

Jitter elimination technology in large temperature intelligent control

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Abstract. On the basis of the analysis of the jitter generation mechanism in large temperature intelligent control system, the ways and principles to eliminate or weaken jitter is discussed. The jitter elimination method designed based on fuzzy power reaching law, and applied in the intelligent temperature control, under the premise of ensuring jitter elimination effect, improves the reaching movement speed of the system as well. The simulation results demonstrate the effectiveness and feasibility of the proposed control method in this paper, and the application example in the control is given, the simulation results show that, this method can effectively weaken the jitter of system, and will not affect the robust performance of controller.

Introduction

In the complex environment, when jitter happens in temperature control equipment, signal acquisition area will change a lot. In order to solve this problem, researchers have done a lot of work. The literature [1] summarized the factors causing jitter as uncertainties of mathematical models of system, with the H optimization method to design switch function of structure vibration control, this method helps the vibration sliding mode to realize the expected frequency reshaping, which can weaken the jittering. The literature [2] continued to using smoothing method of variable structure control of the fixed boundary layer, at the same time, deduced the mathematical relationship between the steady state error index of temperature control system with variable structure and the weighted coefficients in the boundary layer, through the steady-state error index of the system to design the boundary layer, so as to meet the requirements of the system for vibration steady state error. The literature [3] proposed a modified exponential reaching law method, compared with the general exponential reaching law, transition time, jittering of the system and the required control force can be further reduced. In addition, the literature [4] researched switching function of variable slope, put forward three kinds of rules of slope change of switch function, which are linear law, power law and exponential law, switch functions were designed, and finally obtained the conclusion that switching function effect with the power of two rules have optimal vibration control results. The literature [5] presented a fuzzy reasoning rule based on angle of reaching movement and sliding line (surface) in the process of designing fuzzy variable structure, which is more scientific than reasoning from the state and sliding distance, because when the state vector pass through the sliding mode, the problem related to jittering is not only speed, but angle as well.

Jitter elimination method of temperature control system based on fuzzy power reaching law

power reaching law design. Performance of temperature control stage mainly depends on the design of sliding mode surface under the vibration control, while the performance of reaching movement stage can be improved through the designed reaching law. Power reaching law is a reaching law used commonly, its expression is

$$\dot{s} = -k|s|^r \operatorname{sgn}(s), k > 0, 0 < r < 1$$

Because in the power reaching law, $0 < \gamma < 1$, when the temperature control system state close to the sliding surface, the reaching velocity decreases with distance decreases, which helps weakening the jittering. However, when the state is far from the sliding surface, the power reaching law speed is too small, resulting in long reaching time, affecting the performance of the temperature

control system. The power reaching law is improved, on the basis of ensuring its original merits, improving the approaching performance when the state far away from the sliding surface. For the power reaching law, when the state far away from the sliding surface, the γ value is increased to improve the velocity of approach, when the state is close to the sliding surface, the γ value is reduced to weakening jittering. Considering the approach velocity and buffeting suppression, the fuzzy method theory can be adopted to design the γ in the power reaching law. The existence of vibration interference inevitably cause temperature signal error e changes, because the sliding surface s is a function of e , the size of the disturbance will affect the value of s , and the value of s can be utilized to estimate indirectly. Based on this idea, one dimension fuzzy controller can be designed, according to the S 's absolute value to adjust the parameter γ of the reaching law timely, the principle shown in figure 1.

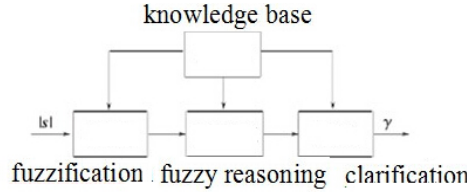


Figure 1 analysis chart of fuzzy control principle

The introduction of the fuzzy control. Implementation of sliding mode and its interference on the vibration have invariance. Fuzzy control is a direct control method which not requires temperature control system mathematical model, in the whole control process, it is in accordance with the rule of inference, and the reasoning domain is not continuous. From this point of view, fuzzy control can also be said as a variable structure control. Based on this consideration, this paper proposed a variable structure power reaching law control similar to the fuzzy rules. In order to simply describe the problem, the variable structure control of two order linear system presented as an example. Considering a system: setting the switching function $S(x)$, which can be two times or linear function, and then acquires control u . Here the controlled variable u is designed into such form:

$$u = \begin{cases} u_i^+, & s > 0 \\ u_j^-, & s < 0 \end{cases}$$

Among them, $i=1,2, m1$; $j=1,2, ..., m2$ are natural number. Here, the $s(x)$ is blurred, and then set a list of discontinuous temperature control u according to its fuzzy value. According to experience to design for the specific problems, similar to the target value of fuzzy rules, and the threshold is determined by the switching function $s(x)$. In the fuzzy variable structure control, considering fuzzy reasoning for the coefficient E of switching function to achieve adaptive adjustment. In this method, the fuzzy rules are one-dimensional, a lot of rules can be set up simply, in order to achieve effectively suppress jittering without affecting the response speed of the system. And this method don't have defuzzification process in fuzzy control, so the realization is simple, control accuracy is guaranteed.

Control law design. The below formula is made differential processing, and it can be known,

$$s = \begin{cases} e + (\alpha + \frac{p}{r} \beta e^{p/r-1})e, & e > 1 \\ e + (\alpha + \frac{r}{p} \beta e^{p/r-1})e, & e < 1 \end{cases}$$

The above formula is taken into, and obtained:

$$s = q_d - q + g(e)$$

$$g(e) = \begin{cases} (\alpha + \frac{p}{r} \beta e^{p/r-1})e, & e > 1 \\ (\alpha + \frac{r}{p} \beta e^{p/r-1})e, & e < 1 \end{cases}$$

It is known: $q = M^{-1}(u + f - Cq - G)$

It can be obtained: $u = M \left\{ g(e) + q_d + k|s|^r \tanh(s) \right\} + Cq + G - f$

In the control laws, F is related to uncertain modeling errors and external disturbances and other factors, reduction of the uncertain modeling error and disturbance, can further reduce the system jittering. According to the control law described above, to design the structure of the temperature control and sliding mode variable structure control system, as shown in figure 2:

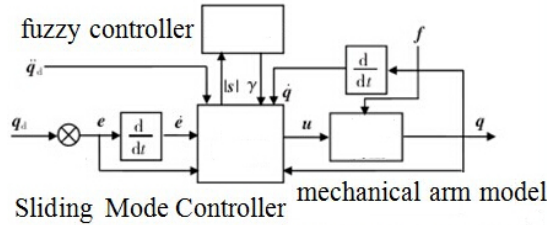


Fig. 2 of control structure of sliding mode variable structure in temperature control system

Experiment results and analysis

sampling signal. For the temperature control system of decomposing furnace, Simulink software package is utilized in the Matlab environment to construct model separately [6]. By using this method to control the temperature signal A stably, 4 stable sampling coefficients as shown in Figure 3.

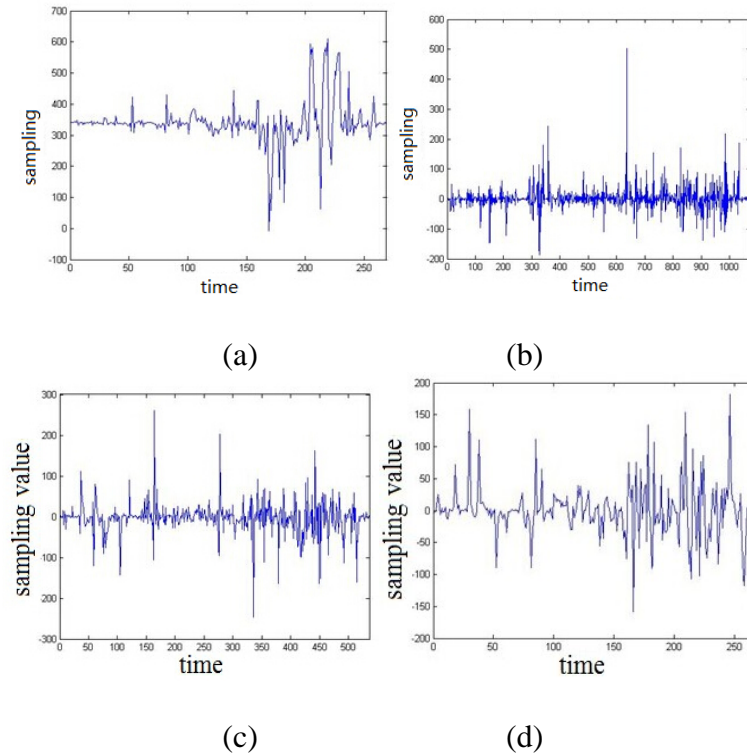


Figure 3 temperature sampling coefficient

When the threshold value of the vibration control is set as 30, decomposition detail signal of 1 level has 1072 elements, including 143 non-zero signal, decomposition detail signal of 2 level are 536, which has 119 nonzero signal, decomposition detail signal of 3 level has 268 elements, including 90 non-zero signal. The low frequency signals obtained from improving last 3 level are 269.

It can be known from the mechanism of vibration signal control, only need to save the nonzero signal, thus, the signal need to be saved are $269 + 143 + 119 + 90 = 621$. The compression ratio CR

can be obtained by the formula of compression ratio:

$$CR = \frac{N_c}{N} \times 100\% = 621/2145 \times 100\% = 28.95\%$$

Analysis of compression performance. After the threshold vibration control is applied for the signal obtained from previous section, the acquired reconstruction signal as shown in figure 4:

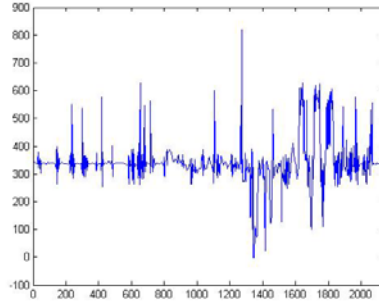
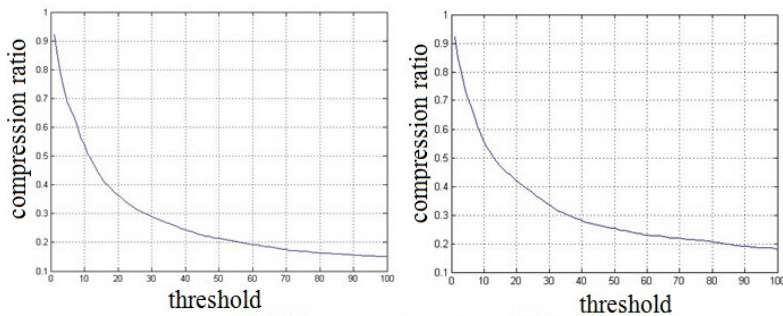


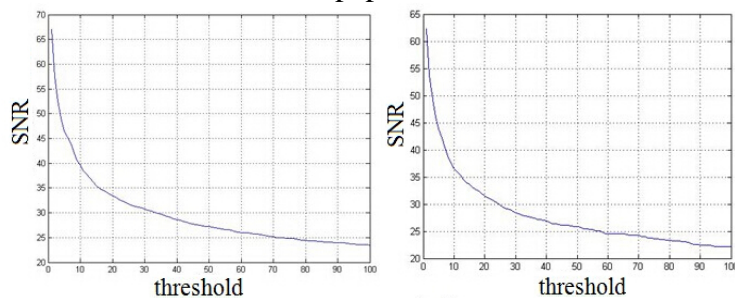
Figure 4 The restored signal after vibration control (threshold 30)

During the monitoring of vibration signal control, the vibration signal of structure at the stage of steady is gentle and less volatile, within a reasonable range, the vibration have no influence on signal. The abnormal mutation signals are in desperate need of monitoring, these signals are often caused by abnormal vibration etc. These are the focus of monitoring. Therefore, through the reasonable choice of threshold, the data loss is negligible.

The following figure shows the vibration signal compression ratio and signal-to-noise ratio with the effect of using the proposed method:



- (a). The relationship between threshold and compression ratio with the traditional method
- (b). The relationship between threshold and compression ratio with the method proposed in this paper



- (c). The relationship between threshold and SNR with the method proposed in this paper

- (d). The relationship between threshold and SNR with the traditional method

Figure 5 The SNR after vibration control

Figure 5 shows the analysis of two kinds of compression efficiency is quite basic, but because of the traditional control process is more complicated, and requires more storage space, the use of this method for vibration control can achieve good effect. Can be seen at the same time, the selection of

threshold for the compression rate and signal-to-noise ratio of the effect is not linear, in this experiment, the threshold value at 20 can achieve the best results.

Conclusion

The jitter elimination method designed based on fuzzy power reaching law, and applied in the intelligent temperature control, under the premise of ensuring jitter elimination effect, improves the reaching movement speed of the system as well. The simulation results demonstrate the effectiveness and feasibility of the proposed control method in this paper, and the application example in the control is given, the simulation results show that, this method can effectively weaken the jitter of system, and will not affect the robust performance of controller.

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