Scholar Publishing Group
Distributed Processing System
https://doi.org/10.38007/DPS.2020.010206
ISSN 2790-0916 Vol. 1, Issue 2: 46-53

Reactive Power Optimization of Power System Based on Distributed Cooperative Particle Swarm Optimization Algorithm

Sitton Candanedo*

Autonomous Univ Morelos State UAEM, Res Ctr Engn & Appl Sci, Ave Univ 1001 Colonia Chamilpa, Cuernavaca 62209, Morelos, Mexico

**corresponding author*

Keywords: Particle Swarm Optimization Algorithm, Distributed Coordination, Power System, Reactive Power Optimization

Abstract: With the gradual increase in the scale of the power grid, the marketization of the power industry, and the rationalization of resource allocation, how to improve the power system has become an urgent issue for the power sector. The power system is of great significance to improve voltage quality, improve power grid safety factor, reduce system active power loss, and improve economic benefits. The purpose of this paper is to study the power system with algorithm. In the experiment, using the reactive power optimization objective function, the program of the power system is optimized, and they are respectively applied to the standard IEEE-30 node model for optimization calculation, and the results are analyzed.

1. Introduction

my country has entered the improvement stage of the "14th Five-Year Plan", and society, economy and life will also enter a period of high-quality improvement. As a pillar industry, the power industry not only has to have extremely high reliability of power supply, but also needs to control the balance of power quality, economic benefits, and energy conservation and efficiency [1]. The problem is to dynamically adjust the voltage, change the voltage ratio of the primary and secondary sides of the adjustable transformer, and increase or decrease equipment according to the system grid load and power flow distribution. With limiting, improve the voltage quality, so that the power grid can supply power to users in a safe, stable and economical manner.

With the improvement of economy, the application of system is becoming more and more extensive. Ullmann M proposed an automatic clustering method to improve the interactions of student. They had different levels of knowledge and interest, and three different roles were chosen among group members. Case studies were conducted on them. Discourses were analysed using two coding schemes to measure student critical thinking evident in online discussions and to examine sociological aspects of group interaction. The results of the study showed that the unskilled group created by this method achieved better scores in most of the categories analyzed compared to the random group [2]. Ramakrishnan D promoted a comprehensive method for finding the best method in power distribution systems using a unified particle optimization algorithm. Generally speaking, grid economics are mainly determined by conductor losses. Therefore, the small loss of active network power is the mitigation problem, and the optimal particle swarm coordination algorithm is used to reduce the network power loss by introducing optimal distributed power resources. The system energy loss is treated as a cost function for each particle in the swarm. The simulation analysis of the distribution system is completed by using MATLAB. Through the solution and particle swarm optimization algorithm, the system loss is minimized [3].Reducing the active power, improving the power supply, economical of the system have become problems that need to be improved urgently.

In this paper, particle swarm optimization,the problem of it and the relative power system are studied. In the experiment, the reactive power optimization objective function is used to verify the effectiveness. And applied to the standard IEEE-30 node model to optimize the calculation and analyze the results.

2. Research on Reactive Power Optimization of Power System Based on Distributed Cooperative Particle Swarm Optimization Algorithm

2.1. Distributed Collaborative Particle Swarm Optimization Algorithm

Particle swarm optimization, also known as particle swarm optimization algorithm [4-5]. It is a kind of swarm intelligence algorithm. Its main idea is to randomly initialize some particles, which carry information that can interact with each other, and then gradually find the target position of the population through iterative update, and judge the pros and cons of these particles. Through fitness, it is mainly updated gradually through the motion trajectory without more complicated operations, and it follows the example particles in the current population to gradually optimize to find the global optimal solution. It is simple to implement, has fast convergence speed, and is used in many optimization fields. The idea is to realize the information exchange between particles and guide the next decision-making of particles through "swarm intelligence" in the academic field. Although the distributed it has been successfully applied in it, the distributed cooperative particle swarm optimization algorithm is affected by the premature phenomenon in these applications, which limits the algorithm to a certain extent. application and promotion.

2.2. Power System Reactive Power Optimization Problem

As the scale and structure of the current power system become larger and more complex, the transmission voltage in the system is also gradually increasing, which also leads to an increase in the rate of change of the reactive power of the system. The constraints on power and voltage are becoming more and more demanding and difficult [6-7].

In the actual power network, the electrical power delivered from the power plant to the electrical equipment consists of two parts: one is active power and the other is reactive power [8-9]. Reactive power only exchanges energy between electric field and magnetic field in the circuit, and it does not do external work by itself. As long as it is a load with an electromagnetic coil, a magnetic field needs to be established, because only when a magnetic field load is established can it work properly, then the load will definitely consume reactive power. In other words, it reflects the power of electrical equipment or the value of electrical energy converted into other forms of energy per unit time, also known as average power.

2.3. Particle Swarm Optimization Algorithm and Mathematical Model of Reactive Power Optimization

Only when the voltage is stable and in a normal state can the system be maintained. Otherwise, the stability and safety of the system may be affected [10-11]. For the problem of efficiency, it is a relatively new and fast-developing artificial intelligence algorithm. Combined with the advantages of the algorithm, it was applied although the improvement time is relatively short. For the basic distributed the algorithm, this paper proposes a new algorithm by improving it, and applies the algorithm to the power system for simulation, and is applied to the standard IEEE-30 node Finally, the simulation results are analyzed [12-13].

According to the actual needs and different focuses, the objective function of reactive power optimization is also the same, mainly including the following [14-15]:

1. From an economic point, the minimum active power loss is the most commonly used and the most classic objective function model. Considering the economic cost, the objective function can also be taken to minimize the total cost of injection [16].

2. From the safety point of the entire power, the voltage deviation of each node is taken as the objective function [17].

3. Considering both economy and safety, the objective function is discussed from multiple objectives such as ensuring voltage stability, reducing network loss and maintaining voltage level stability at the same time [18].

3. Investigation and Research of Power System Based on Distributed Cooperative Particle Swarm Optimization Algorithm

3.1. Research Content

For the distributed collaborative improved particle swarm optimization algorithm proposed in this paper, it is applied to the reactive power optimization objective function is adopted. They are respectively applied to the standard IEEE-30 node model for optimization calculation, and the results are analyzed.

3.2. Reactive Power Optimization Objective Function

(1) Taking the minimum system active network loss as the optimization objective function:

$$minf = min \sum_{(i,j)\in n_1}\left(p_{ij}+p_{ji}\right) = min\sum_{j\in i}^{i\in n} G_{ij}\left(U_i^2 U_j^2 - 1U_i U_j \cos\theta_{ij}\right) \quad (1)$$

In the formula, n_1 represents all branches, U_i , U_j represents the node voltage, θ_{ij} represents the phase angle difference, and p_{ji} represents the conductance of the line.

(2)The objective function is to minimize the sum:

$$minf = min\sum_{i=1}^{N_e}(\alpha_i \times Q_{ei}) + \beta \times P_L \quad (2)$$

(3)Taking the minimum total fuel cost (total consumption) of the system thermal power unit as the objective function:

$$minf = \sum_{i \in n_a} K_i(p_{Gi}) \quad (3)$$

4. Analysis and Research on Reactive Power Optimization of Power System

4.1. IEEE-30 Node Test System Data and Example Analysis

To verify the effectiveness of the improved algorithm, it uses a standard IEEE 30 node example to test the algorithm, analyzes and compares the test simulation results, and comprehensively evaluates the performance of the improved algorithm. In the system node and branch data, the statistics of variable constraints are shown in Table 1 and Figure 1, and Table 2 and Figure 2:

(1) Constraint range of control variables

Table 1. Constraint range of control variables Unit:pu

Controlled variable	Condenser capacity	Transformer voltage ratio T	Generator node voltage
Superior limit	0.08	1.3	1.2
Lower limit	0.05	1.0	1.0

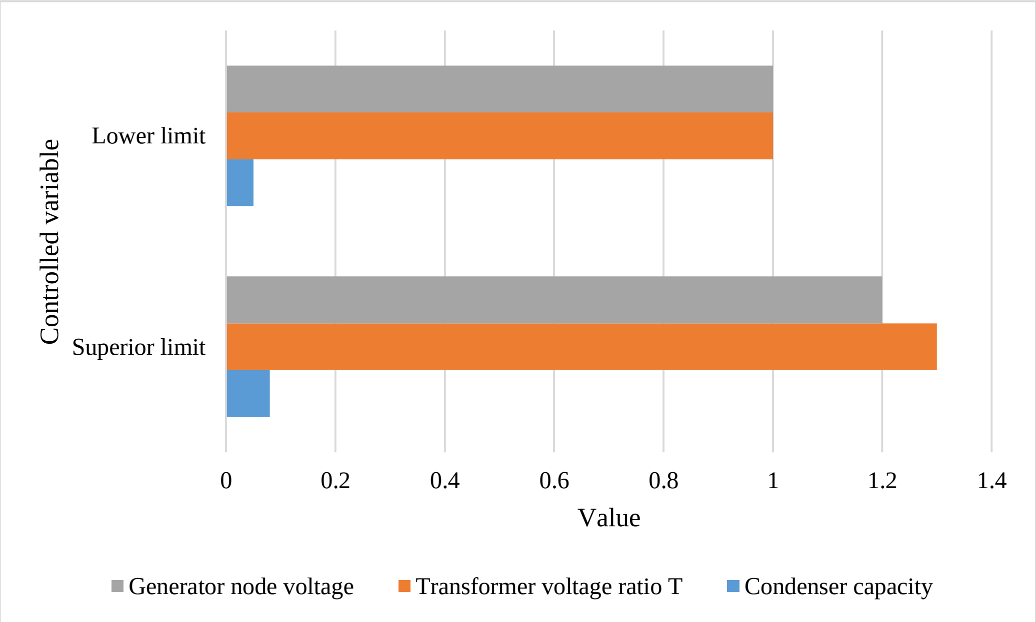

Figure 1. Comparison of data of control variables

(2) Constrained range of state variables

Table 2. State variable constraint range Unit:pu

State variable	1	2	3	4	5
Superior limit	0.624	0.691	0.741	0.524	0.325
Lower limit	-0.365	-0.251	-0.425	0.271	-0.098

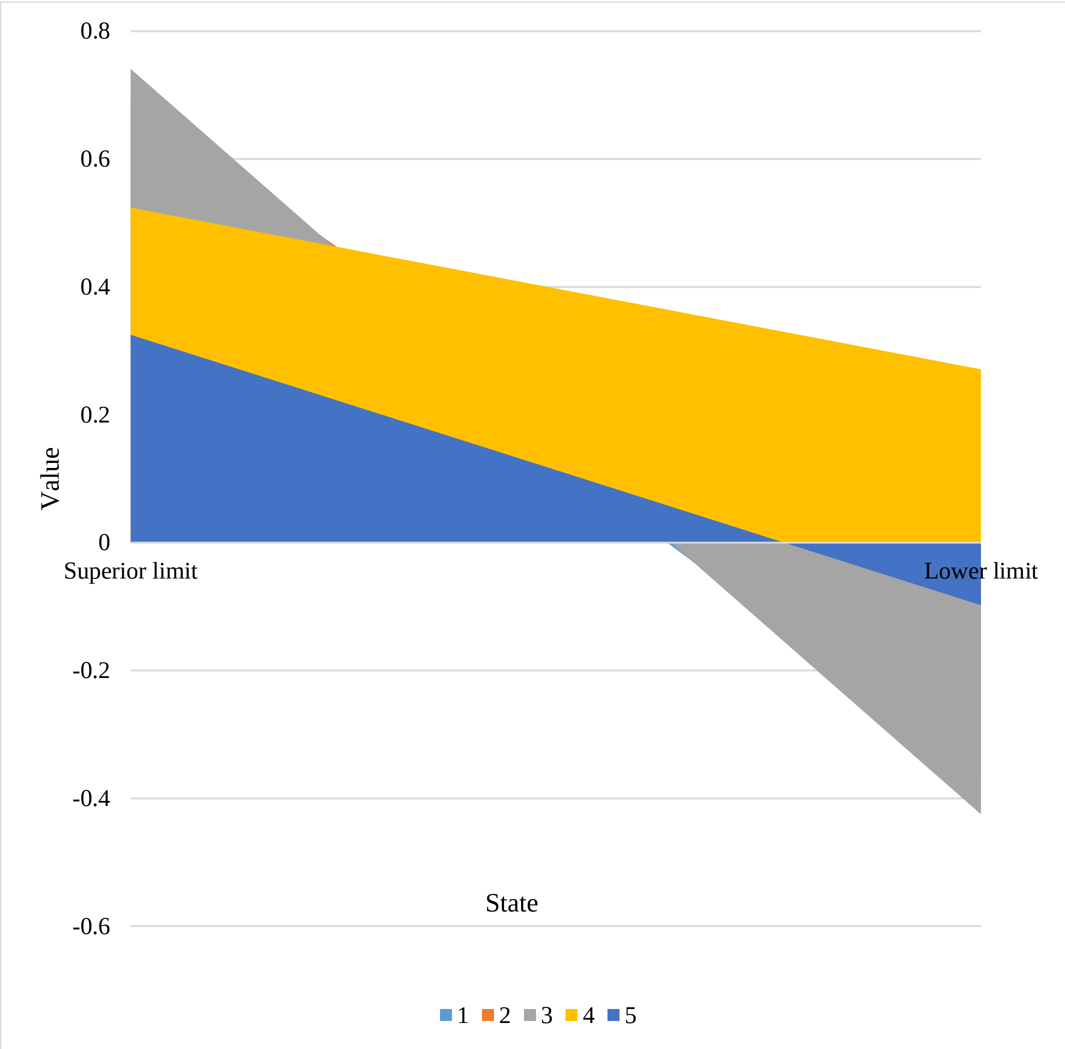

Figure 2. Comparison diagram of capacity change data

4.2. Simulation Results Analysis of IEEE-30 Node Test System

After the algorithm, the analysis of the IEEE30 node optimization results is shown in Table 3 and Figure 3:

Table 3. Analysis of IEEE30 node optimization results

Variable	Initial state tidal current standard	Quasiparticle group algorithm	Improved post-particle swarm algorithm
Network loss value (MW)	9.02	8.6	8.5
Reduce network loss (MW)	0	0.83	0.91
Network loss reduction rate	0	10.0%	11.2%

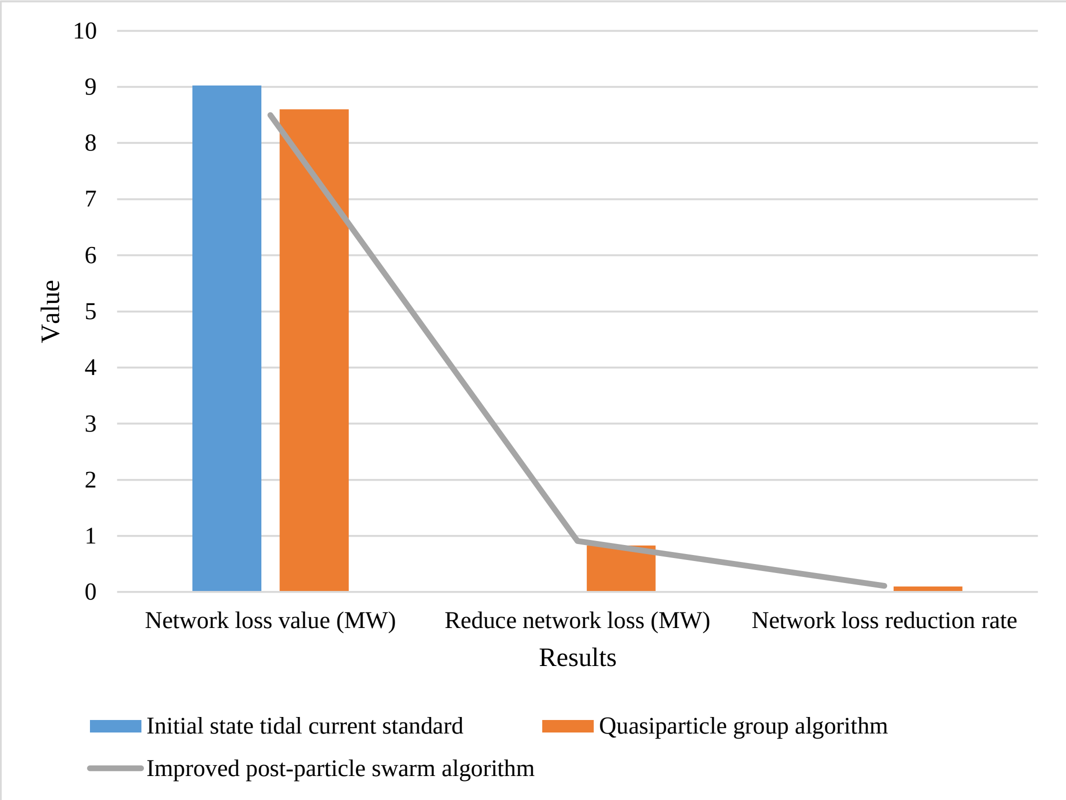

Figure 3. Algorithm optimization results data comparison diagram

The data shows that the initial network loss value of the IEEE30 node system is 9.02MW, and the voltage level of each node is low, and the node voltage does not meet the voltage constraints. Aiming at this problem, the strategy of reactive power optimization should be adopted to increase the voltage level of the system node, improve the operating state of the network system, and enable it to operate economically and reliably. The algorithm has faster iteration speed and better convergence, and it is easier to find the global optimum solution.

5. Conclusion

In recent years, due to the influence of the power market reform and the consideration of the power grid for the objective environment, technological improvement and its own economic benefits, to use resources and meet the power grid's economic requirements, this also reduces the power grid. The flexibility of the system makes it more and more difficult to adjust the system. Once some special circumstances occur, the power grid becomes more fragile. Because the problem of power system has the characteristics of multi-variable, multi-constraint, nonlinear, etc., the limitation of traditional optimization algorithms cannot solve such problems well, leaving room for people to explore and study to solve this problem. With the progress and improvement of artificial intelligence algorithms, it provides a good solution to such problems.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

References

[1] Dall'Anese E, Simonetto A. Optimal Power Flow Pursuit. IEEE Transactions on Smart Grid, 2018, 9(2):942-952. https://doi.org/10.1109/TSG.2016.2571982

[2] Ullmann M, Ferreira D, Camilo-Junior C. An Automatic Group Formation Method to Promote Student Interaction in Distance Education Courses. International Journal of Distance Education Technologies, 2018, 16(4):73-92.

[3] Ramakrishnan D, Pushparajan S. Unified Particle Swarm Optimization Based Distributed Generation Placement in Radial Power Systems. International Journal of Intelligent Engineering and Systems, 2018, 11(1):104-112. https://doi.org/10.22266/ijies2018.0228.11

[4] Mehrtash M, Kargarian A, Mohammadi A. Distributed optimisation-based collaborative security-constrained transmission expansion planning for multi-regional systems. Generation, Transmission & Distribution, IET, 2019, 13(13):2819-2827.

[5] Choudhury M, Mahmud S, Khan M M. A Particle Swarm Based Algorithm for Functional Distributed Constraint Optimization Problems. Proceedings of the AAAI Conference on Artificial Intelligence, 2020, 34(5):7111-7118. https://doi.org/10.1609/aaai.v34i05.6198

[6] Hosseini A D, Moradian M, ‡, et al. Optimal placement of distributed generators with regard to reliability assessment using virus colony search algorithm. International Journal of Renewable Energy Research, 2018, 8(2):714-723.

[7] Jaganathan R. Hybrid of Salp Swarm Optimization Algorithm and Grasshopper Optimization Algorithm (SSOAGOA) for Feature Selection. International Journal of Grid and Distributed Computing, 2020, 14(1):1350-1366.

[8] Ghosh T K, Das S. Job Scheduling in Computational Grid Using a Hybrid Algorithm Based on Particle Swarm Optimization and Extremal Optimization. Journal of Information Technology Research, 2018, 11(4):72-86. https://doi.org/10.4018/JITR.2018100105

[9] Huang J, Golubovic D S, Koh S, et al. Degradation Mechanisms of Mid-Power White-Light

LEDs Under High-Temperature–Humidity Conditions. IEEE Transactions on Device & Materials Reliability, 2018, 15(2):220-228.

[10] Basher H. Autonomous Control of Nuclear Power Plants. Engineering with Computers, 2018, 15(3):219-227.

[11] Gajewski J, Michalski R, K Buśko, et al. Countermovement depth – A variable which clarifies the relationship between the maximum power output and height of a vertical jump. Acta of bioengineering and biomechanics / Wroclaw University of Technology, 2018, 20(1):127-134.

[12] Desjacques V, Jeong D, Schmidt F. The Galaxy Power Spectrum and Bispectrum in Redshift Space. Journal of Cosmology and Astroparticle Physics, 2018, 2018(12):035-035.

[13] Sundt T. The Power and the Pitfalls of Randomized Clinical Trials.. The Annals of thoracic surgery, 2020, 111(2):699-700.

[14] Masoud J, Uosef D T. Double-Boost Switched-Resonator Converter. Iet Power Electronics, 2018, 11(8):1382-1388. https://doi.org/10.1049/iet-pel.2017.0490

[15] Gu Y, Aissa S. RF-based Energy Harvesting in Decode-and-Forward Relaying Systems: Ergodic and Outage Capacities. IEEE Transactions on Wireless Communications, 2018, 14(11):6425-6434.

[16] L.-W C, Fabian A C, Gendreau K C. ASCA and ROSAT observations of the QSF3 field: the X-ray background in the 0.1-7 keV band. Monthly Notices of the Royal Astronomical Society, 2018(3):449-471.

[17] White M, Viana P, Liddle A R, et al. Cold dark matter models with high baryon content. Monthly Notices of the Royal Astronomical Society, 2018, 283(1):107-118. https://doi.org/10.1093/mnras/283.1.107

[18] Storrie-Lombardi L J, Irwin M J, Mcmahon R G. apm z > 4 qso survey: distribution and evolution of high column density hi absorbers. Monthly Notices of the Royal Astronomical Society, 2018, 282(4):1330-1342. https://doi.org/10.1093/mnras/282.4.1330