# Predictive Control Algorithm in the Application of Computer Control

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***Abstract*—According to the error between the model predictive output and the future expected output, ILPC carries out an iterative learning and amending process on the current and the future control input vector, namely performs "forecast, iterative amendment, forecast again, iterative amendment again" repeatedly in the iterative domain. This paper gives a fast high-precision temperature control system's structure, characteristics and realization method. CARI model and the improved generalized predictive control method are used to improve the control precision of the system, and shorten the response time. The quick high precision temperature control system's structure and realization method are given, and according to the requirements of the task, the existing predictive control algorithm has been improved. Through the experiment, its temperature predictive control system's design scheme and realization method is proved to be reasonable and feasible. It can meet the demands for the expected temperature control.**

***Keywords- predictive control algorithm; computer control; application***

## INTRODUCTION

Predictive control is a new type of computer control algorithm developed in recent years. Because it uses the control strategies such as multi-step test, rolling optimization and feedback correction, so control effect is good. It is suitable to control more complex industrial production process in which it is not easy to build accurate digital model, so at the moment it appeared, it has received the attention of engineering community at home and abroad, and has been successfully applied in the control system of industrial departments such as petroleum, chemical, electric power, metallurgy, and machinery.

The industrial production process is complicated. The models we have set up are not perfect. The control effect of the very complicated modern control theory is often unsatisfactory, and even not so good as the traditional PID control in some respects. In the 1970 s, except for strengthening the study of the modeling in production process, system identification and adaptive control and so on, people began to break the traditional concept of thought control and tried to, facing industry, develop a new algorithm which has low requirements for all kinds of models, is convenient for the online calculation and has good comprehensive effect of the control. Within this context, a kind of predictive control, namely MAC - Model Algorithmic Control, was first applied in the industrial control in France. Therefore, the predictive control is not the product of a unified theory, but gradually developed in the industrial practice. At the same time, the development of computer technology also provides the material basis for the realization of the algorithm.

## GENERALIZED PREDICTIVE CONTROL BASIC ALGORITHM

Predictive control is a model-based control method. The model is called prediction model, whose function is to forecast the future output according to the object's historical information and future input prediction. Predictive control is a kind of rolling optimization algorithm, which determines the future control function through the optimization of a performance index. Generally, according to the prediction model and control strategy, the optimization is made in a future finite length of time from the current moment. According to the prediction model, at each sampling time, the optimization of performance index involves only the future limited time from the moment. While to the next moment, this optimization period goes on forward at the same time. Therefore, predictive control is not a same optimization performance index for the global, but an optimization performance index relative to the time in every hour. The relative forms of optimization performance index at different time are same, but the absolute forms, the time zone it contained are different. Therefore, in the predictive control, optimization is not done offline one time, but done online repeatedly. This is also the major point where the predictive control is different from the traditional optimal control. In the system, considering the usual process control system with stochastic uncertainty and the requirement of online real time control, so the GPC algorithm is chosen.

Generalized predictive control uses discrete difference equation with stochastic step disturbance non-stationary noise to describe the mathematical model of the controlled object:

$$A(z^{-1})y(t)=B(z^{-1})u(t-1)+C(z^{-1})\omega(t)/\Delta \quad (1)$$

wherein $A(z^{-1})$, $B(z^{-1})$, $C(z^{-1})$ in(1) are the polynomials of backward shift operator $z^{-1}$.

In order to get the j step predicted value of the system, Diophantine equation is introduced:

$$\begin{cases} 1 = E_j(z^{-1})A(z^{-1})\Delta + z^{-1}F_j(z^{-1}) \\ E_j(z^{-1})B(z^{-1}) = G_j(z^{-1}) + z^{-1}H_j(z^{-1}) \end{cases} \quad (2)$$

The output predictive value of $y(t+j)$ after exporting the j step using the model is:

$$y(t+j) = G_j\Delta u(t+j-1) + F_j y(t) + H_j\Delta u(t-1) + E_j\omega(t+j) \quad (3)$$

The task of generalized predictive control is to make the output $y(t+j)$ of the controlled object close to $y_r(t+j)$ as much as possible. Therefore, the performance index function is defined as follows:

$$J = E\left\{\sum_{j=N_1}^{N_2}[y(t+j) - y_r(t+j)]^2 + \sum_{j=N_1}^{N_u}\lambda(j)[\Delta u(t+j-1)]^2\right. \quad (4)$$

The formula of most control law is as follows:

$$U = (\lambda l + G^T G)^{-1} G^T [Y_r - F_y(t) - H\Delta u(t-1)] \quad (5)$$

## THE IMPROVEMENT OF CONTROL SYSTEM STRUCTURE AND CONTROL ALGORITHM

### *A. The Structure of Control System*

Although predictive control implementation forms vary, but the basic idea is the same and work mechanism. Predicted by the model predictive control, the feedback correction and rolling optimization to calculate the control amount of current and future time, the future output meets a pre-set trajectory.

The whole control system in this paper includes five parts: the temperature transmitter, testing interface circuit boards, control interface circuit boards, solid state relays, control computer and controlled drying oven. Temperature control circuit boards include circuits such as address decoding, counting pulse generation and solid state relay control. In the following experiment, the sampling time we choose is 17 s.

### *B. The Improvement of Control Algorithm*

In the process, we found that if just implement the current step $\Delta u(t)$, the control effect of closed loop control strategy of the control increment recount for $t+1$ and the moment after $t+1$ is better than PID (it can shorten response time), but the steady state error can't meet the requirements. Through analysis, we found that, because the useful information included in $\Delta u(t+1)$, $\Delta u(t+2)$, $\Delta u(t+NU-1)$ of the multi-step prediction has not been fully used, affected by the factors such as measurement error, interference and saturation, the controlled quantity calculated will produce false fluctuations, thus affecting the control effect. In order to make full use of the useful information in multi-step prediction, we adopt the input weighted control law, which have a smoothing filtering function of to improve the control effect of GPC, i.e., the current control quantity is the amount of weighted average of the present and past predictive control quantity of the present.

$$u(t) = \frac{\sum_{i=1}^{NU}\lambda(i)u[t/(t-1)+1]}{\sum_{i=1}^{NU}\lambda(i)} \quad (6)$$

Wherein $\lambda(i)$ is the weighted coefficient of controlled quantity, *NU* is the length of the control horizon.

### *C. The Adjustment Method of Control Parameters*

In the controller designed by generalized predictive control algorithm, many parameters can be adjusted, such as optimal horizon length *N*, control horizon length NU, and the weighted coefficient of controlled quantity $\lambda$ in the optimization performance index. But because these adjustable parameters are implicit in control matrix, it is not easy to find out the explicit relation between the system performance (such as stability, etc.) and adjustable parameters. In order to make it convenient for different users to quickly design stable closed-loop control system corresponding to different systems, through multiple tests, we summed up some principles and calculation methods of selecting parameter, and have given the experimental results.

The weighted coefficient of controlled quantity $\lambda$.

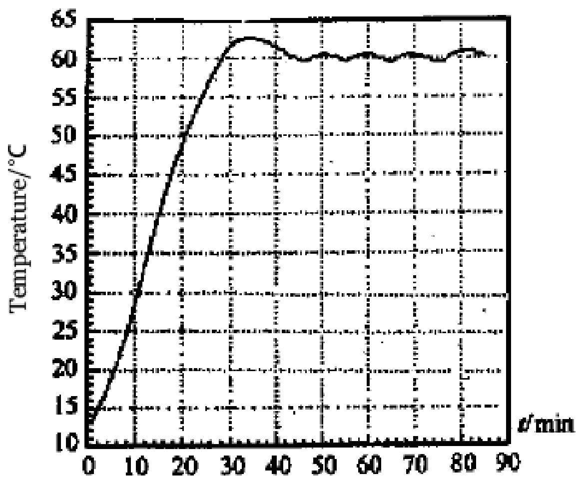
In the optimization performance index, the value scope of the weighted coefficient controlled quantity $\lambda$ is generally 0-1, but the specific value still need to be made sure through experiment. We do more experiments to choose $\lambda$. After the comparison, we know that it is better to take a moment variable value than a constant one. In Figure

3, $\lambda = \exp(\bullet)$ is to point to the time-varying functions when $\lambda$ takes the following section:

$$\begin{cases} \lambda(t) = e^{-\frac{t}{a}} + b, t > a \bullet \ln \dfrac{1}{1-b} \\ \lambda(t) = 1, 0 \le t \le a \bullet \ln \dfrac{1}{1-b} \end{cases} \tag{12}$$

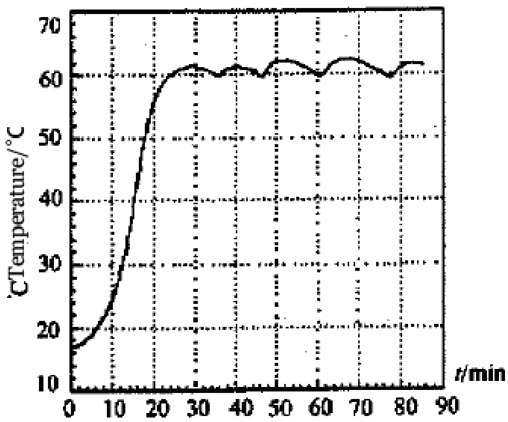
wherein A is the heating up time set by the user, b is the lower limit of $\lambda$. If $a = 120s$, $b = 0.95$, then during the time from 0 to 360s, $\lambda = 1$; when $\lambda > 360s$, its value range is 0.95-1, and if don't set the lower limit of $\lambda$, it will make the system unstable (as shown in Figure 4).

To facilitate the comparison, the experimental curve of PID control (as shown in figure 1) and a best experimental curve of the GPC before improvement (as shown in figure 2) are given. Figure 3 is the experimental curve of control strategy after improvement. The experimental results (as shown in Figure 4) show that it really improves the control effect.



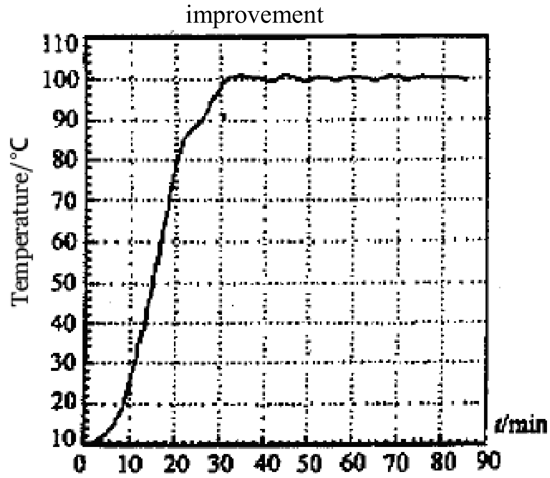

**Response Time:41.93min; steady-state error:-0.48~0.99℃**

Figure1 the experimental curve of PID control




**Response time:23.6min; steady-state error:-0.19~3.78℃**

Figure2 the experimental curve of GPC before improvement




**Response time:29.6min; steady-state error:-0.89~1.13℃**

Figure 3 the experimental curve of GPC after improvement

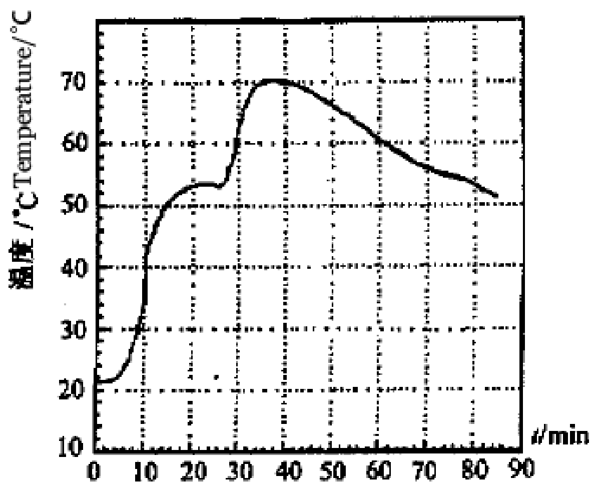



Figure 4 the experimental curve of unstable temperature

The aim In the experiment system of this paper is to reach the system as soon as the set temperature. Thus the reference trajectory is chosen as the set temperature value directly. It is can be clearly seen that the experimental results have better improved system accuracy than the old model.

## CONCLUSION

The temperature is one of the most common and most important controlled variables in all kinds of process control. This paper gives a fast high precision temperature control system's structure, characteristics and realization method. Through the improvement of the existing GPC control method, compared to the existing GPC algorithm and the traditional PID control, the improved predictive control method to improve the control precision of the system and shorten the response time. In addition, based on the real-time display of the user interface in the Windows environment, it can online monitor the changes of controlled quantity in the whole experiment process. The experimental results show that the system structure and the control method can satisfy the requirements of the design task, and have certain universal significance.

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