Design of Power Control System for Electrical Automation Equipment Based on Particle Swarm Optimization

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Abstract

Electrical automation equipment is a very important automatic control equipment, which is widely used in practical production. In terms of the application of electrical automation equipment, in order to ensure the good effect of the overall equipment in the application, it should ensure that all systems can be used normally, and the power control system is a very important content, so it needs to be designed reasonably. For the design of the power control system, each link must be strictly controlled to avoid internal differences as far as possible and ensure the full play of the overall performance of the control system. The scientific optimization design of the power control system can accurately measure the electric energy of the power system, realize the safe transmission and use of electric energy, and effectively control the electric energy consumption in the power control system, The realization of PID controller automatic control is based on setting controller parameters. In this paper, the optimization design method of electric control system of electrical automation equipment based on particle swarm optimization is presented. Firstly, the particle swarm optimization (PSO) algorithm is introduced, and then the application of PSO algorithm in the design of electric control system of electrical automation equipment is emphatically studied.

Keywords*: Particle swarm optimization, Electrical automation equipment, Power control system*

Ⅰ. Introduction

Electrical automation equipment is particularly important in the current equipment application. It is an automatic control equipment, which is widely used in the current production work. The development and breakthrough of computer network technology and electrical automation technology make the application of electrical automation equipment more and more common and extensive, and the design of power control system of electrical automation equipment is becoming more and more perfect [1]. Electrical automation equipment is a very important automatic control equipment, which is widely used in practical production. In terms of the application of electrical automation equipment, in order to ensure the good effect of the overall equipment in the application, it should ensure that all systems can be used normally, and the power control system is a very important content, so it needs to be designed reasonably [2]. Power production needs to consume a lot of fuel, and there is also a lot of consumption in power transmission, distribution and other links. Therefore, for different objectives such as power system planning and operation, power control system needs to select different control variables and constraints to form different types of optimization problems [3]. For the design of electric power control system, every link must be strictly controlled to avoid internal differences as much as possible, so as to ensure that the overall performance of the control system can be brought into full play. Scientific optimization design of electric power control system can accurately measure the electric energy of electric power system, realize the safe transmission and use of electric energy, and effectively control the electric energy consumption. In electric power control system, the realization of automatic control by PID controller is based on setting controller parameters [4]. However, the traditional PID parameter setting process is extremely tedious, and it is necessary to consider the object's requirements for parameters and carry out transitional calculation and testing. Particle swarm optimization (PSO) algorithm has the advantages of good robustness, parallel processing, and higher computational efficiency than traditional random methods, and its application in power control system gradually shows broad application prospects [5].

Therefore, the application of particle swarm optimization algorithm in power control system is proposed to improve the response rate of the whole power control system. As a member of modern heuristic algorithms, particle swarm optimization algorithm has gradually shown its advantages and broad application prospects in the field of power system in recent years. Particle swarm optimization algorithm is a new evolutionary technology based on swarm intelligence, which is used to solve problems that are difficult to be solved by classical optimization algorithms, such as discontinuity Nondifferentiable nonlinear ill conditioned optimization problems and combinatorial optimization problems show strong advantages, which has attracted widespread attention in international academic and engineering circles [6].

Ⅱ. Working Principle of Particle Swarm Optimization Algorithm

Particle Swarm Optimization (PSO) was first proposed by Eberhart and Kennedy in 1995. Its basic concept comes from the simulation of simplified social model of birds and fish feeding behavior. The PSO algorithm is inspired by the behavior characteristics of this biological population and used to solve the optimization problem [7]. In the PSO algorithm, the potential solution of each optimization problem can be imagined as a point in the D-dimensional search space, each point is called "particle", all particles have a fitness value determined by the objective function, and each particle has a speed that determines their flying direction and distance, and then the particles in the particle swarm will follow the best particles in the current swarm to search in the solution space [8]. Taking two-dimensional space as an example, the principle of particle position transfer is described. As shown in Fig. 1.

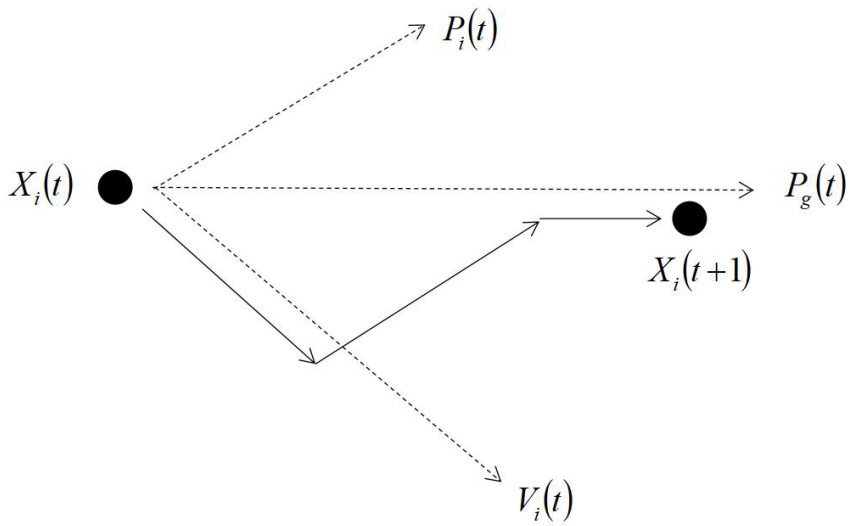

Fig.1 Schematic Diagram of Particle Swarm Optimization Algorithm

The basic idea of particle swarm optimization is that each solution of the optimization problem is called a particle. A coincidence function is defined to measure the superiority of each particle solution. Each particle swims in groups according to the "flight experience" of itself and other particles, so as to achieve the purpose of searching the optimal solution from the whole space [9]. The flow of particle swarm optimization algorithm mainly includes problem description, variable transformation, global coarse search and local fine search. Particle swarm optimization sequence has non repeatability. According to this law, particle swarm optimization sequence traverses all States in a certain range, which is the so-called orbit ergodicity, which is the basis of particle swarm optimization function optimization. As shown in Fig. 2.

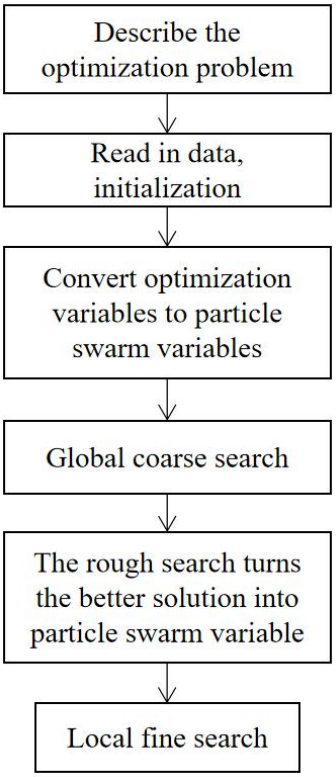

Fig.2 Flow Chart of Particle Swarm Optimization

The specific search process is as follows

Each particle represents a point in n-dimensional space, and xi = [Xi1, XI2,..., Xin] represents the ith particle. The individual optimal solution of the ith particle (the solution corresponding to the minimum fitness of the ith particle) is expressed as pbesti = [Pi1, Pi2,..., pin]; the global optimal solution (the solution corresponding to the minimum fitness of the whole particle swarm in the search process of previous generations) is expressed as gbesti= [pbest1, pbest2,..., pbestn]; and the correction amount (particle moving speed) of iteration K of Xi is expressed as

$$v_i^k = \left[v_{i1}^k, v_{i2}^k, ... v_{in}^k \right] \quad (1)$$

The calculation formula is as follows

$$v_{id}^k = \omega v_{id}^{k-1} + c_1 \times rand_1 \times \left(pbest_i - x_{id}^{k-1} \right) + c_2 \times rand_2 \times \left(gbest_i - x_{id}^{k-1} \right) \quad (2)$$

$$x_{id}^k = x_{id}^{k-1} + v_{id}^k \quad (3)$$

In formula (2), I = 1,2,m; D = 1,2,n, where m is the number of particles in the particle swarm; N is the dimension of the solution vector. C1 and c2 are learning factors greater than 0, respectively representing the weights of the two optimized solutions; Rand1 and rand2 are two independent random numbers between [0,1]; Ω is the inertia weight coefficient, and adjusting its size can change the searching ability. It is shown that the test weight ω will affect the global and local searching ability of PSO. The ω value is larger, the global searching ability is strong, and the local searching ability is weak; otherwise, the local searching ability is strong, but the global searching ability is weak.

PSO algorithm determines the search path according to the particle speed, and searches along the gradient direction, which has fast search speed; In most cases, all particles may converge to the optimal solution quickly; PSO adopts real number coding, which can directly take the objective function itself as the fitness function and carry out iterative search according to the value of the objective function; The information exchange among PSO particles adopts a one-way information flow mode, and the whole search and update process follows the current optimal solution [10].

Ⅲ. Design of Power Control System Based on Particle Swarm Optimization

The PID controller in the power control system of electrical automation equipment based on particle swarm optimization has simple structure, strong adaptability to the environment, few parameters to be adjusted and strong robustness. Take the hydraulic turbine as an example, the whole regulating system of the hydraulic turbine is summarized, and its related components mainly include four aspects, namely, hydraulic turbine, pressure diversion channel and generator, as well as governor, which belongs to a feedback control system [11]. State estimation plays an important role in the advanced application software of power grid dispatching automation system, sometimes known as the “heart” of application software, which mainly plays the role of normal state estimation, detection and identification of bad data and system structure identification. However, the classical weighted least square state estimation algorithm has some shortcomings. In practical application, it should be noted that although the application of intelligent control has achieved some success in the hydraulic turbine governing system, there are still some defects. If the analog governor is selected, the hydraulic turbine governing system can be used as a contact system, and its schematic diagram is shown in Fig. 3.

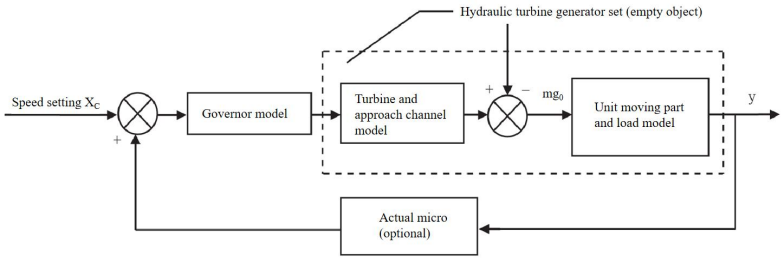

Fig.3 Schematic Diagram of Hydraulic Turbine Power Control System

In the process of practical application, it is of great significance and practical value to study the improvement of existing control methods. On the basis of selecting intelligent control, the hydraulic turbine governor can be better educated and intelligent, which is a very effective method in achieving good control function of hydraulic turbine regulating system. The structure of the power control system of electrical automation equipment based on particle swarm optimization is shown in Fig. 4. As far as the characteristics of hydropower units are concerned, many researches believe that choosing fuzzy control method is an effective solution. In view of the fact that conventional PID controller can't realize on-line parameter self-tuning, fuzzy self-tuning of PID parameters is proposed. The electric power control system consists of speed governor, electric automation equipment and measurement feedback unit. The governor is selected as PID controller. In this section, the control parameters of PID controller are tuned off-line by particle swarm optimization.

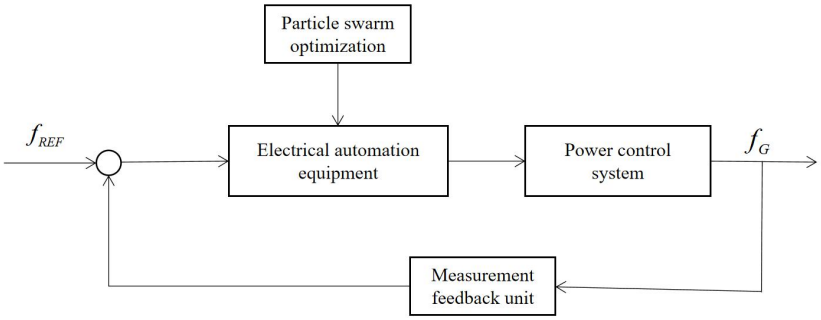

Fig.4 Power Control System Structure Diagram of Electrical Automation Equipment Based on Particle Swarm Optimization Algorithm

As for the intelligent PID controller, it is mainly composed of single neuron, which can realize self-learning and has self-adaptive ability. At the same time, its structure is relatively simple, and it can better adapt to the surrounding environment. Its main characteristics are less field adjustment parameters, easier field debugging, and strong robustness, which can better improve the typical nonlinear time-varying dynamic quality, ensure that the control system is in the best state during actual operation, and its control quality is obviously better than that of the conventional PID controller[12]. In view of the related characteristics of the hydraulic turbine governing system, such as nonlinearity and wide range of structural parameters, a new type of hydraulic turbine governing control strategy is proposed, that is, combining fuzzy neural network system with variable parameter control, which belongs to a modern intelligent control system. If the analog governor is selected, the hydraulic turbine governing system can be used as a contact system. The structure diagram of PID controller based on particle swarm theory is shown in Fig. 5.

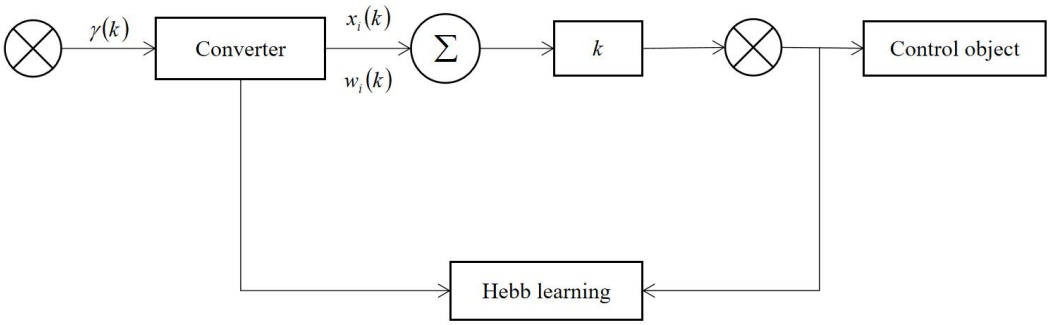

Fig.5 Structure Diagram of Power Control System Based on Particle Swarm Optimization Theory

In the case of a large power grid capacity, for a unit running in parallel, the change of its output power can not affect the frequency of the power system. In this case, the hydraulic turbine regulation feedback system basically has no effect, that is to say, it is in an open-loop state, and in this case, the governor can complete the function of the servo system.

The converter input signal R (k) is the control process and set state. After passing through the converter, R (k) is converted into state quantity Xi, which are x1, X2 and X3 respectively

$$x_1(k) = e(k) \quad (1)$$

$$x_2(k) = e(k) - e(k-1) \quad (2)$$

$$x_3(k)=\Delta^2 e(k)=e(k)-2e(k-1)+e(k-2) \quad (3)$$

Wi(k) is the weighting coefficient corresponding to xi(k), k represents the proportional coefficient of neurons, k is greater than 0, and the control signal is generated by neurons through association search.

Ⅳ. Application Prospect of Particle Swarm Optimization Algorithm in Power Control System of Electrical Automation Equipment

Particle Swarm Optimization (PSO) has not been around for a long time. As a new and potential swarm intelligence evolutionary algorithm, its application in power system optimization has just started. The research is far from forming a systematic analysis method and a certain mathematical foundation like genetic algorithm and simulated annealing [13]. For expert control, because it has two main problems such as real-time control and machine learning, the current expert control still can't be applied in real-time control of hydro-generator set. For fuzzy control, the amount of calculation is relatively small, which can be well applied in real-time control. However, its disadvantage is that the fuzzy rules and the types and parameters of membership functions cannot be well determined [14]. Its application prospect will be very broad. Specifically

① In the basic theoretical research of the algorithm, compared with other mature optimization algorithms, the mathematical basis of PSO algorithm is still relatively weak.

② According to the structure and characteristics of power system, a model using PSO and its improved algorithm is established to make the solution of the problem more effective.

③ Due to the diversity of practical problems in power system, researchers need to propose more effective PSO improved algorithms, set various parameters according to the facts, ensure the convergence of the solution and effectively avoid local optimization.

④ From the application field and current situation of power system, PSO algorithm shows faster convergence speed and greater probability to find the global optimal solution than other algorithms in solving practical problems of power system, especially in multivariable nonlinear constrained programming.

⑤ It is worth noting that a research trend is to develop PSO Hybrid Intelligent Computing System and fully integrate the respective advantages of PSO algorithm, artificial intelligence and traditional optimization algorithm to improve the performance of the algorithm.

Particle swarm optimization power control system can continuously optimize system control parameters, find the range of system control convergence optimization parameters, reduce frequency deviation, converge area control error and optimize system parameters, thus proving the effectiveness of the research. We believe that with the extensive and deep application expansion of PSO algorithm in the field of power system, and the combination with neural network, genetic algorithm and fuzzy theory, it will certainly promote the progress and development of power system optimization theory and method.

Ⅴ. Conclusions

In China, the demand for power in social production and people's life is increasing day by day, and the task of power development is still very arduous. In the process of power development, using advanced electrical automation technology to realize the optimal allocation of power supply and services has become an inevitable choice for the development of China's power industry, which also puts forward higher requirements for electrical managers and technicians. At this stage, in the operation of the power control system of electrical automation equipment, it can

give better play to its overall function, especially the need to design the overall function of the power control system. Thus, in the overall design process of the power control system, the chaotic algorithm is effectively integrated and used to enhance the scientific, reasonable and standardized nature of the overall system. The application of particle swarm optimization algorithm in power control system can more simply and quickly complete the convergence calculation, solve many nonlinear and high-dimensional constraint optimization of power control system, and propose a new way for power control system optimization. In this paper, the optimization design method of power control system based on particle swarm optimization algorithm can shorten the amount of calculation, have strong operability and simplify the parameter setting process of PID controller.

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