ABSTRACT

Implementation of Particle Swarm Optimization (PSO) applications in solving the optimization problems in the field of electric power system is proposed. PSO is a powerful tool for optimizing multidimensional discontinuous nonlinearities.

The optimization problems in power system like economic load dispatch, unit commitment, real power loss minimization, power quality improvement using distributed generation and minimization of energy capacity of a dynamic voltage restorer are identified and analyzed.

PSO algorithm is applied to determine the optimal power generation of each unit that operates for a specific period. This minimizes the total generation cost by considering the generator output as the control variable. The simulations are carried out for (i) a three-unit thermal plant system (ii) a six-unit thermal plant system and (iii) a three-unit thermal plant system in which one unit is a combined cycle co-generation plant.

Due to strict regulations on environmental protection, the conventional operation at minimum fuel cost cannot be the only basis for dispatching electric power. Therefore, the combination of economic and emission dispatch (CEED) is required which leads to a dual objective problem. The purpose of combined economic and emission dispatch problem is to identify the optimal amount of generated power for the generating units in the system by minimizing the fuel cost and emission level simultaneously subjected to various system constraints. The multi objective CEED problem that includes both generation cost and emission cost is solved by swarm intelligence. PSO is applied to the dual objective CEED problem by using a price penalty factor approach to form a single objective. The Particle Swarm Optimization (PSO) based algorithm is developed for finding out the optimal power dispatch in CEED environment of thermal units while satisfying the constraints such as generator capacity limits, power balance and the line flow limits. Using this algorithm, the global optimal generation value is calculated for an IEEE - 30 bus system.
In practical systems, the operating range of all the on-line units is restricted by their ramp rate limits and prohibited operating zones due to physical operational constraints. The prohibited operating zone of an unit divide the operating range between its minimum and maximum generation limits into several disjoint convex sub regions. Hence conventional methods cannot be directly applied to solve economic load dispatch problem with prohibited operating zones. Therefore, a hybrid PSO algorithm is used to solve the economic load dispatch problem of generating units with prohibited operating zones and ramp rate limits. The general system constraints such as system demand, balance of power with network losses and generating capacity limits are also incorporated. The hybrid method incorporates the Genetic Algorithm (GA) to explore the high performance region in solution space and PSO algorithm to exploit the solution space for locating the optimal solution. Thus, the GA guides PSO for better performance in the complex solution space. The proposed algorithm is used to solve a 6, a 15 and a 40 unit test system.

Unit commitment is the problem of determining the schedule of generating units within a power system subjected to operating constraints. A hybrid GA-PSO algorithm is developed in this work for solving the unit commitment problem. The algorithm involves an exhaustive study of all the possible combinations of units to meet the load demand and the combinations corresponding to minimum production cost. GA is used to obtain the ON/OFF status of various generators with an objective function to have generation greater than the demand. The initial solution obtained from GA is applied to PSO based unit commitment algorithm to obtain minimum production cost. The hybrid genetic based unit commitment algorithm is tested on a 10-unit system.

The losses that occur in a power system have to be minimized in order to enhance its overall performance. Therefore, in this proposed work a PSO based algorithm is attempted to minimize the real power losses, with a view to improve the voltage stability of the system. The proposed PSO based algorithm aims at finding optimum settings of Automatic Voltage Regulator, On Load Tap Changer values and requires minimum number of Reactive Power Compensation Equipments subject to equality and inequality constraints. The voltage stability assessment is performed using a line voltage stability index. The particle swarm optimization technique is used for different systems such as Standard-5, IEEE-14, IEEE-30, IEEE-57, IEEE-118 bus systems, Indian Utility systems such as Neyveli Thermal Power Station bus system and Puducherry bus system.
The introduction of Distributed Generation (DG) in a distribution system offers several benefits to utilities, customers, and society. A general approach is applied to assess the major technical benefits to improve power quality issues such as voltage profile improvement and line loss reduction. The proposed PSO based algorithm determines the optimal value of the DG capacity to be connected with the existing system thereby maximizing the power quality by reducing the line losses and increasing the voltage profile of the various buses. The line voltage stability index obtained by performing a Newton-Raphson (NR) load flow solution is used to validate the significance of the PSO based approach. The line index finds out the increase in maximum loadability of the system after using the proposed method.

The growing interest in power quality has led to a variety of devices designed for mitigating power disturbances, primarily voltage sags. Among several devices, a Dynamic Voltage Restorer (DVR) is a novel custom power device proposed to compensate for voltage disturbances in a distribution system. The compensation capability of DVR depends primarily on the maximum voltage injection ability and the amount of stored energy available within the restorer. A novel PSO based phase advancement compensation strategy is proposed in this work for optimizing the energy storage capacity of the DVR in order to enhance the voltage restoration property of the device. The novel proposed algorithm is tested for a sample three phase system for various levels of sag in a particular phase. The proposed algorithm identifies the required value of phase advancement angle corresponding to a minimum power injection from the energy storage element such as a capacitor or a battery.

The results of swarm intelligence and its hybrid based optimization techniques for various power system problems are compared with the conventional, GA and PSO based methods.