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Research on PDCA Optimization Model Based on PID Control Theory

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Abstract: In view of the shortcoming that PDCA cycle theory in management can not point out how to analyze deviation data before processing action, and then put forward what kind of deviation correction treatment strategy should be adopted, the PID-PDCA closed-loop management model is proposed by introducing PID control concept of automatic control principle. It is hoped that the past historical deviation information can be fully used after checking and obtaining the current deviation information and the target deviation information and before taking the correction treatment, so as to realize the comprehensive research and prediction of the past information, the current state and the future trend, so as to provide better guidance for the correction processing. An intuitive and clear analysis strategy model is proposed for the management system to achieve a fast, stable and accurate response to the plan, so that the management is smooth and orderly, and the cost input is controllable and acceptable.

1. Introduction

In management, according to whether the control has feedback loop, it can be divided into open loop control and closed loop control [1]. Open-loop control refers to the control process in which the controlled object does not react to the control subject. Closed-loop control [2] is a control method for correction based on the output feedback of the control object.

PDCA cycle theory is a kind of closed-loop control theory. In essence, PDCA cycle theory only takes corrective treatment according to the deviation information obtained from the current reality and the target, but does not point out how to analyze the deviation data before the processing action, and then puts forward what kind of corrective treatment strategy should be adopted. In view of the above deficiencies, this paper hopes to find an effective deviation analysis strategy model after checking and obtaining the current deviation information between actual and target and before taking corrective treatment, and make full use of the past historical deviation information.

2. Feasibility analysis of PID control theory

Proportional integral differential control, referred to as PID control, is one of the earliest control strategies developed. Due to its simple algorithm, well robustness and high reliability, it has been widely used in industrial process control [3]. The principle of conventional PID control system is a typical unit negative feedback control system [4].

PID control theory is widely used in the field of industrial automation control. The basic principle is clear and concise. As a useful complement to PDCA theory, PID control theory has good feasibility.PID control theory uses PID control ideology to supplement and improve the correction processing (A) of PDCA. Before the correction processing, it analyzes the proportion, integral and differential dimensions, so as to form a more accurate control of the system. PID control does not need to know the model of the system, only according to the amount of deviation can be controlled and adjusted, so PID can be effectively applicable.

3. PID-PDCA closed-loop management model construction

3.1 PID-PDCA closed-loop management model framework

PID-PDCA closed-loop management model framework is shown in the figure. PDCA is divided into four stages: planning, execution, inspection and processing. The management target value is proposed in phase P of the plan; Execution stage D the controlled object executes according to the control value; Check stage C, compare the output value of the controlled object after execution with the management target value, and get the deviation value between the target value and the output value; In the processing stage A, the deviation value is analyzed in proportion P, integral I and differential D, and the control value is output to the controlled object for execution.

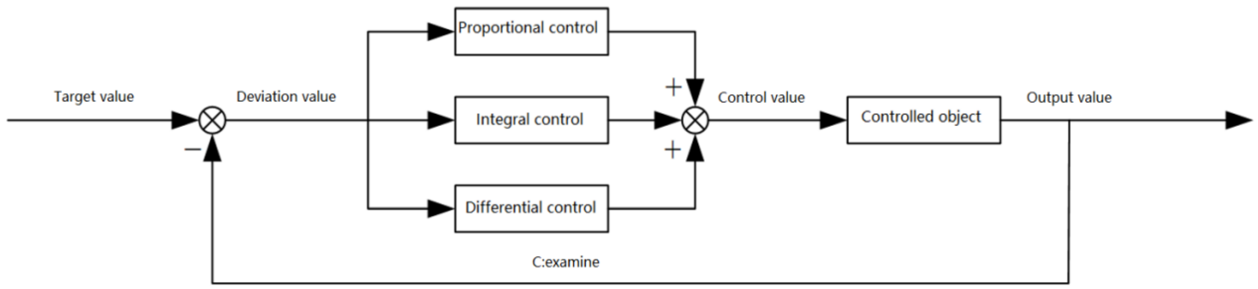

Figure 1: PID-PDCA closed-loop management model framework

3.2 Pid-pdca model effect and management significance analysis

Due to the sociality of organization and the complex and dynamic changes of factors affecting management, it is difficult to establish an accurate analysis model for the actual managed object. Therefore, this paper simulates the controlled object with a second-order system, whose transfer function is $1/(6S^2 +5s+1)$, and whose target value is the unit step signal simulation. Matlab is used for simulation analysis. Thus, a simple mathematical model is established to idealize its control law. The meanings of the variables representing the management process of the model are shown as follows:

$$u(k) = K_p e(k) + K_i \sum_{n=0}^{k} e(n) + K_d((e(k) - e(k-1)) \quad (1)$$

Therefore, the formula of PID-PDCA closed-loop management model is:

Control quantity = proportional coefficient × current deviation value + integral coefficient × cumulative historical deviation value + differential coefficient × deviation trend. (2)

3.2.1 Proportional control

Proportional control model is:

$$\text{Control quantity} = \text{proportional coefficient} \times \text{current deviation} \tag{3}$$

Proportional control is proportional control based on the size of the deviation value during inspection, that is, the larger the deviation is, the larger the control quantity is.

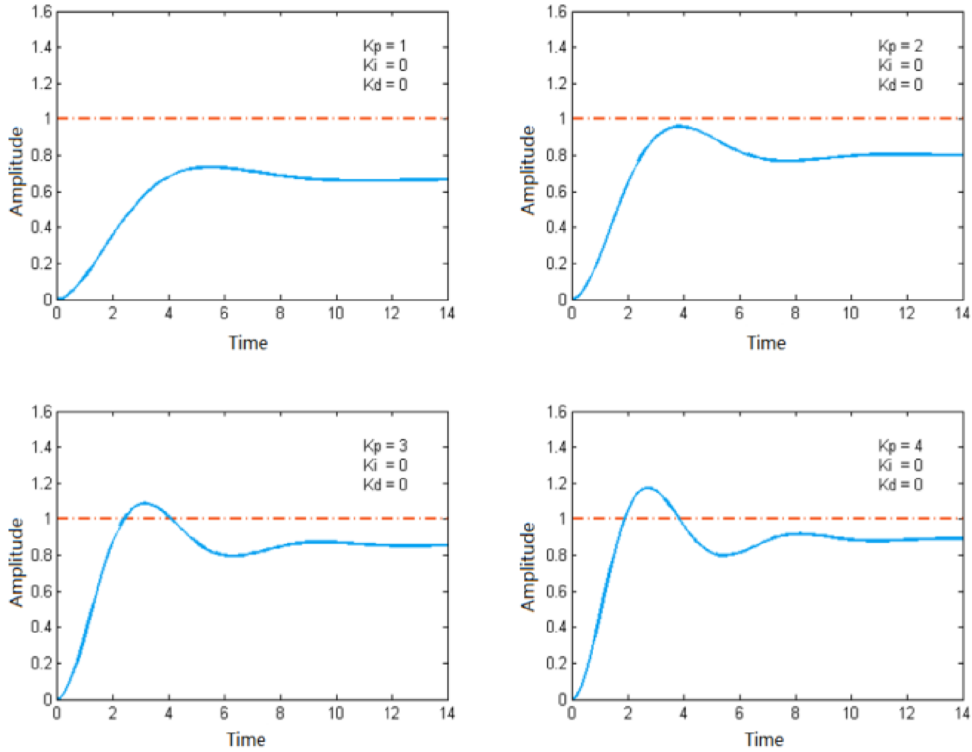

Figure 2: The role of proportional control

In daily management practice:

(1) The proportional control coefficient K_p is small, the control force is not enough, and the response time is long.

(2) The proportional control coefficient K_p is large, the control force is too strong, and the response time is short, but there is overshoot shock.

(3) Due to the resistance of system characteristics, no matter how large the proportional coefficient K_p is, the steady-state error cannot be eliminated. In order to solve this problem, there are two solutions: one is dynamic K_p value, increasing the proportion control between partitions; The second is to introduce integral I control.

3.2.2 Integral control

Integral control management model is:

$$\text{Control quantity} = \text{proportional coefficient} \times \text{current deviation value} + \text{Integral coefficient} \times \text{accumulated historical deviation value} \tag{4}$$

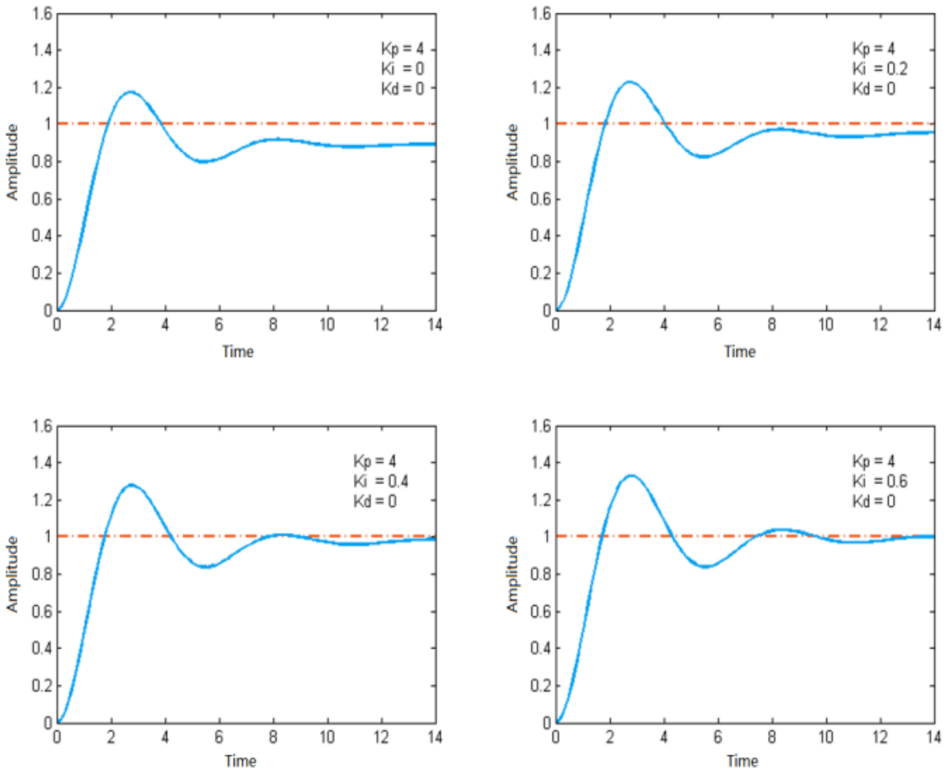

Figure 3: The role of integral control

The function of the integral is to eliminate the steady state error so that the controlled output value finally agrees with the given target value. The solid line represents the response curve of the system with the same proportional coefficient K_p and different integral coefficient K_i over time, and the dotted line represents the target value. In the case of the same proportional coefficient K_p, the integral coefficient K_i increases and the steady-state error is gradually eliminated. However, if the integral coefficient K_i is too large, the system enters into a small amplitude oscillation.

In daily management practice, the management system can not reach the target value for a long time, so the idea of integral control is needed. The longer the deviation time is, the higher the integral value is, which means the greater the response of additional integral control.

3.2.3 Differential control

Both proportion adjustment and integral adjustment are established to eliminate errors after errors are produced. But the general control system, not only to the stability control requirements, but also to the dynamic index requirements, usually require management system changes or given adjustment caused by disturbance, return to the steady state speed to be fast, so must introduce differential effect.

Differential function is preventive control in advance, once the output is found to be larger or smaller trend, immediately output a control signal to prevent its change, in order to prevent overshoot or overshoot. Differential D control management model formula:

Control quantity = proportional coefficient × current deviation value + integral coefficient × accumulated historical deviation value + Differential coefficient × deviation trend (5)

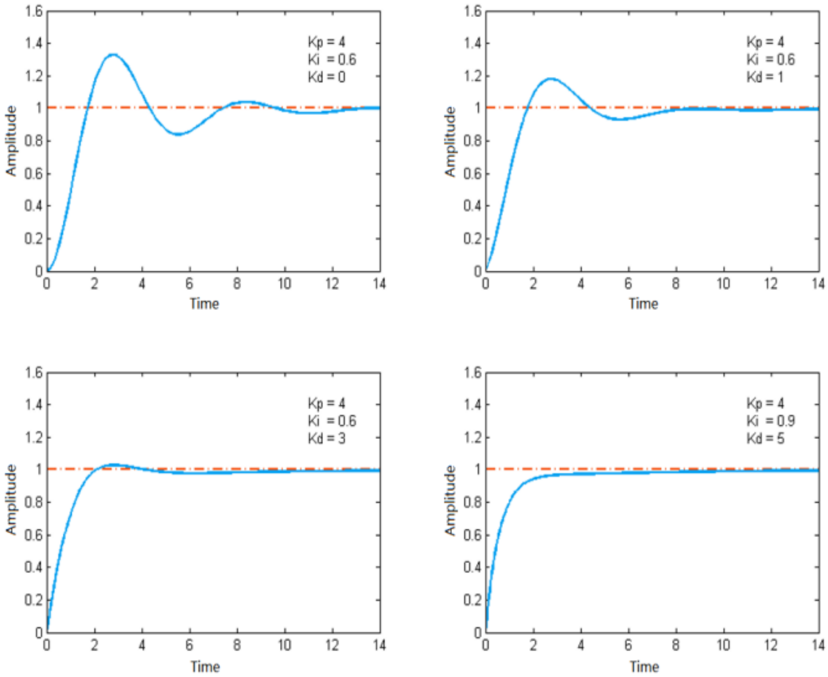

Figure 4: The role of differential control

In daily management practice, when the deviation from the target changes rapidly, it is necessary to predict to suppress this over-strong change. For example, when the management target is proposed at the beginning, the deviation is large, and the idea of rushing forward needs to be suppressed. When the project rush schedule is suddenly accelerated, it may be necessary to pay attention to the risks in quality and cost. Although the small problems in management are not harmful, they have a strong tendency and need to be predicted and corrected in advance.

4. Conclusion

In practice, the ultimate target is a fixed value, belongs to the step signal, but this kind of goal against implementation process control, so it is often possible to make decisions more enforceable by making plans that break them down into time nodes, before the given time point in the earned value management plans to complete the activity budget cost in PV, PV line is commonly S curve.

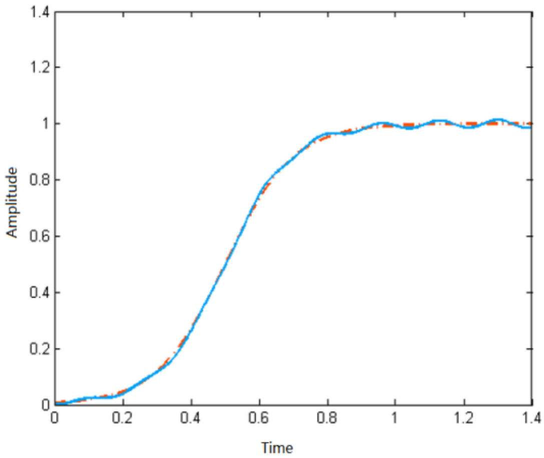

Figure 5: PID system response to s-curve target

On the basis of resource utilization and risk control, the safest schedule management of project management is that EV curve of earned value converges to PV curve as much as possible. As shown in the figure, the solid line represents the system response curve (EV curve) and the dotted line represents the S-curve target (PV curve). The EV curve and PV curve fit well under PID control.

PID-PDCA closed-loop management model can not only respond to the plan, but also respond to the dynamic plan in time. However, the analysis is more complicated, and the management cost will increase. The PID-PDCA model does not describe the interaction between multiple management domains when they are at the same level, and there is still room for further study.

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