Design of a Control System of Poplar and Willow Catkins Collection Device

Liqin Ji*, Zhengyi Zhang, Pengfei Xie, Chao Chen, Manyu Lin
Institute of Intelligent Manufacturing, Anhui Xinhua University, Hefei 230088, China
*Corresponding author’s e-mail: jiliqin@axhu.edu.cn

Abstract: The device that can collect poplar and willow catkins is designed to solve the environmental pollution caused by flying willow catkins and to affect people's health in the spring. The article first conducts the background analysis, then gives the device design scheme, then completes the control system hardware design, software design, and finally designs a highly automatic and energy-efficient willow catkins automatic collection and control device for people.

1. Foreword
In spring, the poplar and willow catkins flew in sky, not only pollute the environment, but also affect people's travel and health. The catkins are seeds of the poplar and willow trees, which containing a lot of oil, it will cause burning when encounter open flame, and spread very fast, very dangerous[1]. In order to avoid the above situation, a control device capable of automatically collecting willow catkins is designed. The device is a new flocculation device with efficient collection of poplar and catkins for the purpose of purifying the air.

2. Design scheme
The device is set on a vehicle, mainly composed of six parts: fan adsorption system, collection system, minimum system of controller, water supply system, solar power supply system and human-machine interface. See figure 1 for details.
2.1. **Fan adsorption system**
It consists of four sets of fans, and each group is equipped with one air inlet, one filter screen and one air outlet. During working, the impeller in the fan rotates at high speed, so the centrifugal force of the air in the fan shell is removed from the air outlet is "pressed" from the fan. Then the air absorb the air from the air inlet continuously and absorb the air into the collection device through the filter screen.

2.2. **Collection system**
It consists of a collection box, a catkins compression plate (1 DC motor positive reverse drive), two position sensors and motor drive modules. During working, poplar and catkins automatically enter the catkins collection box through the filter screen. After the set time, the compression plate above the control collection box is automatically compressed driven by the motor. The compressed air and wastewater are discharged from the exhaust port, and the collected poplar and catkins are collected at the bottom of the dust collection box; When the compression plate reaches the lower limit position of the collection box, the motor stops and then reverses, and the compression plate is automatically restored to the original position, that is, the upper limit.

2.3. **Water supply system**
It consists of one water tank, one water inlet solenoid valve, one flower sprinkler head (solenoid valve control), and two water tank level sensors. When the liquid level is below the lower level sensor height, the control system will automatically open the inlet valve inlet (supplied by the outside) and automatically close the inlet valve when the liquid level is higher than the upper level sensor. When the device works and the catkins enters the collection box, the flower sprinkler solenoid valve will open simultaneously with the compression plate to moisten the catkins.

2.4. **Minimum system of controller**
This part is the control core of the unit, responsible for collecting the height of collection box compression board, the height of water tank level, output control fan, sprinkler head, compression plate motor, etc., so as to realize catkins collection and compression catkins. The control system also has a display for displaying some parameters of the system and the operating buttons that can be set or manually controlled.

2.5. **Solar power supply system**
Solar power generation is an emerging industry and a green energy source\[1,2\]. The power supply system consists of solar panel, solar controller (solar power supply supporting device), 24V battery and voltage stabilizing circuit. The solar panels convert solar radiation energy into electricity, send it to the...
battery for storage and supply the voltage stabilization circuit, which outputs power to the control system. The solar controller acts as overcharge protection and overdischarge protection for the battery\[3\]. The 24V battery supplies the fan, compressor motor, inlet valve and sprinkler head solenoid valve.

3. Hardware composition and circuit design of the control system
The control system of flocculation collection device consists of single chip computer and minimum system, fan drive circuit, compression board motor drive module, water inlet solenoid valve, sprinkler solenoid valve, water tank level sensor, compression plate position sensor, LCD display screen and operation button.

3.1. Single chip machine and minimum system
The MCchip in the control system is STM32F103C8T6. It is a 32-bit microprocessor based on the ARM Cortex-M kernel, with rich I/O ports and hardware resources to meet the needs of the device. The circuit of the controller and minimum system are shown in figure 2, consisting of single-chip computer, power supply circuit, reset circuit and crystal vibration circuit.

![Controller and minimum system circuit](image)

**Figure 2. Controller and minimum system circuit**

3.2. Fan drive circuit
The four groups of fans used in the fan adsorption system are all 24V DC fans. Due to no speed adjustment problem, the driving circuit uses a relay drive. One set of driving circuits is shown in figure 3.
3.3. Compression board motor drive module

The compression plate in the device collection system is driven by a 24V DC motor. The 24V DC motor drive module uses the AQMH2407ND DC motor drive module. The drive module needs to control the positive rotation and reversal of the motor with the microcontroller output control signal, and there are three control signals connected to the single microcontroller, respectively IN1, IN2, ENA. See Table 1 for the control signal status and the motor state in correspondence.

| IN1 | IN2 | ENA | Motor condition                      |
|-----|-----|-----|--------------------------------------|
| 1   | 0   | PWM | Forward rotation and Speed regulation|
| 0   | 1   | PWM | Inverts and Speed regulation         |
| 1   | 0   | 1   | Full speed and Forward rotation      |
| 0   | 1   | 1   | Full speed and Inverts              |

Single-chip computer, drive circuit and motor connection mode see figure 4.

3.4. Solenoid valve drive circuit

The inlet solenoid and sprinkler solenoid have the same operating voltage as the 24V, drive circuit. Figure 5 shows the driving circuit of the inlet solenoid valve. The single chip controller Q5, operates the field effect tube Q6 and supplies the solenoid valve, otherwise, the solenoid valve is not switched on and the solenoid valve does not operate\[^4\].
3.5. Water tank level sensor
The tank level sensor is a non-contact active level sensor XKC-Y26-V. The sensor is not affected by the thickness of the container and realizes the detection of the liquid level height in the closed container. The sensor is simply installed on the outer wall of the height of the tested liquid level, without opening and easy to install[5]. The sensor operating voltage 5V, outputs a high level when the liquid level is above the detection level. The link between the sensor and the CM is shown in figure 6. The device is equipped with high level sensor and low level sensor.

3.6. High and low limit sensors
The sensor used for detecting the high and low position of the compression plate in the collection box is two limit switches, namely, the sensor provides a switch signal, passive. The sensor circuit for detecting the high and low position of the compression plate is shown in figure 7.

3.7. The LCD display circuit
The display screen is used to display the set parameters, working hours, etc., and provides a display screen for human-machine operation. See figure 8 for the circuit diagram.
3.8. Key circuit
The device sets four operation buttons, one mode key, one setting plus key, one set minus button, and one open machine key. See figure 9 for the key-button circuit diagram.

4. Control system software design
The control system software includes the master programs, subroutines, and interrupt programs. Among them, the subroutine has the initialization subroutine, display, key subroutine, boot control subroutine, shutdown control subroutine, fault processing subroutine, etc. interrupt program has scheduled interrupt program, etc. In the main program, different subroutines are called to achieve preset different functions. The main program flow chart is shown in figure 10.
Initializes the subroutine mainly initializes the display screen, timer, initial status of the display outputs; sends display data to the display screen and controls the display.

The key subroutine determines the key state and handles the button: when the "mode" button is pressed, the set state and the normal operation button switch in the set state; When the "add" button is pressed, only set data add 1 and the "decrease" button is pressed, only set data decrease 1; when the start / shutdown button is pressed once, the start state and shutdown button are exchanged once.

In the startup sub-program, open the fan of the collecting device, collect poplar and catkins. When the collection time arrives, close the fan, start the sprinkler solenoid valve, sprinkling, start the compression board motor, drive the compression plate to the bottom of the collection box, close the sprinkler solenoid valve, open the compression box to place the collected catkins in the special collection bag, then close the collection box, and reopen the collection fan to collect willow catkins. The shutdown sub-program is mainly responsible for shutting off the fan, compression plate motor, etc., so that the collecting device will no longer collect poplar and willow catkins.

The fault processing program is that after opening the inlet solenoid valve for a certain time, the level solenoid valve still can not detect the level, then the system reports the fault, on the display prompt "The inlet pipe is watery", and the system turns off, and cannot start again.

5. Conclusions and outlook
The poplar and willow catkins collection device is an automatic device based on automatic control technology. At present, the device design has been completed and made and tested, and all the functions of the device setting can be realized and patented. The next step will be put into production on the basis of further improvement. I believe that in the spring of willow catkins, the device can achieve air purification and bring great convenience to people's life and travel.

Supported by the “teaching team of electrics and electronics course group” in Anhui Xinhua University, project code: 2019jxtdx03.
References
[1] Yuchuan, J., (2019) A catkin collection device. J. Introduction for Technology Innovation, 16 (12): 120-121 + 123.
[2] Bingnan, W., (2020) Solar Power Generation Technology Research. J. Power system equipment, (1): 45-46.
[3] YD/T2321-2011, Technical requirements and test methods for converter-regulated solar power supply controllers for communications.
[4] Yikai, Q., Zhimin Z., (2012) Improvements to a classic solenoid valve drive circuit. J. Electronic World, (10): 54-56.
[5] Shenzhen Xingkechuang Technology Co., Ltd. (2019) Specification for non-contact liquid level sensor. https://www.ybzhan.cn/st107921/article_335118.html.