ISSN: 2414-1895 DOI: 10.6919/ICJE.202112_7(12).0080

Waste heat recovery system of waste bath hot water based on water source heat pump

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Abstract

In order to reasonably recover and utilize the waste heat of shower wastewater, the waste bath hot water is centrally filtered and stored, and the water source heat pump is used as the main heat recovery device to preliminarily heat up the clean cold water, and then the auxiliary heating module is used to heat it again to make the water temperature reach the established temperature. The system can utilize low-grade heat to a great extent, and the investment benefit is good.

Keywords

Waste heat recovery, water source heat pump, energy saving and emission reduction.

1. Background introduction

In the middle and north of China, public baths are a very common way of shower in communities, colleges and universities. Hot water is a necessity for bathing, but the hot water flows out of the shower head and still maintains a high temperature when it enters the sewer after use. A large amount of low-grade heat is stored in the waste bath hot water. Through experimental measurement, the temperature of hot water flowing out from the shower nozzle outlet is generally about 40 ℃, and the water temperature after entering the sewer is still as high as 34 ℃. These waste bath hot water will directly flow into the sewage tank through the sewer, resulting in great heat loss and energy loss. The utility model relates to a waste bath hot water waste heat recovery device based on a water source heat pump, which can recover this part of heat to a certain extent and effectively utilize it, help energy conservation and emission reduction, and the corresponding call for carbon neutralization. Organization of the Text.

2. Research status

At present, there is little research on waste heat recovery of waste bath hot water in centralized bathhouse. The existing waste heat recovery device is that waste bath hot water and clean cold water directly exchange heat through the recovery machine through a special medium, which not only has low heat exchange efficiency, but also has a great impact on the discharge of waste bath hot water. The existing equipment can not well overcome the problems of blockage and scaling of waste bath hot water. Therefore, abandon the traditional way of concentrating waste bath hot water on the machine, directly discharge the waste bath hot water in the temporary concentration tank, and then use the water source heat pump to directly absorb the low-grade heat of waste bath hot water for heating fresh cold water.

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3. System principle

The bathhouse wastewater is filtered on a large scale and then discharged into the reservoir. The evaporation pipes of multiple water source heat pumps are buried in the reservoir. The low-temperature medium R-134a in the pipe absorbs the heat of waste hot water and enters the condensing pipe to convection the clean cold water in the pipe for preliminary temperature rise after secondary temperature rise by the compressor. The waste bath hot water and clean cold water are heat exchanged through the water source heat pump, and then heated to the established temperature through the auxiliary heating module for heating or shower in the bathhouse. The system is mainly composed of water source filter, sewage tank and multiple water source heat pumps. At the same time, the transformation of bathroom shall be carried out under the guidance of hot water engineering company or HVAC professional technicians, see Fig. 1.

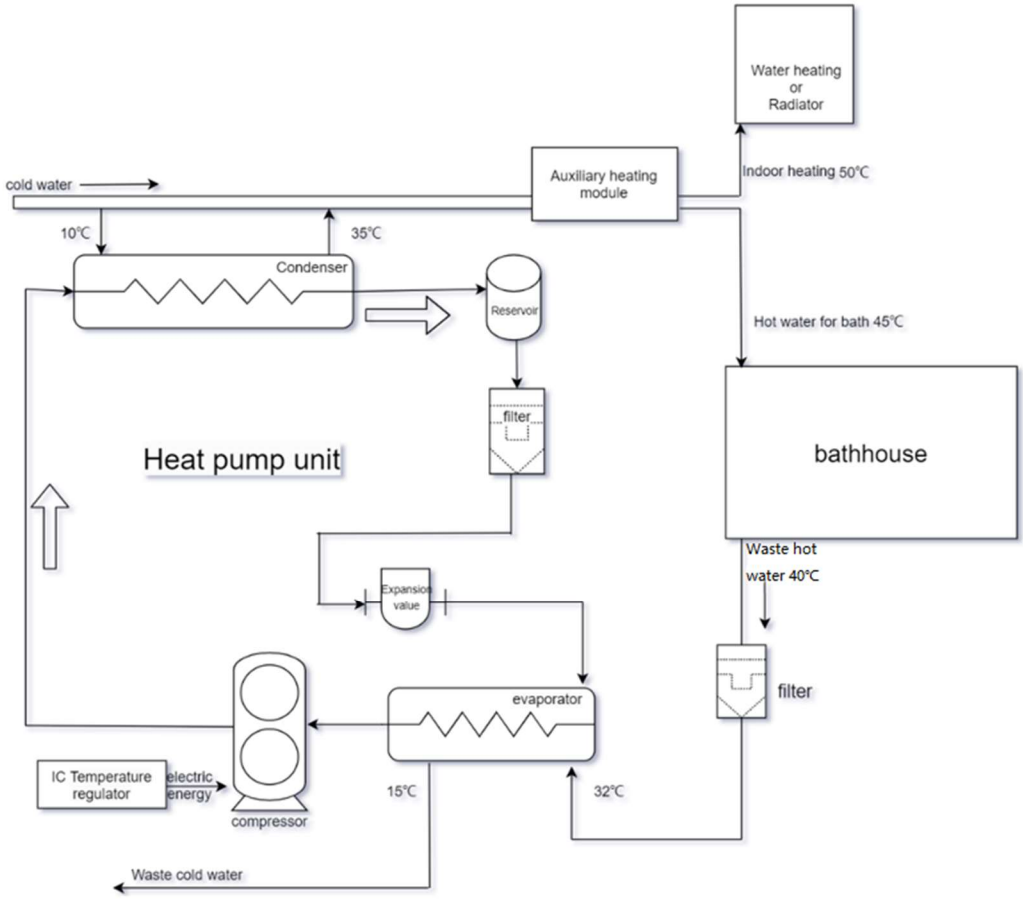

Fig. 1 Waste heat recovery system

4. Feasibility analysis

4.1 Water consumption and economic analysis of bathing in autumn semester

Taking the centralized bathhouse of a university as an example, about 38000 students now live. According to the calculation of the 120d autumn semester, the water consumption for each bath is 40L, and the water consumption for each bath is once every 3D, so the total water consumption for bathing in the autumn semester is about 6.08 × 107l, affected by different seasons, weather environment and personal habits, the total amount of bathing drainage per day is not necessarily the same, but there is no large fluctuation error based on the four-month semester. By calculating the available amount of waste heat in the waste heat pool, set Δ T is 25 ℃ (temperature TL in waste heat pool is 35 ℃, drainage overflow temperature is 10 ℃).

$$Q_1 = c \times m_1 \times \Delta t_1 = 4.2 \times 10^3 \times 6.08 \times 10^7 \times 25 = 6.384 \times 10^{12} J = 1.7733 \times 10^6 kW \cdot h$$

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4.2 Water consumption and economic analysis of bathing in spring semester

Taking the centralized bathhouse of a university as an example, about 38000 students now live. According to the calculation of 120 day summer semester, the water consumption for each bath is 20L, and the total water consumption for bathing in two days, then the total water consumption for bathing in summer semester is about 4.56 × 107l, affected by different seasons, weather environment and personal habits, the total amount of bathing drainage per day is not necessarily the same, but there is no large fluctuation error based on the four-month semester. By calculating the available amount of waste heat in the waste heat pool, set Δ t as 22 ℃ (the temperature TL in the waste heat pool is 32 ℃, and the drainage overflow temperature is 10 ℃).

$$Q_2 = c \times m_2 \times \Delta t_2 = 4.2 \times 10^3 \times 4.56 \times 10^7 \times 22 = 4.21344 \times 10^{12} J = 1.1704 \times 10^6 kW \cdot h$$

According to the above formula, the heat that can be obtained from the bathing wastewater of all students in the spring semester is 1.1704 × 10^6kW·h.3.5112 calories per day × 1010J, the average daily power demand of heat pump compressor is 6.79323 × 10^9J, at the condenser, about 4 × 10^5L of 10 ℃ cold water is preheated and heated to 35 ℃.

From the above calculation and analysis, it can be concluded that the waste heat recovery water source heat pump system can obtain the total heat from the bathing wastewater of all students in the school year, Q = Q1 + Q2 = 2.94373 × 10^6kW·h. The energy consumption and economic analysis are shown in Table 1.

Table 1 Energy consumption and economic analysis of different systems

	Total annual hot water consumption /m3 (240d) Annual hot water consumption and total energy consumption /kW（240d）		$Q = c \cdot m \cdot \Delta t$	
	Waste heat recovery water source heat pump system	Air source heat pump system	Natural gas system	Power system
major equipment	Water source heat pump unit, filter water tank, heating side circulating pump, hot water supply pump, electrical control and pipe network, etc	Air source heat pump unit, insulated stainless steel water tank, heating side circulating pump, hot water supply pump, electrical control and pipe network, etc	Natural gas boiler, insulated stainless steel water tank, heating side circulating pump, hot water supply pump, electrical control and official website, etc	Electric heating boiler, heat preservation stainless water tank, heating side circulating pump, hot water supply pump, power cable, electrical control and pipe network, etc
Energy saving mode	COP6.5	COP3.0	None	None
Annual input power	452 882kW	981 243kW	8 192 800Nm3	2 943 730kW
Equivalent to RMB	¥ 271 729	¥ 588 746	¥ 22 120 560	¥ 1 766 238
Emissions	No emission	No emission	Small emission	No emission

5. Application prospect

Compared with the traditional energy supply system, the heat pump system obviously has the advantages of high cop, energy saving and high efficiency. In the internal comparison of heat pumps,

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the energy consumption ratio of water source heat pump is higher than that of air source heat pump, which can save 30% - 40% of electric energy while producing the same heating effect, and achieve the purpose of green environmental protection, energy conservation and emission reduction. From an economic point of view, when the same heating effect is achieved, the electric energy cost required for the operation of water source heat pump is 85% less than that of power system, 99% less than that of natural gas system and 54% less than that of air source heat pump system. Taking 1000 yuan / ton of standard coal as an example, 362 tons of standard coal are required for the operation of the traditional power system, and the required capital is 362000 yuan. Only 56 tons of standard coal are required for the operation of the waste heat recovery water source heat pump system, and the capital is only 56000 yuan, a year-on-year decrease of 84.5% of the resource capital investment, which is about the operation cost of the system in the same season of energy conservation and emission reduction. Based on the above analysis, due to the large number of middle school students, the use of water source heat pump will produce greater economic benefits and obtain more heat from wastewater. Therefore, the waste heat recovery water source heat pump system is the best choice.

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