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Reactive Power Optimization of Wind Farm based on Improved Genetic Algorithm

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Abstract

Reactive power optimization plays a significant role in the operation of wind farm grid intern connection to maintaining voltage stability and system reliability. Genetic algorithm (GA) is an efficient method which can be applied in reactive power optimization to reduce power loss and improve power quality. However, traditional GA has some defects, such as slow convergence and prematurity. For improvement, the paper modified decoding method, genetic operators, crossover and mutation probability, iteration stopping criterion based on the theory of Catastrophism. A reactive power optimization techniques based on improved genetic algorithm (IGA) of wind farm is such presented. Simulation results for Chinese Mongolia Huitengliang Power Plant show that the proposed method has satisfied global performance, high convergence speed and stable convergence performance, so it is suitable to solve the optimal reactive power planning.

Keywords: improved genetic algorithm, reactive power optimization, wind farm.

1. Introduction

With the rapid development of wind power technology and national policies on the renewable energy sources, wind energy has been widely used in power generation. However, the large-scale wind farm grid interconnection will have a great influences on the system reliability and the stable operation in the power system for two reasons: (1) The areas where possesses rich wind sources, that can be used to make large-scale development of the wind generation, are generally in the terminal of the network, where the power grid structure is weak; (2) The wind energy is an unstable and random energy, so active power output changes along with the wind speed. The most serious problem is that the voltage quality on local power grid within or close to wind farm decreases seriously, since the grid interconnection will cause the

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fluctuation of the reactive power and then influences the system voltage or even cause the collapse of entire power system.

The reactive power optimization of power system is the most efficient method to decrease the loss on power network and maintain the voltage level of the power grid by reasonable allocation of reactive sources and rational compensation of reactive load.

For decades, many electric power experts have made a great research on the reactive power optimization and carried out many methods. Reference [1] introduces tabu search (TS), which has a strong ability of global optimization, can be arranged for the operation, and has the potential of online decision-making . However, it is difficult to adjust parameters and the result is greatly affected by the randomly generated initial solution. Genetic/Tabu search hybrid algorithm is proposed in [2], combines the advantages of two algorithms, in spite of that, it is difficult to achieve is obvious.

The paper improved decoding method, genetic operators and iteration stopping criterion of the traditional GA [3-4]. A novel improved GA based on catastrophic genetic algorithm, which is suitable for reactive power optimization, was proposed. In addition, grouping decimal integer encoding [5], tournament selection, adjacent mutation and the operation of the disaster are discussed. This method is suitable to the actual situation and can get the optimal solution quickly.

2. Model of Wind Farm Reactive Power Optimization

The reactive power optimization is a nonlinear optimal problem, for its multivariable and multi-constraints [6], it can be described as follows:

2.1. Objective function

Reactive power optimization objective function includes technical performance indicators and key economic indicators, and there are differences between two objective due to the optimize focus. In this paper, the objective function is loss minimum for the reactive power compensation capacity and network losses.

$$\min F = \sum_{i=1}^{N_R} \alpha_{Ri} Q_{Ri} + \sum_{j=1}^{N_C} \alpha_{Cj} Q_{Cj} + C\tau_{\max} P_S \tag{1}$$

α_{Ri} : The inductive reactive power compensation per capacity of node i; Q_{Ri} : The inductive reactive power compensation capacity of node i; N_R : The inductive node number of the power network; α_{Cj} : The capacitive reactive power compensation per capacity of node j; Q_{Cj} : The capacitive reactive power compensation capacity of node j; N_C : The capacitive node number of the power network; C : The price of active power loss; P_S : The active power loss. $\tau_{\max}$: The time of the maximum load loss;

2.2. Equality constraint

The equality constraints of each node are as follows:

$$P_{Gi} - P_{Gi} = U_i \sum_{j=1}^{N} U_j (G_{ij} \cos\delta_{ij} + B_{ij} \sin\delta_{ij}) \tag{2}$$

$$Q_{Gi} + Q_{Ci} - Q_{Li} - Q_{Ri} = U_i \sum_{j=1}^{N} U_j (G_{ij} \sin\delta_{ij} - B_{ij} \cos\delta_{ij}) \tag{3}$$