A Preventive Security-Constrained Optimal Power Flow with Hybrid Genetic-Ant Colony Optimization

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Abstract
This paper presents preventive security-constrained optimal power flow (PSCOPF) with hybrid genetic-ant colony optimization (HGACO) is presented. The PSCOPF can be divided into three steps involving security analysis, severest event selection, and preventive algorithm. First, Novel security analysis will be conducted before fault occurred in the system by current-based power flow technique. Second, ranking method will be used to highlight the most severe event caused by the specific facility. And finally, a preventive algorithm will make use of the contingency information, and could be kept the operator system security and avoided congestion when fault occurred. The HGACO is integrated with genetic algorithm and ant colony optimization, and the objective of GA is to improve the searching quality of ants by optimizing themselves to generate a better result, because the ants produced randomly by pheromone process are not necessary better. This method can not only enhance the neighborhood search, but can also search the optimum solution quickly to advance convergence.

Index Terms—optimal power flow; preventive security-constrained OPF; hybrid genetic-ant colony optimization, genetic algorithm, ant colony optimization.

1. Introduction

In recent years, the power system loading was continued to increase in all country. It is hard to add power plant and power transmission line, and making power dispatch problems. So numerous accidents of voltage collapse were took place. Therefore, power companies and researchers pay more attention to power system security issues. The main reasons for the occurrence of these events: 1) bus load continued to grow up (direct factor); 2) the disturbance caused by overloaded power lines or over-range electrical energy of generators in this system (indirect factor) [1]. In general, the central dispatch center of Power Company is responsible for monitoring and dispatching the operating power system. The duty dispatchers gain the operating situation of system from central dispatch center to which the measured parameters would send by specific communication system in all loading area. The function of central dispatch center concern about system security can be divided into three parts: i) system monitoring; ii) security analysis (SA) or contingency analysis; iii) security-constrained optimal power flow (SCOPF) [2].

The security mechanism of electric power dispatching center design can divide into preceding and past failure of security dispatch [2]. The security dispatch of preceding failure is the optimized power flow program which operated under normal situation that limited by system data and data execution safety. The function of program can control all adjustable values and avoid accidents when the system was operated at violating limits. SCOPF can consider occasional accidents and calculate the adjustable values, such as generator power and voltage, transformer tap, electricity trading, etc. The security dispatch of past failure is based on SCOPF results, when the failure was happened, power dispatchers can dispatch for the system according to their experience.

In the Industry, the Optimal Power Flow (OPF) can only deal with continuous variables. However, if we want to join the objective function or restricted equation into the security restrictions, OPF couldn’t solve related issues [3]. But Artificial Intelligence (AI) issues was developed in recent years, such as Genetic Algorithm (GA), Evolutionary Programming (EP), Ant Colony Optimization, Particle Swarm Optimization (PSO), etc [4-7]. In view of this, we propose Hybrid Genetic-Ant Colony Optimization (HGACO) to solve the security restrictions of optimized power flow. It’s based on power flow model of equivalent current injection method [8-9], and combined with interior point algorithm to solve continuous variables of OPF. For the discrete ones under security restrictions, we adopt HGACO to solve, and propose preventive security-constraint optimal power flow (PSCOPF) of preventative security restrictions. The system could adjust and dispatch security for the specific most dangerous accident by the results of PSCOPF. When the accidents were happened, we could avoid the system operated at violating limits, and don’t change any dispatch that the system still could safety operated under the restrictions.

2. Technical background

2.1. Hybrid Genetic-Ant Colony Optimization

The vast literature on metaheuristics tells us that a promising approach to obtaining high-quality solutions is to couple a local search algorithm with a mechanism to generate initial solutions. In fact, in most search procedures, the better the solutions quality returned, the higher the computation time required. Such a coupling of solution construction of ant colony system with local search of GA is a promising approach for unit commitment problems. GA has been successfully applied to a wide range of applications, mainly in solving combination