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Design of wood drying control system based on PLC

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Abstract. The wood drying process control is a very important part, directly related to the quality of timber drying. In this paper a control system based on programmable logic controller (PLC) and the configuration interface are designed to dry wood. The system can realize automatic control of drying through the host computer PC and PLC. First a suitable drying criterion is set and the drying process is conducted on the timber. At the same time, the data of temperature, humidity and wood moisture content etc. in the kiln are collected. After filtering and standardization, the above data are put into the PID table. The proposed algorithm is applied to achieve PID regulator, then the interface outputs signal to control the opening of the corresponding valve to adjust the temperature and humidity in kiln and the wood moisture content of timber. Experimental results show that the control system can achieve the real requirements.

Key words. Wood drying, PLC, configuration, Proportion Integration Differentiation (PID)
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1. Introduction

The wood drying is one of the important measures which can preserve the good characteristics of wood, enhance materials, and rationally use of wood. The wood drying process control is a very important part, directly related to the quality of timber drying the pros. This paper uses programmable logic controller (PLC), which is widely used in the field of automatic control, to establish the control system for wood drying. Use PID as regulating means to control temperature, humidity, and moisture content and other drying parameters. In accordance with the drying technologies to achieve effective and accurate real-time control purpose of the drying process.

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1.1. The structure of control system

The core control part of the system adopts the combination of lower computer-PLC and upper computer-PC through configuration software [1–3]. PLC has the advantage of working stability, strong anti-interference, programming convenience, and is easy to expand etc. [4]. PLC can form a good human-computer interface through configuration programming which can observe the real-time change of parameters in the drying process and modify the various control parameters and techniques. PLC controls the various implementing agencies in the drying scene and make data processing[5–6]. PC displays and saves all kinds of real-time parameters and alarm messages. It also can set and modify parameters and calculate parameters by intelligent algorithms. System block diagram is shown in Fig. 1.

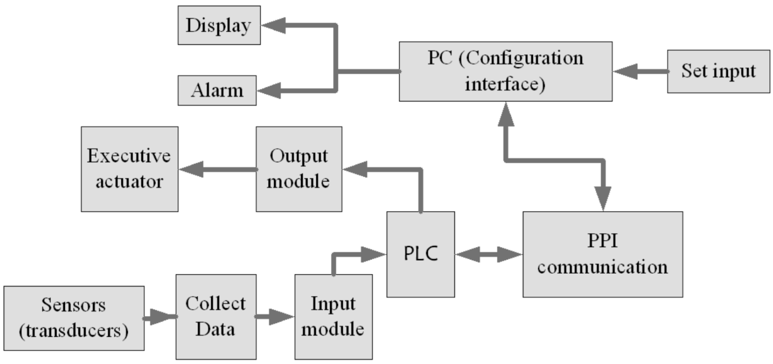

Fig. 1. Structure of system

First of all, select or input a suitable drying criterion bases on timber to be dried and the whole process of drying is according to the criterion to complete. The first work of the system is to collect the real-time data of temperature, humidity, wood moisture content, etc. in the kiln. The system is designed as six-way loop collection program. Eliminate the filter wave in bad data and arithmetic mean value to get the real-time temperature, humidity and wood moisture content. To obtain the given value of temperature and humidity according to the current moisture content and the drying criterion. And after the standardization of data, put it into the PID table which is corresponding to temperature and humidity. The adjusted program is designed to achieve PID regulator. The analog output interface outputs signal to control the opening of the corresponding valve in order to control the temperature and humidity in kiln and adjust the wood moisture content, drying timber in the drying criterion.

1.2. PLC Selection and module expansion

The system uses Siemens S7-200 series PLC with 224 CPU [7]. The total expansion of analog I/O module are five EM235. This is shown in Fig. 2.

All sensors (transducers) have in the system output 0–10 V voltage signal. The

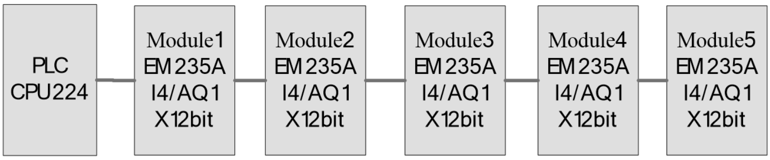

Fig. 2. Hardware module chart

five EM235-analog input and output modules all use voltage wiring, while DIP switch is slid to 0–10V. The system uses multi-point acquisition mode, the setting are as follows: Input analog signal: kiln temperature × 6 Road, kiln humidity × 6 Road, wood moisture content × 6 Road. Output analog signal: heating × 1 Road. humidifying × 1 Road. Input switch variable signal: fan operates and wind direction confirms × 2 Input point, amendment of tree species × 4 Input point. Output switch variable signal: intake × 1 Output point, exhaust × 1 Output point, fan forward and backward × 1 Output point, fan operates × 1 Output point. Heating and humidification control valves are all electric valves, regulating the opening to complete the temperature and humidity regulation in drying kiln. As the analog output is 0∼10 V voltage signal, the VVI41.15-2.5 type electric valve is selected, and the actuator is SQX62. The hardware resource allocation and functions of the system are shown in Table 1.

1.3. Sensor selection and detection circuit

Temperature and humidity are the main parameters of drying kiln. Because the environment is complex and the range of changes in temperature and humidity is large in drying kiln, the sensor should have the characteristic such as temperature drift is small, measuring range is large, damp-resisting, anti-corrosive and so on. The system selects KZC2.HD/9 temperature and humidity integrated sensor (transducers) with a strong aluminum body. It can measure the relative or relative humidity and temperature humidity of air and other non-corrosive gases. It is able to be used at pressures up to 25 bar as well as temperatures up to 160 °C. Its temperature measuring range is –40 °C∼160 °C and humidity measuring range is 0–100 % RH [8].

Transducer outputs are 0–10 V of standard voltage which can be directly connected to the EM235 analog input module.

EAL (Electronic apical locator) is used to measure the real-time wood moisture content and probes are used to measure the moisture content of drying kiln at 6 value. When the wood moisture content is between 28 % to the fiber saturation point, the relationship between the logarithm of specific resistance and the logarithm of moisture content abide by linearity relations. When it is the above fiber saturation point, the moisture content and the logarithm of resistance rate has linear relationship. According to the electrical properties of wood, use the measurement of the resistance value of wood in the wood drying process to online detect changes in the moisture content of wood. The test range of moisture content is of 8 % to 80 %, and the corresponding change range in resistance value is 1400 MΩ ∼ hundreds kΩ.

The input resistance with the high input impedance, high common mode rejection ratio (CMRR) of the bootstrap amplifier operation expanded in inverse proportion to enlarge, then enter the logarithmic amplifier, converted to the voltage 0∼10 V input PLC. Logarithmic amplifier circuit is shown in Fig. 3.

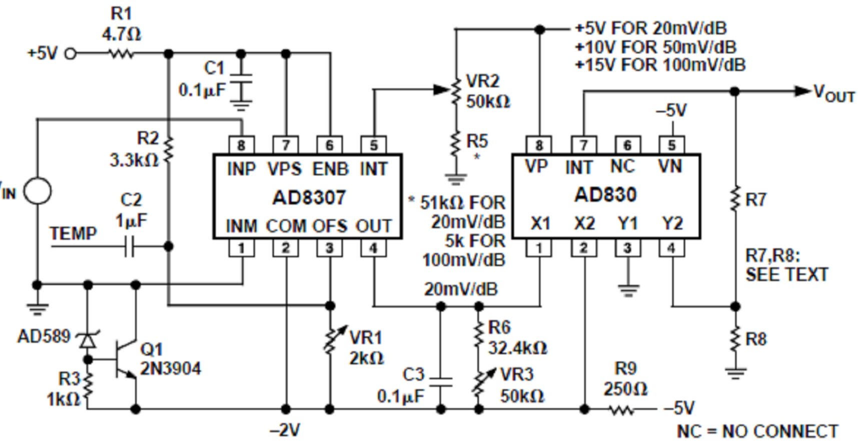

Fig. 3. Logarithmic amplifier circuit

The characteristic of this circuit is to use a logarithmic amplifier as the conversion module of a resistor voltage. As the amplifying circuit requires high input impedance, therefore use the bootstrap circuit to improve the input resistance. Circuit output connects AD8307 logarithmic operational amplifier input Vin. AD8307 can be used in industrial temperature range: from –40 °C up to 85 °C, and can be used for DC input. AD830 is used to eliminate the impact of output resulting from negative power [9–10]. Select 50 mV/dB, R7 = 3 kΩ, R8 = 2 kΩ,the output is VOUT =10-log10 (Rx).

The standard 0–10 V output voltage can be directly connected to the EM235 Analog Input Module.

2. Design of control system software

The design of system software uses modular thinking. System software is made up of function modules that have relatively independent of the function. According to different functions, the modules can be divided into the following sections:

(1) Control of the main program module. The main functions of system's main program are: initialization, data processing, open timer interrupt, transfer alarm program and Completed drying base table changes when PC gives directions.

(2) Initialization module. Connected to the system power, and then automatically start the control system software in the first scan cycle, go to "System Initialization" module. The module was completed for: Memory cleared, Moisture content - the initialization of temperature and humidity table, PID parameter initialization, Set the final moisture content.

(3) The subroutine of Moisture content data pre-processing shown in Fig. 4.

(4) PID adjustment subroutine (timer interrupt module). The main functions of the module: The establishment of temperature, humidity PID table PC chooses whether adjusts temperature, humidity PID.

(5) Output module (heating valve, steam valve output).

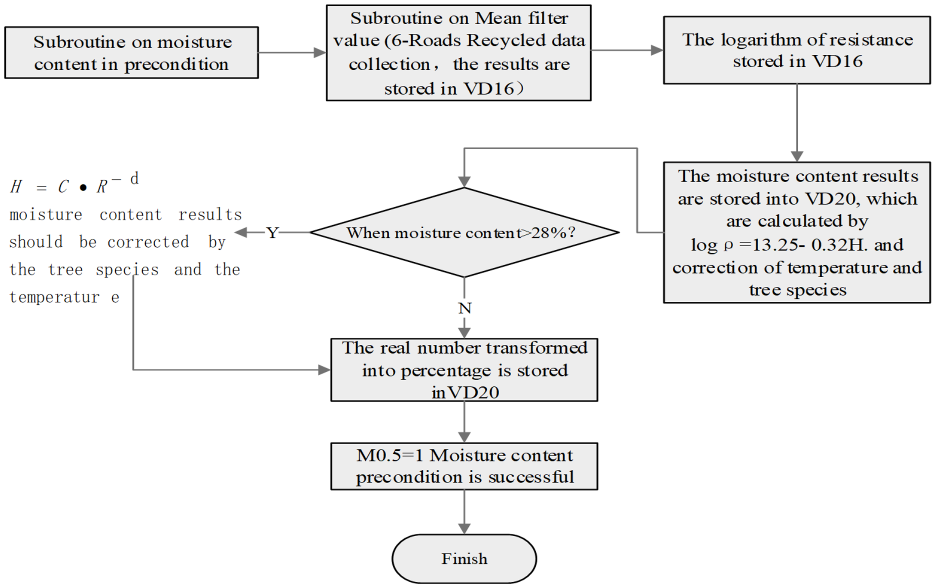

Fig. 4. Subroutine flow chart of Moisture content data pre-processing

3. Conclusion

The automatic test system of wood drying kiln is used in the dying process for the poplar trees. The drying experiment is going on for four consecutive days, wood moisture content decreased from 74.2 % to 8.3 %. In order to verify the accuracy of the system, the wood moisture content is measured by weighing method and system measurement method. Experimental results showed that the error between the moisture content came from multi-parameter test system of the wood drying kiln and the moisture content came from weighing method is less than ±1 % in the final moisture content phase. Results show that the error of the moisture content of the final stage value is less than ±1 %, comparing with that of weighing method. The control system for wood drying process will shorten the drying time, reduce drying energy consumption and improve the drying quality.

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