**2019 7th International Conference on Machinery, Materials and Computing Technology (ICMMCT 2019)**

# Research on a Class of Aircraft Parameter Adjustment Method Based on Particle Swarm Optimization

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**Keywords:** Attack angle; Particle Swarm; Feedback; Aircraft; Control system

**Abstract.** Firstly, aiming at the simplified linear model of aircraft pitch channel, a basic framework of angle-of-attack stabilization controller considering limiting amplitude is designed. Particle swarm optimization (PSO) algorithm is introduced to adjust the parameters of the aircraft in terms of the ratio, angular velocity feedback parameters and integral parameters. Finally, the digital simulation is carried out and good results are obtained. It shows that the particle swarm optimization algorithm can automatically select the parameters of the aircraft, thus solving the problem of waste of manpower and material resources by manual parameter adjustment relying on experience.

## Introduction

Particle Swarm Optimization (PSO) is an evolutionary analysis technology based on the evolution of swarm intelligence to select the optimal solution to achieve the final selection of the optimal solution. The emergence of PSO is not accidental, but an optimization algorithm developed by imitating the natural law [1-4]. It has many advantages, among which there are many comparisons with genetic algorithm. The crossover mutation operation of the latter is complex. The former is relatively easy to implement. As soon as particle swarm optimization (PSO) was proposed [5-9], it immediately caused great concern in evolutionary computing and various demand optimization algorithms, and became the research center of various scholars. But it also has its own shortcomings and shortcomings, such as short development time, imperfect and so on. It belongs to a new research field, and its application has not been widely promoted [10-15]. At present, the research on PSO is focused on the improvement and development of the basic particle swarm optimization (PSO) algorithm and various practical applications. The research direction of this paper is to optimize, integrate and select the parameters of aircraft control devices by using particle swarm optimization (PSO)

## PSO Control Structure

In order to tune the PID parameters, three parameters should be selected to form a three-dimensional search space. Next, an optimal one is found from the three parameters to make the PID controller present the best. Its structure is shown in Figure 1.

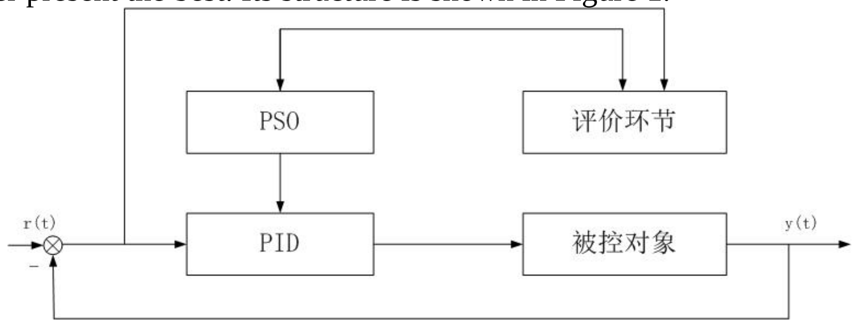

Fig.1 PSO control structure

## Pitch Channel Model of Aircraft

The nonlinear pitch channel model of a kind of missile system can be described as

$$\begin{cases} \dot{\alpha} = \omega_z - \dfrac{qS}{mv} C_y(M_m, \rho, \alpha, \omega_z, \delta_z) \\ \dot{\omega}_z = \dfrac{qSL}{J_z} C_m(M_m, \rho, \alpha, \omega_z, \delta_z) \\ A_{yB} = \dfrac{qS}{m} C_y(M_m, \rho, \alpha, \omega_z, \delta_z) = n_{yB} g \end{cases} \tag{1}$$

And if the attack angle is very small, then its linear model can be written as

$$\begin{cases} \dot{\alpha} = \omega_z - a_{34}\alpha - a_{35}\delta_z = \omega_z - \dfrac{g}{v} n_y \\ \dot{\omega}_z = a_{24}\alpha + a_{22}\omega_z + a_{25}\delta_z \\ n_y = \dfrac{v}{g} a_{34}\alpha + \dfrac{v}{g} a_{35}\delta_z \end{cases} \tag{2}$$

And the control objective is to design a fractional order controller to make the missile attack angle to track the desired value.

## Basic Control Structure

We design a basic attack angle tracking controller as follows

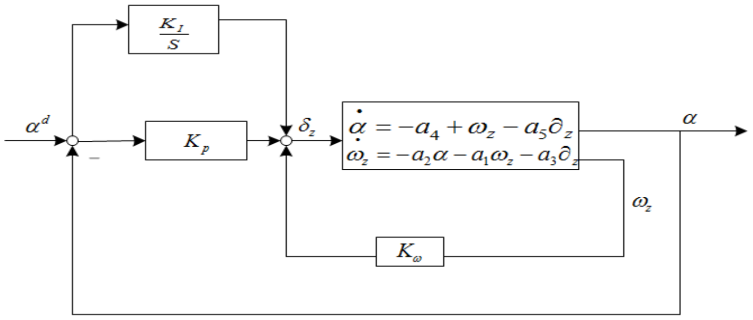

Fig. 2 Attack angle tracking system

And the control law is designed as

$$\delta_z = K_P\left(\alpha^d - \alpha\right) + K_I\int_0^t\left(\alpha^d - \alpha\right)dt + K_\omega\omega_z$$

(3)

And $\alpha^d$ is the idea attack angle, $K_p$ and $K_I$ are coefficients of controller.

## Optimum Design of Flight Control Parameters Based on PSO

Set it as the number of particles, and its position vector is composed of three parameters, namely, the dimension of particle vector.

$$P(n,D) = \begin{bmatrix} K_p^1 & K_i^1 & K_d^1 \\ K_p^2 & K_i^2 & K_d^2 \\ \vdots & \vdots & \vdots \\ K_p^n & K_i^n & K_d^n \end{bmatrix}$$

(4)

The parameter optimization of PID is to find a minimum value. Considering that the system designed in this paper can be better regulated, it uses ISE and overshoot as the final function form we want to choose.

$$F = 10\int_{0}^{\infty} e^2(t)dt + 10\sigma\% \tag{5}$$

The first step is to determine the population size, dimension and maximum evolutionary number. Particle swarm optimization (PSO) is divided randomly into initial position, individual extreme value, velocity and global extreme value.

The second step is to get the fitness values of each particle by using fitness evaluation function.

The third step: Compare the current fitness values of each particle, if the former is small, it can be regarded as the individual extreme value, and then find out all the minimum extremes, and compare with each other, if less than, it can become the global extreme value.

Step 4: Update the velocity and position of each particle according to formula 4, if, then; if, then;

Step 5: Analyze the final conditions. If the maximum number of iterations occurs, the subsequent cycle can be stopped; if not, jump to step 2. When all is done, we can output the best results of three parameters.

## Simulation

We choose parameters for aircraft body as v=1000, $a_4 = 0.0215$ , $a_2 = -0.396$ , $a_1 = 0.0198$ , $a_3 = 5.389$ , $a_5 = 0.01$, $n$=50, $c_1, c_2$ are set as 0.12 and 1.2, and $w = 0.9$, and set the max converge number as 50 generation, then the optimal parameters are chosen out as

$$k_p = -15.2441,\ \ k_d = 2.7560,\ \ k_i = 0.0375$$

And simulation result as following figures

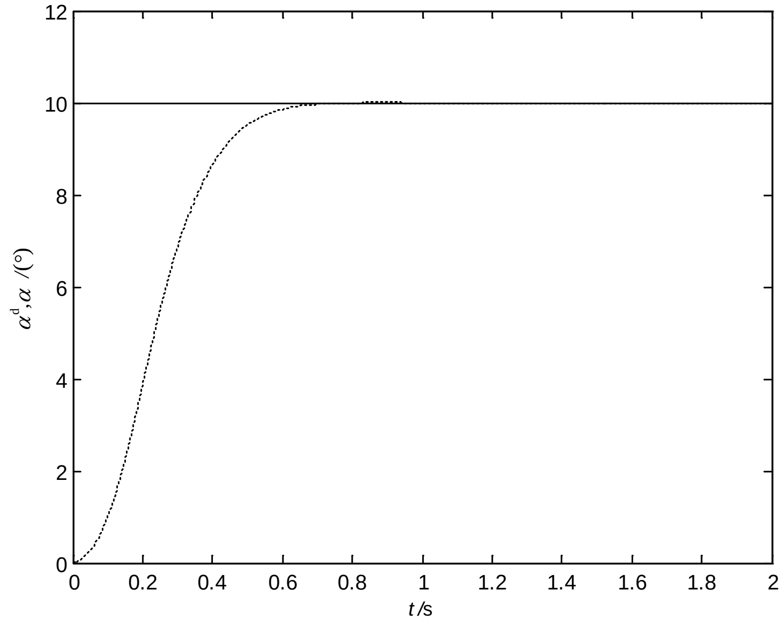

Fig. 3 Attack angle

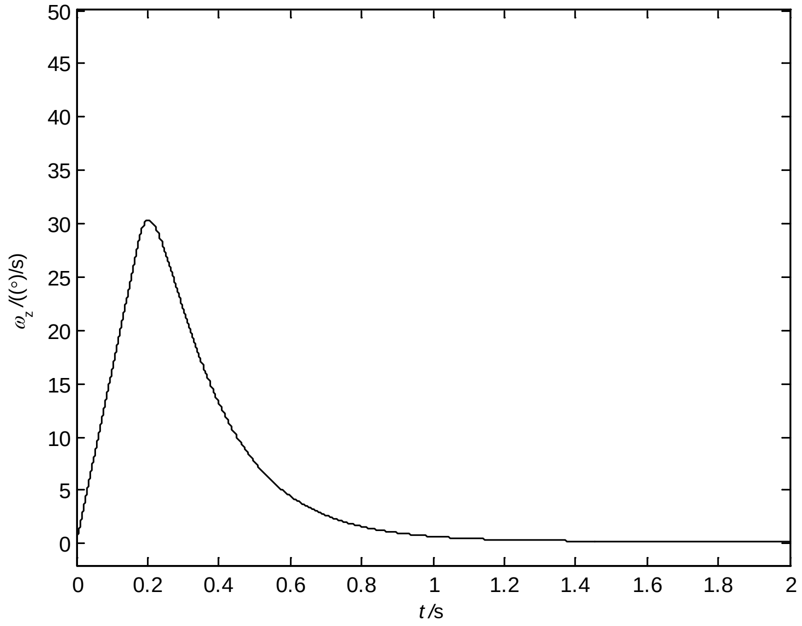

Fig.4 Pitch angle speed

## Result Analysis

Comparing Fig. 3 and Fig.4 with common PID controller, it can be seen that the aircraft PID control optimized by PSO algorithm can track the desired angle of attack more quickly, the rising time is about 0.4 s, the adjusting time is less than 0.6 s, and there is almost no overshoot; the pitch angular velocity decreases quickly to a smaller value. At first, the rudder deflection angle is very large, and then it is reduced to a smaller value faster than the PID control.

## Conclusion

In this paper, a parameter tuning method based on particle swarm optimization (PSO) is proposed. Through simulation analysis, it can be seen that the response curve of the system proposed in this paper after tuning has obvious improvement. Therefore, this method can completely solve the waste of time in traditional manual parameter selection, and does not rely on the engineering experience of the parameter debugger.

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