ECONOMIC LOAD DISPATCH USING HYBRID PARTICLE SWARM OPTIMIZATION

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Abstract — In recent years, generation cost and fuel emission have been essential to minimize to sustain on the planet. Fossil fuel has been enormously utilized for power generation for a long time. It is required to manage the demand of customer and efficiently utilize the fossil fuels. The economic load dispatch problem has been considered to solve the crisis of conventional energy resources. So here, a novel stochastic optimization approach to solve constrained economic load dispatch problem using hybridization of Particle swarm optimization. This review paper shows that by applying hybridPSO algorithm the power demand can be successfully met at minimum generation cost incurring minimum transmission loss.

I. Introduction

In the present scenario, the study focuses on small thermal power generating system where main concern is continuous and reliable power generation to meet the increasing demand with optimum generation schedule of the generators. With the increase in power demand and fuel cost, the generation cost is higher which ultimately affects the user community. So the other aim of optimization of power generation and distribution is to minimize the overall generation cost and power loss in transmission lines.

The economic dispatch (ED) aims at determining the optimal scheduling of thermal generating units so as to minimize the fuel cost while satisfying several operational and power system network constraints. The generator fuel cost functions are invariably nonlinear and also exhibit discontinuities due to prohibited operating zones (POZs). In addition, the valve point loading effect causes non-convex characteristics with multiple minima in the generator fuel cost functions and thus imposes challenges of obtaining the global optima for high dimensional ED problems. Thus, ED is a highly nonlinear, complex combinatorial, non-convex, and multi constraint optimization problem with continuous decision variables. The classical mathematical methods like gradient, Lagrange relaxation methods, and so forth, except dynamic programming, are not suitable for such complex optimization problems. The modern metaheuristic search techniques such as Particle swarm optimization (PSO), genetic algorithms (GAs), biogeography-based optimization (BBO), differential evolution (DE), ant colony optimization (ACO), artificial bee colony (ABC), and hybrid swarm intelligent based harmony search algorithm (HHS) have shown potential to solve such complex ED problems due to their ability to obtain global or near global solution but are computationally demanding especially for modern power systems which are large and complex.

The PSO has several advantages over other metaheuristic techniques in terms of simplicity, convergence speed, and robustness. It provides convergence to the global or near global optima irrespective of the shape or discontinuities of the cost function. The potential of PSO to handle non-smooth and non-convex ED problem was demonstrated. However, the performance of the PSO greatly depends on its parameters and it often suffers from the problems such as being trapped in local optima due to premature convergence, lack of efficient mechanism to treat the constraints, and loss of diversity and performance in optimization process. PSO is a population based optimization technique in which the movement of the particles is governed by the two stochastic acceleration coefficients, that is, cognitive and social components and the inertia component. In order to enhance the exploration and exploitation capabilities of PSO, the components affecting velocity of particles should be properly managed and controlled.
2. PROBLEM FORMULATION

The generator cost function is usually considered as quadratic, when valve-point loading effects are neglected. The large turbine generators usually have a number of fuel admission valves which are operated in sequence to meet out increased generation. The opening of a valve the throttling losses rapidly and thus the incremental heat rate rises suddenly. This valve-point loading effect introduces ripples in the heat-rate curves which introduces non-convexity in the generator fuel cost function as shown in Figure 1. The effect of valve-point loading effects can be modeled as sinusoidal function in the cost function. Therefore, the increases Advances in Electrical Engineering 3 objective function for the non-convex ED problem may be stated as

\[
\text{Minimize } F(P_{Gi}) = \sum_{i=1}^{N_G} (a_i + b_i P_{Gi} + c_i P_{Gi}^2) + |c_i \sin(f_i(P_{Gi} - P_{Gi}^{\text{th}}))|,
\]

where \(a_i, b_i, \) and \(c_i\) are the cost coefficients of the \(i\)th generator, \(f_i\) and \(b_i\) are the valve-point effect coefficients, \(P_{Gi}\) is the real power output of the \(i\)th generator, and \(N_G\) is the number of generating units in the system.

Subject to the following constraints:

(1) **Power Balance Constraint**

The total power generation of all generators must be equal to the sum of total power demand plus the network power loss. The network power loss can be evaluated using \(B\)-coefficient loss formula. Therefore, the generator power balance equation may be stated as follows:

\[
\sum_{j=1}^{N_G} P_{Gj} = PD + \sum_{i=1}^{N_G} P_{Gi} B_{ij} + \sum_{i=1}^{N_G} P_{Gi} B_{ij} + B_{00},
\]

where \(B_{ij}\) is the transmission loss coefficient \(i = 1, 2, \ldots, N_G\) and \(j = 1, 2, \ldots, N_G, B_{00}\) is the \(i\)th element of the loss coefficient vector. \(B_{00}\) is the loss coefficient constant.

(2) **Generator Constraint.**

For stable operation, power output of each generator is restricted within its minimum and maximum limits. The generator power limits are expressed as follows:

\[
P_{Gi}^{\text{min}} \leq P_{Gi} \leq P_{Gi}^{\text{max}}.
\]

Prohibited operating zones lead to discontinuities in the input output relation of generators. Prohibited zones divide the operating region between minimum and maximum generation limits into disjoint convex sub regions. The generation limits for the \(i\)th unit with \(j\) number of prohibited zones can be expressed as follows:

\[
P_{Gi}^{\text{min}} \leq P_{Gi} \leq P_{Gi}^{\text{max}},
\]

where superscripts \(L\) and \(U\) stand for the lower and upper limit of prohibited operating zones of generators. \(NGPZ\) and \(NPZ_{ij}\) denote the total number of generators with prohibited zones and the total number of prohibited zones for the \(i\)th generator, respectively.

3. HYBRID PSO-ACO APPROACH

PSO is a population-based heuristic search algorithm that emulates the movement of swarm in finding best solution of an optimization problem. In PSO, the particles make parallel searches for optima in the search space by updating their velocity and position dynamically. In every iteration, the PSO keeps track of two updated \(\text{‘best’ values} – one is the \text{‘gbest’} or the best value \text{‘fitness} achieved so far by a given particle while the other is the \text{‘gbest’ i.e., the best value attained so far by the population. ACO is another swarm based method for finding optimum solution by following the strategy of movement of an ant colony towards the source of food through the shortest path. Though each ant finds a new solution, better solutions are yielded by exchanging information with other ants through the \text{‘pheromone’} trail. Thus, analogous to an ant, the ACO algorithm constructively builds or improves a solution to an optimization problem by moving through nodes (or states) of a neighborhood graph. Though PSO is good for ELDP problems for its flexibility, robustness and fast convergence, it sometimes give unsatisfactory result due to large accumulation of particles at \text{‘gbest’} position. ACO, on the other hand, known for its good downhill behaviour near the global optimal region, imparts better balance between local and global search when combined with PSO in the hybridPSO-ACO algorithm.
4. REFERENCES

1. Particle Swarm Optimization By Aleksandar Lazinica using Evolutionary Algorithms By Kalyanmoy Deb

2. Multi-Objective Optimization


