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Research and Design of Embedded Timber Drying Monitoring System Based on ARM9

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Abstract

Wood drying is one of the most important processes in wood production and processing. The purpose of the study is to improve the level of automation of small and medium-sized wood drying enterprises and to improve the drying efficiency and quality. Using Visual Basic6.0, this article completes the development of host computer monitor software, which not only monitors on-site equipments, but also integrates the knowledge base of local wood drying experts and remote expert server. Furthermore, micro-processor is embedded into the slave computer which is of low energy consumption, fast operation and high reliability as its main controller. This system has been applied in Harbin timber factory, and the results show that the system is reliable, low cost, and has certain commonality. Therefore, the results of this study show that this method can serve as a reference and promote the upgrading and transformation of the automation level of wood drying enterprises.

Keywords: *computer control; embedded; wood drying*

1. Introduction

With the popularity of computer technology growing, it has been recognized by all industries to control the production process through computers. Wood drying control system also develops towards an intelligent way. Its controller develops from an 8-bit processor chip with SCM and PLC to a 32-bit high-speed processor with ARM and DSP [5]. The embedded system does not only has the general characteristics of high operation speed, high accuracy, capabilities of memory and logic judgment, program control and automatic operation, but also features in small size, low power consumption, high reliability and strong adaptability. Wood drying is an important procedure in the production of wood, which is directly related to the quality of the final product. It is also a procedure that consumes the most energy in the whole process, accounting for 40%~70% of the total energy consumption. Compared with conventional instruments [4], it will be more convenient and accurate to use embedded system to control the temperature and humidity of the drying medium in the wood drying kilns to realize the control over the whole wood drying process, which will also shorten the time of drying and has a practical significance in improving drying quality and labor productivity, and reducing energy consumption and drying costs [6-7].

Yiqing Peng *et al*. pointed out that wood drying was an essential step in the manufacture of wood products, a power-consuming and time-consuming process [3]. Both the rate of drying and the drying cycle affect the economic benefits of enterprises. The rate of drying is an important economical indicator during wood drying. If the rate of drying is improved, it will have important implications for reducing the drying cycle time

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and cutting drying cost. Therefore, it is necessary to find an effective method to control the rate of drying of wood.

Arun suggested that wood drying monitoring was an interdisciplinary science and when developing wood drying control system [1]. Givon Chuen pointed out that it was the future trend of enterprises' production management to apply computer and automatic control technology to the production line[2]. The automatic control of the production process has been applied in the industrial field, which can improve production efficiency and reduce labor intensity. Proper control of the wood drying kiln is the guarantee of wood drying quality, but the key is to reduce the drying time.

The wood drying control system's processor is ARM 9 chip, which transplants the Linux real-time operating system and graphical interface Qt/Embedded. The system also provides independent power to other related parts and made it a comprehensive independent automatic control system. Compared with micro-controller and PLC system, this system can be directly connected with functional chip, do sample conversion to various analogs and rapidly process data to facilitate the development of the system's hardware and software. This system can also greatly improve the efficiency of wood drying and reduce the energy consumption and costs [8-9]. The practical application shows that the system can make the wood drying efficiency increased by 22% and saving about 11% of the energy.

2. The Technical Route

Hardware design: the slave computer adopts the Samsung S3C2410 microprocessor series, mainly to complete the designs of external memory circuit, keyboard, touch screen interface circuit, the signal input and output drive circuit, and to connect with monitoring host computer to realize the communication[10].

Software design: the monitoring host computer implements the interactive interface design by using visual programming language Visual Basic6.0 under Windows operating system, and realizes the communication with the slave computer by using the serial communication function of Visual Basic6.0. The slave computer uses Linux language to design all sub-features and features, and design the communication program to realize its communication with the host computer[11].

3. The System Composition and Function

The system needs to complete the acquisition of temperature and humidity in the drying kiln, equilibrium moisture content, moisture content and drying potential, and compare these parameters with the preset values[12]. To control the heating, spray, exhaust and ventilation equipment, completing heating, preheating, drying, humidity and cooling processes of wood drying in order to achieve fully automatic timber drying. System components are shown in Figure 1.

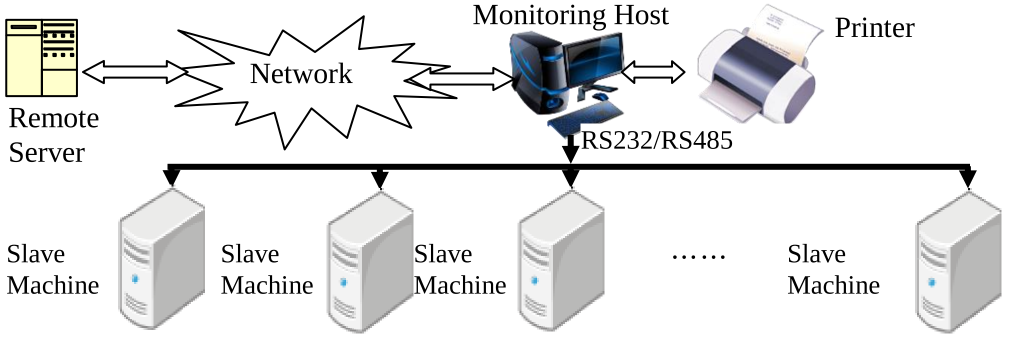

Figure 1. System Components

Monitoring host is mainly to complete the selection of detection points of wood moisture, the settings, selection and modification of drying benchmark, the limited number of drying kiln, and the query and print of drying history. During the drying process, the monitoring host communicates with the next-bit machine via the serial interface, and controls the slave computer. When confronted with monitoring expert system and the host does not solve the urgent problems, they can live with a remote server in order to get in touch with drying expert so that problems can be solved timely.

4. System Control Design

4.1. Slave Machine Design

Embedded microprocessor should be far superior constituted than a micro controller or PLC control system in computing speed, storage capacity, communication capabilities, reliability, anti-jamming capabilities, and the number of parameters that can be collected and controlled [13-15]. Therefore, the system uses Samsung's S3C2410 embedded microprocessor as the core of the system control unit.

The slave machine is mainly to complete field data collection and real-time control. It has two modes, stand-alone and online. In stand-alone mode, it can automatically completes the task of drying control. In online mode, it does not only complete the task of stand-alone mode, but also regularly monitor the sampling data uploaded to the host, and receive parameter setting and control commands of the host computer. Slave machine is equipped with a touch screen and lights. Through the touch screen you can set the initial parameters and conduct system start and stop operations. The lights can indicate operating status of the equipment and serves as an alarm. The hardware schematic diagram of the slave machine is shown in Figure 2.

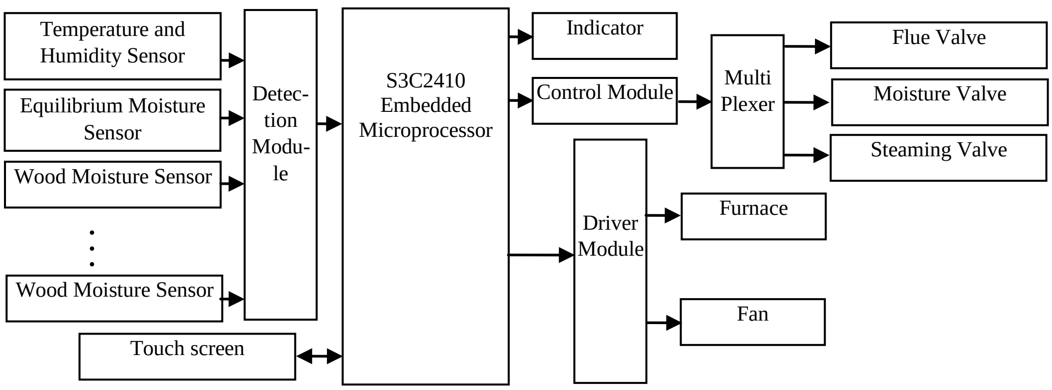

Figure 2. Lower Machine Hardware Schematics

According to the data in real-time detection, the system dynamically change of the status of the valve to ensure that the drying process is in accordance with the drying benchmark. lower machine-kind shown in Figure 3.

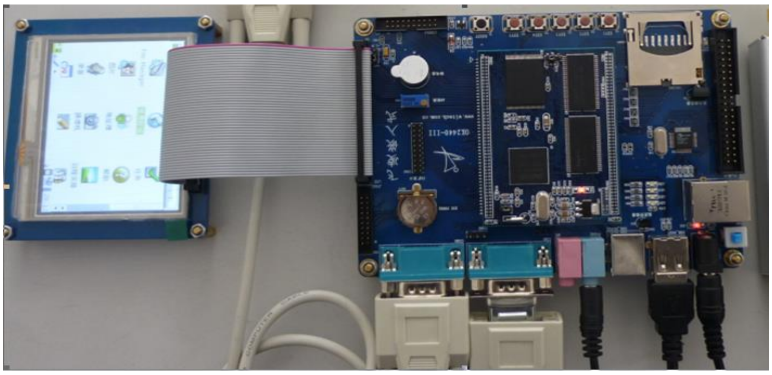

Figure 3. Lower Machine Physical Map

4.2. Measurement Devices of Temperature and Humidity in Drying Kiln and Control of Them

In the wood drying process, the range of temperature measurement is 0~100 ℃, and the range of humidity measurement is 0~100% RH. This system adopts JCJ100TLB Temperature Sensor as its temperature sensor[16].

During the drying process, the temperature control and equilibrium moisture control are independent, which is currently the mainstream in the form of wood drying control. Temperature of the medium is controlled by means of the steam valve based on changes in the moisture content of wood.

4.3. The Measurement and Control of Wood Moisture Content

Currently, there are various ways to measure the wood moisture content, specifically resistance method, capacitors, microwave method and gravimetric method, but they have different measuring principles, ranges and accuracy. Because in the wood drying process, the range of wood moisture content measurement is 0 to 50% and measurement accuracy is ±1%, and the measurement must be conducted continuously in an environment with high temperature and high humidity, the system selects the weighing method to measure the drying process of wood moisture content [17].

During the drying process, the equilibrium moisture content of the media is controlled through the moisture gradient of the wood. In the drying process, the moisture gradient has been set an upper and a lower limit, which are based on the critical moisture gradient of the dried wood. They are lower than the critical moisture content gradient and are determined by the degree of drying difficulty of the wood. The specific method is that, when the moisture gradient is close to its upper limit, the steaming valve opens and starts to steaming the wood[18]. Under normal condition, steaming valve is closed and trying to use the steam of the wood itself to increase evaporation wet. When moisture gradient reaches the lower limit, the system will open the intake and exhaust valves for exhaust tide to reduce humidity.

5. Software Design

5.1. Master Program Design

After initialization is completed, the user can set drying information, choose drying standard, select control mode and set drying process parameter. When all the settings above are completed, the system will automatically execute user-defined process. In the whole process, system parameters will be displayed, controlled and stored. When user-defined procedure execution is completed, the system automatically stops, and the whole operation process of the historical curve will display to the user. System control program flow chart is shown in Figure 4.

5.2. Serial Communication Program Design

S3C2410 has four full-duplex universal asynchronous/synchronous serial transceivers, namely USARTO, USART1, USART2 and USART3, which supports four clock operating modes: normal asynchronous mode, double-speed asynchronous mode, the host and slave synchronous mode. This system adopts normal asynchronous mode. The communication baud rate is[19]:

$$BAUD = \frac{f_{osc}}{8(UBRR + 1)} \tag{1}$$

BAUD is the rate of the communications. Fosc is the system clock frequency. UBRR is the baud rate register values. Before USART interface starts a communication, you must first initialize it, which usually includes baud rate settings, frame structure settings and enabling of the receiver or transmitter. For interrupt driven USART operation, when conducting the initialization, the global interrupt flag should first be cleared. The system serial communication procedures include serial communications between main controller and touch screen, and communications between main controller wood moisture content and acquisition program.

5.2.1. Touch Screen Serial Communication Program Design: The core of the program is the communication between the main controller and the touch screen[22]. The system uses asynchronous method to transmit data, with 4bytes frame terminator and a rate of 115200bps. The different functions of wood drying kilns are divided into different pages, and the system functionality is achieved through mutual switch between these pages[20]. On the same page, main controller determines the position through the received packet information of the touch screen, and then the system executes the operation. Meanwhile, in order to prevent the influences of high and low system lines on the communication, the contents of the packet should be judged. Figure 5 is the serial communication between the main controller and the touch screen flowchart.

5.2.2. Design of the Wood Moisture Collecting Communication Program: The core of the program is the communication between main controller and the wood moisture content acquisition program. Asynchronous method was used to transfer data with a rate of 9600bps[21]. Figure 6 is the serial communication between main controller and wood moisture content acquisition program flowchart.

5.3. Design of the Drying Kiln Sampling Interrupt Programming Parameters

This procedure mainly completes the acquisition of drying kiln temperature and humidity, drying potential and equilibrium moisture content of wood and other parameters. Drying kiln parameter sampling interrupt program flow chart is shown in Figure 7.

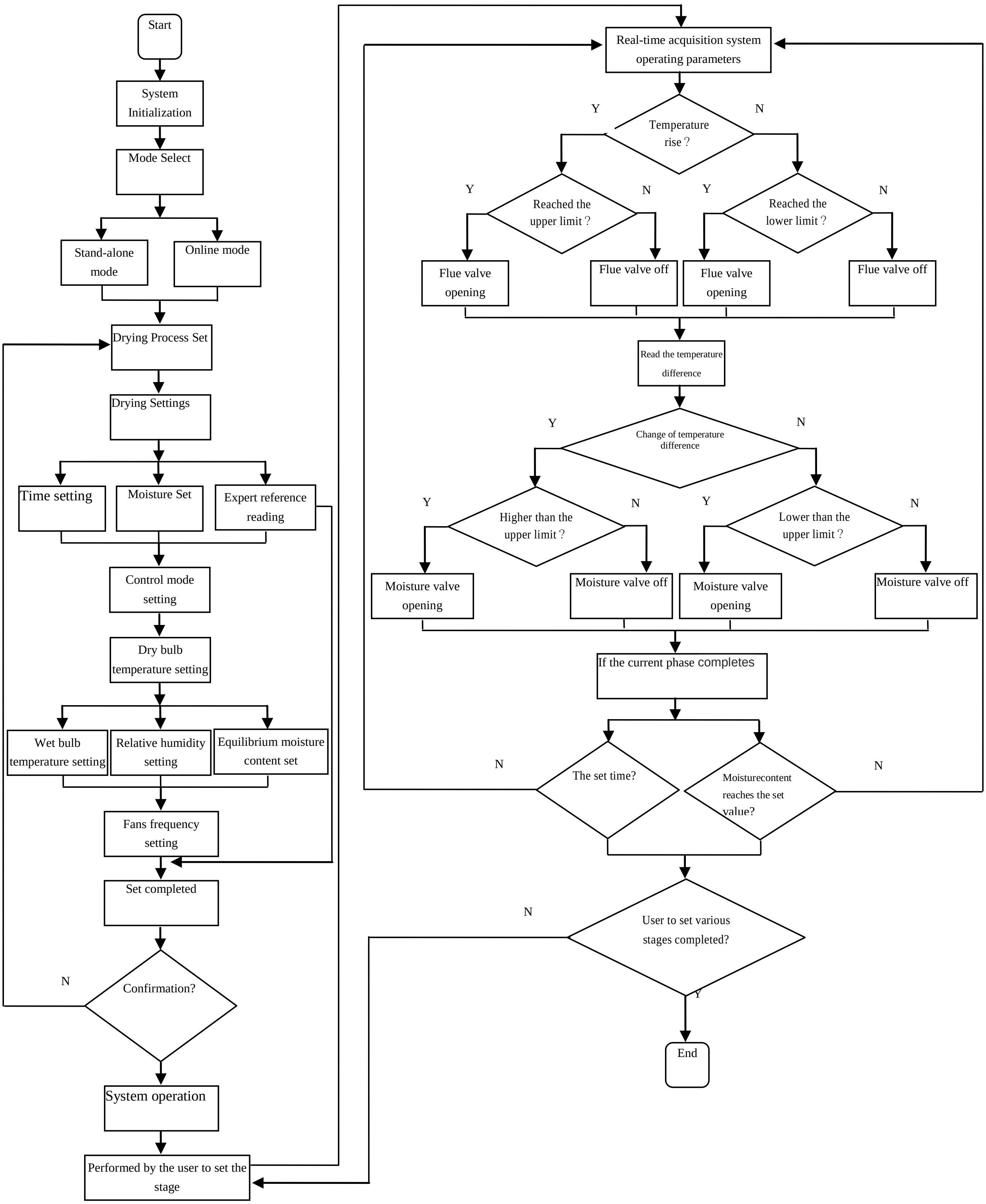

Figure 4. System Control Program Flow Chart

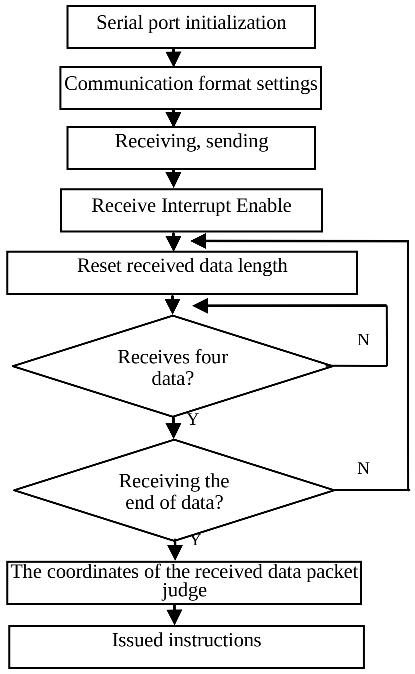

Figure 5. Touch Screen and Master Communication Flowchart

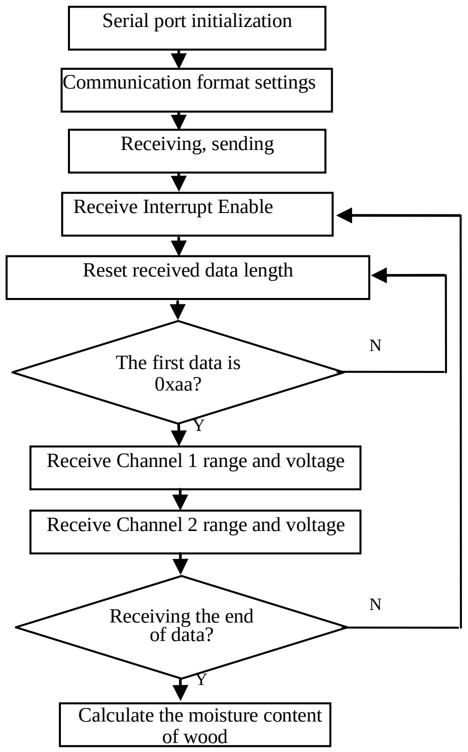

Figure 6. Main Controller Collection Procedures with Wood Moisture Communication Flowchart

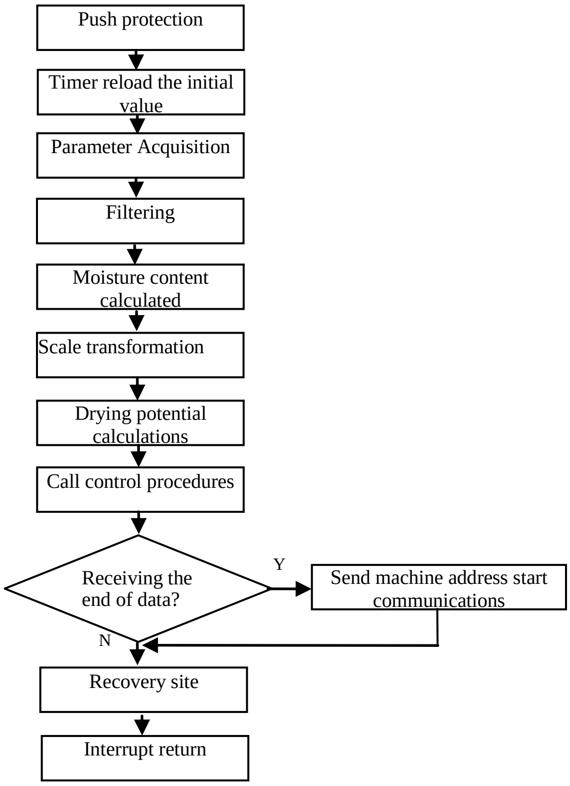

Figure 7. Drying Kiln Parameter Sampling Interrupt Program Flow Chart

6. Conclusion

Based on present research status of wood drying control system, combined with the actual situation of wood drying industry, the embedded wood drying automatic monitoring system was developed in the paper. Computer control technology, object-oriented programming technology, database technology, Windows communication technology and embedded technology were applied in the system.

This system uses embedded technology development and the embedded development board on-chip resources, an embedded microprocessor-based control, to make the complex control process become simple and reliable, so it has stronger practicality, real-time, reliability, and security than the micro-controller-based development wood drying automatic monitoring system.

Adaptive PID control algorithm was applied in this system so that the degree of accuracy of the whole system has been greatly improved. This system increased the alarm function with a 4 alarm functions, namely equilibrium moisture content high rate alarm, low rate alarm equilibrium moisture content, temperature alarm and low temperature alarm.

Wood drying expert system in this system provides best solutions to common tree species and can preserve the optimal dried solution. This system has two work modes, *i.e.* offline and online mode. In stand-alone mode, the slave machine can separate from the host computer and form a direct digital control system by fulfilling automatic control tasks independently. Companies can select working mode according to the actual situation. Therefore, the system has strong flexibility. The development cost of the system is also much cheaper than conventional wood drying automatic monitoring system, having a very good price competitive advantage.

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