Prospects of Air Conditioning Condensate Recovery and Utilization Technology

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Abstract. As an excellent indoor environment conditioning equipment, air conditioners have been used on a large scale since they were listed. However, with the popularization of air conditioners, many discharged condensed water has caused many problems such as waste of resources and environmental pollution. Therefore, it is imperative to recover and use condensed water. Generally speaking, air or atmosphere is humid air, mainly composed of dry air and water vapor. This paper introduces the feasibility of recycling air-conditioning condensate water as irrigation and green water through theoretical research and analysis. Based on the formation process of condensate, through theoretical analysis and calculation, it is concluded that condensate has the three characteristics of higher water quality, lower temperature and considerable water volume. The advantages of the two condensate recovery technologies of open recovery and closed recovery are dialectically analyzed. Disadvantages, the primary utilization method of condensate water "as a water resource" is systematically explained. A particular scientific outlook is made for the future recycling and utilization technology of air-conditioning condensate water.

1. Introduction

With society's progress and the improvement of people's living standards, and the vigorous promotion and strict implementation of my country's energy-saving and emission-reduction policies, air-conditioning has gradually become a popular household appliance. While it has brought us a comfortable life, it has also caused air-conditioning condensation. The production and discharge of water. When the air conditioner is running and cooling typically, the evaporator or coil's temperature will be lower than the air's average temperature. The water vapour in the moist air will liquefy and condense to form condensate when it flows through the surface of the air conditioner evaporator or coil. The water is collected in the drip tray and discharged outdoors through the drain pipe. It should be noted that the air conditioner condensate is the water of relatively high purity, and its corrosiveness is more vital than that of ordinary water. Therefore, pipes or containers used to transport condensate water need to have specific corrosion resistance. Air-conditioning condensate, as a kind of water resources with development and utilisation value, should never become useless wastewater in people's eyes but should become one of the breakthroughs in energy saving and emission reduction beneficial water the country and the people. Efficient recycling and utilisation of air-conditioning condensate align with the concept...
of energy-saving and emission reduction in my country. It reduces the discharge of sewage, reduces pollution to the urban water environment, and effectively saves water resources, significantly improving the recycling rate of water and effectively alleviating water scarcity in China and even the world. Today is of great significance to the sustainable development of population, water resources and the environment.

At present, almost all air conditioners used in the country are in a straight row method, which wastes a lot of water resources and damages the building itself or the surrounding walls. This article makes a scientific outlook on the future recycling and utilisation technology of air-conditioning condensate through the theoretical analysis and calculation of Chifeng's local data.

2. Condensate recovery technology at this stage
In the 1980s, condensate recovery technology has been produced. Due to the shortage of resources at that time and the inability to control costs well, relevant technicians began to optimise and improve the air conditioner's additional equipment to realise the recovery of condensate. In the initial stage, technicians usually adopt relatively simple and rude recovery methods and directly modify the original equipment's recovery equipment to achieve condensation. In the 1990s, the condensed water from the air conditioner was turned off and recycled in various ways.

The technology used has long been popularised in developed countries abroad. For example, German scientists have mainly researched and invented air-conditioning recycling as a working fluid for cooling condensers. The technology has been very mature. In the United States, they have many utility model patents on recycling condensate water generated by air-conditioning. Over time, the technical means have become more mature, and two recycling technologies of open recovery and closed recovery of condensate have been gradually formed. Due to the higher recovery efficiency of a fast recovery and the complete recovery equipment, two mainstream recovery technologies of current condensate open recovery and closed recovery have gradually formed.

To sum up, under the premise that the air moisture content is relatively high in summer, the amount of condensed water generated per hour by the air conditioner in regular use is considerable. Simultaneously, the condensed water also contains a large amount of high-quality cold energy, which has high research and utilisation value at the same time. Here, according to the different characteristics of condensed water produced by other air-conditioning condensate utilisation methods, we divide it into two categories: "utilisation as a water resource" and "utilisation as an auxiliary cold source".

![Figure 1. Natural room temperature in summer.](image)
3. About the recovery plan of air conditioning condensate

3.1. Characteristics of condensate

The condensed water is pure in theory but considering that harmful substances such as dust in the air will be mixed with water vapour precipitation. There is some dirt on the surface of the evaporator itself. The condensed water carries these when it is formed. Impurities are not pure water. Still, its higher water quality can be fully recycled and used in daily life, urban greening and other aspects.

The air conditioner evaporator's surface temperature is usually 7-12°C, and the temperature of the condensed water will be slightly higher than the evaporator's surface temperature, generally stable in the low-temperature range of 10-15°C. Studies at home and abroad have shown that using condensate as an auxiliary cold source to use its cooling capacity has considerable economic benefits and is ideal for utilisation. The amount of condensate produced is proportional to the air's moisture content, and the air contains moisture. The more significant the amount, the more condensed water is produced.

![Figure 2. The overall structure diagram.](image)

3.2. Calculation model

The process of indoor air conditioning in summer can be regarded as a return air treatment. Point N is the indoor air state point, and point W is the outdoor air state point. The fresh return air from indoor and outdoor is mixed with pointing O. It is cooled and dehumidified by the evaporator to reach the air supply state point L, and then sent to the room to absorb heat and moisture to the state point N, then enter the next cycle. This is the summer air circulation process. Now take the Gree 1.5-hp air conditioner as an example to calculate the condensed water volume. The air conditioner's rated cooling capacity is 3500W, the circulating air volume is 680 m³/h, and the energy efficiency ratio is 4.7. Assuming that the dry bulb temperature of the indoor return air point N is \( t_n = 26°C \), and the relative humidity \( \phi = 50\% \), the moisture content of this point \( d_n = 10.6g/kg \) can be found according to the enthalpy diagram. The outdoor air parameters are based on January. Take the Chifeng area as an example, the outdoor \( \phi = 39\% \) and the moisture content \( d_w = 10g/kg \) were found from the weather APP. The maximum air supply temperature difference and relative humidity jointly determine the dry bulb temperature of air supply state point L as \( t_L = 24°C \), relative humidity \( \phi = 92.5\% \), and moisture content \( d_L = 9.3g/kg \).

The humidity calculation formula of the mixing point O is:

\[
d = \frac{q \times d_w + q_n \times d_n}{q_x + q_n}
\]  

(1)

Where \( q_x \) is fresh air volume and \( q_n \) is the volume of return air. There is no new air duct in the house, the minimum fresh air ratio is 10%. \( d_n \) is indoor moisture content, \( d_n \) outdoor moisture content. The calculation formula for the amount of condensed water is \( \Phi = \rho v (d_0 - d_L) \) where \( \rho \) is the air density involved in the circulation, \( \rho = 1.2kg/m^3 \), \( v \) is the circulating air volume, m³/h.

After calculation, the humidity at the mixing point \( d_n = 3.5g/kg \) (dry air), and the amount of condensed water generated is \( \Phi = 0.763kg/h \).
Refer to the previous theoretical calculations and experimental determinations by relevant experts in terms of condensate output: We take the master bedroom with 30/m² as an example, using a fan coil plus fresh air system, fan production coil condensate is 0.63kg/h.

In summary, the amount of condensed water produced by general household air conditioners under normal working conditions is considerable in the north. As the circulating air volume increases, the amount of condensed water will increase accordingly.

**Figure 3.** The air condition changes when the air conditioner is working.

4. **Prospects and conclusions on condensate water recycling technology**

There are more and more air-conditioning users in my country at this stage, and the recovery of condensed water is also getting better and better. The technology of how to recover and reuse air-conditioning condensate is also increasingly perfect. At the same time, air-conditioning condensate is the main body for research. Various results have been achieved in energy conservation and emission reduction. The following is a particular explanation of recycling technology and recycling technology. It is believed that the addition of this technology will make our energy-saving and emission-reduction goals "more efficient, more economical and more advanced".

The current main condensate recovery methods are mainly divided into two types, namely, open recovery and closed recovery. Although the recovery structure of the open type recovery is relatively simple and the modification device's cost is low. The recovery device's efficiency is low, causing serious loss to the existing recovery equipment, so it is more likely to cause a burden when used in a large area; the closed recovery pipeline has a constant. The pressure value can effectively ensure the water quality of the recovered condensate and prevent deterioration. Simultaneously, the post-processing of the recovered water is much cheaper than the previous recovery method, and the service life of the recovery equipment has also been extended.

In contrast, closed recycling has become the preferred method of recycling air conditioning condensate. Of course, simply considering the condensate recovery system and recovery efficiency is far from reaching the requirements. Therefore, in future research, reference indicators such as energy-saving benefits and economic benefits should be started by studying the backpressure value, temperature and humidity. To improve the energy-saving efficiency of the recovery system and other factors, and simultaneously use part of the existing system's relevant devices to achieve deoxygenation, avoid the cost of adding additional equipment, and improve the efficiency of the recovery system. The energy-saving effect is optimised through this method, the economic energy-saving impact is the most efficient, and the final recycling concept is the most advanced.
Although condensed water is theoretically neutral and pure water with fewer impurities, it can be used as drinking water in theory after the subsequent recovery. Disinfection treatment reaches the national standard. However, due to its purity and lack of essential mineral elements for human consumption, it is not suitable for long-term drinking. Therefore, it is not recommended to convert air-conditioning condensate water into drinking water in large quantities. At present, air-conditioning condensate water is mainly used in places where water quality is not high, such as water landscape layout, urban green plant water, daily cleaning water, etc. In these aspects, improving the transmission efficiency of air-conditioning condensate water is essential. Most of them have already combined the recycling and reuse of air-conditioning condensate water with the building's water supply and drainage system engineering during the construction process. Through the pre-design optimisation, the condensed water transmission channel has been prepared in advance. And then realise the efficient transportation of condensate water. Simultaneously, this combined construction plan can also reuse the air-conditioning condensate as an auxiliary cold source, thus achieving the purpose of reusing high-quality cold energy and meeting the requirements of saving urban water resources. At this stage, most of the research results are still in writing Because of its noticeable energy-saving effect. It has become the leading research direction of energy-saving and emission reduction in the future.

5. Conclusion
Based on theoretical analysis and theoretical calculations, this paper compares the advantages and disadvantages of air conditioning condensate recovery and utilisation technologies through various factors and draws the following conclusions:

(1) Through the analysis of the process of air conditioning condensate formation and the theoretical numerical calculation of its possible output, the air conditioning condensate has less water quality and impurities, low water temperature, and many water production. It is a commercial use that can be recycled Water resources.

(2) Closed recovery has more advantages than open recovery condensate recovery technology, but different recovery methods should be selected according to local conditions. In the current practical application example, priority should be given to the on-site situation. The specific application of the recycling system should be selected according to the on-site situation. The recycling equipment that meets the site should be chosen to avoid unnecessary waste due to improper selection.

(3) At present, domestic and foreign research mainly focuses on utilising air-conditioning condensate, and the research direction is to reuse its water. Use air conditioning condensate water as urban water, landscape water or domestic clean water. This utilisation method is straightforward and convenient for construction sites; however, a more optimal research and utilisation direction should be to make full use of the condensate water volume. Utilising the cold energy of condensate water as an auxiliary cold source to achieve more efficient energy-saving purposes is the genuine concept of energy-saving and emission reduction.

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