The Status of Foreign Advanced Pasture Water Supply Technology

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Abstract. Pasture water supply is of great significance for rational management of grassland, maintaining grassland ecological balance and promoting the development of animal husbandry. The investigation of international advanced pasture water supply technology has important reference value for the development of science, technology and economy in domestic pasture area. The advanced pasture water supply technology in the United States, Canada and Holland was summarized and analyzed through the literature retrieval with database. And the current situation of water supply technology in typical pastures of China was investigated and summarized through the field investigation of the Inner Mongolia pasture and the visit of the local herdsmen. The foreign pasture advanced water supply technology of Fresh Water Mill, batteryless photovoltaic water supply system, stand-alone mixed energy supply system, wireless data collection system of remote water supply system, automatic constant temperature water supply system and automatic water supply control system for pasture are put forward in accordance with the characteristics of pasture in China.

1. Introduction
Pasture is a production base for livestock, draft animals and breeding stock. Animal husbandry in the United States and other developed countries accounts for more than 50% of the total agricultural output value, occupying a very important position in the national economy. Most of the world's pastures are between 40-50 degrees north latitude and 40-50 degrees south latitude. High-quality pastures in the northern hemisphere are distributed in the Netherlands, Mongolia, Inner Mongolia, the northern United States and Australia, New Zealand in the southern hemisphere. Chinese pastures are mainly distributed in Inner Mongolia, Xinjiang, Tibet, Qinghai, Sichuan, Gansu and other places. Most of the pastures belong to continental climate with less precipitation and uneven distribution[1]. And there are some problems such as backward water supply mode and technical equipment, lack of necessary specialized technical support for pasture water supply, which result in the problem of livestock drinking water. In recent years, there are more and more researches on water supply for pasture in China, but there is no corresponding technical system and water supply strategy, which makes the development of pasture restricted for a long time.

The research and development of automatic water supply technology for pasture in developed countries has a long history, and there are advanced water supply mode and automation equipment in developed countries such as the United States and the Netherlands. In this paper, the information and literature of international advanced pasture water supply technologies are searched through major databases. The management modes and water supply modes of pastures in Australia and the Netherlands are summarized. The advanced water supply technologies of pastures which are representative and applicable to China's pastures are summarized. Through learning from the
successful experience and advanced technology, it can provide guidance for solving the problems of water supply technology in typical pastures in China.

2. The development of pastures abroad

In North America, Europe and Australia, half of animal husbandry output comes from grassland animal husbandry. The development of grassland animal husbandry depends mainly on pasture water supply[2]. And the water supply standards which guide for piping layout, layout optimization and automation of water dispenser is formulated through the different types of pasture water supply[3].

2.1 Current situation of water supply in American pasture

Modern animal husbandry in the United States has developed greatly in a few decades. Most of the country have suitable climate and abundant precipitation with an average annual precipitation of 760mm. The permanent grassland is about 240 million hm², and the possessive quantity of grassland is in the forefront of the world. Most American pastures are located in the Central Plains and around the Great Lakes.

Large-scale pastures in the United States are generally combined farming and animal husbandry by large pumping stations as a source of water supply with the pipeline network. And automation control pumping stations can control the flow of water with remote control of water terminals. Solar power pump systems are used generally in some small and remote pastures which store water in high-level tanks with potential energy, then supplied to multiple pastures through a network of pipes and control system. And some pastures can make the system more stable by adding storage batteries[2].

2.2 Current situation of water supply in Australia pasture

Northern Australia belongs to the tropics and the South belongs to temperate zone. The central and western regions are deserts. Grassland is distributed in the north and south where vast is flat with abundant rainfall and humid climate, which is suitable for large-scale development of animal husbandry. Australian pastures are widely distributed, large in scale and highly automated in machinery. Many pastures in Australia use natural terrain differences to build reservoirs at high altitudes, piping water to water terminals, which are controlled by automatic drinking tanks for livestock drinking[4-5].

Herdsmen living in remote areas are usually hundreds of kilometers away from the grid infrastructure, which are mainly relying on autarky renewable energy. Small systems that provide power services in remote areas are called stand-alone power supply (SPS) systems internationally, which are often referred to as remote area power supply (RAPS) systems in Australia. The stand-alone power supply system provides the power source for the water supply equipment, which not only has low operating cost in the later period, but also has convenient operation for the remote pastoral areas[6-10].

2.3 Current situation of water supply in Netherlands

About 1/3 of Netherlands is pasture, which has a very developed animal husbandry, accounting for about 70% of the agricultural output value. Animal husbandry in the Netherlands is divided into common and intensive types. Common type refers to the grazing which is dispersed in large area. Intensive type refers to the establishment of a large-scale centralized artificial feeding environment, which occupies less land. With the development of economy and modernization, the scale of pasture has gradually changed from small common type to large-scale intensive type. The total number of pastures has decreased. A small number of large-scale intensive pastures supply most of the livestock meat and dairy products for the whole country[11-13].

2.4 Current situation of water supply in New Zealand

New Zealand is one of the most important animal husbandry countries in the world of which the natural pasture accounts for half of the land area. The value of animal husbandry accounts for about
80% of the total agricultural output. The population engaged in animal husbandry accounts for about 80% of the agricultural population. It is the country with the largest cattle and sheep per capita in the world. Due to the abundant precipitation in South Island, the amount of pasture in South Island is more than that in North Island[14].

Because of the excellent natural conditions, New Zealand pastures are rich in surface water resources and groundwater resources. Research on water supply technology for decentralized pastures is mainly focused on the source of water supply power.

3. Water supply technology and equipment of advanced international pasture

Wind and solar energy are widely used as energy power in pastures abroad. American pastures are equipped with special power equipment (photovoltaic panels, wind turbines, windmills), water pipelines, drinking tanks, etc. Netherlands pastures use wind turbine pumps to fill the reservoir with wind energy. The reservoir is mounted on the high ground, and the water automatically flows out of the reservoir. It can supply water to pastures in different directions at the same time.

3.1 Fresh water mill of soltesQ energy B.V.

Fresh Water Mill (FWM) is a stand-alone system, powered by renewable energy sources, which can provide fresh water and electricity for pastures without power grid. The main body is based on a hydraulic windmill, which can convert wind energy into high pressure, as the main energy source of reverse osmosis water purification system. FWM uses a double-bladed Lagerwey 18/80 wind turbine with rated power of 80 kW. The wind turbines can reach about 100 kW and the losses in gears and generators are greatly eliminated by using hydraulic transmission system instead of typical electromechanical transmission system. The power generation system consists of a hydroelectric generator, a photovoltaic system and a battery pack, which are placed in parallel with the reverse osmosis water purification system. The system structure is shown in Fig. 1.

3.2 Battery-free photovoltaic water supply system

Fig. 2 is a battery-free photovoltaic pump water system, which consists of photovoltaic array, maximum power tracking controller, inverter, induction motors and pumps. It mainly regulates current
frequency through maximum power tracking algorithm, so as to control induction motors, which achieve the purpose of regulating water flow, and make the output water stable and controllable.

Battery-free photovoltaic water supply system is suitable for small households, livestock and small area irrigation water. Its system advantage is that there is no energy storage link at work. When water supply is needed, the system can be directly converted to electricity by solar energy to drive water pumps, which reduces the cost of equipment purchase, installation and maintenance. It is economical and practical. However, the shortcomings are obvious. It is not suitable for areas with poor solar energy resources and can not provide water on cloudy days.

![Fig. 2. Schematic diagram of battery-free photovoltaic water supply system](image)

**3.3 Stand-alone multi-energy water supply system**

Fig. 3 illustrates the multi-energy complementary water supply model used in Colorado pasture in the United States. The first water transmission line is as follows. First, the mechanical Windmill Pump (Fig. 4) pumps the water into the storage tank, then the electric drive pump delivers the water to the pressure tank, and finally to the distribution network. The second water transmission line is as follows: first, the wind turbine and photovoltaic system generate electricity, part of the direct current is stored in the storage battery, part of the water is transferred to the distribution network by driving the DC pump, the rest of the direct current is connected to the AC load terminal and the AC pump through the inverters, and finally the water is transferred to the distribution network by the AC pump. Backup generator is used as emergency energy sources when other power systems cannot operate normally[17, 18].

![Fig. 3 Schematic diagram of stand-alone hybrid energy water supply system](image)
Stand-alone hybrid energy water supply system is suitable for large and medium pastures. Its advantages are that multiple energy sources can complement each other, or operate independently, adaptability to various environmental conditions, stability of the water supply, convenient and safe. The disadvantage are that the construction investment is large, the operation is complex, the daily maintenance and maintenance needs professional and technical personnel, and high cost of the battery replacement.

3.4 Remote wireless data acquisition system for photovoltaic water supply

Fig. 5 is a schematic diagram of the system. The information from the sensor is transmitted to the microcontroller, where it is processed and transmitted to the external memory, and then transmitted to the computer through the communication interface. The processed data are converted into actual physical values (current, voltage, irradiation, etc.) by microcontroller and used by personal computer to analyze and monitor the performance and operation status of photovoltaic pumping system[19].

The advantages of remote wireless data acquisition system for photovoltaic water supply lie in low investment cost, which can monitor the working status of photovoltaic water supply system in real
time and improve the stability of photovoltaic water supply system. But the system needs mobile network signal coverage in its area.

3.5 Automatic water supply control system for pasture

In Figure 6, water is pumped into the water supply tower and filtered through quartz filters for large particles of impurities. After softening by zeolite ion exchanger, water enters the constant temperature heater, and then reaches the terminal drinking water heater through ultraviolet sterilization. In each stage, the parameters of flow, temperature and water pressure are collected by sensors and fed back to the control system. According to setting, the system automatically adjusts and controls the flow, temperature, water pressure, water hardness and ultraviolet radiation dose of water supply in each stage, thus ensuring the safety of water quality and water supply, and achieving the goal of energy-saving water supply[20].

![Fig. 6. Schematic diagram automatic water supply control system for pasture](image)

The advantage of the system is that there is a complete filtration system and control system in the water supply system. The working parameters of each module can be set according to the actual water quality situation of the pasture source, so as to ensure the safety of water use. The disadvantage is that the cost is high, it needs to be built indoors, and the filter parts in the system need to be replaced frequently.

3.6 Automatic constant temperature water supply system

In Figure 7, W is a temperature sensor. Four temperature sensors are responsible for collecting the inlet temperature of the constant temperature water tank, the working temperature of the system, the water temperature in the heat preservation tank and the outlet temperature of the heat preservation tank. Fs is a float switch. Five switches are responsible for controlling the upper water level and the lower water level in the thermostat, the upper water level, the middle water level and the lower water level in the thermostat.Port is the control signal of the solenoid valve. Three solenoid valves are responsible for controlling the conveying water of the thermostat and the thermostat respectively. The system also has a turbine flowmeter and two manual on-off valves to control water flow[21-22].

![Fig. 6. Schematic diagram automatic water supply control system for pasture](image)
Fig. 7. Schematic diagram of automatic constant temperature water supply system

Automatic constant temperature water supply system is suitable for human and livestock water supply in cold winter area. Its advantage is that it can synchronize external water supply in time-sharing, and its working condition is less affected by the environment. Compared with the traditional constant temperature water supply method, the system has higher accuracy and stability by using integrated microelectronics technology, embedded technology, computer technology and other high and new technologies. The disadvantage is the high energy consumption. When applied to remote pastures, new energy can be used for power supply.

4. Current Situation of Water Supply in Pastoral Areas of China

The main water supply modes of pasture in China are: single well of groundwater (machine well or shaft well), independent water supply by surface water pipeline, multi-source water supply by single well of groundwater, water supply by rainwater harvesting, and water supply by natural water sources (springs, rivers, lakes). Most of the pasture dwellers in China live in scattered and remote areas, and there is no conventional power grid. Most of the water supply modes are small and scattered [23-25]. The main energy sources for water supply are diesel engines and gasoline engines. For herdsmen, the annual energy consumption expenditure is high, and it is not conducive to the ecological environment. Some pastures began to use wind and solar energy as energy power, but there was no automation and informatization because of large one-time investment, low energy utilization and inadequate training for maintenance personnel [26].

5. Conclusion

In this paper, technical investigation is carried out from three parts: different water pumping system, data acquisition system and water supply terminal system. Several combinations are summarized to adapt to different water supply situation of pasture. Through the research of foreign advanced technology and the analysis of China's national conditions, the conclusions are as follows:
China's wind and solar power generation technology is in the leading position in the world in the promotion and application, but the research and application of wind and solar water supply technology is less. By combining wind and solar power generation technology in China and drawing lessons from advanced clean energy water supply technology in foreign countries, we can provide technical support for our pasture water supply.

Through the case of advanced technology in the world, China can draw lessons from the water-pumping technology, such as Fresh Water Mill water supply system, battery-free photovoltaic water supply system, independent hybrid energy water supply system.

Data acquisition technology: wireless data acquisition system of remote water supply system.

Water supply terminal technology: water supply technology of automatic constant temperature water supply system and automatic water supply control system of pasture.

Through the understanding of water supply technology under different conditions of international advanced pasture, combining with natural and economic conditions of pastoral areas in China, the research on water supply technology of international advanced pasture was completed, which provided background support for improving the water supply situation in remote pastoral areas in China, and provided reference information for the development mode and future direction of water supply technology in pastoral areas in China.

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