

Design of Intelligent Temperature and Humidity Controller for Tobacco Bulk Curing Barn

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Abstract. Aimed at the temperature and humidity nonlinear variation and coupling phenomena in tobacco bulk curing barn, an intelligent temperature and humidity controller is proposed. The controller using a microcomputer and fuzzy decoupling control technique can meet the requirements of temperature and humidity variation according to the predetermined technology curves, realized tobacco curing overall automation, thereby improved the quality of fluecured tobacco. The principle and composition of the controller are presented in this paper. The control method can be applied to other temperature and humidity control field when it is changed in some sort, has popularization and application value.

Introduction

Tobacco bulk curing barn is the specialized apparatus for tobacco bulk curing, the quality of fluecured tobacco depends on the temperature control and humidity control in tobacco curing process. During the curing process, temperature and humidity interaction and nonlinearity is more serious, and affect each other. In the heating process, the moisture content of tobacco leaves increases, during the dehumidification process, the temperature can also be affected because of the introduction of outdoor air. This coupling phenomenon of conventional control method is difficult to meet the requirements. For this purpose, an intelligent temperature and humidity controller based on fuzzy decoupling control is designed. The controller can detect temperature and humidity of tobacco room and control corresponding actuators automatically according to the predetermined technology curve, realized tobacco curing overall automation, improved the quality of flue-cured tobacco.

Control principle [1, 2]

The control principle by using micro controller unit and fuzzy control theory is shown in Fig. 1, according to the temperature error and humidity error detected, on the basis of fuzzy control rule established in ROM of the micro controller unit, to determine the control output, then, through the decoupling coefficient by experience determined to realize fuzzy decoupling control.

In figure 1, S_t and T_t respectively represent the set temperature and real temperature, E_t , E_t' are temperature deviation and deviation rate; S_h and T_h respectively represent the set humidity and real humidity, E_h , E_h' are humidity deviation and deviation rate; C_t , C_h are respectively for control output. If using the NB, NM, NS, ZO, PS, PM, PB respectively represent each of these variables is negative big, negative medium, negative small, zero, positive small, positive medium, positive big, by the bulk curing barn temperature and humidity control experience, can be summed up experience fuzzy control rules as shown in table 1, table 1 shows, a total of 49 fuzzy control rule exist, for example, if (E_t =NB) AND (E_t' =NB) THEN (C_t =PB).

In this controller, given fuzzy subset of E_t , E_h , E_t' , E_h' , C_t , C_h associated with { NB, NM, NS, ZO, PS, PM, PB }, given quantization level of input variable E_t , E_h , E_t' , E_h' associated with 13 grade, that is { -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6 }. Choose uniform triangle function to describe the variables

membership function corresponding to its field, as shown in Fig. 2, we can obtain the equation (1) and equation (2) according to the rules of fuzzy inference synthesis.

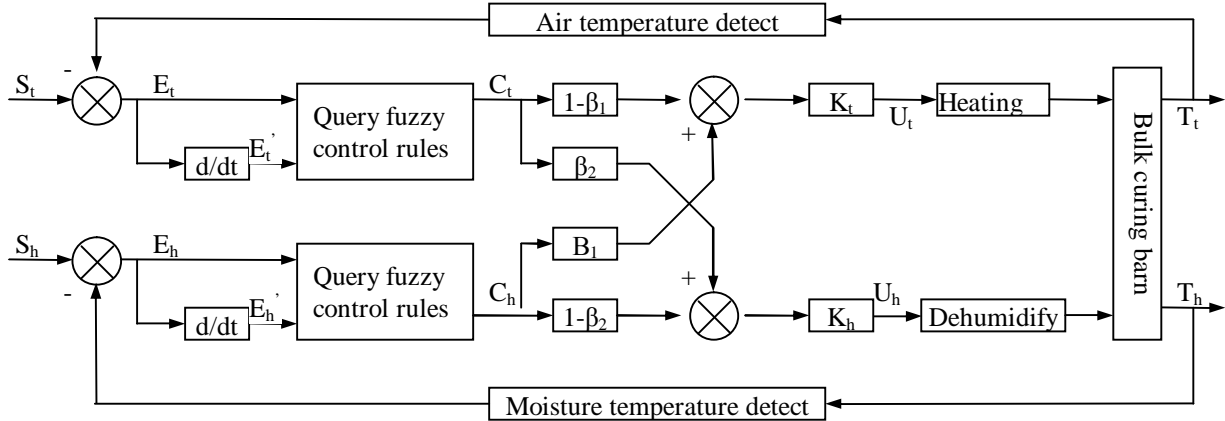


Fig. 1 Fuzzy decoupling control principle

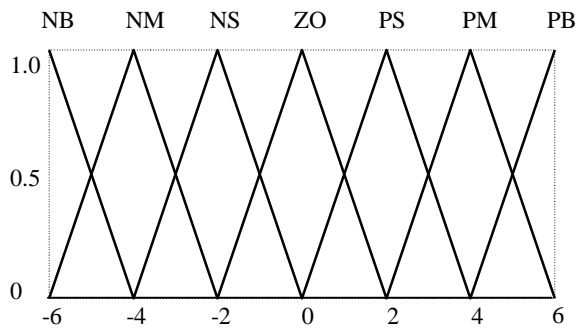


Fig. 2 Fuzzy membership functions for the controller

Table 1 Fuzzy control rules

E_t / E_h	E_t' / E_h'						
	NB	NM	NS	ZE	PS	PM	PB
NB	PB	PB	PB	PM	PS	PS	ZO
NM	PB	PB	PM	PM	PS	ZO	ZS
NS	PB	PB	PM	PS	ZO	NS	NM
ZE	PB	PM	PS	ZO	NS	NM	NB
PS	PM	PS	ZO	NS	NM	NB	NB
PM	PS	ZO	NS	NS	NM	NB	NB
PB	ZO	NS	NS	NM	NB	NB	NB

$$C_t = (E_t \times E_t') \times R_t \quad (1)$$

$$C_h = (E_h \times E_h') \times R_h \quad (2)$$

Through introducing the decoupling coefficient β_1 and β_2 further realize the decoupling control.

$$U_t = K_t [(1 - \beta_1) \times C_t + \beta_1 \times C_h] \quad (\beta_1 = 0 \sim 1) \quad (3)$$

$$U_h = K_h [(1 - \beta_2) \times C_h + \beta_2 \times C_t] \quad (\beta_2 = 0 \sim 1) \quad (4)$$

The actual value of β_1 and β_2 need to be determined by experiment, specifically, in the curing process from the beginning of 0 increases ceaselessly, when temperature and humidity fluctuations of the hour, the values of β_1 and β_2 are optimal decoupling coefficient.

The Controller Hardware Design

The controller is composed of a controller main board, an operation panel, sensors interface, actuators drive module interface, power supply module etc., its composition principle as shown in Fig.3 on the left dashed box. The actuators include a circulating fan, a heating furnace fan and air inlet damper mounting in the bulk curing barn. The control system can achieve heating up and steadying temperature through controlling oxygen quantity of coal burning by adjusting rotate speed of heating furnace fan, the control system can keep humidity smooth in curing barn by controlling quantity of air entering in fact. In addition, through adjusting rotate speed of circulating fan, decreases difference in temperature between top and bottom of curing barn, achieves fundamental leveling of temperature. The controller can effectively control running states of actuators, these is the reason that ensure the baking quality of tobacco.

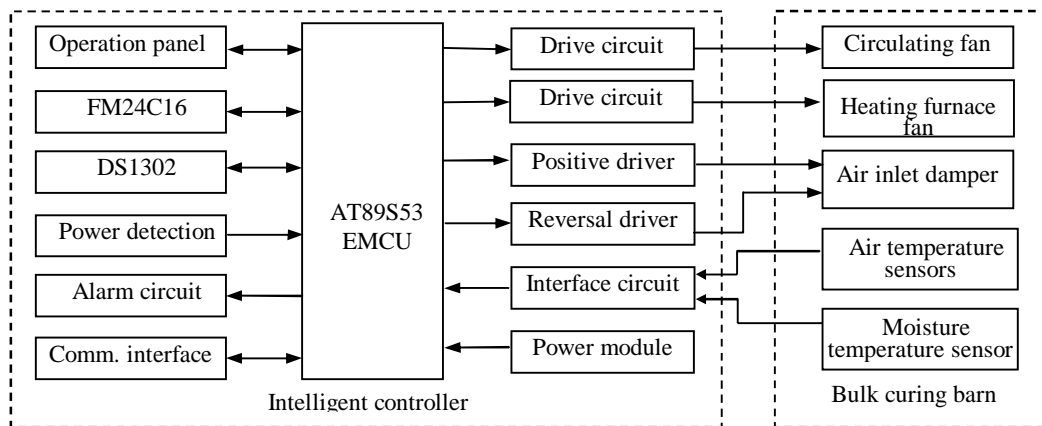


Fig. 3 Tobacco bulk curing barn controller block diagram

The controller main board circuit as shown in Fig.4. AT89S53 is a low-power, high-performance CMOS 8-bit microcomputer with 12K bytes of downloadable Flash, 256 bytes of RAM, 32 I/O lines, programmable watchdog timer, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. FM24C16 is nonvolatile memory for storing the set temperature and humidity curves, expert curves and baking process data. Clock chip DS1302 is used to provide the corresponding time of baking process to MCU. Power detect circuit is used for detection of power-down to switch to a battery power supply. Using a pair of DS18B20 sensor to detect the temperature and humidity of tobacco in bulk curing barn, DS18B20 is a programmable resolution 1-wire digital thermometer, has $\pm 0.5^{\circ}\text{C}$ accuracy from -10°C to $+85^{\circ}\text{C}$, is very suitable for long distance data transmission.

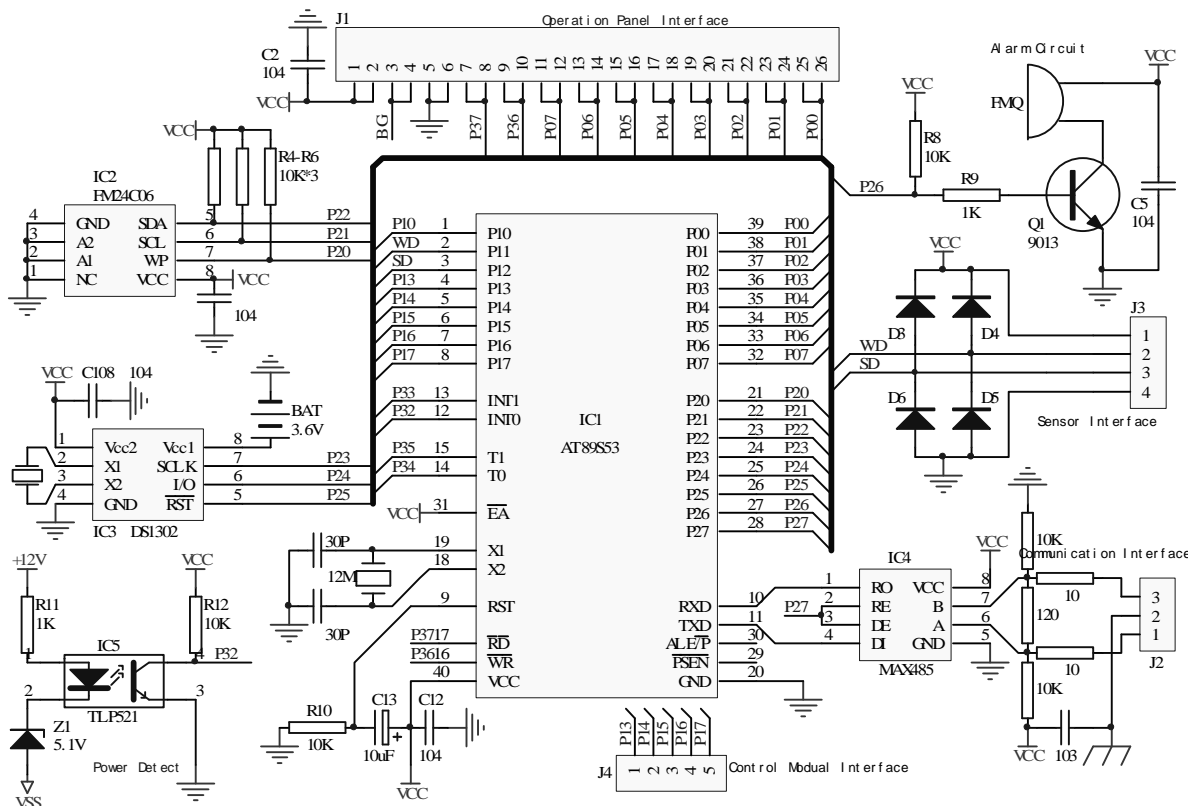


Fig. 4 The controller main board circuit

The controller program design

The controller work flow is: before baking, firstly choose a specialist technology curve stored in controller or set up a technology curve according to process requirements through the operation panel, and then start baking. During the baking process, the temperature and humidity controller control

actuators based on the detection and target temperature and humidity, around a preset process curve automatic regulation. When the air temperature or moisture temperature exceeds the set value of $\pm 2.0^{\circ}\text{C}$, the controller alarm and display alarm code. Here are the main program flowchart fig. 5 and fuzzy decoupling control algorithm flowchart fig. 6.

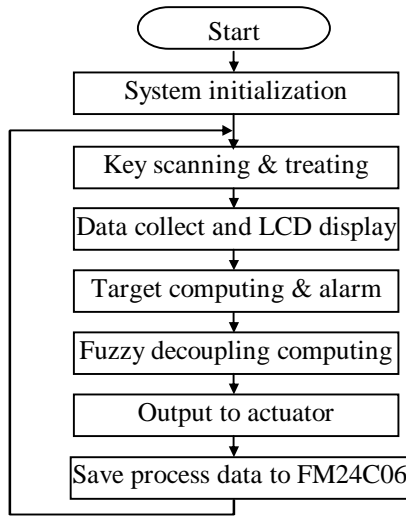


Fig. 5 Flowchart of main program

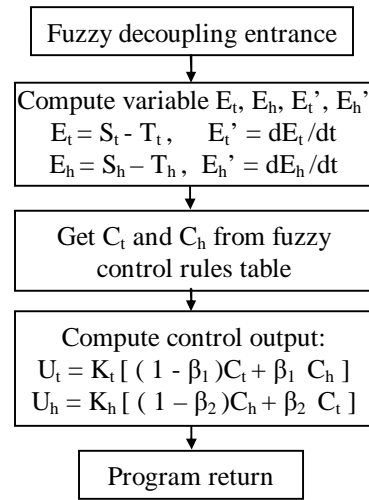


Fig. 6 Flowchart of fuzzy decoupling algorithm

Conclusions

Through the practical test in tobacco bulk curing barn, the controller based on the above design has $\pm 1.0^{\circ}\text{C}$ air/moisture temperature control accuracy from 20°C to 80°C , the temperature-humidity coupling phenomena in tobacco baking process is prevented, fluecured tobacco in color, moisture, elastic and other aspects of quality are improved. In addition, compared with the traditional control methods, it has a short time to reach the set temperature, small steady-state temperature fluctuation, sensitive reaction, strong anti-jamming ability. The control method introduced in this paper can be applied to porcelain baking, crops baking etc., has popularization and application value.

Acknowledgements

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