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Direct wind heating greenhouse underground heating system

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Abstract. China's three northern regions are rich in wind energy resources, with annual wind speeds of more than 3m/s reaching 5,000 hours. Traditional greenhouses use coal-fired heating, which has high pollution and low efficiency. Therefore, the system ingeniously combines wind and heating, and proposes a system that directly combines water agitation heating and greenhouse heating to realize the direct conversion of wind energy to thermal energy. The working principle of the system is: when the wind speed reaches the starting wind speed of the wind turbine, the wind turbine blade rotates to drive the stirring device, and the water in the stirring device is heated by the heat, and when the local table temperature is low, the water can be released, and the water is buried. The serpentine pipes in the greenhouse soil heat the soil, and the temperature in the greenhouse will also increase. At the same time, the temperature in the greenhouse is monitored by the temperature control system. If the temperature rises faster, the fluid flow is adjusted to reduce the heat release. Achieve intelligent regulation of greenhouse temperature to maintain its temperature in a suitable range. The system uses a wind-mixing device to use the abundant wind resources in the Sanbei area for greenhouse heating, thereby keeping the greenhouse temperature stable. From the perspective of green and energy saving, it has created an effective way to warm the greenhouse in winter. In the true sense, the consumption of fossil energy has been reduced, and the criteria for appropriate localization and recycling and renewable development have been realized.

1. Research background and significance

Wind energy is inexhaustible, inexhaustible, clean and pollution-free renewable energy[1]. The three northern regions of China are close to the wind source, and there are many windy weather and abundant wind energy resources. At the same time, the low temperature of the traditional greenhouse at night, low ground temperature will lead to slow growth of plant roots, frequent occurrence of pests and diseases, is not conducive to plant growth and development. However, the existing greenhouses mostly use coal as the main energy supply mode, which has high energy consumption, high cost and serious pollution, and cannot meet the requirements of sustainable agricultural development. Therefore, direct wind heating is a new wind energy utilization method that directly converts wind energy into heat energy. The system uses it in greenhouse heating.

The system directly converts wind energy into heat energy, which can first reduce the cost, and secondly can improve the utilization efficiency of wind energy. Compared with the prior art, the system has the characteristics of large heat supply, energy saving and emission reduction, good promotion, limited restriction factors, stable heat supply, low economic cost and fast benefit recovery. If it can be

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fully utilized in greenhouse heating, it will inevitably generate greater social and economic benefits. It also implements the concept of ecological civilization advocated at present and realizes innovation in the field of environmental protection. It is an inevitable choice for building a resource-saving and environment-friendly society.

2. Design plan

2.1. Design principle

The system first collects abundant wind energy through the fan outside the greenhouse, and rotates the stirring shaft through the gear box. The eccentric stirring device starts to work, stirs the water in the device to warm it, and controls the water in the device through the real-time temperature control system. Whether to release the heating, and at the same time add a micro-quiet water pump at the end of the buried pipeline to recover the cooled water to the storage tank to form an autonomous cycle.

The products of this project are mainly composed of wind mixing system and pipeline circulation system.

Wind agitating system: When the wind blows the blade, the fan converts the wind energy into mechanical energy to drive the stirring shaft to rotate, the stirring device starts to work, and the rotating disc blade in the mixing barrel stirs the water. Water with a certain viscosity obtains a certain flow field morphology in the rotating disc. The fixed disc and the rotating disc divide the entire flow field into three layers of agitation space, and the relatively closed agitation space increases the fluid pressure and the friction between the water molecules is intensified. The agitating blades on the fixed disc form a hindrance to the flow field, aggravate the solid-liquid friction heat generation, and promote system energy exchange.

Pipeline circulation system: Wind energy drives the agitation device to heat the water to 55 °C. When the light temperature is insufficient, the heated water is placed in the underground heat pipe. Since the plant roots are generally located at 25 cm, the pipeline is laid 30 cm underground because it does not cause obstacles to the tilling operation and does not affect the root growth of the crop. The heat of the heat pipe is used to raise the shallow ground temperature of the greenhouse to meet the requirements of the root temperature of the crop; when the water temperature in the pipeline drops to a certain temperature, the water is used to introduce the cold water into the liquid storage tank, and the temperature of the water is monitored by the temperature control system. When the agitation causes the water heating temperature to reach the desired level, the next water discharge is performed, thereby achieving the system's circulation control.

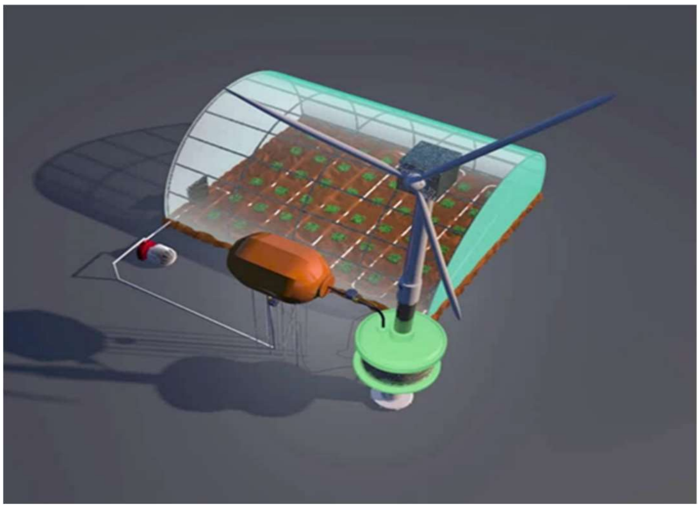

Figure 1. Three-dimensional diagram of underground heating system in wind-heating

2.2. The working principle and structure of each part of the system

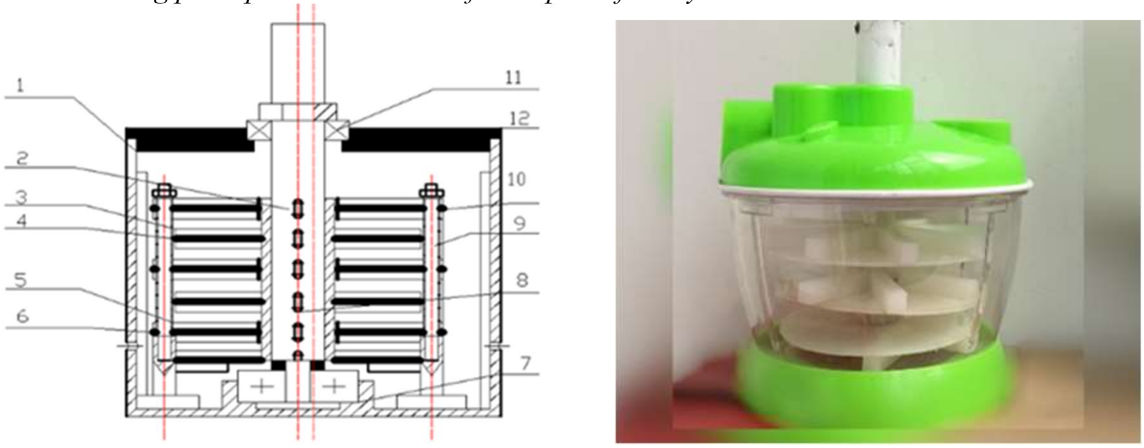

Figure 2. Eccentric stirring device profile and schematic

2.2.1. Stirring heating device. The geometry of the agitating heating device is as shown in Fig. 2, and is mainly composed of a fixed portion including a stirring drum 1 fixing disc 5 and a fixing bolt 9; the rotating portion includes a stirring shaft 2 and a rotating disc 3. A large gap is left between the fixed disc and the agitating shaft, and is connected to the agitating barrel through a fixing bolt 9; the rotating disc is mounted on the agitating shaft 2 through a key 8; the agitating shaft is mounted on the agitating barrel through the bearing 11 and the bearing 7. The device has 3 rotations and 3 fixed discs. The upper and lower end faces of the fixed disc and the rotating disc are equipped with a stirring blade 4, and the rotating disc rotates in a space formed by the two fixed discs to form a 3-layer water stirring. Floor. A small gap is left between the fixed disc and the inner wall of the mixing drum to form a throttle orifice.

Secondly, the agitating disc is placed eccentrically, so that the velocity distribution of water in the mixing tank is not uniform. According to the Bernoulli equation, the water velocity is slow and the pressure is strong on the telecentric side, and the water velocity is fast and the pressure is small on the eccentric side. Without stratified agitation, eddy currents are more likely to occur, and the number is large, the size is small, the internal energy conversion of the system is accelerated, and the heating effect is obviously improved.

2.2.2. Temperature control system. The temperature control system consists of temperature measuring instrument 18B20 temperature sensor, K60 single chip microcomputer, relay, liquid crystal display and adjustment button. The temperature measuring instrument measures the temperature in the mixing drum and transmits it to the single chip microcomputer, and determines whether the temperature reaches the set temperature through the program. If the set temperature is not reached, the liquid discharging valve controlled by the single chip microcomputer is turned off, when the temperature rises to the set temperature and the light temperature Open the drain valve when it is not enough. At the same time, the liquid storage tank refills the mixing tank, and the real-time temperature and set temperature of the mixing tank water during the whole cycle are displayed through the liquid crystal display for monitoring. Moreover, we have also designed a temperature setting plus or minus button to make it easier to change the set temperature.

2.2.3. Underground heat storage pipe. The underground heat storage system is divided into four parts, each part is a serpentine pipe structure. The heat pipe is made of hard PVC material and buried 30cm underground. The pipe spacing is 30cm and the pipe inner diameter is 40mm. When working, hot water flows in from the left side and flows out on the right side. There are curved pipes on both sides of the north and south to increase heat dissipation. Such a distributed serpentine pipe system can effectively balance the ground temperature in the greenhouse.

3. Experimental verification of eccentric stirring device

The project carried out the following experiment through the completed model of the stirring heating device. The volume of the device used was 4L, the diameter of the stirring blade was 16cm, the volume of water in the device was 3L, and the initial temperature was 20 °C. The inverter was controlled by different speeds and measured. The temperature of the water in the device changes with time. Within 60 min, the temperature of the liquid increases by 8.38 °C at 300 rpm; at 350 rpm, the temperature of the liquid rises by 12.26 °C; at 400 rpm, the temperature of the liquid rises. 17.02 ° C. It can be seen that as the rotational speed increases, the temperature of the liquid in the heater gradually increases with the increase of the rotational speed.

Taking the 18KW wind turbine as an example, the blade tip speed ratio is 7, the blade diameter is 8m, the gearbox transmission ratio is 1:10, and when the wind speed is 2.3m/s, the stirring device rotation speed is 384r/min, through experimental analysis, about The ambient temperature water can be heated to 50 ° C in three hours. The annual average wind speed in the Sanbei area reaches 2.5m/s, and the device meets the requirements for use.

Figure 3. Straight and device blade

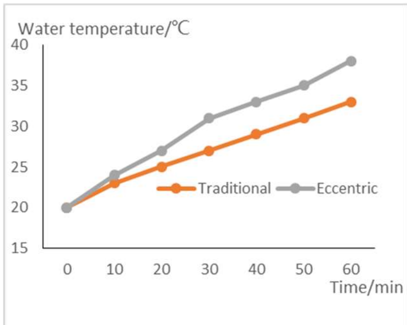

Figure 4. Blade heating comparison chart

Conventional mixing and heating devices mostly use straight-type blades (Fig. 3), which have the characteristics of simple structure and good radial discharge capacity [2]. At the same speed, two kinds of blade stirring water were installed to raise the temperature. The experimental results show that the blade used in this project has better heating effect on water and higher temperature rise.

4. Performance analysis

In the Sanbei area, the heating season is converted to 120 days. According to empirical data, the wind power density during this period is about 200-300W/m^2 [3], taking 250 W/m^2. The wind turbine is used to stir and heat. The 18 kW wind turbine is selected to have a diameter of 8 meters and the sweeping area is 50.26m^2, which can generate 130273.92 MJ of heat. The standard coal calorific value is 29,250 MJ/ton. If lump coal is used as fuel, its thermal efficiency can reach 54.7%-59.2% [4], and it is necessary to burn standard coal of 8.10 ton/year.

Table 1. Energy saving analysis result

Greenhouse area(m^2)	One heating season heat release (MJ/ quarter)	Coal saving (ton/ quarter)	Reduce carbon dioxide emissions (kg/quarter)	Reduce sulfur dioxide emissions (kg/quarter)	Reduce nitrogen oxide emissions (kg/quarter)
420	130273.92	8.10	21222	68.85	59.94

Burning one ton of standard coal produces 2,620 kilograms of carbon dioxide, 8.5 kilograms of sulfur dioxide, and 7.4 kilograms of nitrogen oxides. The amount of heating by the wind heating device. In the experimental greenhouse, the coal volume in a heating season can reach 8.10 tons, and the carbon dioxide emission is reduced to 21.22 tons. It can be seen that the energy saving and emission reduction effect of the system is very significant.

5. Innovation and application prospects

5.1. Innovation

5.1.1. Use wind energy - clean, reduce emissions. Traditional greenhouses mainly use coal as an energy source with low efficiency and high pollution. The greenhouse underground heating system uses non-polluting wind energy as an energy supply, which effectively reduces the emission of carbon dioxide, toxic and harmful gases and solid particulate matter. The North China region is located in a wind-enriched region and has a unique natural advantage.

5.1.2. Direct mixing and heating - high conversion rate. The greenhouse underground heating system directly uses the wind turbine to drive the stirring device to heat, and the wind resource can be utilized most efficiently. The stirring heating method does not require an auxiliary device, has a simple structure, is inexpensive, is easy to manufacture, has a small volume, and has no wearable parts, and has no strict requirements on the heat carrier medium. Secondly, during the whole operation process, the stirring and heating device can convert all the input energy into heat energy, which can well match the output power characteristics of the wind turbine and have a large power coefficient.

5.1.3. Temperature controllable, automatic adjustment – humanization. The system independently designed the temperature control system, the user can set the temperature according to the plant growth demand, the degree of automation is high, and the use is convenient. Real-time monitoring and recording of indoor and outdoor indicators to achieve more precise control of the heating system.

5.1.4. Long service life, fast investment recovery – low cost. The service life of the wind turbine is 20~30 years [5]. The project only runs during the heating season, and it runs for 3-4 months a year, so the service life can exceed 30 years. Compared to traditional coal-fired greenhouses, the cost of use has been reduced by nearly 40%. At the same time, greenhouse construction investment has not increased much compared to traditional greenhouses.

5.2. Application prospect

The system ingeniously uses wind energy directly for heat production, making full use of the abundant wind energy resources in the Three North Region. Nowadays, agricultural modernization is developing rapidly, and the application scope of new greenhouses is more and more extensive. This system can not only ensure the growth of crops in the greenhouse, improve the yield and quality of crops, but also optimize the production process, save time and effort, and reduce Cost, the role of increasing income. In the face of increasingly serious environmental pollution problems, the system will have broad application prospects and social benefits in the Three North region.

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