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Application of Data Fusion Technology in Ice Cream Control System of Pouring Model

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***Abstract*—In this paper, the variance of two temperature observations is weighted and fused with the pouring model ice cream maker. The temperature data with large variance is given smaller weight and the variance with small variance is given larger weight. This data fusion method can obtain more reliable measurement results than the arithmetic mean.With the design method of SCR sequence control chart, the strategy to control overheating is compiled, and the intelligent PID control of R404a flow is carried out. The table of main data points, real-time monitoring chart of production and historical trend curve are given, which greatly increases the authenticity and accuracy of data and achieves ideal control effect.**

Keywords- Pouring Model Ice Cream machine， Data fusion， Superheat，SFC

I. INTRODUCTION

The traditional relay and time control methods are simple and easy to control, with very low control accuracy and poor ice cream quality. The single-chip computer and temperature control methods have been improved, but the simple control of temperature will cause severe freezing in the barrel, which will damage the knife easily and be greatly affected by the temperature sensor.The ice cream of type II has appropriate hardness and good taste, but the change of current before and after is not very difficult to control, and the motor torque control mode is also not easy to control.

This paper presents a control system based on Siemens PLC.Through temperature control module, pressure control module, frequency converter module, communication module, electronic expansion valve module, the overheat control method is used to control the ice cream maker. The upper computer uses Wincc software to realize the operation control, status display, alarm chain protection and other functions of the ice cream maker, such as high-speed, low-speed operation, discharging, cleaning parameter settings, etc.The whole design process uses the concept of item-down design, with clear design ideas, so that each module can be designed and debugged separately [1].

II. Temperature Control Theory and Algorithms

A. Estimation Theory

Because of the different errors, X is separated into two independent unbiased estimates, X1 and X2, according to the least squares method, to form a new estimate X.

$$E=X-X_G=(1-W)(X-X_1)+W(X-X_2)$$

$$E(e^2)=E[(1-W)^2(X-X_1^2)+W^2(X-X_2)^2+2W(1-W)(X-X_1)(X-X_2)]$$

According to probability theory, the observed values X_1 and X_2 are independent of each other and independent of $(X-X_1)$ and $(X-X_2)$. The variances σ_1 and σ_2 can be obtained. The variance expression can be obtained and its derivative is equal to zero, and the optimal weight is obtained. The minimum dominant variance is and the error variance is respectively:

$$\bar{X}_G=\frac{\sigma_1^2\bar{X}_1+\sigma_2^2\bar{X}_2}{\sigma_1^2+\sigma_2^2}，\ \sigma^2=\frac{\sigma_1^2\sigma_2^2}{\sigma_1^2+\sigma_2^2}$$

It can be concluded that: the estimation error is smaller than any single estimation error, XG is the fusion result of fusion observation value calculation.

B. Data fusion algorithm

Two groups of evaporator outlet temperature data were measured by thermal resistance PT100 sensor and temperature processing module, ， The consistency measurement data of the first group of temperature sensors are $[X_{i]} = [4.0,4.1,3.4,4.8,3.9,4.6,4.5,4.9]$, and the second group $[X_J] = [4.2,3.6,3.7,4.2,3.8,4.1,3.5,4.9]$, The two groups of data were preprocessed to remove the maximum value and minimum value, and each group left 6 data [2]

$$\bar{X}_1=\frac{1}{m}\sum_{i=1}^{m}x_i = (4.1+4.1+4.2+3.9+4.6+4.5)/6=4.2$$

$$\bar{X}_2=\frac{1}{n}\sum_{j=1}^{n}x_j = (4.2+3.6+3.7+4.2+3.8+4.1)/6=3.9$$

$$\sigma_1=\sqrt{\tfrac{1}{m-1}\sum_{i=1}^{m}(x_{1i}-\bar{X}_1)^2}=0.236$$

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$$\sigma_2 = \sqrt{\tfrac{1}{n-1}\sum_{j=1}^{n}(x_{2j} - \vec{X}_2)^2} = 0.225$$

The temperature fusion value based on multi-channel sensor can be obtained.

$$\vec{X}_G = \frac{\sigma_1^2 \vec{X}_1 + \sigma_2^2 \vec{X}_2}{\sigma_1^2 + \sigma_2^2} = 4.08169$$

The error is 0.08169, which is obviously smaller than the arithmetic average of 0.3 and 0.1 using single temperature sensor. It can be concluded that the minimum variance estimation theory can fuse the multi-channel temperature sensor observations together, improve the accuracy of temperature measurement, ensure the accuracy of the system temperature reading, and increase the reliability of the system [3].

III. DESIGN OF MONITORING SYSTEM

The control system is based on Siemens PLC, including computer, touch screen TP270, temperature, pressure, flow sensor and AI / AO module.

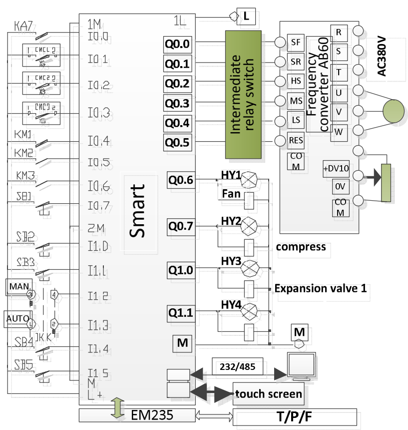

Fig1. Main control system diagram

The ideal temperature and pressure can be controlled by controlling the power frequency / frequency conversion of frequency converter, Calculate D-value between TIC101 and TIC102, control the opening of expansion valve, so as to increase / decrease the amount of refrigerant, which has reached the closed-loop PID control. The AI module collects the temperature and pressure values and outputs them to the electronic expansion valve and frequency converter after calculation, which is used to control the mixing motor, compressor and fan of the ice cream machine, and is transmitted to the HMI and the upper computer for real-time display through PROFIBUS. It adopts two control modes of touch screen and computer.

When the superheat is too large, the superheat decreases with the increase of the expansion valve opening and refrigeration dosage; when the superheat is small, the superheat increases when the expansion valve opening and refrigeration dosage are reduced. This method ensures the high utilization rate of evaporator, makes the refrigeration cycle run stably, reduces the amount of icing, protects the agitator, and thus reduces the load of the motor.

The high and low speed speed of mixing motor is controlled by frequency converter. The power of the motor is 15 kW and the speed is 1200 r / min. The uniform speed regulation method is adopted to ensure the small angular acceleration of speed regulation, so as to restrain the increase of load torque caused by speed regulation [4-7].

A. program design

The control program includes start program module and run program module，The program module is divided into high-speed, low-speed, variable flow, cleaning four program modules. The cleaning module is a public module. The agitator and mixing blade of ice cream machine need to run this module for cleaning before and after use. When cleaning, set the cleaning time T5 on the upper machine beforehand, press the cleaning button, and the stator M2.6 starts the motor to run at high speed. When T5 time comes, the motor stops automatically and the waste water is discharged through the outlet spout. This process is repeated several times until the mixing drum is cleaned, then the cleaning is completed. High speed, low speed and variable flow are three different methods of making ice cream, one of which needs to be selected.Because the production process is a typical sequential control, the SCR state transition diagram shown in Figure 3 is used for programming.

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The control mode can be manual or automatic. Automatic methods include continuous, single-cycle, automatic return to the initial state of work. M3.3 is a continuous and single-cycle selection switch. For OFF, a single-cycle operation mode is selected. After pressing the start button I1.2, start from the initial step M0.0. The start module mainly controls the start and stop of the system and the reset of each register. Select a module, the user first set the compressor running time T1 and discharging time T4 on the upper machine, start the motor running at low speed by M2.0 state machine, start the compressor and fan after T0 seconds, start the compressor and fan automatically after T1 time, stop the compressor and fan automatically, stop the motor after T2 seconds, open the discharging door for discharging, and stop the motor automatically after T4 seconds.This completes the

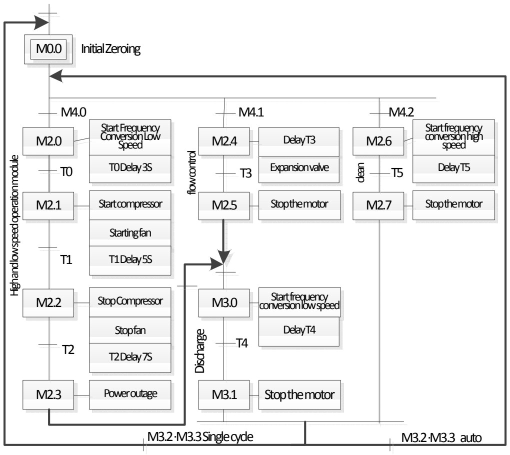

Figure 2 sequence control flow chart

automatic operation of the whole ice cream machine. After completing a cycle of work as specified in the Sequential Functional Map, return and stay in the initial step. For ON is a continuous mode of operation, after pressing the start button in its initial state, it works continuously from the initial step one cycle after another until the stop key is pressed.Press the stop button and do not stop working immediately. After the last cycle of work is completed, the system returns and stays in the initial step. The discharging program module is made of ice cream, and the compressor and motor stop running.Set the discharging time T4 in advance, open the discharging spout, press the discharging button of the upper machine and discharging automatically.After T4 seconds, the motor stops and the discharging process ends.

B. Monitoring Picture Design

On the basis of researching and sorting out the technological requirements of ice cream production line, nine pictures were designed with the monitoring software WinCC. These are: user login screen, production line process screen, refrigeration control screen, sequence control screen, parameter setting screen, trend curve screen, alarm screen, report screen and monitoring system security screen, to achieve dynamic monitoring of ice cream production line process, as shown in Fig. 3 and 4.

The function of the sequential screen is to control the ice cream maker in real time. It has three selection buttons and six function buttons.Single/automatic selection button, single cycle/continuous selection button, start button, stop button, cleaning button, high/low speed/variable flow selection button, discharge button, stop discharge button, emergency stop button.

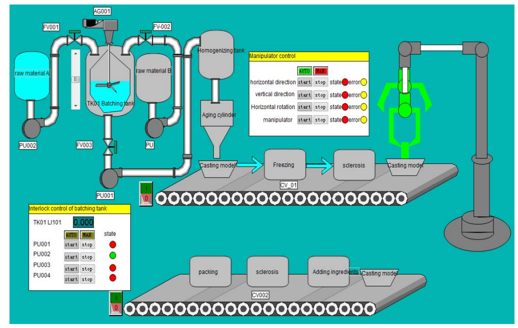

Figure 3 Process flow chart of ice cream production line

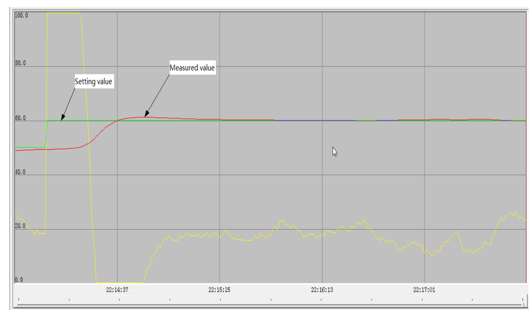

Figure 4 trend curve

According to the experimental data, the single loop PID control of data fusion algorithm is faster and more stable than the conventional PID control algorithm. So the control algorithm can better achieve the experimental results, which shows that the whole control system has good stability, robustness and anti-interference [8-10].

IV. PERORATION

Through the use of computer and touch screen, the functions designed in the functional block diagram are realized, and the functions of manual / automatic control and one key opening of production process are realized. The automation level of the ice cream machine control system has been improved.

The soft start of the motor is realized by using the frequency converter, which avoids the tripping and shaking of the power supply circuit system caused by the speed switching, reduces the impact on the mechanical equipment during the system speed regulation, improves the safety and reliability of the system, and reduces the maintenance cost.

Through the data fusion strategy of controlling superheat, PID intelligent control method is used to control the refrigerant flow. The heat transfer mode of evaporator to mixing drum is improved. The control operation parameters are adjusted appropriately through the screen to increase the accuracy of data, improve the heat transfer efficiency and refrigeration efficiency, save energy, and further improve the economic value of the control system.

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