Node-voltage-based and branch-current-based hybrid electric power network equations and research of reactive power optimization problem.

W. Chengmin
Department of Electric Engineering, Shanghai Jiaotong University, Shanghai.

The networks are widely existed in nature and human society. There are a large number of theories and approaches proposed to study the flow in networks, which is especially aimed to the traffic network. The network flow arithmetic is also used in power system calculation with the dc power flow formulation being the most common representation for the transmission system. The dc power flow formulation is only a simple model for power system analysis, so it is essentially different between electric power network flow and the conventional traffic network flow. There is no damp for the traffic network flow, but the active power flow of electric power network is decreasing because of the branch impedance.

The line current may be adopted to replace the active power as electric power network flow due to it is not damped, therefore the successful theories and approaches in network flow can be used for power system calculation.

The electric power network is traditionally described by node-voltage-based equations if the line current is not regarded. In the last century, the loop current model is developed by Goswami[1 4] etc for load flow calculation of distribution systems with better convergence and meshed modeling while the grounding admittance is ignored and the constant impedance model of load is used, but it is improper and limited in the transmission network with such assumptions.

The reactive power optimization problem is described by an optimal power flow model with the objective function as network losses minimization, and various approaches are proposed such as interior point methods, evolutionary algorithms and others, which are summarized in literature[5]. It is discommodious for the network losses that are generally represented by the sum of injective active powers at slack nodes or all nodes, and it is necessary to improve the computational efficiency of present reactive power optimization approaches.

In this paper, the enlarged electric power network equations are established by regarding the grounding branch as a current source with node voltage and branch current variables, so the objective function can be wrote as the product of line current and resistance, and the reactive power optimization problem can be decomposed into two sub-problems with a minimum cost flow model and a linear equations. It is solved to the minimum cost flow model by a quadric programming approach, therefore the computational efficiency is improved and the found optimal solution is closed to global. The case study is made at the IEEE-30 system and the better results are obtained.

The assumptions are introduced in this paper as following: 1) The reactive power optimization is aimed to the injective reactive power at all nodes; 2) The transformer’s tap ratio optimization is ignored because it is not obvious to reduce the network losses; 3) The active power is considered as constant, and the reactive power and node voltage at all nodes are regarded as variables.