temperature and COP is also increased. while the

ambient temperature increased by 5˚C, The average heat power is increased by 7.23%, the average increase of the heat input power is increased by 5.07%, the average performance of the system is increased by 5.12%.

Summary

Nowadays, heat pump is more and more favored by all walks of life. With the increasing demand of heat pump, people begin to use the heat pump in the field of high temperature and high temperature.The experiment on performance of high temperature heat pump water heater of R1234ze results show that the stability of this type of engineering is very suitable for high temperature heat pump system. The results of this study provide a reference for the development and popularization of high temperature air source heat pump, which has a certain practical value.

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