Application Analysis on the Power Distribution Network Three-phase Power Flow Based on Hybrid Particle Swarm Algorithm

WANG Yijun[1, a]

[1]Department of Electric Power Engineering,North China Electric Power University， Baoding,071003, China

[a]huadianwyj@126.com

Keywords: Distribution network, Particle swarm algorithm, Power flow, Network model.

Abstract. According to the structure characteristics of distribution network, this paper proposes a hybrid algorithm based on particle swarm optimization to process the calculation problem of three-phase power flow in less loop distribution network. Through the MATLAB simulation data, it can be seen clearly that the algorithm not only controls the iterations number of the linear equation in the calculation, but also reduces the power consumption in the distribution system, which can greatly shorten the calculation time to improve work efficiency, and also puts forward a new method for the power flow calculation in distribution network.

Introduction

One of the most important link is the distribution network in the electric power system, it is the power from the power plant to the user, to provide users with direct power supply [1]. Although the voltage level of distribution network in the power system is lower than the voltage level of transmission grid, but with the rapid development of the whole city distribution network, the distribution network in the city accounted for the proportion is also growing. With the rapid development of distribution network automation, the network analysis and optimization problem are becoming more and more attention [2,3]. Power flow calculation has become the basic operation in the power system, and the essence of power flow calculation in power generation and load conditions is each node voltage distribution network. Usually, the solution uses the Newton method or other derivative algorithm. Although the use of these algorithms have been successfully to the ring structure in the transmission network, due to the large amount of calculation by using Newton method, each iteration must be corrected to linear equations in the matrix operation, so we have to reduce the amount of matrix iteration calculation, we add some necessary hypothesis: the first is the problem of impedance, we assume that the input impedance is greater than the resistance in computing distribution network, which is aimed at correction equation can decouple the active power and reactive power; Second is the phase difference of voltage, in the process of calculating we generally believe that the voltage phase angle difference between two nodes is relatively small [4-6]. Only in this way, it can turn the Jacobian matrix into constant matrix in the back of the calculation, the calculation process of the final is not invariant.

At present, some scholars have put forward some algorithms according to the structure characteristics of distribution network, but these algorithms had not some cognitive standard, some peolpe selected the appropriate method according to the state component, some peolpe carried out calculation the divisions according to the processing mode among the three phase, and some peolpe carried out calculation and analysis combining with the two algorithms [7]. But these methods can not control their convergence times for the iterative linear equations, the number of too much iterations will be unable to improve the computational efficiency. Therefore, it is particularly important to put forward a kind of effective calculation method.

The Three-phase Line Distribution Network Model

In the calculation of power system three-phase power flow, we can choose to suit the parameters according to the construction of line model. when the three-phase line symmetry, the mutual coupling three-phase system is coupled into the mutual decoupling symmetrical system; when the three-phase equilibrium, we can directly calculate the positive sequence component. The feeder model is shown in Figure 1.

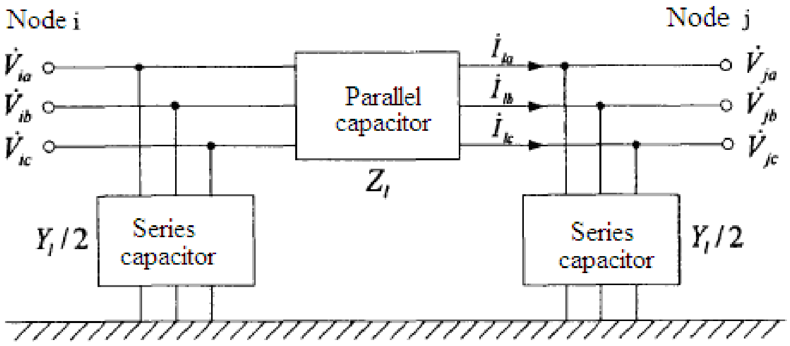
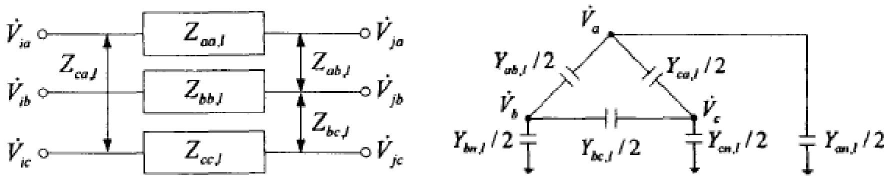


Fig. 1 The three-phase line feeder model

The series impedance matrix and parallel impedance matrix are a complex matrix, in which the impedance diagram is shown in Figure 2.



(a) Three-phase series impedance (b) Three-phase feedback shunt capacitor

Fig. 2 Impedance model

The series impedance matrix Z_j is:

$$Z_j = \begin{bmatrix} Z_{aaj} & Z_{abj} & Z_{acj} \\ Z_{baj} & Z_{bbj} & Z_{bcj} \\ Z_{caj} & Z_{cbj} & Z_{ccj} \end{bmatrix} \tag{1}$$

The parallel admittance matrix Y_j is:

$$Y_j = \begin{bmatrix} Y_{aaj} & Y_{abj} & Y_{acj} \\ Y_{baj} & Y_{bbj} & Y_{bcj} \\ Y_{caj} & Y_{cbj} & Y_{ccj} \end{bmatrix} \tag{2}$$

Application of Particle Swarm Optimization Algorithm

Study on the particle swarm algorithm. The basic idea of particle swarm algorithm is proposed an evolution computer technology based on an evolutionary biology ability, it is mainly for the global search, strong stability and high calculation efficiency, and the less parameters need to be modified. However, the distribution network flow calculation need to calculate hundreds of analysis [8,9]. In the three-phase distribution network structure, mostly radial structure is adopted, so the mixed particle swarm optimization algorithm is convenient for the flow calculation distribution network.

Through the establishment of a fitness function to determine particle quality in solution, each particle is movement in the feasible solution space domain, the speed variable can determine the direction and distance of the next step, the particle can go through the current population followed by the optimal particle, then we can get the optimal solution in the solution space after a generational search. According to the space position, we set the position of initial t as follows:

First, we define the current position:

$$X_i^t = (X_{i1}^t, X_{i2}^t, \cdots X_{id}^t, \cdots X_{iD}^t) \tag{1}$$

Its speed is:

$$v_i^t = (v_{i1}^t, v_{i2}^t, \cdots v_{id}^t, \cdots v_{iD}^t) \tag{2}$$

The global extremum is:

$$P_i^t = (P_{i1}^t, P_{i2}^t, \cdots P_{id}^t, \cdots P_{iD}^t) \tag{3}$$

The individual extremum is:

$$p_i^t = (p_{i1}^t, p_{i2}^t, \cdots p_{id}^t, \cdots p_{iD}^t) \tag{4}$$

In the $t+1$ time, the position of the particle is:

$$v_{id}^{t+1} = \omega v_{id}^t + c_1 r_1 (p_{id}^t - x_{id}^t) + c_2 r_2 (p_{gd}^t - x_{gd}^t) \tag{5}$$

$$x_{id}^{t+1} = x_{id}^t + v_{id}^{t+1} \tag{6}$$

In formula(6), *w* represents its weight parameters, c_1 and c_2 are learning factor system, r_1 and r_2 are a random factor, the values are distributed in 0 and 1.

The implementation process of algorithm. In the application of particle swarm algorithm, it goes through four steps to complete the optimization algorithm, the algorithm flow is shown in Figure 3.

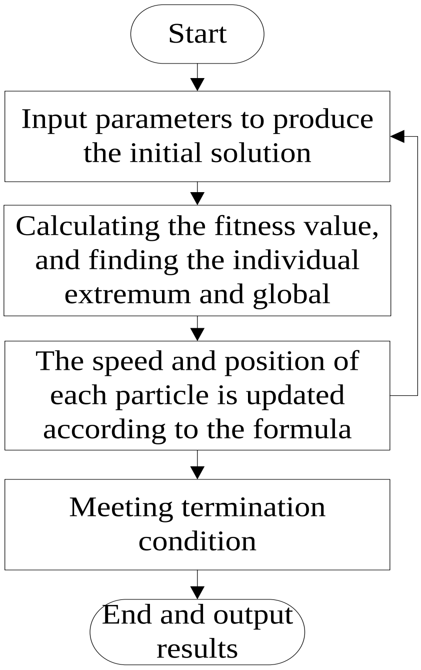


Fig.3 The particle algorithm flow chart

The operation process can be divided into four steps: the first step is to initialize the algorithm. According to the topic request, it need to input parameter values, such as population size, the number of iterations, convergence speed and initial position; the second step is to calculate the degree of adaptation. According to the particle fitness, each particle will be evaluated, and then according to the evaluation parameters, we set the individual extremum; the third step is to update the particle state. According to the above formula, we update the wholeparticle swarm; the fourth step is to test [10,11]. The output result is checked, if it meets the optimal value, it will be output; If it does not meet the optimal value, then it will feedback to the second step, it needs to modify the parameters, until the date.

Example Analysis

In the calculation of three-phase power flow in distribution network, the distribution network operation usually uses a circular or closed loop system. This paper uses the structure model of less ring network as an example in distribution network, to study the particle swarm optimization algorithm. First of all, the contact ring point is equivalent to two three-phase voltage series, wherein the two three-phase voltage source are equal and opposite polarity, but the size is is determined by open-loop voltage difference decision of the open-loop node. Then, the whole network is divided into two parts, one part is the radial network, the other part is the ring network. The algorithm structure is shown in Figure 4.

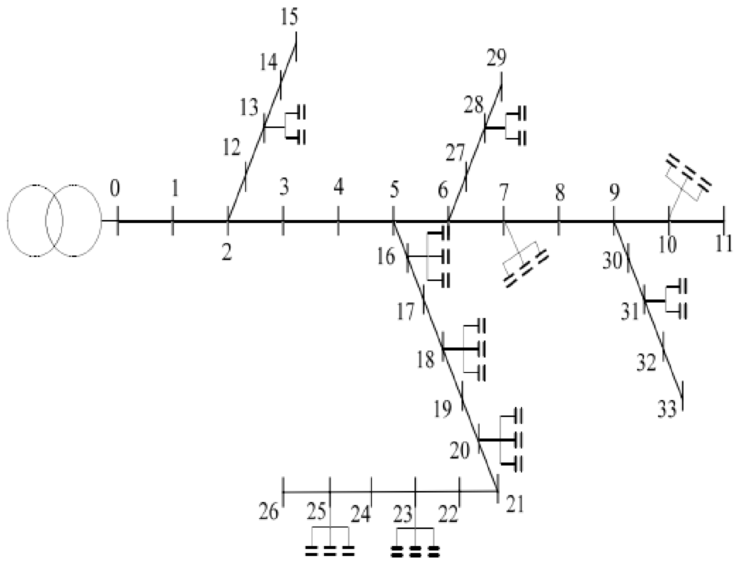


Fig. 4 Distribution network structure

Load data model group is shown in Figure 5.

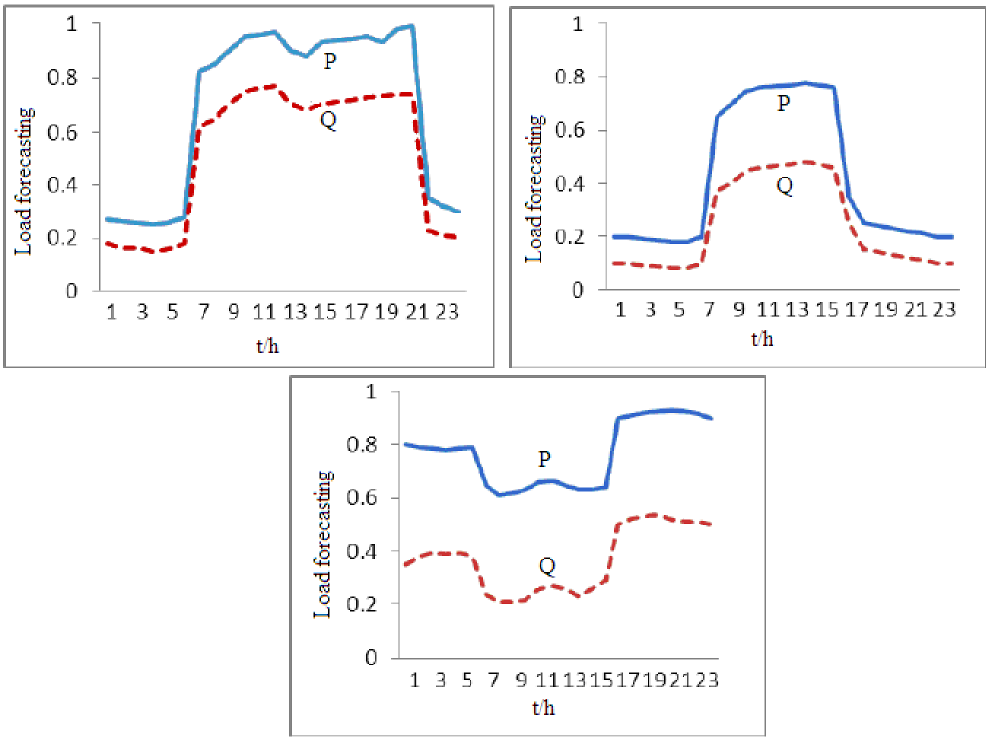


Fig. 5 Algorithm data distribution

From the data distribution, we can clearly see that the establishment of a particle swarm algorithm greatly simplifies the calculation method in the process of solving the three-phase power flow in the distribution network. Through the less iterative data, we can not only find the accurate results, but also shorten the optimization time.

Summary

In the operation and planning of power distribution network, power flow calculation and its optimization problem are the long hot issue of many experts and scholars to study. In the network reconfiguration, service restoration and capacitor configuration, they should go through hundreds or even thousands of power flow calculation, this paper proposes an appropriate optimization algorithm. Based on the three-phase model, this paper proposes the hybrid particle swarm algorithm to calculate the three-phase power flow, the distribution network is divided into two models by using the superposition principle, one is the pure radial network without the ring structure, another is the puremeshed network without radiation structure, finanlly the use of hybrid particle algorithm carries out iterative to calculate the results. The hybrid algorithm is put forward and applied for the power flow optimization calculation proposed a new method for reference in this paper.

References

[1] J.S. L., Y.M. D., B.M. Z.. Application of integrated power flow model and its in distribution network reconfiguration system. In proceedings of CSEE, 2001,21(1): 57-62.

[2] B.Y. W., D.F. Z., Y. L.. A new distribution network reconfiguration optimal flow pattern algorithm. Journal of Xi'an Jiao Tong University, 2013,33 (4): 21-24.

[3] Z.C. H., X.F. W.. The time control strategy of distribution network reactive power optimization. Automatic power system, 2013, 26(6):45-49.

[4] Y. Y., G.Q. L.. A new method of distribution network dynamic reactive power optimization space-time decoupling. Power system protection and control, 2013, 38(21): 39-43.

[5] M.Z. G.. The research and software development of distribution network reactive power optimization planning. Zhejiang: Hangzhou Dianzi University, 2012: 310-335.

[6] F. W, L.Y, S. J, et al. Distribution system voltage and VaR optimization: Power and Energy Society General Meeting, 2014:1-8.

[7] Stahlhut J W, Heydt G T, Kyriakides E. A Comparison of Local vs. Sensory, Input-Driven, Wide Area Reactive Power Control. Power Engineering Society General Meeting, 2013: 1-7.

[8] L.Q. C., F.B. L., J.M. D.. Application of the tabu search and particle swarm algorithm in reactive power optimization. Network technology, 2014, 35(7): 129-133.

[9] M. X.. Study of transmission planning modeling and solving method under the power market environment. Wuhan: Huazhong University of Science and Technology, 2013: 112-130.

[10] Y. L., Z.X. H.. Dynamic optimization algorithm of reactive power compensation. Proceedings ofthecsee, 2013, 7(10):79-85.

[11] Y.M. D., B.M. Z., N.D. X.. The virtual flow theory and algorithm of distribution network reconfiguration. Journal of Tsinghua University, 2012, 37(7): 113-116.